CONNECTIVE TIES IN DISCOURSE: THREE ERP- STUDIES ON CAUSAL, TEMPORAL, AND CONCESSIVE CONNECTIVE TIES AND THEIR INFLUENCE ON LANGUAGE PROCESSING

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Erklärung

Ich versichere, dass ich die Dissertation einschließlich beigefügter Zeichnungen, Kartenskizzen, Darstellungen u.ä.m. selbstständig angefertigt und keine anderen als die angegebenen Hilfsmittel benutzt habe.

Alle Stellen, die dem Wortlaut oder dem Sinn nach anderen Werken entnommen sind, habe ich in jedem einzelnen Fall unter genauer Angabe der Quelle deutlich als Entlehnung gekennzeichnet.

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I. INTRODUCTION

"In your brain, various electrons are surging to and fro in various nerve fibers. Chemical molecules are combining together, or breaking up, to make new ones. Modern sensing apparatus […] can reconstruct a three-dimensional image of your brain, showing which regions are active when you are thinking about that elephant. Materially, your brain is buzzing in some complicated way. Science can see how it is buzzing, but it can't (yet) extract the elephant."

The Science of Discworld II: The Globe. Pratchett, Stewart & Cohen, (2002).

The above quote touches on something that is also known as the 'black box' metaphor, a term that probably first appeared in the 1940's in connection with flight recorders in aircrafts, and was then used in engineering for any 'complex piece of equipment, usually a unit in an electronic system, with contents which are mysterious to the user' (Oxford Dictionary and Thesaurus). In electronics, there is generally someone who knows how the thing actually works, at the latest the person who put it together. In cognitive science, we do not have that luxury. The term black box has also been adapted for use in psychology (the first time probably by von Neumann, 1951), to denote any model used in formulating hypothetical constructs: knowing what the input is, and having developed a model as to how the human mind processes that input, there can be predictions made as to the output. These models can then be tested by systematically varying the input, which is precisely what is done in psycholinguistics.

To develop a model, one has to know, or at least have a good idea of, the processes that influence how the input is 'dealt with'. The more processes are assumed to be involved, the more complex the model will become, and the margin for error and misinterpretation grows proportionately.

Understanding language is a highly complex process, and the examination of how single words and sentences are understood has already provided ample work and riddles for empiricists for many years to come. As if that is not enough, there are many researchers, including the author of the present work, who seem to be asking for even more punishment by not examining single sentences, but looking at the processing of several sentences, of a discourse.

For a reader or a participant in an experiment, the understanding of a discourse involves not only all aspects of sentence processing, but also the mechanisms involved in connecting separate sentences into a text representation, of the relations between sentences that make up what the text is about.

For the experimenter, this means that one unfortunately has to reduce oneself to a few aspects that are to be examined, i.e. that one can only satisfy one's curiosity as to how things work in discourse processing with respect to one little 'corner', since to obtain informative data one must reduce the variation of the experimental materials used as much as possible. In other words, one will always only see a small part of the big picture. On the brighter side, many, many people have already looked at a huge number of small parts, meaning that one happily does not have to start from scratch, but can proceed from the point reached already.

In the case of discourse processing, it is already known that readers try to connect sentences in a text into a whole. It is also known that there are linguistic tools that make this job easier for a reader, that provide assembly instructions to aid in the deciphering of

what the writer of a text was trying to convey. One of these tools, called connective ties here, is the object of investigation in this work. Connective ties, such as *therefore*, *because*, *nevertheless*, *afterwards*, *despite that* and all their colleagues (350 are listed for German in the 'Handbuch der deutschen Konnektoren' by Pasch, Brauße, Breindl, Waßner & Herrmann, 2003), provide a handy window into the processing of relations between two sentences by explicitly stating the connection to be made.

The present work will examine how these linguistic tools are processed, whether (and if so, when) the information they provide is used, whether there is a difference between such connective ties and words that do not explicitly connect two sentences, and whether there is a contrast between different types of connective ties.

The results reported here will hopefully provide a little more information concerning how we manage to extract more or less useful information from written text. However, to pick up the initial metaphor, the present work will not extract the elephant. The empirical method used here, ERPs (event-related potentials) is incapable of doing that or even of determining where the elephant is currently residing. It can however, so to speak, investigate its tracks and follow it very closely.

I.1. ROAD MAP

Due to the wealth of previous research on discourse in all disciplines involved, and, to a lesser extent, on connective ties, as well as the large database of general ERP-research (event-related potentials), the extent of the groundwork that had to be laid down before the experiments could be reported is rather large. An attempt was made, however, to structure the immense amount of information, and to provide shortcuts for anyone already familiar with one or more fields.

The work is split up into four major parts. The first deals with theoretical syntactic and semantic aspects of discourse, the second with language processing, the third with ERP reseach on language processing, and the fourth presents the four experiments. The first three parts are always subdivided into one chapter on the respective topic in general, followed by a chapter on connective ties dealing with aspects discussed in the previous chapter, and finishing with a successively updated list of questions to be examined in the experiments. A quick tour of the main topics of each chapter is given below.

PART A: Things Theoretical

Chapter II: This chapter introduces general theoretical aspects of discourse, such as coherence, cohesion and inferences.

Chapter III: This chapter deals with syntactic and (formal) semantic aspects of connective ties.

PART B: Language Processing

Chapter IV: The exception to the pattern: it introduces the empirical method used, ERPs.

Chapter V: This chapter deals first with theories and models of sentence processing and problems that can occur during same, and secondly with theories and models of discourse processing and problems that can occur in the understanding of a discourse.

Chapter VI: This chapter introduces previous studies on connective ties that used reaction time-, reading time-, recall- and eye-tracking methods.

PART C: ERPs in Language Processing

Chapter VII: This chapter presents previous ERP research, first studies of sentence processing and then studies of discourse processing.

Chapter VIII: This chapter presents the two already existing ERP studies and one fMRI study on connective ties.

PART D: Experimental Part

Chapter IX: Here, the four experiments, one reading time study and three ERP studies, are presented and discussed.

Chapter X: General discussion, outlook and conclusions.

PART A: THINGS THEORETICAL

II. DISCOURSE: GENERAL ASPECTS

To understand what a text one is reading or listening to is about, one must form a representation of it, which in turn is the result of decoding the linguistic information in the text (or discourse). The following chapter will introduce and describe general linguistic aspects of discourse and this decoding process –or text comprehension. The question how a discourse is structured has been around for a very, very long time. One of the first known publications on the topic stems from Plato (~350 b.c.). Since then, the investigation of not only the structure of discourse but also how people understand it has resulted in a truly vast amount of formal linguistic and psycholinguistic approaches being developed, tested, changed and refined, not only pertaining to text as such but also to all the aspects that enter into how humans understand and produce language. A detailed description of even half of these approaches and models would result in this work being useable for seating extra guests at parties. Therefore, only a rough and incomplete overview of the field can be given here, with more detailed descriptions of those aspects relevant to the present work.

The fact that many disciplines have investigated one or more aspects of text representation also means that the same terms are often used to describe qualitatively different concepts as well as the same concept being given different names in different disciplines. An attempt will be made in the text to keep different uses of the same terms apart as well as signal where different terms are used to refer to the same phenomenon.

First, basic properties of discourse will be introduced, namely coherence, cohesion, and information structure. A central psycholinguistic aspect of text comprehension is the drawing of inferences, another 'preliminary' section. The linguistic tools under investigation here, connective ties, have a chapter to themselves. Unless otherwise specified within the text, this first theoretical part is based on the works of McKoon & Ratcliff, (1992); Singer, (1994); van den Broek (1994); Carpenter, Miyake & Just (1995); Graesser, Millis & Zwaan (1997); Clifton & Duffy (2001); Zwaan & Singer (2003); Foltz (2003); Ward & Birner (2003); and Vallduví (1992).

II.1. COHERENCE

Comprehending a text is a complex process and takes place on several linguistic and cognitive levels. Words must be identified, syntactic structures detected, and meaning extracted from individual sentences. However, just understanding the separate sentences is not enough, they must be brought into a relation to each other and to the comprehender's knowledge of the real world. The cognitive side of the process –integrating words and building syntactic structures in individual sentences, and potential problems during same–, as well as the subsequent steps of 'making' a representation of the whole text or discourse, is discussed in detail in chapter V.

Understanding a text can only be successful if the text in question is *coherent*, i.e. if the separate words make up sentences and the sentences actually have something to do with each other and the real world, in other words if they are not merely a disjointed 'pile' of bits and pieces of unrelated words and information. Whether a text is coherent or not is not necessarily a property of the text itself, but a property of the interpretation of said text that a reader arrives at while reading it (Hobbs, 1979, Sanford & Garrod, 1994). In a conversation it is still possible for a hearer to interject a question if something was not quite clear, but when reading a text the only information available is the text itself and the knowledge of the reader, which might not be enough to establish coherence. The following examples demonstrate incoherence on several levels of understanding a text.

1.

a. The pelmet is not wide enough. Jane wanted to replace it.

b. Press the steam pre-selector key, whereby the indicator will blink.
When the pre-heating is completed, the 'steam' indicator will glow and you can commence the production of steam.

c. Elvis has left the building. My dog has fleas.

Example 1.a shows a local and global incoherence stemming from one, extremely infrequent word, namely *pelmet*[1]. The sentences are connected, as demonstrated by the pronoun in the second sentence referring to the first sentence. Not knowing what a pelmet is, however, a reader is left with an incomplete mental representation of what it is Jane wanted to replace. In example 1.b, all the words are frequent and well known and the sentences are obviously connected. It is possible to tell that the discourse instructs how to go about producing steam with something, but not with what and what the resulting steam is to be used for. What is missing here is the topic or theme of the discourse. The text is locally coherent, but globally incoherent. Once the global information is available (it is the milk frothing device on an espresso maker), the text is no longer incoherent. In example 1.c, the two propositions are easily understood, but the connection between them is nonexistent, and the discourse incoherent, at least without further information.

Although coherence exists in the mind of the reader, a text can make it easy or difficult for coherence to be established. Three aspects that influence how a reader can establish coherence are the presence of cohesion, information structure, and the ease of inference building. These three properties of texts can often not be clearly distinguished, i.e. they influence each other, are interdependent, and operate on the level of the explicit discourse as well as making connections to the 'real world', but each has idiosyncratic characteristica and for the sake of clarity they will be discussed separately, as far as that is possible.

II.2. COHESION

Cohesion, very globally speaking, is an explicit relationship between two parts of a discourse. These relationships can be divided into two main groups. The first concerns identity, the second could be said to concern manner, also called *referential* coherence and *relational* coherence respectively in Sanders Schilperoord & Spooren, (2001). Both support coherence-building in a text by signaling that the respective parts of the discourse are connected.

II.2.1. Referential coherence in discourse

Referential coherence in discourse is also known as co-reference. Co-reference means that two discourse entities refer to the same discourse-external object or person. These connections between noun phrases can be expressed in different ways, one of them being pronominal (2.a) or reflexive (2.b) co-reference:

2.

a. $(\text{John}_i\text{'s room})_j$ was a shambles. [He_i decided to straighten $\text{itself}_{*i\,/\,*j}$ / it_j up].

[1] A pelmet is a narrow strip of cloth, wood, etc., usually found above windows concealing the curtain rod.

b. [A cat$_i$ always washes itself$_i$ / it$_{*i}$ after a meal].

Example 2.a shows two cases of pronominal identity: *He* in the second sentence refers to the name John, and *it* to the (chaotic) room. Both *John* and *it* refer to a male human called John. Pronouns cannot be bound within their governing domain (usually the clause they stand in, Binding Principle B, Chomsky, 1980, 1981a, 1982, 1986a, square-bracketed text), as shown by the fact that *it* in 2.b cannot refer to *cat*. A reflexive on the other hand must be bound within its governing domain (Binding Principle A), as shown by examples 2.a and 2.b: *itself* cannot refer to *room* or *he* in 2.a, *the room* being outside its governing domain and *he* the wrong gender, but can refer to *the cat* in 2.b.

Pronouns and reflexives have the same function, that of referring to a previously mentioned discourse entity in the explicit discourse by being bound by it, but are found in complementary distribution: within a clause, a reflexive must be used and a pronoun can not, between clauses a pronoun must be used and a reflexive can not.

Binding Principle C states that a referring expression, a full noun phrase, must be free everywhere. This means that they cannot be *bound* by another element (3.a). It does not mean, however, that two referring expressions in separate clauses can not have the same extension (3.b and 3.c):

3.

a. The boy$_i$ told the boy $_{*i\,/\,j}$ to get lost.

b. There's [a new exhibition]$_i$ of photographs in town.
The artist is quite shortsighted, and his photographs show how he sees the world without glasses.
[The new exhibition]$_i$/It$_{?i\,/\,?j}$ is very interesting, and tickets are cheap.

c. [My cat]$_i$ keeps climbing into things he can't get out of.
I'm constantly rescuing [the silly thing]$_i$.

Example 3.a demonstrates Binding Principle C: there must be two boys. The short discourse in example 3.b shows that co-reference of two full noun phrases can also be established when using an identical noun. If the intervening sentence in that example were not present, however, the discourse would be odd. Use of identical nouns is only felicitous if there is a reason to emphasize the co-reference, for instance if in the meantime other possible discourse antecedents have been introduced (*the world*), and it is important to clarify that an earlier discourse-antecedent is being picked up again. Use of a pronoun here could introduce a referential ambiguity.

In contrast, the two expressions *my cat* and *the silly thing* in 3.c are composed of different words, but can and do refer to the same feline entity. In this case the co-reference is established by pragmatic canonicity (cats that get stuck are silly things), but there are many cases where there is a more obvious semantic relation between two discourse entities, called *posets* (**p**artially **o**rdered **set**s) by Ward & Birner (2003). Two elements A and B in a poset can have three different relations to each other: A is of a higher value than B (hyperonym, example 4.a), A is of a lower value than B (hyponym, 4.b), or A and B are of equal rank (synonym, 4.c):

4.

a. I don't like folding [laundry]$_A$. [Shirts]$_B$ are fiddly to get straight.

b. Eat more [spinach]$_A$. [Veggies]$_B$ are good for you.

c. [Amaranthus albus]$_A$ is a major feature in wild-west movies. There are hardly any westerns without a scene of [tumbleweed]$_B$ being blown across the landscape.

A pronoun and its antecedent could be argued to constitute a poset as well, but the relation between the two elements would always be that of equal rank. Another important difference between referring expressions and pronouns, following from the above, is that the second referring expression in a poset can extend the semantic content of the discourse entity being talked about: calling a cat a silly thing describes that cat beyond the plain meaning of the word *cat*. The extension of the discourse entity being talked about is then a combination of the two elements (*cat* + *silly*). A pronoun could be said to simply 'inherit' or restate the extension of its antecedent, but not add to it (*it* = *cat*).

In sum, identity relations (also called referential coherence) connect two entities in discourse by establishing or signaling that the two entities have the same extension, or refer to the same discourse-external object or person.

II.2.2. Relational coherence in discourse

The second type of explicit connection between two parts of discourse signals a relation *between* two 'bits' in a discourse that can, if they be nouns, thereby *not* be co-referential. The 'connectees', or arguments, can be single words (5.a, 5.b and 5.c), but also whole constituents (such as a verb phrase: 5.d) and separate sentences (6.a and 6.b). The relation between the elements depends on the connector. Not all connectors can be used to connect all of the elements listed above. Two ubiquitous connectors that can connect all of them are *and* and *or*:

5.

a.	I want cookies *and* ice cream.	…cookies *or* ice cream.
b.	All he does is eat *and* sleep.	…eat *or* sleep.
c.	A lift can go up *and* down.	…up *or* down.
d.	Chop onions *and* peel potatoes.	…chop onions *or* peel potatoes.

6.

a. Taking a taxi in Mexico City is an adventure. The drivers try to take the most roundabout route possible, *and* they keep making side trips to visit friends.

b. Taking a taxi in Mexico City is an adventure. The drivers try to take the most roundabout route possible, *or* they keep making side trips to visit friends.

Many connectors are not that liberally applicable: *therefore* can not connect two single words, but must have complete propositions as arguments:

7.

a. sink *or* swim
b. *think *therefore* am.
c. [I think] *therefore* [I am].

The single verbs *sink* and *swim* in 7.a, as well as *think* and *am* in 7.b do not constitute propositions: *or* can correlate single words, but *therefore* cannot. In 7.c, the arguments of the connective tie are full propositions, and the use of *therefore* is felicitous.

These types of connectors that need to (or can: *or* can be used with single words as well as propositions) correlate two propositions will henceforth be called *connective ties* to distinguish them from other relational lexical items. They are the central object of investigation in this work. Their semantic and syntactic properties will be discussed in detail in chapter III.

Connective ties are unique in that they do not only connect two propositions, similar to referential coherence, but also convey the type of connection with their semantic content, for instance CAUSE-CONSEQUENCE or PROBLEM-SOLUTION (*therefore*, *because*). Referential coherence in contrast is always a connection of identity. As discussed above, one discourse element in a co-reference relation can extend the semantic content of its partner, the extension of what is being referred to thus becoming a combination or the two elements. Connective ties on the other hand add semantic and pragmatic content *beyond* that of their two arguments: their semantic content is the type of connection (implication or possible *inference*, see section II.4 below) between two propositions. Connective ties also operate exclusively on the discourse-level in that both their arguments have to be explicitly present (8.a), in contrast to other relational lexical items such as deictical sentential adverbs (8.b):

8.

a. *Because the bathroom flooded.
b. Yesterday the bathroom flooded.

The connective tie *because* in 8.a is missing one of its arguments, and without that cannot fulfill its function, that of denoting the relation between two propositions. In 8.b, on the other hand, *yesterday* has the function of relating its single argument, the subsequent proposition, to the real world. This is an innate property of deictical elements such as *here*, *there*, *down*, *up*, *you*, *me*, *yesterday*, *tomorrow* and many more: the extension or meaning of a deictical element depends on the circumstances a utterance is made in. The important point is that deictical relational elements are one-place operators where the explicit discourse is concerned: they need have only one explicit argument. Connective ties need both arguments to be explicit, they are two-place operators.

II.2.3. Cohesion: summary

Both types of relational coherence differ from referential coherence. Referential coherence can influence or extend the meaning of the extension denoted, but does not add local, temporal or other external information, as connective ties and deictical elements do. Referential coherence connects two elements in a discourse, but only states that they refer to the same extension, and can not modify the manner of the relation, as connective ties can.

II.3. INFORMATION STRUCTURE

There are autonomous rules that apply as to how a sentence can be put together, regardless of where, when and why a sentence is uttered, and whether it stands alone or is part of a larger text. They are often referred to as 'narrow syntax', (Chomsky, 1995). Beyond this narrow syntax, there are also rules as to how the information in a discourse is

or must be structured. Every sentence in a discourse must connect to previous information, and at the same time conveys new information, too (de Swart & de Hoop, 2000). Old information in discourse is called Topic in Information Structure (IS), and new information is called Focus. Depending on what is already known in a discourse, the new information can be presented in many different ways. What the Topic in a sentence can be is not only dependent on the previous discourse, but also on for instance a speaker's or writer's intentions, which information they wish to emphasize, and what they consider to be already known to a hearer or reader. From the receptive point of view, coherence is influenced by how successful a writer or speaker is in assessing the mental state and knowledge of the reader and listener, and in structuring the text accordingly. Although Topic and Focus are the main terms in IS, the old-new dichotomy is usually based on only one of the two[2]: Focus (new) and presupposition (old), Topic (old) and Comment (new), Theme (old) and Rheme (new), see also Vallduví (1992), Molnár (1993), and de Swart and de Hoop, (2000).

II.3.1. Focus and presupposition

In a written text, one of the main sources of clues as to what is important, what is considered old information and what is new is missing: prosody. The term focus can not only denote what is new information based on previous discourse, but also what is prosodically emphasized, or receives 'narrow focus'. Very roughly speaking, by putting emphasis on a part of a sentence in spoken language, a speaker can mark that part as particularly worthy of attention (signaled by the words in capitals):

9.

a. I haven't seen a bad storm **FOR YEARS**.
b. I haven't seen a **BAD** storm for years.
c. **I** haven't seen a bad storm for years.

In all three examples, the syntactic structure and order of words is identical, and the theme of conversation is storms. But depending on which element receives emphasis (or intonational focus), the information the sentence conveys as old or presupposed versus the new information differs: in example 9.a, the idea a listener gets is that it has been a long time since the last big storm (focus), but that there have been some in the past (presupposition). In contrast, sentence 9.b implies that there have been minor meteorological upheavals (presupposition), but no disastrous ones (focus), and in 9.c, the speaker has been spared (presupposition), but it is implied that others haven't (focus). In a written text, such additional information has to be either added explicitly (10.a, as written correlate of 9.c), or other tools employed, such as a changing the word order by for instance preposing a part of the sentence (10.b, as written correlate of 9.a):

10.

a. I haven't seen a bad storm for years, <u>but my friends in the black forest have</u>.
b. <u>As to bad storms</u>, there hasn't been one for years[3].

In a discourse, information prior to the sentence in question often already restricts what will or can be the new information in a subsequent one[4]:

---

[2] Many thanks to Ingo Feldhausen for a quick but thorough initiation into this thorny field.
[3] Ward & Birner (2003) note that the preposed part has to be discourse-old for the structure to be felicitous in a discourse, see section II.3.2 below.

11. My friends in the black forest often get hailstorms.
I haven't seen a bad storm for years.

Since bad weather has already been mentioned in the first sentence in example 11, and is therefore *discourse-old*, the new information conveyed in the second sentence is contrastive, so to speak whatever has not been previously mentioned: *my friends* versus *I*, and *often* versus *for years*. This distinction into discourse-new and discourse-old, or focus and presupposition in pragmatic approaches, is one dimension along which a discourse reflects information ordering at the sentence level.

II.3.2. New and old in discourse

It is important to note that those two terms, discourse-old and discourse-new, only refer to what has been explicitly mentioned in a text. A second, psychological, distinction should be made between what is new or old in the discourse and what is new or old to the hearer (or reader in written texts). This second aspect, hearer-new and hearer-old, is rather tricky, as it involves what a speaker or writer of a text assumes to be known to the hearer or listener (Prince, 1992). It includes such aspects as canonicity, things that are generally well known and need therefore not be elaborated, but depends very much on what a hearer knows, i.e. it is relative (Ward & Birner, 2003). Thus, an element in a discourse can be discourse-new but hearer-old (12.a), discourse-old and hearer-old (12.b) or discourse-new and hearer-new (12.c)[5].

12.
a. The moon is very pretty tonight.
b. The moon was very pretty tonight. I noticed it after finishing work.
c. I called a friend to tell her about it.

It is unnecessary to elaborate what the moon is (12.a), at least in everyday life, as there is only one we can see without serious optical equipment, and therefore there is only one possible thing the phrase *the moon* can denote, at least in a non-astronomical or -science-fictional context. In example 12.b, the antecedent for the pronoun *it* has been already mentioned in the discourse, is discourse-old and hearer-old. The noun phrase *a friend* in 12.c is discourse-new. That it is also considered to be *hearer-new* is signaled by the use of the indefinite determiner *a*, which explicitly marks it as such. Indefinite determiners are traditionally also seen as existential quantifiers (∃, or 'there is one', Frege, 1892). A definite determiner in this position would mark the noun phrase as discourse-old and hearer-old (13.a). Marking a canonically discourse- *and* reader-old element as new via an indefinite pronoun results in a pragmatic violation (13.b). A repeated indefinite noun phrase can only mean that one is talking about two separate instances of that noun phrase (13.c), but is somewhat odd without further elaboration (the text in brackets), while a repeated definite

[4] The term focus here is used in a contextual aspect. For sentence-internal IS, see Halliday (1967), Reinhart (1982).
[5] Discourse-old but hearer-new elements are difficult to exemplify under the assumption that a reader or listener is paying attention.

noun phrase also seems odd, or at least unnecessarily explicit without further context (13.d)[6]:

13.

a. I called the friend to tell her about it.
b. ?A moon is very pretty tonight.
c. A friend$_i$ called me tonight. A [different]$_j$ friend$_{*i/j}$ told me about her vacation.
d. The friend called me tonight. The friend told me about…

An indefinite determiner (*a, one*) is a linguistic tool of introducing new elements, marking them discourse- or reader-new. In contrast, a definite determiner (*the*), marks an element as reader-old and / or discourse-old (the 'familiarity theory of definiteness', Hawkins, 1978; Heim, 1983). Cataphoric determiners (*those, this, that*, etc.) have the function of marking an element as likely to be important later on in the discourse, a tool that is frequently employed in jokes (14.a), while using no determiner at all signals that the noun is canonically reader-old (14.b):

14.

a. This man walked into a bar…
b. Free climbing can be risky business.

II.3.3. Syntactic structure

An aspect that can help or hinder a reader on his way through a text rests on syntactic structure. This ranges from limits on the processing capacity of people, such as the fact that multiple center embedding is very hard on working memory, as the incomplete constituents have to be held in memory until the phrases can be closed (15.a versus 15.b), over the tendency to place very long or heavy constituents at the end of a sentence as opposed to the beginning (15.c versus 15.d), to stating separate propositions in separate sentences, as very long and complex sentences can severely slow a reader down. Short sentences are much easier to understand.

15.

a. ?[The mouse [that the cat [that the dog chased] caught] managed to escape].

b. [The mouse [that was caught by the cat [that was chased by the dog]] managed to escape].

c. [The teenager who had already been grounded twice for staying out way too late and had defied her parents both times] climbed out of the bedroom window again.

d. Climbing out of the bedroom window again was [the teenager who had already been grounded twice for staying out way too late and had defied her parents both times].

[6] Repeated explicit mention of a proper name is a feature of a register or style of text commonly seen in early elementary school: 'Jane sees Spot. Spot runs. Run, Spot, run!'. It appears that six-year-olds are considered unable to distinguish between discourse-new and discourse-old.

Another syntactic aspect of psycholinguistic discourse coherence has been formulated as the *parallel function strategy* (Gordon & Scearce, 1995). Originally developed for pronouns, it states that a pronoun is easier to connect to its antecedent if it stands in the same syntactic position as that antecedent. Also, if there are two potential antecedents, a pronoun will preferably be bound to the antecedent that is standing in the same syntactic position (16):

16. Grandpa$_i$ had taught Cole$_j$ how to make a kite.
    He$_{i\,/\,?j}$ was very happy with the finished product.

Of course, gender marking and context can prevent difficulties such as in 16, as can be seen in example 17:

17. Grandpa$_i$ had taught Grace$_j$ how to make a kite.
    She$_{i\,/\,*j}$ was very happy with the finished product.

In example 17, there is no doubt who is happy, although several studies have shown that in the case of several possible antecedents all of them are activated temporarily (McKoon & Ratcliff, 1980, among others), and that if a pronoun has no felicitous antecedent in the discourse, an attempt to bind to an obviously impossible antecedent might be made anyway (Osterhout & Mobley, 1995). This also suggests that use of a pronoun indicates that the object or person being referred to is hearer-*and* discourse-old.

The parallel function strategy has been shown to apply not only to pronouns but also to previously mentioned full NPs, which can be seen in example 18, taken from Cowles (2003):

18. A queen, an advisor and a banker were arguing over taxes.
    Who did the queen silence with a word, the banker or the advisor?
    It was the queen that silenced the banker.

The question in sentence two establishes the expectation that one of the two objects of that sentence will be the focus in the answer, the third sentence. Although the third sentence contains all the information expected, the 'information packaging' (Vallduví, 1992) is wrong, the expected focus not being one of the objects but the subject from the second sentence. This makes it difficult for the reader to connect the entities in the third sentence to their discourse antecedents.

II.3.3.1. Information structure: summary

One of the main tasks a reader has when going through a text is separating old from new information and determining what is important, has been mentioned before, or will be crucial later on. In a written text, prosody as a source of information is not available, so a reader has to rely on other clues. Separating old from new information is made easier by the fact that in many cases new information will be marked as such, either by an appropriate determiner or by its position within the sentence. A process of exclusion is also possible: when already mentioned information has been identified as old, what is left 'must' be new information. Determiners play a crucial role in marking objects or people in the discourse as old, new, or relevant in future. A distinction must be made, however, between discourse-old / discourse-new, i.e. already explicitly mentioned or not, and hearer-old / hearer-new, which rests on what is relatively considered to be known to the reader and is as such not a

property of the discourse. Syntactic structure in discourse can also establish preferences for the position in which certain discourse entities are expected to appear again, and this can influence discourse-antecedent identification and with it the ease of establishing coherence across more than one sentence in a discourse.

II.4. INFERENCES

An inference in discourse can be described as information that is not necessarily explicit in the text, but must –more or less easily –be added (or inferred) by the reader if coherence is to be maintained. It could also be said that the content of an inference is implied in the actual text:

19.

a. All men are mortal.
b. Socrates is a man.
c. Socrates is mortal.

20.

a. The boy couldn't wait to taste the soup.
b. He burned his mouth.
c. ?

Example 19 is the classic case of *modus ponens*, the logical rule by which a conclusion (19.c) is drawn from two premises (19.a and 19.b). The conclusion to be drawn in example 20 could be that the soup was too hot. The difference between the two examples is that in 19, all information needed for the conclusion is explicit in the text and the conclusion is one hundred percent certain; the inference (19.c) can be made by what in the psycholinguistic literature is called *argument overlap* (Kintsch & van Dijk, 1978). This strategy would not be successful in example 20, as the necessary information is not mentioned in the text. Here, the link between the two sentences must come from external knowledge: The soup being too hot it is the most *probable* reason for the boy to burn his mouth. Choosing the most likely connection between two sentences –making an inference –is a process that is central to establishing coherence in a text. Every new proposition must be connected to the preceding text, via inferences if the connection is not obviously stated, and an inference is also involved if a reader predicts what will happen next.

Inferences can be classified according to the type of relation between two propositions (*causal*, *temporal*, *instrumental* and *thematic* being the most frequently discussed), and according to whether they are made to connect two already known propositions (*backward* inferences) or to predict subsequent events (*forward* or *predictive* inferences). Examples 21.a through 21.e show different types of inference, 21.a doubling as an example of a causal and a backward inference, 21.b and 21.c demonstrating temporal and instrumental inferences, and 21.d and 21.e two forward inferences, a thematic inference (21.d) and a causal predictive inference (21.e):

21.

a. Causal Backward: The stove was broken. We made salad for supper.

b. Temporal: John brushed his teeth. He washed his face.

c. Instrumental: The woman went to work. She got stuck in traffic.

d. Them. forward: The little girl laid out paper and pens on her desk.
She wanted to be ready when the teacher came.

e. Causal forward: Bob went to see what made those noises.
When he didn't come back, Mary went to look for him.

In example 21.a, the reason for the cold meal is inability to heat anything. In 21.b, there is no obvious causal connection, but a temporal one, namely that John did one thing after the other, implied by the order in which the propositions are stated. In 21.c, a possible inference revolves around the instrument the woman used to go to work, namely a car, and in example 21.d, the theme that can be inferred is that of a lesson in school about to start. Example 21.e shows a classical case of a predictive or forward inference: people who go investigating strange noises in basements tend to have short roles, as do those who go looking for said people.

II.4.1. Bridging and elaborative inferences

From a psycholinguistic standpoint, inferences can be divided in to two main groups: *bridging* and *elaborative*. Bridging inferences are considered to be the ones necessary for maintaining (local) coherence in a text, while elaborative inferences, when not made, do not result in local incoherence:

22.

a. The boy had been playing with mud. His mother told him to wash his hands.
b. The boy washed his hands. He dried them, and went to dinner.

To understand why the boy was told to wash his hands, a reader has to infer that playing with mud gets ones hands dirty (22.a). In example 22.b, it is not necessary to infer that the boy used a towel when drying his hands to understand what is going on.

In many treatments of inference processes referential coherence is included among the inference types as anaphoric inference. In example 22.a, the pronoun *'he'* in the second sentence is an instance of an anaphoric inference having to be made, since to understand who was told to wash, a reader has to infer that *'he'* refers to the previously mentioned boy in the first sentence. To understand why, the reader has to make the connection between playing with mud and dirty hands. Since the first process involves connecting two explicitly mentioned lexical items, and the second involves information external to the actual propositions in the discourse, it is proposed here that such a process of discourse-antecedent binding is qualitatively different from inferring that mud is dirty. Therefore, anaphoric inference is discussed as discourse-antecedent binding in section II.2.1 above.

Including lexical cohesion / anaphoric inferences, bridging inferences are those inferences that *must* be made to maintain coherence in a text, i.e. to keep understanding it as one reads through it. This involves making connections between the current sentence or proposition and the preceding ones. These inferences are assumed to be obligatory, as discourse coherence is interrupted if they are not or cannot be drawn, i.e. if the text is incoherent (as in example 1.c).

Elaborative inferences on the other hand are not immediately necessary, and might not be drawn, depending on the circumstances, such as working memory capacity, interest, goal and / or task of the reader and obscurity of the inference.

That this division is not merely theoretical can be seen in a large number of empirical studies showing that closely connected sentences reduce reading times for the second sentences, compared to less obvious or nonexistent connections (Myers, Shinjo & Duffy, 1987; Singer, 1994, among others), or that reaction times are shorter to words or questions explicitly stating a previous bridging inference compared to an elaborative one. It has also been demonstrated that the ease with which an inference can be drawn between two sentences immediately influences the semantic integration of incoming words in the second sentence (Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004), as well as the ease of semantic integration for the words in a later sentence explicitly stating the inference (St. George, 1995, St. George, Mannes & Hoffmann, 1997).

II.4.2. Automatic and strategic inferences

Yet another way to distinguish inferences is to divide them into groups according to whether they are obligatory, made as it were automatically when reading a text, or only made under special circumstances, strategically (McKoon & Ratcliff, 1992). The division into automatic versus strategic inferences in the literature coincides in large parts with that into bridging and elaborative inferences, although whether readers at first do more than the absolutely necessary, i.e. draw bridging inferences, is a question that has received much attention. Proposed models range from what Graesser, Millis & Zwaan (1997) call the promiscuous kind, which assumes that every scrap of information possible and then some is extracted online, to the other extreme, which assumes that readers draw no inferences immediately and rely instead on argument overlap for local coherence, i.e. identity relations between discourse entities or cohesion (Kintsch & van Dijk, 1978). The former claim is termed a 'straw person position', by Graesser et al., as inferring *all* causes, goals, actions, instruments, possible circumstances and consequences beyond the obvious ones needed for the moment would not be possible with the more or less restricted working-memory capacity people have at their disposal[7].

Which inferences are drawn by readers online at the other end of that scale also depends very much on the task or goal a reader has. When instructed to read for comprehension (deep task), subjects were later better at recalling the content of a text or recognizing related words than when given a shallow task such as counting the pronouns in a text (Schallert, 1976, Till & Walsh, 1980). An everyday example for the influence of task-depth on text comprehension is the fact that one can rarely recall much of a text one has read when one was spell-checking it as opposed to reading it for comprehension. On the other hand, mnemonics, a strategy similar to elaborative inferencing, can be used to memorize large lists of, for instance, unrelated words. By constructing an artificial connection between the separate items, the elements in the list are no longer unrelated and easier to remember. Both extremes rest on the amount of working memory allocated to building a representation. There are indications that people with higher working memory capacity (as ascertained with the reading-span test, Daneman & Carpenter, 1980) draw inferences beyond the necessary bridging connections (St. George, 1995).

[7] This applies only in those situations where there is a time constraint, such as in a conversation or an experimental setting. On the other hand, one cannot spend infinite amounts of time on a text, either, so the question of what is automatic in inference-drawing is not purely academic.

The *minimalist* model put forward by McKoon & Ratcliff (1992) proposes that only those inferences occur online that are necessary for local coherence, i.e. bridging and anaphoric inferences. Graesser, Singer & Trabasso (1994) in contrast suggest in their *constructionist* view of text comprehension that readers actively try to maintain both local and global coherence online. In addition to local bridging inferences, they suggest that thematic inferences are made during reading as well. Both approaches agree, however, that elaborative or predictive inferences are made only under special circumstances, such as when a certain outcome is inevitable and obvious, such as Tom running out of gas on the highway (23):

23. Just as Tom had passed the last exit for the next 200 miles, he noticed that the gas-meter pointed to 'empty'.

In sum, to maintain coherence in a text a reader must connect statements, using information that does not necessarily have to be explicit in the text. Although accounts and studies disagree as to the extent to which connections are made automatically, there is a general consensus that two consecutive propositions have to be connected, and that an attempt to do so will be made automatically.

III. CONNECTIVE TIES 1

As has been shown in the previous chapter, a discourse consists of more than one sentence, and these sentences are ideally connected such that the reader or hearer can form a representation of the content of the text, i.e. of what the text is about. Making a connection between two sentences or propositions in a discourse involves the drawing of bridging inferences. There are many linguistic tools that make the drawing of such an inference easier, by signaling that the two sentences or propositions are indeed directly associated. Co-reference, discussed above, does so by establishing that two noun phrases denote the same object or person, while deictical expressions establish a local or temporal relation to the real world. These words signal that there is a possible relation connecting the two propositions, but they do not specify what type. There is another group of words that exclusively have the function of signaling the type of inference that can be drawn between two sentences or propositions: connective ties. In the following chapter the theoretical syntactic and semantic properties of connective ties, the main focus of this work, will be introduced.

III.1. GENERAL STOCKTAKING

Connective ties have been called connectors, connectives, connective expressions, linguistic markers of coherence relations, cohesive ties, cohesion markers, relational adverbs, pronominal adverbs, conjunctions and subjunctions, particles, modifiers, Würzworte (seasoning words), and Abtönungsworte (coloring words), to name a few terms, which demonstrates that while connective ties are ubiquitous in the field of text comprehension, they are hard to define clearly. Their characteristica combine semantic, pragmatic and syntactic aspects, making it a thankless task to approach them from one viewpoint exclusively. Until recently, there were no comprehensive attempts to delineate connective ties as a group. Especially in lexica and thesauri the descriptions of the meaning and use of connective ties are occasionally vague or even misleading, as Pasch, Brauße, Waßner, & Herrmann, (2003) note. The classificational problems begin when one notices that connective ties, so to speak, come syntactically 'from all over': there are particles (1.a) as well as adverbial connective ties (1.b). Some are single words, or even part of the group of closed-class or function words, but there are multi-word phrases that are also used as connective ties and could be considered to be freely inventible (1.c):

1.
   a. The tire was losing air, *so* John replaced it.
   b. The tire was losing air. *Finally* John replaced it.
   c. *In view of the fact that* the tire was losing air, John replaced it.

Defining connective ties via their syntactic category is apparently the wrong way to go about it. A more promising route is starting not with what they are, but with what they do, with a functional description. This is what was done in Pasch, Brauße, Breindl, Waßner & Herrmann (2003), introduced in the next section.

III.2. WHAT IS A CONNECTIVE TIE

The following criteria are taken from the Handbook of German Connectors ("Handbuch der deutschen Konnektoren" hereafter HdK, Pasch et al., 2003). Although they were developed originally for German, these criteria serve to define and delimit connective ties

in English as well, as shall be shown below[8]. The separate criteria were originally numbered as M1 through M5 (M for the German '*Merkmal*', property), but will be referred to here as P1 through P5. Following the listing of the separate properties, each one will be discussed in turn.

2. Properties of connective ties: X is a connective tie if:

P1. X cannot be inflected.
P2. X does not assign case to its syntactic surroundings.
P3. The meaning of X is a two-place relation.
P4. The arguments of the meaning of X are propositions.
P5. The arguments of the meaning of X must be stateable as sentences.

III.2.1. Property 1

P1: X cannot be inflected.

This first property separates connective ties from all content (open class) words such as nouns and adjectives, as well as verbs, but also from referential markers of coherence such as pronouns, anaphors, reflexives and cataphors. In contrast to a pronoun such as '*she*', which has a different form for, for instance, accusative ('*her*'), a connective tie like English '*because*' or German *deshalb* cannot be inflected. It can not be assigned a case or appear in a plural form. It can also not be converted to another category by derivational morphology (examples 3.a-3.c), or appear in different degrees (example 3.d):

3.

a.	*becausely	*deshalblich	(adjectival ending)
b.	*the becauser	*der Deshalber	(nominalization)
c.	*to because	*deshalben	(verbalization).
d.	*because, *becauser, *becausest		*deshalb, *deshalber, *deshalbest

The possible exception is a certain type of nominalization (4.a, 4.b):

4.

a. I can think of a lot of *buts* regarding that idea.
b. There are so many *ifs* and *whens* in her plans that she'll never get anything done.

While in these cases the connective ties *but*, *if* and *when* have certainly been nominalized, they are not being used as connective ties, but as paraphrases for other nouns (examples 5.a and 5.b). These nominalizations cannot in turn be used as connective ties (5.c, 5.d):

5.

a. I can think of a lot of *objections* regarding that plan.
b. There are so many *uncertainties* in her plans…

[8] Connective ties are of course not only found in English and German. On the contrary, it is likely that they exist in every language on the planet. Some relevant works on other languages are: Rudolph (1996) for adversative and concessive connective ties in German, English, Latin, Spanish and Portuguese, Mori (1999) for connective ties in Japanese, Mendoza (1996) for Russian, Michaelis (1994) for Seychelles-Creole, Gil (1995) for French, Spanish and Italian.

c. *That's not a bad idea, *buts*…
d. *We can do that *ifs* and *whens*…

As to the generation of new connective ties, it seems that while quite a few of them are morphologically simple (*if*, *when*, *but*, *and*, *or*, to name but a few), others are obviously combinations of several original words or even appear as idioms: *never-the-less*, *in spite of*, *be-cause*, *be-fore*, *so that* in English, and *trotz-dem*, *nichts-desto-trotz* (nevertheless), *des-halb* and *da-rum* (because, due to), *be-vor* (before) and *so daß* (so that) in German. The combined connective ties are the end product of a process of univerbalization ('Univerbierung', Eisenberg, 1998) and subsequent lexicalization. The connective tie *so that* (*so daß* in German) shows this process very nicely:

In English *so that* is still strictly written as a syntagma, i.e. in separate words. The German synonym *so daß* can currently be used in writing either separately or together. This connective tie is not lexicalized yet in German (or in English).

The causal connective *because* on the other hand is well past lexicalization: it stems from the Middle English 'bi cause of', *by cause of*. Originally used with the preposition *of*, that has disappeared and the remaining two words have been combined to the point that the underlying construction is not apparent anymore (pseudo-affixation), in contrast to *nevertheless*, which is also used as one word.

In sum, connective ties display all the properties of closed-class and function-words, with the exception of there being the possibility of making new connective ties, and they also resist any kind of morphological inflection or derivation, at least if they are to keep their original use.

III.2.2. Property 2

P2: X does not assign case to its syntactic surroundings.

The second property delimits connective ties from verbs and prepositions that do assign case to their arguments. A verb has a subcategorization frame that imposes strict rules, it assigns case and theta roles and must have precisely as many arguments as it needs if the sentence is to be grammatical (6.a). A preposition assigns case and a theta role as well (6.b):

6.

a. *Susie slept *the toad*. → no case/ theta role assigned to object NP.
b. *I made cookies with. → unfilled argument position: *with* needs dative NP.

Connective ties are also transitive in the sense of needing two arguments for the sentence or discourse in which they stand to be felicitous (see section III.2.3), but their need for arguments does not manifest itself overtly by way of syntactic case assignment. Many connective ties are still used with prepositions that can embed an entire clause, as for instance *because of*, but here it is the preposition assigning case (7.a). If the connective tie is used without the preposition, the second argument is also a full clause, which is however not assigned case (7.b):

7.

a. We have no clean mugs *because of* [me_{OBJ} forgetting to do the dishes].
b. We have no clean mugs *because* [I forgot to do the dishes].

Interestingly, although connective ties do not assign case, the making of a complex connective tie often involves case assignment, as many connective ties are a combination of a preposition and a noun or, in German, an article:

8.
a. because = by + cause of +OBJ
b. deswegen (because, that's why) = des_{GEN} + wegen

Under the assumption that prepositions are the 'raw material' from which connective ties can be made, the following, rather speculative, explanation suggests itself. The preposition *wegen* for instance must assign a case: genitive. One argument of the coordination is, however, the preceding sentence. Since case assignment is not possible over sentence boundaries, the article '*der'* is used as a placeholder, at the same time referring to the previous sentence and receiving the case. This would mean that while some complex connective ties are markers of relational coherence, they also have co-referential characteristica.

III.2.3. Property 3

P3: The meaning of X is a two-place relation.

As has been hinted at in the previous section, the semantic content of connective ties is a two-place relation, requiring two arguments, as can easily be seen in examples 9.a through 9.d, showing German and English connective ties in sentences where one argument is missing:

9.
a. **Afterwards* the potatoes were peeled.

b. **Therefore* the floor got wet.

c. **Danach* hat man die Tür abgeschlossen.
After that has one the door locked.
'After that they locked the door.'

d. **Deshalb* zog die Familie nach Kanada.
That's why moved the family to Canada.
'That's why the family moved to Canada.'

This property delimits connective ties from one-place sentential adverbs such as *actually* and *unfortunately* and from deictical expressions such as *yesterday* in English and their German correlates *eigentlich*, *unglücklicherweise* and *gestern*, respectively, which only require one argument, as can be seen in examples 10.a through 10.f, with the German examples being translations of the preceding English ones:

10.
a. *Actually* tofu tastes okay.
b. *Eigentlich* schmeckt Tofu ganz gut.
c. *Unfortunately* they had forgotten the tickets.
d. *Unglücklicherweise* hatten sie die Eintrittskarten vergessen.

e. *Yesterday* a thunderstorm ended the heat wave.
f. *Gestern* beendete ein Gewitter die Hitzewelle.

It has been shown in the previous section that this need for arguments is not analogous to syntactic case assignment for connective ties (or one-place sentential adverbs). Despite that, connective ties need two arguments: they are used as signals that two propositions stand in a certain kind of relation.

The type of connective tie that can felicitously be used depends on the type of relation between the two propositions. A causal relation is signaled by a causal connective tie (11.a), while for a temporal relation a temporal connective tie is used (11.b):

11.
a. John went to the barbecue *because* he loved parties.
b. John went to the barbecue *after* he had taken a shower.

While using the 'wrong' connective tie does not result in total unintelligibility or ungrammaticality, it renders the sentences somewhat odd, as can be seen in examples 12.a and 12.b, where the connective ties from examples 11.a and 11.b have been switched:

12.
a. ?John went to the barbecue *after* he loved parties.
b. ?John went to the barbecue *because* he had taken a shower.

It seems that connective ties state a relation between propositions that is present with or without the explicit signal. Sometimes, however, the relation between two propositions is not patently obvious, or hearer-old (13.a, 13.c). Here a connective tie can for instance establish a new temporal order or causal connection (13.b and 13.d, respectively). For some situations, the connective tie is even needed to prevent a pragmatic violation that would occur without it, as with concessive connective ties (examples 13.e and 13.f):

13.
a. He peeled potatoes. He chopped onions.
b. He peeled potatoes *after* he chopped onions.
c. The cat howled. It was six p.m..
d. The cat howled *because* it was six p.m.[9]
e. ?The public transport system in Berlin is very good. Ken called a taxi.
f. The public transport system in Berlin is very good. *Nevertheless* Ken called a taxi.

This kind of 'ordering' of propositions –explicitly stating what happened in which order or because of what else– is a semantic / pragmatic process. Connective ties are operators on two propositions on the discourse level, signals of relational coherence (Sanders, Schilperood & Sporen, 2001).

[9] He's always fed at that time and knows it.

III.2.4. Property 4

P4: The arguments of the meaning of X are propositions.

This property separates the use of certain expressions as connective ties from their also possible use as deictical expressions in German: *darum* used as a connective tie (14.a) is used in a two-place causal relation ('that's why'), while *darum* as a deictical expression (14.b) denotes a one-place relation, with *da-* referring to an object and *–rum* providing the local, deictical information. ('around sth'.):

14.

a. Hans kann nicht schlafen. *Darum* liest er ein Buch.
John can not sleep. That's why reads he a book.
'John can't sleep. That's why he reads a book.'

b. Ich habe einfach Klebeband *darum* gewickelt.
I have simply duct-tape around-it wrapped.
'I simply wrapped duct-tape around it.'

At first glance this distinction between two uses of the same word seems somewhat ad hoc, but there are deciding differences between *darum* as a connective tie and *darum* as a deictical expression. First, the two arguments of the connective version are propositions, while the deictic version refers to an object in the real world (an NP): whatever the duct-tape is being wrapped around. Secondly, the deictical use of *darum* does not carry the connotation of a causal relation, which the connective use does. As has already been discussed (in section III.2.2), many German connective ties appear to be combinations of co-referential and prepositional parts. There is nothing preventing their use as one-place deictical expressions, in which case the preposition retains its original, literal meaning. The connective version, however, has a derived, more obscure meaning.

The main difference between connective and deictical uses is that connective ties operate on the discourse-level only: both arguments are propositions that must be explicit in the discourse, while the deictical use is a real-world relation, external to the discourse structure as such. Of course there are exceptions, for instance a movie title ('Before the Rain') and the classical child-parent exchange, 'why?-because!', but in the first case the implication is that what happened 'before the rain' is the content of the movie, and in the second case both arguments have generally been discussed at length and are well known to both parties.

III.2.5. Property 5

P5: The arguments of the meaning of X must be stateable as sentences.

This fifth property delimits connective ties from expressions that govern infinitival constructions, such as *to* in English and *um zu* in German (15.a), but cannot govern complete sentences (15.b):

15.

a. Julius Caesar verließ den Senat, *um zu* [essen].
Julius Caesar left the senate to [eat].
'J. Caesar left the senate to eat.'

b. *Julius Caesar verließ den Senat, *um zu* [er isst].
Julius Caesar left the senate to [he eats].
'J. Caesar left the senate to he eats.'

Applied to connective ties, this property turns out to be tricky. Many connective ties can also be used in sentences where they do not relate two complete sentences (16.a, 16.b). It is however always possible to rephrase those constructions such that the arguments of the connective tie constitute complete sentences (16.c, 16.d)[10]:

16.

a. …the, *because of* a sprained ankle, rather immobile aunt.

b. …die, *weil* ständig verprügelten, vorsichtigen Römer.
...the, because constantly beaten up, careful Romans.

c. My aunt is rather immobile *because* she sprained her ankle.

d. Sie sind vorsichtig, *weil* sie ständig verprügelt werden.
They are careful because theyconstantly beat up are.
'They (the Romans) are careful, because they are constantly beaten up.'

In other words, an expression is a connective tie if it can be used relating two sentences, and it is not if it cannot be rephrased such that it does.

III.2.6. Definition of connective ties: summary

Deciding whether an expression is a connective tie in the sense of that it is a relational marker of discourse coherence is mostly a process of exclusion:

- P1 (X cannot be inflected) states that if it is not possible to inflect the expression while still preserving the original meaning, i.e. pluralize or nominalize it or state it as a comparative, it might be a connective tie (or a preposition or a one-place sentential adverb).
- P2 (X does not assign case to its syntactic surroundings) states that if the expression does not assign case when standing in a sentence, and if P1 holds, it could be a connective tie (or a one-place sentential adverb).
- P3 (The meaning of X is a two-place relation) states that if the expression requires two arguments to be semantically and pragmatically correct, and if the relation between the two arguments is explicitly stated by the expression, and if P1 and P2 hold, it is likely to be a connective tie (or a one-place sentential adverb).
- P4 (The arguments of the meaning of X are propositions) states that if both arguments can be propositions, and P1, P2 and P3 hold, it is a connective tie, and not a one-place sentential adverb.
- P5 (The arguments of the meaning of X must be stateable as sentences) states that if the expression can be used with two full and / or separate sentences, and P1, P2, P3, and P4 hold, it is definitely a connective tie.

[10] The German examples are adapted from Goscinny & Uderzo (1968), p. 11.

III.3. SYNTACTIC PROPERTIES OF CONNECTIVE TIES

After establishing a method which to identify connective ties in general, Pasch et al. turn to the task of establishing syntactic classifications within the domain of connective ties. They do not adopt the classical division into con- and sub-junctions (*and, if*), particles (*even*, *indeed*) and adverbs (*because*, *before, nevertheless*), but first introduce a more general binary division into 'konnekt-integrierbare Konnektoren' and 'nicht-konnekt-integrierbare Konnektoren', which will here be translated as *argument-integrateable connective ties* and *non-argument-integrateable connective ties*.

III.3.1. External and internal arguments of connective ties

Before turning to syntactic and semantic properties of connective ties, a formal distinction between their two arguments will be introduced. Analogous to Pasch et al., the argument directly following the connective tie, or the argument the connective tie can be integrated into will be called the *internal argument*, while the second argument will be called the *external argument*. This differentiation is needed, as connective ties can, depending on their type, make impositions on the syntactic structure of either the internal argument only or on both their arguments. The semantic content of connective ties can also have an influence on which of two propositions in a discourse can felicitously be the internal and which the external argument, as shall be shown in section III.4.

III.3.2. (Non)-argument-integratability

Argument-integratable connective ties are those that can be direct constituents of their internal arguments (17.b), while non-argument-integratable connective ties can not (17.d):

17.

a. [It has been raining a lot lately]. *Nevertheless* [we'll go camping].
b. [It has been raining a lot lately]. [We'll *nevertheless* go camping].
c. [Anja will pack a camping cooker], *and* [Eva will provide fuel].
d. [Anja will pack a camping cooker], *[Eva *and* will provide fuel].

The non-argument-integratable connective ties encompass conjunctions as well as subjunctions, and two additional classes relevant in German, where embedded sentences canonically have a verb-end structure (verb-second-embedding connective ties and so-called postponers, see next section). The group of argument-integratable connective ties contains particles[11] and adverbial connective ties.

Pasch et al. remark that this division alone is too coarse to be of much practical use, but it provides the basis for more fine-grained distinctions within those two categories. The following two sections will provide an overview of each of these categories and their subdivisions.

[11] The HdK does not use the term *particle* at all but subsumes particles and adverbial connective ties under "Adverbkonnektoren", adverbial connectors.

III.3.2.1. Non-argument-integratable connective ties

Conjunctions as well as subjunctions can not be integrated into one of their arguments. Despite that, both types of non-argument-integratable connective ties have an influence on the syntactic structure of their arguments.

Conjunctions such as *and* demand that both their arguments have the same syntactic category. In 18, *and* cannot take a CP and an NP as arguments:

18. *I'll go see [whether the grill is ready]$_{CP}$ *and* [John]$_{NP}$.

Since conjunctions coordinate their arguments, this property could be argued to be of a semantic nature. *And* expresses that both arguments have the same status; consequently both arguments must have the same form. This is not an innate property of conjunctions, but follows from their semantic function. Conjunctions also cannot be embedded together with their internal argument (IA) into their external argument (EA), a feature that they share with postponing non-argument-integratable connective ties such as *so that*: hence the name postponer (examples 19.a and 19.b respectively):

19.

a. *[I saw, [*and* he was doing a very good job]$_{IA}$, someone stacking soup cans]$_{EA}$.

b. *[I saw, [*so that* the entire tower collapsed]$_{IA}$, someone stack too many soup cans]$_{EA}$.

The other two types of non-argument-integratable connective ties, verb-second-embedders such as *provided* and subjunctions such as *if*, can in contrast be embedded into their external argument along with their internal argument (examples 20.a and 20.b):

20.

a. [He will, [*if* the tower does not collapse]$_{IA}$, stack the soup cans]$_{EA}$.
b. [He will, [*provided* the tower does not collapse]$_{IA}$, stack the soup cans]$_{EA}$.

The reason for the division between verb-second embedders and subjunctions becomes apparent in German, where these two types of connective ties impose different syntactic structures on their internal argument. Embedded sentences in German take the form of SOV (or OSV, German being a scrambling language), with the inflected verb at the end of the embedded sentence. While subjunctions are felicitous with just that surface order of their internal argument (21.a), as are postponers, verb-second embedders such as *vorausgesetzt*, (*provided*, example 21.b), must have an internal argument that has the inflected verb (in bold font) in second position in German:

21.

a. Er wird alle Dosen stapeln, *wenn* der Turm nicht **kollabiert**.
   He will all cans stack, if the tower not collapses.

b. Er wird alle Dosen stapeln, *vorausgesetzt* der Turm **kollabiert** nicht.
   He will all cans stack, provided the tower collapses not.

In sum, these types of connective ties are called non-argument-integratable in Pasch et al. because they cannot be a constituent of their internal argument. The group of non-argument-integratable connective ties is subdivided according to their distribution and the syntactic demands they make of their internal argument or in the case of conjunctions, both their arguments.

- Conjunctions coordinate two arguments that must have the same syntactic category.
- Conjunctions and postponers cannot be integrated with their internal argument into their external argument.
- Subjunctions and verb-second-embedders can be integrated into their external argument along with their internal argument.
- Subjunctions and postponers take verb-end sentences as internal arguments.
- Verb-second embedders take verb-second clauses as their internal arguments.

III.3.2.2. Argument-integratable connective ties

In contrast to the first group of connective ties, adverbial connective ties can be a constituent of their internal argument, as demonstrated in example **Fehler! Verweisquelle konnte nicht gefunden werden.**, repeated here as example 22:

22.

a. [It has been raining a lot lately]. *Nevertheless* [we'll go camping].
b. [It has been raining a lot lately]. [We'll *nevertheless* go camping].

Further subdivisions the HdK makes within the group of argument-integratable connective ties are based on the possible positions these connective ties can appear in within their internal argument. As far as it is possible, English as well as German examples will be given, but within the group of adverbial connective ties the classifications the HdK makes appear not as easily transferable to English as was the case up to this point.

Some adverbial connective ties are unrestricted and can appear in several positions within their internal argument, as for instance the German *allerdings*, and the English counterpart *however*:

23.

a. *However* I would eat a sandwich.

b. *Allerdings* würde ich ein Brötchen essen.
However would I a roll eat.

c. I would *however* eat a sandwich.

d. Ich würde *allerdings* ein Brötchen essen.
I would however a roll eat.

e. A sandwich *however* I would eat.

f. Ein Brötchen *allerdings* würde ich essen.
A roll however would I eat.

The first position (English example 23.a, German example 23.b) is the 'Vorfeldposition', *pre-field position*, in front of the inflected verb[12]; the second is called 'Mittelfeldposition', *midfield-position*, after the inflected verb 23.c and 23.d); the third is termed the 'Nacherst-Position', *post-first-position*, where the object of the sentence has been preposed (23.e and 23.f). The example for the post-first position has a rather archaic if not questionable character in English. It is not unusual in German, as long as the preceding element has contrastive focus:

24.	Ich mag Würstchen nicht.	Ein Brötchen	*allerdings*	würde ich essen.
	I don't like wieners.	A roll	however	would I eat.

This type of connective tie is the most freely applicable. The second class that the HdK introduces is somewhat more restricted. "Nicht-nacherstfähige Konnektoren", 'non-post-first positionable connective ties', cannot appear in post-first position (25.c), but must be grammatical in the other two positions, prefield (25.a) and midfield (25.b):

25.

a. Das Haus wird renoviert. *Damit* ist ein Umzug unvermeidlich.
The house will be renovated. *With that* is a move unavoidable.
'The house will be renovated. With that a move is unavoidable.'

b. Das Haus wird renoviert. Ein Umzug ist *damit* unvermeidlich.
The house will be renovated. A move is *with that* unavoidable.

c. *Das Haus wird renoviert. Ein Umzug *damit* ist unvermeidlich.
The house will be renovated. A move *with that* is unavoidable.

The last group of adverbial connective ties ('Nicht-vorfeldfähige Konnektoren'), not-pre-field positionable connective ties, is comprised of those that cannot appear in either the post-first position (26.a) or the prefield position (26.b), but must be grammatical in the midfield position (26.c):

26.

a. *Der Kühlschrank ist leer. *Sogar* haben wir die Gurken gegessen.
The fridge is empty. Even have we the pickles eaten.

b. *Der Kühlschrank ist leer. Die Gurken *sogar* haben wir gegessen.
The fridge is empty. The pickles even have we eaten.

c. Der Kühlschrank ist leer. Wir haben *sogar* die Gurken gegessen.
The fridge is empty. We have even the pickles eaten.
'The fridge is empty. We have even eaten the pickles.'

There are more positions that connective ties from the three groups can appear in, but in those positions the connective tie can be argued not to be a constituent of the internal

[12] Note that since the connective tie occupies the SpecCP position, the subject pronoun cannot be moved there, and stays in SpecIP. It is assumed that a German sentence always has a CP as highest functional projection.

argument. These positions are the pre-first position ('Vorerstposition', 27.a), the post-field position ('Nachfeldposition', 27.b), the zero-position ('Nullposition', 27.c), and the position as an additional sentence ('Nachsatzposition', 27.d):

27.

a. *Zum Beispiel* Nils könnte man fragen.
For instance Nils could one ask.

b. Nils könnte man fragen *zum Beispiel*.
Nils could one ask for instance.

c. *Zum Beispiel:* Nils könnte man fragen.
For instance: Nils could one ask.

d. Nils könnte man fragen. *Zum Beispiel*.
Nils could one ask. For instance.

That the connective tie is not a constituent of its internal argument in 27.a can be seen by the fact that the subject appears before the inflected verb in German, which is not the case when the connective tie stands in prefield position (compare 27.a to 25.a).

In sum, adverbial connective ties can be a constituent of their internal argument. This group of argument-integratable connective ties is subdivided according to the positions within the internal argument that the connective tie can appear in:

- Unrestricted adverbial connective ties can appear in either of the following three positions: pre-field, midfield and post-first position.
- Not-post-first positionable connective ties (Nicht nacherstfähige Konnektoren') can appear in pre-field and in midfield position, but not in post-first position.
- Not-prefield positionable connective ties ('Nicht vorfeldfähige Konnektoren') can only be used in midfield position if they are to be a constituent of their internal argument.

III.4. SEMANTIC PROPERTIES OF CONNECTIVE TIES

Unfortunately, an examination of the semantic properties of all types of connective ties would again lead to this work growing to furniture-like size. Therefore, only the connective ties that were investigated here will be discussed in this section: six adverbial connective ties that cannot appear in post-first position, namely *deshalb*, *darum*, *dennoch*, *trotzdem*, *danach* and *hinterher*. *Deshalb* and *darum* are causal adverbial connective ties synonymous with the English *that's why* or *therefore*; *dennoch* and *trotzdem* are concessive connective ties synonymous with *despite that,* and *danach* and *hinterher* are temporal connective ties synonymous with *afterwards*. Other connective ties will also be occasionally included for expository purposes.

III.4.1. Causal connective ties

Unless otherwise stated, this section on causal connective ties is based on the contributions by Lang (2004), Ballweg (2004), Breindl (2004) and Waßner (2004).

Both *deshalb* and *darum* signal a causal relation of the type CAUSE-CONSQUENCE, with the external argument standing in first position, taking the role of cause, and the internal argument being the consequence and standing in second position.

28. Die Schale wurde fallengelassen. *Deshalb / Darum* zerbrach sie.
The bowl was dropped. That's why broke it.
'The bowl was dropped. That's why it broke.

Before turning to some details of the semantics of these two connective ties, a few general remarks on causes, consequences and human understanding of causality are in order.

III.4.1.1. Cause and effect

After doing away with three of Aristotle's modes of causality (namely formal, material and final cause), and keeping only efficient cause, the 'primary source of change', modern philosophers were faced with the problem of how humans could know that event a causes event b, given that human perception, our source of information, is not always reliable. Descartes (1641) sees such knowledge as accessible only by reason, as the senses cannot be trusted. 'a' as a cause for b for Descartes was an absolute truth innate to creation. These truths are waiting to be discovered by humans thinking about them – humans equipped by a higher being with the ability to avoid misleading sensory input and only rely on 'clear and distinct ideas' produced by objects external to the mind[13]. Hume (1777) proposed that there was no such thing as innate knowledge of causality, but only experience, i.e. repeated sensory input: the first time an event a is witnessed to occur, there is no way to predict b as a consequence. Knowing that b is a consequence of a is only possible if *b-like* events have happened because of *a-like* events before. In other words, there is a separation between individual events a and b and the hypothetical law underlying their causal relation, which can only be formulated as a statement operating on sets of events, A and B, if event a is known to be a member of the set A, and b known to be a member of the set B. According to Hume then, any causal inference is based on prior knowledge.

Ballweg (2004) gives the following initial description of causality (p. 326, translated from German) that incorporates Hume's idea of experience and is equivalent to the conditional *if-then*:

29. A causal connection of two events a and b can be said to exist if:
   a. a and b occurred in such a form that the cause a occurred before the effect b[14].
   b. A-type-events are necessarily followed by B-type events, in other words if A-type events are deterministic concerning the occurrence of B-type events.
   c. Not-A-type events are not deterministic concerning the occurrence of B-type-effects, leave their occurrence open.

In the strictest interpretation, these criteria make it possible to say that a causes b if b *is guaranteed to always* happen *after* a happens. 'b' can occur also without a having happened

[13] For Descartes, whether an idea is clear and distinct, i.e., whether an object or event is real, is mediated by that higher being: if the object or event turns out not to be real, the idea it produced can't have been clear and distinct. This rests also on Descartes assumption that a supreme being would not lie.

[14] This temporal order of cause and effect as given has been argued against (see Faye 2001) for a rough overview.

before, i.e. a may not be the only cause for b. This ideal relation between cause and effect is however usually only found in the realm of science[15].

Applying this definition to discourse, two events a and b are simply statements. They can, but do not have to be causally related:

30.	*event a*	*event b*
a.	The porcelain bowl was dropped.	It broke.
b.	It rained.	The bowl broke.

Whether the two events are causally related depends, according to Hume, not on the events themselves but on whether one knows, because of prior experience, that events similar to the current events a and b were causally related: sets A and B. A causal relation is therefore not an innate feature of a specific pair of events, but is established by a 'detour' over sets of events that are causally related. Similarity in this case could be expressed in the form of 'sharing features', such as porcelain being a brittle material (30.a), that dropped things fall, etc. If the current event a shares features with other events a already experienced, it is possible to determine that the current event a is a member of a set of events A, whose other members have similar features. Since the outcome of those other events a in set A is already known, it is possible now to 'check' whether the current event b shares features with the set B that set A is causally related to, such as that brittle things break when they hit the ground. If that in turn works out, one has established a causal relation between two statements a and b.

The more features are shared between a current event a and a set of events A, and the more often other events a have previously had an outcome b$\in$B, the easier the establishment of this causal relation for the current two events would be. This could be said to be the upper end of a scale of canonicity[16].

Conversely, the less features are shared between an event a and a possible set A, the more difficult it is to determine if the current event a is indeed an element of a given set A, and consequently it is more difficult to determine which set B is associated.

Additionally, not all events actually have a consequence, and it is therefore not always possible to determine if any given event is to be associated with a set A or a set B: there might simply not be a causal relation between two events, such as in example 30.b above, or an event could be a member of a set A, or even several sets A^1 through A^n, as well as a member of a set B or B^1 through B^n. In set theoretical terms, neither can domain and range be clearly separated for any given event, nor is the mapping between sets one-to-one, or a bijective function.

Another important feature of this idea is therefore that relations between sets A and B are often not exact, cannot usually be assigned a numerical value like 'a dropped bowl will break in 60% of all cases'. All that can be said is that if an event a shares features with a set A, then the likelihood or probability of the associated event b, if it is $\in$B is, as Ballweg (2004, p. 330) puts it, 'significantly raised' (see also section III.4.1.6).

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[15] For instance in the oxyhydrogen gas experiment: a mix of oxygen and hydrogen gas will explode if it comes in contact with fire. It can also explode for other reasons, such as pressure, but a spark is guaranteed to lead to a bang.

[16] Of course, we are not born with already established sets of causally related events. One very good example that these sets and relations have to be learned is the fact that small children tirelessly throw objects to the ground, possibly to see if *everything* will indeed fall down, and to see which objects will break and which ones will not, quite apart from amusing their elders.

III.4.1.2. Cause before effect

Both adverbial connective ties signal an inference of the type CAUSE-CONSQUENCE and must have the consequence of a causal relation as internal argument (31.a) and the external argument must precede the internal argument (31.b):

31.

a. *Die Schale zerbrach. *Deshalb / Darum* wurde sie fallengelassen.
The bowl broke. That's why / Therefore was it dropped.

b. ?*Deshalb / Darum* zerbrach die Schale. Sie wurde fallengelassen.
That's why / Therefore the bowl broke. It was dropped.

Example 31.a states the consequence (bowls breaking when they're dropped) before the canonical cause (dropping the bowl). The use of the connective tie marks the canonical cause as the consequence, making the example decidedly odd. This interplay of canonical situations and possible role-assignment of the connective ties to their arguments will be discussed in section III.4.1.3 below. Example 31.b is not starred, e.g. completely out, because there are situations in which the two sentences could be uttered felicitously in that form, a detective-like setting: someone pointing at leftover shards on the floor and deducing the cause for the bowl breaking. It can be argued, however, that the external argument for the connective tie is the deduction itself, which must still eventually be known in explicit form to the hearer. Example 31.b would be felicitous in a written text if a description of someone pointing at shards on the floor or similar preceded the connective tie (32.a). Note that the discourse does indeed seem odd if the cause is not stated explicitly, is left out (32.b):

32.

a. Sherlock Holmes pointed at the shards on the floor and said, 'That's why the bowl broke. It was dropped.'
b. ?Sherlock Holmes pointed at the shards on the floor and said, 'That's why the bowl broke.'

This use of *deshalb* and *darum* represents a *conclusive* application (Waßner, 2004).

Canonically, however, and if only two propositions are present, causes must precede consequences. Since *deshalb* and *darum* mark their internal argument as the consequence, the *external* argument, the cause, must have come before, at least in the absence of special circumstances: A consequence without a cause makes little sense.

These observations could suggest that since cause must precede effect in a CAUSE-CONSEQUENCE inference, causal connective ties mark first the cause and then the consequence, but there is a caveat, at least for German: both *deshalb* and *darum* contain a co-referential 'ingredient', as discussed in section III.2.2 above. This means that their external argument would have to be present not only to take the role of cause, but also to serve as antecedent. Anaphoric reflexives and pronouns can however linearly precede their antecedent, if a constituent containing the reflexive or pronoun has been preposed: 'After eating *himself* silly all day, John suffered from indigestion.', 'After eating the contents of *his* fridge, John didn't feel too good.' For the type of connective ties under investigation here this is not possible. In other words, it can not be excluded that *deshalb* and *darum* require

their external argument to precede them because they assign the external role of CAUSE first.

It remains that the two causal connective ties *deshalb* and *darum* mark their external argument as cause and their internal argument as consequence. In a discourse consisting of two sentences, the external argument must precede the connective tie and its internal argument.

III.4.1.3. Role assignment

So far, it has not been clearly characterized what precisely it is that connective ties 'do' to their arguments. It has only been stated that connective ties mark a certain relation. For *deshalb* and *darum*, this means that their external argument is the cause, and their internal argument the consequence. This is not dissimilar to thematic role assignment by verbs or prepositions, minus the additional case assignment. The question is whether this role assignment is so strong that relations already existing without the connective tie can be broken. The intuitive answer is of course negative, but it doesn't hurt to check:

33.

a. Die Porzellanschale wurde fallengelassen. Sie zerbrach.
The porcelain bowl was dropped. That's why / Therefore it broke.

b. Die Porzellanschale wurde fallengelassen. *Deshalb / Darum* zerbrach sie.
The porcelain bowl was dropped. That's why / Therefore it broke.

c. *Die Porzellanschale wurde fallengelassen. *Deshalb / Darum* blieb sie ganz.
The porcelain bowl was dropped. That's why / Therefore it stayed whole.

d. ? Die Porzellanschale zerbrach. *Deshalb / Darum* wurde sie fallengelassen.
The porcelain bowl broke. That's why / Therefore was it dropped.

Example 33.a shows the two sentences without a connective tie, to show that the causal relation is already present, since a porcelain bowl breaking when dropped is a fairly certain outcome. Example 33.b shows that a connective tie does not change the situation if the roles it assigns its arguments coincide with the original relation. In 33.c, the second sentence does not state the canonical outcome of a porcelain bowl being dropped, but the opposite. The use of the connective tie results in incoherence, because the causal connective tie assigns a role that does not match the semantic content of the internal argument, similar to the violation in 'John ate a rock'. Lastly, in 33.d, internal and external argument are switched, but the already existing relation cannot be overridden, and the discourse is incoherent. In sum, then, when used to emphasize canonical causal relations, connective must match an already existing relation.

Another aspect of causal relations that is relevant here is the fact that a lot of situations in which a causal connective tie can be used do not represent a causal relation of the type 'oxygen + hydrogen + spark = explosion', i.e. roughly speaking a physical reaction. Connective ties can also be used to signal a cause-consequence relation based on opinions (34.a) or motives (34.b), as in the following examples:

34.

a. I think geraniums are ugly. *That's why* I bought lilies.
b. We wanted to get good seats. *That's why* we arrived early.

Both examples, 34.a and 34.b, do not contain a 'classical' causal relation, but the first sentence is still the cause and the second sentence is still the consequence of the first, as denoted by the connective tie, and switching causes and consequences around works in neither of the two discourses.

To summarize, connective ties do appear to assign something not dissimilar to thematic roles to their arguments. Analogous to thematic role assignment by verbs, the arguments' features have to match the demands of the role assigned them by the connective tie.

III.4.1.4. If-then versus causal connective ties

It has been defined in section III.4.1.1 above that a causal relation can expressed with an *if-then* relation, which reflects the relation between associated sets of events A and B. In the case of closely causally related statements, this relation holds with or without the use of a connective tie, as both events a and b are not completely new events but it is known to a reader that a∈ A and b∈ B. This raises the question of what the function of a connective tie is, or, more precisely, is a connective tie formally redundant if the relation is present anyway, i.e. it does not change anything?

The following example shows a canonical relation with a causal connective tie (35.a) and with an *if-then* relation (35.b):

35.	event a		event b
a.	It rained heavily.	*That's why*	the fire went out.
b.	It rained heavily.		The fire went out.

In both 35.a and 35.b, if one accepts both separate sentences as true, the combinations of first and second sentences are true as well. Similarly, if one assumes only the first sentences to be true and the second sentences false, the combinations are false as well, but there is a difference between the connective-tie version and the implicit if-then relation: in the connective tie version, assuming that one of the two sentences is true forces the other sentence to be true as well, since the connective tie asserts that both its internal and external arguments are true, are obligatorily extensionalized (Breindl, 2004). If one assumes the first sentences to be false, and the second sentences true, the outcomes differ: in the connective-tie version (35.a), the combination is false: if the internal argument is true, the external argument must be true as well. In the if-then version (35.b), it is not explicitly stated that the rain is the reason for the fire to go out: fires can go out for other reasons as well, such as lack of fuel. Accepting the second sentence as true does not force the first sentence to be accepted as true as well, and the combination is true as long as the second sentence is true. Lastly, if both sentences are false, the if-then relation returns a value of 'true', while the connective-tie version returns 'false', for the reasons mentioned above.

A summary of the above discussion is shown in Table III-1:

Table III-1**:** Comparison of truth conditions: *If-then* versus *deshalb*.

a	b	a *if-then* b	a *deshalb* b
1	1	1	1
1	0	0	0
0	1	1	0
0	0	1	0

As can be seen in Table III-1, causal connective ties do not merely restate an already present canonical *if-then* relation: they are not redundant even in closely causally related situations. The pattern displayed by the connective tie is that of a conjunction: &[17]. Merely equating causal connective ties such as *deshalb* and *darum* with & is not sufficient, however, because it does not reflect the causal connection implied by the connective tie, hence the two arguments have to be additionally joined by the use of the primitive 'cause'. A first (tentative) definition of *deshalb* and *darum* could therefore be the following:

36. deshalb / darum: λa λb ((a & b) ∧ (cause (a,b)),

where a is the external argument, b is the internal argument, and the function of a causal connective tie is to assign a unidirectional CAUSE & CONSQUENCE relation to its arguments, the left (external) argument first receiving the role of cause, and then the second (internal) argument receiving the role of consequence. This definition accounts for the external argument having to precede the connective ties *deshalb* and *darum*[18], and it can also account for the incoherence resulting from a switch of closely related arguments, as well as one argument not being a possible element of one of two causally related sets A or B: if the roles assigned by the connective tie do not match the underlying relation, i.e. events a or b are not members of A and B respectively, use of a connective tie results in incoherence.

This definition is however rather crude and hence constitutes only a first step. A refinement will be attempted in the discussion of concessive connective ties, when additional information is available.

In sum, and to answer the question raised above, a connective tie is not formally redundant even if the there is a close causal relation between the arguments

III.4.1.5. Causal chains: proximity and distality

One problem with simply stating that connective ties are felicitous if there is an underlying causal relation is that this description does not take causal chains into account. A causal chain as defined by Schank & Abelson (1977) and others is a 'sequence of events, actions and states that leads from the beginning of the text to its end' (van den Broek, 1994, p. 542). Example 37.a shows two ends of a causal chain connected with *therefore* (adapted from McKiernan (1997), p. 158), and the entire chain (37.b):

37.

a. *I jumped up a coney. *Therefore*, the realm fell into ruin.

b. "[…] I could jump up a coney and it run into the jaws of a fox and the fox not raid a henhouse, and the farmer sell the nonstolen hen to a sailor who would take it across the sea […], where it lays eggs which are sold to a peddler who in turn sells them to a royal cook, who prepares them wrong and as a result a king or emperor […] dies, and then the realm falls into ruin."

[17] The symbol '&' is used here instead of the logical operator ∧, as '&' makes co-reference between pronouns and antecedents in separate sentences possible, which ∧ does not. See also Staudacher (1987) and Gronendijk and Stokhof (1991).

[18] Disregarding the co-referential aspect.

Despite the fact that in example 37.a the first and last statement are causally related, the connective tie *therefore* is not felicitous, because the intervening steps are unknown to the reader: cause and effect are too distal. In other words, stating that a causal connective tie is felicitous if there any underlying causal relation present is too simplistic, since the intermediate relations must be known to or at least inferable by the reader:

38.

a. Spring was rather warm this year. The roses bloomed early.
b. The bathroom drain was clogged. The roses bloomed early.

There is a known causal chain between the temperature early in the year and the time of roses blooming (38.a). There is none between a blocked drain and shrub growth schedules (38.b). Inferring that whatever blocked the drain was used to fertilize the flower beds would take some doing, and as long as these intermediate steps are not known to a reader, such an elaborative inference would not be undertaken.

Connective ties and causal chains

A more exact description of the role assignment of connective ties would then be that the external argument must be a possible *direct* cause of the internal argument, and that if the consequence stated in the internal argument is not the immediate one, the intervening steps must be known to a reader or hearer[19]:

39.

a. The porcelain bowl was dropped. *That's why* the baby cried.
b. *We wanted to get good seats. *That's why* we brought blankets.

In 39.a, it is possible to infer that dropping the bowl made a loud noise, that that noise startled the baby, and that's why it cried. In example 39.b by contrast, the connection between blankets and good seats is not immediately inferable: the connective tie signals a direct causal relation that is not present, or at least not known to the reader.

Violations of causal chains

Example 40 shows two incoherent mini-discourses:

40.

a. *The bathroom drain was clogged. *Therefore* the roses bloomed early.
b. *Spring was rather cold this year. *Therefore* the roses bloomed early.

In 40.a, the reason for the incoherence are the missing and unknown intermediate steps. The violation in 40.b on the other hand seems to be of a different quality: 'roses blooming early' is an *improbable* consequence of a cold spell early in the year. In fact, the violation in 40.b does not result in global incoherence, as 40.a does, but allows for a fairly specific diagnosis: the temperature early in the year does have an influence on shrub growth schedules, i.e. there is a causal relation, but: roses bloom *late* if spring was cold, not early. More precisely, the violation in 40.b is one of the point on a semantic scale of *early-late* that the connective tie selects. The coherent version differs from the violating one only with respect to that scale. This idea is similar to Krifka's (1995) treatment of the semantics of polarity items. According to Krifka, a negative polarity item *introduces* alternatives

[19] I am indebted to Edmund Pohl for bringing this distinction to my attention.

pertaining to a semantic scale. Connective ties possibly do just the opposite, as will be discussed below. The qualitative difference between violation-types will be clarified, and will turn out to be crucial in the discussion of concessive connective ties, but for now the relatively unfounded assumption will be made that causally related but highly improbable outcomes b are included in the set B causally related to set A, while unrelated outcomes b are not.

III.4.1.6. Probability manipulations

How direct a cause an event a is for a given event b could also be restated as the probability with which an event b will follow an event a, a certain outcome b having a probability of 1, and a guarantee that b will not happen having a probability of zero[20]. The following examples show several situations with different probabilities for event b, always given event a as the direct cause (example 41.b adapted from Ballweg, 2004):

41.	*event a*	*event b*
a.	Eva dropped the porcelain bowl.	It broke.
b.	Hugo took the new SNORK pills.	His cold went away.
c.	John didn't have much money.	His account was overdrawn.
d.	Laura let go of her drink on the roller coaster.	It hung in the air.
e.	Bryan tossed a coin.	It came up tails.

The b-event in example 41.a has a high probability, as the bowl could potentially also not break, but this is rather unlikely. The b-event in example 41.b has a probability of above chance (or at least one would hope so). The b-event in example 41.c is also a possible outcome of the preceding a-event. As to the probability with which this b-event will follow its a-event, it can only be said that the probability is above zero, but it can not be specifically stated. A drink just hanging in the air when let go of on a roller coaster is impossible (41.d), in this case the b-event has a probability of zero. A coin coming up tails (41.e) when tossed happens half the time, the b-event has a known probability of exactly 0.5.

Now, if a connective tie has the effect of signaling that the a-event is a member of a set A and the resulting b-event must be a *possible member* of the directly associated set B, one way of predicting whether a causal connective tie can be used would be to postulate that:

The use of a connective tie is felicitous if

- the probability of event b as a consequence of a is above zero.

Happily, this works out rather nicely, as can be seen in the following example restating the events from example 41, this time with a causal connective tie:

42.	*event a∈ A*	*event b∈ B?*
a.	Eva dropped the porcelain bowl.	Therefore it broke.
b.	Hugo took the new SNORK pills.	Therefore his cold went away.
c.	John didn't have much money.	Therefore his account...
d.	Laura let go of her drink on the roller coaster.	*Therefore it hung in the air.
e.	Bryan tossed a coin.	*Therefore it came up tails.

[20] Formally, there are no events that have a probability of zero or one. The terms are to be understood here in the sense of that the particular outcome is practically impossible or practically certain respectively.

Examples 42.a, 42.b and 42.c are perfectly all right, as per expectations: all three b-events had a probability of above zero without the connective tie. Example 42.d shows that use of a causal connective tie is not possible if the b-event had a probability of zero.

Example 42.e shows that, in the case of a 50-50 chance, use of a connective tie is odd, which at first glance disproves the hypothesis, since a probability of an outcome of 50% is noticeably above chance. The difference between example 42.e and examples 42.a through 42.c, however, is that in 42.a through 42.c, the probability of the outcome is above zero, but the *precise* probability is not known, in contrast to example 42.e. When a coin is tossed, there are only two possible outcomes: heads or tails. The set of B-events for the specific A-event of tossing a coin is therefore of fixed size, and all outcomes b ∈ B have known equal probability.

The revised hypothesis would then have to be:

The use of a connective tie is felicitous if

- the probability of event b as a consequence of event a is above zero,
- event b is not a member of a set B of fixed size with more than one element[21],
- all b∈ B do not have equal probability (there is no uniform distribution).

Testing that hypothesis in other situations with a known number of outcomes with a uniform distribution shows that at least as far as can be determined here, the hypothesis holds water:

43.

a.	Bill rolled the die.	*Therefore he rolled a six.
b.	My neighbor is pregnant.	*Therefore she will have a boy.

Example 42 included a number of different events with differing probabilities. The hypothesis formulated above should however also hold when tested on different outcomes of the same situation that are not uniformly distributed:

44.

a.	The porcelain bowl fell onto the stone floor.	Therefore it broke.
b.	The porcelain bowl fell onto the stone floor.	Therefore it was chipped.
c.	?The porcelain bowl fell onto the stone floor.	Therefore it rolled under the table.
d.	?The porcelain bowl fell onto the stone floor.	Therefore it got dirty.
e.	*The porcelain bowl fell onto the stone floor.	Therefore it stayed whole.

The judgments in example 44 are very dependent on individual experience (as are all judgments concerning most causal relations), and thus the following conclusions should be seen as speculative only. Nevertheless, it seems that for an outcome to have a probability of above zero is not enough. It is not impossible that a porcelain bowl dropped onto a stone floor will just roll away, but it is rather unlikely *compared to the other possible outcomes*. The second revision of the hypothesis would hence be:

[21] This qualification is included since some events have only one outcome, and the associated set B is therefore of fixed size, but contains only one member. The probability associated with that event b ∈ B is then 1.

The use of a connective tie is felicitous if

- the probability of event b as a consequence of event a is above a certain threshold compared to other possible outcomes,
- event b is not a member of a set B of fixed size with more than one element,
- all b∈ B do not have equal probability (there is no uniform distribution).

It seems, then, that causal connective ties have some requirement of the probability of an event b∈B following an event a∈A. Whatever it is precludes the probability of other events b∈B having the same probability as the explicitly mentioned event b as a consequence of event a. One thing that trivially cannot be done in the case of known equally probable events b is to *exclude* the possibility of any alternative event b∈B. If connective ties cannot be used in situations where all possible events b∈B have a uniform probability distribution, it must be that they do exclude any alternative event b given an event a *in this specific situation.* This is only possible in situations where there is only one outcome, or, if there are multiple outcomes, if it is not known that these outcomes are equally likely: It is not possible in situations where it is known that the stated outcome was *precisely* as likely as one or more alternatives.

III.4.1.7. Deshalb and darum: summary

Adverbial causal connective ties such as *deshalb* and *darum* assign the role of CAUSE to their external argument and the role of CONSEQUENCE to their internal argument, thereby signaling that the two arguments are directly causally related. The precise relation can encompass classical cause-and-effect relations as well as consequences due opinions or motives, but if the outcome denoted in the internal argument is not the immediate one, the intervening steps must be known to the reader.

The external argument must precede the connective tie and the internal argument. It is not clear why this is the case. It could be that the role of cause is generally assigned first, not only for adverbial causal connective ties, but for all causal connective ties.

This is not an unlikely assumption, since the precise content of the external argument must be known before it can be determined whether the internal argument can felicitously take the role of consequence. This idea was elaborated here in terms of the external and internal arguments as events a and b, which had to be possible members of sets A and B respectively, where sets A and B are causally related. An alternative reason for the adverbial causal connective ties *deshalb* and *darum* to demand that their external argument precede them is that both have a co-referential character.

Adverbial causal connective ties also do not merely restate an already existing causal relation, as they are felicitous only if both their arguments are accepted to be true statements.

An adverbial causal connective tie cannot violate an already existing causal relation. Whether or not a relation is already present can be expressed in at least two ways. One is to postulate that both the external and internal arguments share features with some causally related sets A and B, are elements of these sets. These feature can however only be 'used' to identify whether the set B that the event b is a member of is causally related to set A. On their own, features cannot be easily employed to predict which element b of B can felicitously be an internal argument. The other approach discussed here is to state a causal relation in terms of the probability of the outcome stated in the internal argument, as compared to other possible outcomes, i.e. other members of set B, given A. This probability

must be above a certain threshold compared to other possible outcomes of the same situation for a causal connective tie to be felicitous.

The second approach led to the hypothesis that the rather vaguely formulated 'signaling of a causal relation' could be specified by assuming that a connective tie excludes other, alternative, outcomes of the situation specified in the discourse. In other words, a causal connective tie asserts that in the specific situation stated in the discourse, the consequence denoted by the internal argument is the only one that took place and has only the cause stated by the external argument.

III.4.2. Concessive connective ties

Concessive relations are the one subgroup of generally contrastive relations that are fairly unanimously separated from that larger group. The exact relationship between concessivity and other contrastive relations such as adversativity, substitutivity, restrictiveness, and pure contrastiveness is not clear, however (Blühdorn, Breindl, & Waßner 2004). An aspect of concessivity there is agreement on is that it is, similarly to causality, based on an underlying conditional relation. Adverbial concessive connective ties are, just like adverbial causal connective ties, seen as conjunctive, i.e. asserting the truth of both their arguments. Fortuitously, this means that many of the characteristica already discussed for causal connective ties can be 'recycled' in the examination of concessive connective ties, and hypotheses developed can be tested further. Only the two adverbial concessive connective ties *trotzdem* and *dennoch* and aspects concerning them will be discussed. Examples will be given in English, using the synonymous '*despite that*', unless specific aspects of *trotzdem* and *dennoch* render that strategy confusing, i.e. as long as the aspect to be demonstrated in the example is as clear in the English example as it is in a synonymous German version.

Unless otherwise stated, this section is based on Stede (2004), Di Meola (2004), and Breindl (2004) in Blühdorn, Breindl, & Waßner (2004)..

Since concessive connective ties were directly compared to causal connective ties in the relevant experiment 4, much of the following discussion is centered on that comparison, and consequently ignores a number of additional characteristica of concessive connective ties.

III.4.2.1. Concessive connective ties: generalities

The concessive connective ties *trotzdem* and *dennoch* can be used in the following situations, representing a subgroup of the contrastive relations proposed by Stede (2004):

- **Rejection of an obvious conclusion**: the external argument has a canonical consequence that however is not to be accepted by the reader in this case.
- **Surprising outcomes**: The reader is informed that the outcome of an action was not the intended one.
- **Report on the failure of a plan**: The reader is informed that a plan failed, although it should have been successful.
- **Serendipities**: similar to the surprising outcomes, but there was no intention involved.

The following examples illustrate each of the uses of the concessive connective ties *trotzdem* and *dennoch*, translated as *despite that*:

45.

a. Someone had wiped up the spilled juice. *Despite that*, the floor was sticky.
b. John crammed for the exam for two weeks. *Despite that*, he got an F.
c. Karin planned ample time for packing. *Despite that*, she was not done in time.
d. The boat leaked heavily. *Despite that*, it didn't sink.

In example 45.a, the most likely outcome would have been a non-sticky floor; in 45.b, getting a bad grade in spite of studying hard for two weeks is rather surprising. Leaving lots of time for packing should have resulted in being done in good time, but didn't in 45.c, and finally, in 45.d, the outcome of the boat not sinking is surprising as well, but inanimate objects generally can not have any intentions, even if Murphy's law would have it so.

Common to all of these situations is an underlying causal relation that does not have the expected outcome. Due to this element of surprise, the connective tie in such situations can not always be left out with the discourse preserved as is, as demonstrated in examples 46.a through 46.d:

46.

a. *Someone had wiped up the spilled juice. The floor was sticky.
b. John crammed for the exam for two weeks. He got an F.
c. Karin planned ample time for packing. She was not done in time.
d. ?The boat leaked heavily. It didn't sink.

In example 46.a, omission of the connective tie results in incoherence. There is a close underlying causal relation between an untended juice spill and a tacky floor. The causal relation in 46.b is not as close: there are reasons why studying for two weeks can fail to produce at least a passing grade, such as the student testing very badly or not being the brightest light in the harbor to begin with. These reasons are, however, external to the explicit discourse and must be actively inferred. The same arguments apply in example 46.c, a possible reason for not being done in time being that Karin is a perfectionist who leaves few tasks not done to her satisfaction. Example 46.d is again at least odd: a boat taking on a lot of water is more likely to sink than not to. Regardless of whether the connective tie can be left out, explicitly stating it results in the surprising outcome being less surprising, as the connective tie already gives a warning that something normally unexpected is to follow.

An interesting aspect of concessive connective ties is that a causal situation in which a causal connective tie can be used can often be converted to a situation in which a concessive connective tie is possible, by inserting a negation into one of the two arguments:

47.

a. The porcelain bowl was dropped. *That's why* it broke.
b. The porcelain bowl was dropped. *Despite that*, it did **not** break.
c. The porcelain bowl was **not** dropped. *Despite that*, it broke.

This observation has led to the assumption that concessive connective ties negate a potential causal relation (Di Meola, 2004). This assumption will be examined in more detail below.

In sum, concessive connective ties appear in causally related situations, but take a usually unexpected outcome as their internal argument.

III.4.2.2. Role assignment

The role assignment of the concessive connective ties *trotzdem* and *dennoch* is very similar to that of causal connective ties, namely CAUSE for the external argument and CONSEQUENCE for the internal argument. Analogous to causal connective ties the concessive connective ties and their internal argument cannot precede the external argument (48):

48. **Despite that*, the floor was sticky. Someone had wiped up the spilled juice.

The reason for the connective tie with the internal argument being unable to precede the external argument is proposed here to be the same as for the parallel inability of causal connective ties. Causes must precede consequences, and it is possible that causal as well as concessive connective ties assign the role of cause first, as well as the content of the external argument having to be known before the internal argument can be evaluated in a causal connection. The alternative explanation, that of the concessive ties containing a co-referential part, holds only for one of the two German concessive connective ties under investigation here. *Trotzdem* has a referential aspect: the dative definite determiner *dem*. *Trotz* is concessive: translatable with *in spite*. *Dennoch* does not contain a referring morpheme, its first morpheme *denn* is a causal subjunction, translatable as *because*. *Noch* is temporal, its translation is *still*. Neither *trotzdem* nor *dennoch* can precede the external argument with their internal argument in German:

49.

a. **Trotzdem* war der Boden klebrig. Jemand hatte den Saft aufgewischt.
   Despite that was the floor sticky. Someone had the juice wiped up.
b. **Dennoch* war der Boden klebrig. Jemand hatte den Saft aufgewischt.
   Despite that was the floor sticky. Someone had the juice wiped up.

Another similarity of concessive connective ties and causal ones is that the roles cannot be switched around if the original relation is to be preserved, (50):

50. ?The floor was sticky. *Despite that*, someone had wiped up the spilled juice.

Example 50 is not incoherent, but the sticky floor cannot have been caused by the juice spill: the original causal relation does not hold. The reading of the sentence is rather 'The floor was a mess already. Despite that, someone had wiped up that particular spill, in contrast to all the other ignored ones.' The contrastive character is preserved, but the causal relation is a different one and much more obscure, resting on the slightly illogical action of cleaning just a small patch, a rather elaborate inference. It seems that concessive connective ties are closely dependent on underlying causal relations –why would it be possible or necessary otherwise to infer such an obscure relation to save the discourse from incoherence? Whether this dependence takes the form of completely negating the causal relation remains to be seen.

III.4.2.3. Concessive connective ties as conjunctions

Concessive connective ties are seen as conjunctive, as asserting the truth of both their arguments, just as causal connective ties are (see also Rudolph, 1996). If that is the case, a

comparison between a causal and a concessive connective tie, each in suitable discourses, should yield identical results:

51.

	event a		*event b*
a.	It rained.	*Therefore,*	the fire went out.
b.	It rained.	*Despite that*,	the fire did not go out.

If both first and second sentences are assumed to be true, both discourses are true also. In both discourses, it is not possible to assume that the second sentences are false and the first ones true or vice versa: the connective ties assert the truth of both their arguments. Trivially, this excludes the last possibility, that of both first and second sentences to be false, as well.

In sum, concessive connective ties are conjunctive: they assert the truth of both their internal and external arguments.

III.4.2.4. Concessive connective ties and causality

As stated above, concessivity is described as based on a causal relation. Causality was described as an if-then relation between two sets A and B, with which the specific events a and b denoted in the discourse share features. Causal connective ties can assert an already existent causal relation, and are felicitous if the probability of the outcome $b \in B$ given the cause $a \in A$ is above a certain threshold compared to other possible outcomes in B, if known. Example 52 shows a felicitous use of a causal connective tie (52.a) and a violation (52.b). In examples 52.c and 52.d, the causal connective tie has been replaced with a concessive connective tie:

52.

a. Nobody wiped up the spilled juice. *That's why* the floor is sticky.
b. *Nobody wiped up the spilled juice. *That's why* the floor is not sticky.
c. *Nobody wiped up the spilled juice. *Despite that* the floor is sticky.
d. Nobody wiped up the spilled juice. *Despite that* the floor is not sticky.

Example 52.a does not require much elaboration anymore. In example 52.b, the probability of the outcome (non-sticky floor) is below the threshold given the cause (spilled juice), and an assertion of a causal relation results in incoherence. Interestingly, the same lexical material as in 52.a and 52.b displays the opposite pattern of acceptability with a concessive connective tie: in 52.c, the same discourse where a causal connective tie is felicitous, a concessive connective tie is not. Conversely, in 52.d, the context in which a causal connective tie is not acceptable, a concessive connective tie is perfectly all right. If concessive connective ties are indeed felicitous everywhere a causal connective tie would not be, in other words if concessive connective ties are found in complementary distribution with causal connective ties, the first hypothesis regarding the use of concessive connective ties would be as follows:

- Concessive connective ties are felicitous if causal connective ties are not.

This is of course not satisfactory. It would be better to find an independent rule for the use of concessive connective ties, one that does not involve a comparison with another type of connective tie every single time. The idea does appear to have some merits, however. It

has been shown that causal connective ties 'pick' a certain end of a scale that is implied in the internal argument. Concessive connective ties seemingly choose the other end:

53.

a. Laura let go of her drink while running. *Therefore*, it splashed all over.
b. *Laura let go of her drink while running. *Therefore*, it hardly spilled at all.
c. Laura let go of her drink while running. *Despite that*, it hardly spilled at all.
d. *Laura let go of her drink while running. *Despite that*, it splashed all over.

The relevant scale here would be between big and little messes. It can be seen that the causal connective tie is indeed felicitous with those ends of the scale that concessive ties are not, and vice versa. Nevertheless, the hypothesis formulated above is so global that it must hold in all situations, which it does not, as the following examples show:

54.

a. *Laura let go of her drink on the roller coaster. *Despite that*, it hung in the air.
b. *Laura let go of her drink on the roller coaster. *Therefore* it hung in the air.

Both the causal and the concessive connective tie cannot be used here, hence the statement that causal and concessive connective ties are found in complementary distribution is untenable, at least if phrased this globally. What can also be seen in the above examples is that, similarly to causal connective ties, concessive connective ties cannot violate a known underlying causal connection either: a drink just hanging in the air is simply impossible if one is not in orbit, regardless of whether that outcome is stated as *because* or *in spite of* Laura having lost her grip on it. This in turn means that another potential way to define concessive connective ties is 'out', namely the following:

55. trotzdem / dennoch: $\lambda a\, \lambda b\, ((a \,\&\, b) \wedge (\neg \text{cause}\ (a,b))$,

where 'a' is the external argument, b is the internal argument, and the function of a concessive connective tie is to *exclude* a unidirectional CAUSE & CONSQUENCE relation of its arguments.

Also unsuitable is the following way to exclude a causal relationship between a and b:

56. trotzdem / dennoch: $\lambda a\, \lambda b\, ((a \,\&\, b) \wedge (\text{cause}\ (a, \neg b))$

A quick examination of the truth conditions for this definition shows that this way of defining concessive connective ties would result in any discourse with a concessive connective tie being incoherent all the time, as illustrated in Table III-2:

Table III-2**:** Examination of truth conditions: $a \,\&\, b \wedge (a \rightarrow \neg b)$

$a \,\&\, b$	$a \rightarrow \neg b$	$(a \,\&\, b) \wedge (a \rightarrow \neg b)$
1	0	0
0	1	0
0	1	0
0	1	0

In sum, concessive connective ties are useable in situations with an underlying causal relation, just as causal connective ties are. Concessive connective ties also cannot violate that underlying relation, although they are felicitous in situations where a causal connective tie is not, as long as the underlying causal relation holds. It seems that a flat-out negation of a causal connection in the definition of the connective tie is not the way to go about it.

III.4.2.5. Concessive connective ties and sets

Causality is expressed as an if-then relation. According to Breindl (2004, translated from p. 222), concessive connective ties are used to signal that 'events of type p usually do not result in events of type q, or: p' $\rightarrow \neg$q', (p' and q' being suitable generalizations over p and q)'. 'p' and q have been called a and b here. The phrasing 'suitable generalizations' then seems suspiciously alike to saying that a$\in$A and b$\in$B, i.e. that a and b have to share features with sets of events A and B respectively. In that case, the causal relation between sets A and B for concessive connective ties would be A $\rightarrow \neg$B (A $\rightarrow$ B for causal connective ties). This is equivalent to negating a causal connection, but on a different level than between a and b themselves. '$\neg$B' is also logically equivalent to the complement of B, more precisely $D_{<<s,t>,t>} \setminus B$. If B is the set of all probable and improbable outcomes of A, then $\neg$B would be *all* outcomes *not* causally related to A. At this point it is already clear that this hypothesis is going to produce goofy results as well:

57. *The bathroom flooded. *Despite that*, the roses bloomed.

It seems that there is no way around the fact that the underlying causal relation must hold[22]. This would mean that the definition given above for causal connective ties applies to concessive connective ties as well, as all approaches to account for the contrast between the two types of connective ties by changing that definition failed:

58. trotzdem / dennoch: λa λb ((a & b) $\wedge$ (cause (a,b))

This is, of course, blatant nonsense. Concessive connective ties do *not* have the same meaning as causal connective ties: there is a crucial aspect missing in the definition.

The contrast between causal and concessive connective ties must lie in *which* elements of B can be used with causal and which with concessive connective ties.

III.4.2.6. Scales and probabilities

It has been postulated above that causal and concessive connective ties select opposite ends of a scale contained in the internal argument. First, another quick look at whether that is actually the case, using the relative temporal scale of *late – on time – early*:

59.

a.	This spring was rather cold.	*Therefore* the roses bloomed late.
b.	?This spring was rather cold.	*Therefore* the roses bloomed on time.
c.	*This spring was rather cold.	*Therefore* the roses bloomed early.
d.	*This spring was rather cold.	*Despite that* the roses bloomed late.
e.	This spring was rather cold.	*Despite that* the roses bloomed on time.

[22] Simply excluding improbable results from B would of course be possible as well, but then neither the contrast between different types of violations (example 40) could be explained, nor the in some respects indeed complementary distribution of causal and concessive connective ties.

f. This spring was rather cold. *Despite that* the roses bloomed early.

There is an underlying causal connection in all cases. Examples 59.a and 59.f, as well as 59.c and 59.d, which involve the endpoints of the scale, confirm the hypothesis: causal connective ties select the opposite extreme to concessive connective ties. Example 59.b, using the middle point of the scale and a causal tie, is not incoherent, but definitely shaky. Example 59.e, also with the middle point of the scale, but with a concessive tie, is by contrast quite unremarkable. One way to summarize all these situations in which concessive connective ties can appear is to say that the outcome stated is unusual or surprising. 'Surprising' or 'unusual' is the same as improbable. Causal connective ties can be used in situations where the outcome stated is above a certain threshold compared to other possible outcomes included in set B, where $A \rightarrow B$. Therefore, concessive connective ties can be used in situations where the outcome is *below* that same threshold, compared to other possible outcomes included in set B, where $A \rightarrow B$. The definitions for the concessive connective ties *trotzdem* and *dennoch*, and the refinement for the causal connective ties *deshalb* and *darum* would then be:

60.

a. deshalb / darum: $\lambda a\, \lambda b\, (a \,\&\, b \wedge \text{cause}\,(a, b) \wedge P(b|a) > K_a)$
b. trotzdem / dennoch: $\lambda a\, \lambda b\, (a \,\&\, b \wedge P(b|a) < K_a)$

where 'a' is the external argument, b is the internal argument, and the function of both types of connective ties is to assign a unidirectional CAUSE & CONSQUENCE relation to their arguments, the left (external) argument first receiving the role of cause, and then the second (internal) argument receiving the role of consequence. For causal connective ties, the additional condition is that the probability P of b, given a, must be above the threshold K, a function of a. For concessive connective ties, the additional condition states that the probability P of b, given a, must be below the threshold K.

Whether or not a and b are members of causally related sets A and B respectively is not to be included in the meaning of the connective ties, because that condition must hold without a connective tie. The causal primitive cannot be dispensed with for the causal connective ties, since these connective ties state a causal connection, regardless of whether it is actually present or not, as can be seen in examples of these connective ties in causally unrelated situations. The conditional does not have to be included for concessive connective ties, because the underlying causal relation between A and B must hold independently, and concessive connective ties do not force a causal connection between a and b.

The definitions reflect the partial complementary distribution of causal and concessive connective ties, and can account for the intuitive difference between violations of probability thresholds and the violations resulting if the underlying causal relation is missing, thereby supporting the postulated inclusion of improbable events in B. They can also account for the infelicity of causal connective ties in unrelated situations as well as the 'unhinging' of the original causal relation if the arguments are reversed for concessive connective ties: the assertion of an existing causal relation is not an innate function of the concessive connective ties *trotzdem* and *dennoch*.

The last task remaining is to confirm that concessive connective ties can also not be used in situations where all outcomes $b \in B$ have a uniform probability distribution:

61.

a.	Bryan tossed a coin.	*Despite that, it came up tails.
b.	Bill rolled the die.	*Despite that, he rolled a six.
c.	My neighbor is pregnant.	*Despite that, she will have a boy.

Q.E.D.

III.4.2.7. Trotzdem and dennoch: summary

The adverbial concessive connective ties *trotzdem* and *dennoch* are conjunctive in that they assert the truth of both their internal and external argument. Similar to causal connective ties, they assign the role of CAUSE to their external and the role of CONSEQUENCE to their internal argument.

The relations denoted by both concessive connective ties are based on an underlying causal relation. In contrast to the causal connective ties *deshalb* and *darum*, *trotzdem* and *dennoch* do not reinforce a causal connection between their two arguments that must then match the underlying relation. The arguments of *trotzdem* and *dennoch* can therefore trade places even in the presence of an underlying causal relation, but the original relation is thereby lost, and a new one must be inferred.

Trotzdem and *dennoch* 'announce' unusual or surprising outcomes of a situation: outcomes that are improbable given the underlying causal relation. They do not, however, negate that relation. This led to the assumption that the underlying causal relation must hold in the presence of a concessive connective tie as well as in the presence of causal connective ties. To avoid postulating different kinds of causal relations for concessive and causal connective ties, improbable results were included in the set of possible outcomes of a given situation.

A comparison of contexts in which causal and concessive connective ties are felicitous showed that in certain respects, causal and concessive connective ties are found in complementary distribution: if there is an underlying causal relation, *deshalb* and *darum*

are useable with all outcomes above a certain threshold, and *trotzdem* and *dennoch* are felicitous with all outcomes below that same threshold.

Thresholds are influenced by scales between properties included in the internal argument, such as hot-cold or early-late. *Deshalb* and *darum* can be used with whichever end of the scale shares features with the probable outcomes, while *trotzdem* and *dennoch* can appear with the end of the scale that shares features with the improbable outcomes of a given situation.

Due to the fact that *trotzdem* and *dennoch* do appear in situations with unexpected and surprising outcomes, leaving them out results in incoherence if the underlying causal relation is very close.

III.4.3. Temporal connective ties

Since the temporal connective ties *danach* and *hinterher* were compared directly to causal connective ties (experiment 2), only a few aspects of adverbial temporal connective ties beyond that comparison will be discussed in the following sections, for the sake of brevity. Unless otherwise stated, the discussion is based on contributions by Lohnstein (2004), Schilder (2004) and Blühdorn (2004) in Blühdorn, Breindl, & Waßner (2004).

III.4.3.1. Temporal connective ties: Generalities

Similarly to causal and concessive connective ties, the temporal connective ties *danach* (*after that*) and *hinterher* (*afterwards)* take facts or circumstances as arguments, and are conjunctive in that they assert the truth of both their arguments (Lascarides & Oberlander, 1993). In contrast to causal and concessive connective ties, they do not require an underlying causal relation:

62.

a. Olaf put away the shopping. He played with the kids.
b. Olaf put away the shopping. *After that*, he played with the kids.
c. Olaf played with the kids. He put away the shopping.
d. Olaf put away the shopping. *After that*, wrote a letter.

There is no reason to assume a causal relation between putting away groceries and playing with one's children. The relation is instead a temporal one: one thing being done after the other. Examples 62.a and 62.c show that if the two sentences are stated without a connective tie, the resulting temporal order is simply the linear one: whatever is stated first happened first. Since the connective ties *danach* and *hinterher* assign precisely the same temporal order to their arguments (62.b and 62.d), the question is what they are needed for in the first place.

III.4.3.2. Temporal connective ties: roles and relations

Danach and *hinterher* state that the circumstance denoted with their external argument took place before that denoted with their internal argument. If there is no canonical temporal relation between the two arguments, the arguments can be switched around (see examples 62.b and 62.d). If there is a canonical temporal relation, i.e. if one thing usually happens *after* another, the connective tie cannot violate that relation:

63.

a. Bryan got the bread out of the breadbox. *Afterwards*, he made ham sandwiches.
b. ?Bryan made ham sandwiches. *Afterwards*, he got the bread out of the breadbox.

Usually, one takes the bread out of the breadbox *before* one starts making lunch. Example 63.b can only be 'made' coherent if one assumes that Bryan put the bread away and then for some reason decided to take it out again. The example seems odd because that intervening event is not mentioned, but is relevant to both arguments. The first hint of what is going on here can be found by looking at the sentences in example 63 without the connective tie:

64.

a. Bryan got the bread out of the breadbox. He made ham sandwiches.
b. Bryan made ham sandwiches. He got the bread out of the breadbox.

Without the connective tie, example 64.b is not marked. The reading one arrives at now is that the process of making ham sandwiches (x), *starts* with getting the bread out (y), but continues past that point. In example 64.a on the other hand, the process of getting the bread out is over at the time the making of ham sandwiches starts. If the temporal connective ties *danach* and *hinterher* can only be used with situations of the type denoted in example 64.a, then they must require that the event denoted in their external argument (x) be concluded before the event described by the internal argument (y) commences. Schilder (2004) uses the refinement of Allen's definitions of temporal intervals (Allen, 1983) suggested by Freksa (1992), to describe this temporal order. Freksa differentiates between the beginning and the end of an event. The beginning is denoted by α, and the end of an event by ω. For *danach* and *hinterher*, the relation they assign must then be $\omega_x < \alpha_y$. This relation must match the underlying one without the temporal connective tie, similar to causal connective ties. The roles assigned are simply 'EVENT x' and 'EVENT y'. A comparison between a situation in which the temporal extent of x is forced to overlap the beginning of the internal argument ($\omega_x > \alpha_y$) and a situation in which the end of x precedes y shows that this relation is indeed the one assigned by *danach* and *hinterher*, since the use of the connective tie results in incoherence in the former, but not the latter:

65.

a. *Elke carefully updated every single file. *Afterwards*, she updated the long ones.
b. Elke carefully updated every short file. *Afterwards*, she updated the long ones.

In example 65.a, the event x of updating *every single file* includes all files, long and short. Event y, updating the long ones, is included in event x. The connective tie however signals that the event x, updating all files, is over by the time Elke starts on the long ones, resulting in incoherence. In example 65.b on the other hand, event x does not include event y, and the connective tie does not violate the underlying temporal relation.

Additionally, use of the connective ties *danach* and *hinterher* seems to force event x to be concluded, or rather, the connective tie emphasizes those points in time that coincide with its meaning:

66. Maaret was finishing university when she had Oskar.

a. Maaret finished her degree. She took care of Oskar.
b. ?Maaret finished her degree. *Afterwards*, she took care of Oskar.

When someone has a baby while in university, it is highly likely that for a time, they will be doing both: university work and childcare (66.a). With the connective tie, this contemporary reading is no longer available (66.b): the connective tie places event y at a time at which event x is concluded, and at the same time seems to imply that event y did not overlap event x, either. In other words, that event x be concluded is not just a requirement the connective ties have of the underlying relation of their arguments, but something that the connective ties add. This is rather similar to the addition of a causal relation irregardless of its existence that causal connective ties display.

The meaning of the two connective ties could therefore be described as follows:

67. danach / hinterher: $\lambda x\, \lambda y\, (x \,\&\, y \wedge \omega_x < \alpha_y)$,

where x is the external argument, y the internal argument and the function of the connective ties *danach* and *hinterher* is to assert the truth of both arguments and assign the temporal relation of the end ω of the event x preceding the beginning α of event y.

III.4.3.3. Durations of events

In his master's thesis, Baggio (2004) suggests the following definition of the meaning of the temporal connective tie *after p,q,* (example 68), which differs from the adverbial temporal connective ties *danach* and *hinterher* with regard to syntactic class, but not with regard to meaning (68.b taken from Baggio, 2004, p 32):

68.

a. After $[\text{Ilse gets up}]_p$, $[\text{she has a mug of coffee}]_q$.
b. Ap,q iff $\exists t_1[q(t_1) \wedge \exists t_2[t_2 < t_1 \wedge p(t_2)]]$,

where p is the external argument, q the internal argument, and 'after p,q' is true if and only if there is a time 1 at which p is true, a time 2 at which q is true, and time 2 is before time 1. The definition arrived at here (repeated as example 69) differs from that suggested by Baggio:

69.

a. $[\text{Ilse gets up}]_x$. After that, $[\text{she has a mug of coffee}]_y$.
b. danach / hinterher: $\lambda x\, \lambda y\, (x \,\&\, y \wedge \omega_x < \alpha_y)$,

where x is the external argument, y the internal argument, and 'x after that y' is true if both x and y are true and the end of x precedes the beginning of y.

The main difference between the two definitions rests in the treatment of the extents of events. Baggio works, so the speak, with the events as a whole, while the definition in 69 uses the beginnings and ends of events as the markers to be ordered. Both definitions are applicable in situations where the temporal extensions of the events x and y are completely distinct, do not overlap. Baggio's treatment of the temporal extent of events as absolutes would however not be able to handle a temporal relation in which one event starts before the other and continues past the end of the first event. Neither *danach* nor *hinterher* nor *after* signal such a relation, but *zwischendrin* (in between) for instance can:

70.	Ilse machte das Abendbrot.	*Zwischendrin*	deckte	Burkhard den Tisch.
	Ilse made the dinner.	*In between*	set_{PAST}	Burkhard the table.

This temporal relation would be difficult to define clearly using single terms for the entire extent of each event. If the beginnings and ends of events can be 'addressed' separately, it is much easier: '$\alpha_x < \alpha_y \wedge \omega_x > \omega_y$'.

This seems a good reason for including such fiddly distinctions as the beginnings and the ends of events, especially since a combination of temporal connective ties and verb meaning as well as -tempus often results in an overlap of events (*'After* Maaret *had started* work on her thesis, Oskar *started* growing a lot'). Working with entire events would therefore make an extension of a definition to other connective ties and temporal relations

difficult. For two-proposition 'textoids' with *danach* and *hinterher*, as well as *after*, however, the distinction is largely academic.

III.4.3.4. Temporal proximity and distality

It has been shown so far that the temporal connective ties *danach* and *hinterher* signal a consecutive temporal relation: event x is followed by event y, and event x is concluded by the time event y starts. One thing these connective ties do not signal in and of themselves is how far apart the two events can or have to be (examples 71.b and 71.c adapted from Schilder, 2004, pp. 164 and 172):

71.

a.	John took a shower.	*Afterwards*, he had dinner.
b.	John went to a movie.	*Afterwards*, he went to a pub.
c.	John finished his bachelor's degree.	*Afterwards*, he went to Australia.

In example 71.a, it is likely that event y immediately followed event x. The discourse would be very strange if it was known that John did the shopping or went on a two-week hiking trip between the two events, i.e. if there was any activity intervening that takes longer than a couple of minutes. In example 71.b on the other hand, it would not result in oddity if John stopped by his home after the movie, took a quick shower and ate a bite before heading down to the local. It would be odd if he went to a performance of Macbeth between the movie and the pint. Finally, in example 71.c, John could (and probably would) do all the things in 71.a and 71.b several times over between finishing college and setting out for down under. If he interjected a two-year masters program in London, however, the discourse would be strange. Temporal connective ties apparently do not specify how closely the events denoted in x and y follow each other, but they do preclude other events intervening that take longer or are of the same type than the events described in x and y (such as *movie*, *play*, and *pub* all being evening entertainment and falling into the temporal category of 'a couple of hours'). Interestingly, the connective ties also require that both their arguments be of the same type:

72.

a.	?John took a shower.	*Afterwards*, he went to Australia.
b.	?John finished his bachelor's degree.	*Afterwards*, he had dinner.

The discourses are not incoherent, both events y can follow the events described in x, but both do involve a serious switch in event types between the first and second argument. This switch could be said to be an upward 'jump' for example 72.a, and a downward jump for 72.b. To reuse a tool from the discussion of causal and concessive connective ties, events x and y must be members of sets X and Y, and the relation between the sets is one of (roughly) equal types of events: all events in X must take similar amounts of time as the events in Y.

In sum, temporal connective ties do not specify that event x is immediately followed by event y (not $\omega_x = \alpha_y$), but by requiring that both their arguments are of the same event type with regard to temporal extension, they signal that no event of equal or greater temporal extent intervened between the two arguments.

III.4.3.5. Temporal connective ties and causal relations

If temporal connective ties require that the event described in their external argument be concluded, the should be useable in situations describing a causal relation, provided that the situation allows for event x to be over already:

73.

a.	We ran out of clean towels.	*Therefore*, we did laundry.
b.	We ran out of clean towels.	*After that*, we did laundry.
c.	The bowl fell onto the stone floor.	*Therefore*, it broke.
d.	*The bowl fell onto the stone floor.	*After that*, it broke.

In examples 73.a and 73.b, there is a causal relation, and event x is or can be concluded by the time event y starts: both types of connective tie can be used, since cause-and-effect situations also have a marked temporal aspect, but depending on which connective tie is used the causal *or* the temporal relation is emphasized, with the other dimension being present in the underlying relation[23]. In examples 73.c and 73.d, by contrast, the event of the bowl falling to the stone floor is concluded *by* the thing breaking, and the temporal connective tie cannot be used (73.d), as it implies that event x is already done with.

Temporal connective ties are therefore useable in certain causal situations. They seem to mark the second dimension present in a causal relation, namely that of the temporal order of cause and consequence. This dimension is the one not marked by causal connective ties, but is present nonetheless. Trivially, in situations where there is no direct causal relation, temporal connective ties do not imply one, but instead add a temporal relation.

III.4.3.6. Temporal connective ties: summary

The adverbial temporal connective ties *danach* and *hinterher* order their two arguments in time such that the first-stated external argument (x) occurred before the internal argument (y). They also imply that x is concluded by the time y starts. This relation was here defined by stating that the end of event x (ω_x) precede the beginning of event y (α_y), following Freksa (1992). This distinction between beginnings and ends of events is not required for a precise definition of the connective ties *danach* and *hinterher*. It is possible to describe them using terms denoting the entirety of events x and y, such as t_1 and t_2, as done in Baggio (2004).

If there is a known temporal order between the two arguments, the connective ties cannot violate that order or superimpose the order denoted by the connective tie.

Danach and *hinterher* also require the events denoted by their arguments to be of the same type, to each have roughly the same duration. They do not specify precisely how closely the two events described by their arguments follow each other, but do imply that not events of equal or greater duration intervened. The two temporal connective ties can appear in causally related situations, provided that event x, the cause, is or can be concluded by the time event y commences. In causally related situations, *danach* or *hinterher* emphasize the temporal aspect present in causal situations, namely that the cause precede the effect.

[23] The requirement of that the cause, event a, must start before the consequence b can easily be added to the conditional relation between the two sets A and B: $(A \rightarrow B \wedge \alpha_A < \alpha_B)$.

III.5. ASPECTS TO BE EXAMINED 1

This chapter has, by examining only two instances each of causal, concessive and temporal adverbial connective ties (more precisely only non-post-first positionable and argument-integrateable adverbial connective ties), provided questions and hypothesis for a number of experiments that by far exceeds the amount that can be performed in one dissertation. This section therefore has the function of stating precisely which aspects are examined in the four experiments reported in chapter IX.

General questions

Questions common to all experiments were:

- First of all, can empirical evidence be found for the theoretical distinction between connective ties and other elements that can occupy the same syntactic position, namely one-place (deictical) sentential adverbs (experiments 1, 2 and 3)?
- Secondly, does the semantic content of the connective ties play a primary role, i.e. is the major distinction to be made indeed between 'connective' and 'non-connective' or instead between causal, temporal and concessive (experiments 3 and 4)?

Causal connective ties versus non-connective elements

In experiments 1 and 2, the causal connective ties *deshalb* and *darum* are compared to temporal deictical non-connective elements (*gestern* and *vorhin*: *yesterday* and *just now*) in causally related and incoherent discourses. The question examined in both experiments, in addition to the first general question, that is relevant to the present chapter is:

- What is the effect of a connective tie in incoherent discourses, where a causal connective tie signals a relation that is not present? A non-connective element would not enforce a relation here. In other words: can evidence be found that causal connective ties do indeed enforce a causal relation?

Causal versus temporal connective ties versus non-connective elements

In experiment 3, the temporal (*danach* and *hinterher*) and causal connective ties (*deshalb* and *darum*) were compared to each other and to temporal (*gestern* and *vorhin*) and non-temporal non-connective elements (*gern* and *lieber*: *gladly* and *rather*), all in coherent, causally-, and thereby also temporally related situations. The relevant questions examined are:

- Is there a difference between causal and temporal connective ties in situations where both types of connective tie are felicitous?
- If so, do temporal connective ties pattern with temporal non-connective elements, i.e. is the relevant distinction the one between causal and temporal semantic content?
- If not, is the relevant distinction between connective and non-connective elements, i.e. do both types of connective ties differ in the same way from temporal and non-temporal sentential adverbs?

Causal versus concessive connective ties

In the last experiment (4), causal connective ties (*deshalb* and *darum*) were compared to concessive connective ties (*trotzdem* and *dennoch*) in causally related situations. The outcome denoted in the second argument was either probable or improbable. Causal connective ties were felicitous with the probable outcomes, while concessive connective ties were compatible with the improbable outcomes. The relevant questions were:

- Is there a difference between causal and concessive connective ties?

- Is there evidence that causal and concessive connective ties are indeed found in complementary distribution in such relations?
- What happens if the end of the scale included in the internal argument is 'the wrong one'? Is the reaction equivalent to incoherent discourses for causal connective ties?
- Is there evidence that improbable outcomes are also included in a set of outcomes B that is causally related to set A, as postulated here?

PART B: LANGUAGE PROCESSING

IV. EXPERIMENTAL METHOD: THE ERP

In the following paragraphs the method used in studies 2, 3 and 4, the event-related potentials (ERPs) and their source, the EEG (Electro-Encephalo-Gram) will be briefly described. A short description of the neurophysiological foundations and the theoretical assumptions will be given along with a discussion of advantages and disadvantages of the method. More detailed expositions of EEGs and ERPs can be found among many others in Rösler, (1982), Bösel (1996), Niedermeyer & Da Silva (1999), and Rugg & Coles (1995), Frisch (2000) and Hahne (1997).

IV.1. NEUROPHYSIOLOGICAL FOUNDATIONS

In the third, fourth and fifth layer of the seven layers of the cortex -also known as gray matter- the pyramidal cells are found. The name derives from the form of the cell body (soma) which looks like a pyramid. These pyramidal cells consist of the aforementioned soma and a long dendrite or multi-branching process of the cell continuing throughout the upper layers of the cortex towards the cortex surface: the dendron tree with apical dendrites. The pyramidal cells are arranged in cell clusters parallel to each other and orthogonal to the surface of the cortex (see also Figure IV-1). Negativities in the EEG are commonly associated with excitatory post-synaptic potentials (EPSP), resulting in the area surrounding the apical dendrites being negatively charged, while the cell soma remains at rest due to the relatively high thresholds. The cell itself is therefore negatively charged while its immediate surroundings are positively charged. This depolarization results in electricity flowing towards the soma on the inside and away from the cell soma towards the depolarization at the apical dendrites on the outside. If many cells are stimulated at the same time the depolarization in the area immediately surrounding the cells cannot be equalized anymore and the electric potentials flow through the white matter, the scull and the dura mater as well. The electric *open field* thus produced is measurable if and when cell clusters of at least 10^3 cells are excited simultaneously. Positivities in the EEG on the other hand are thought to be due to either to a reduction of the thalamic discharge rate at the apical dendrites, alternately a surplus of inhibitory post-synaptic potentials, or stimulation in deeper layers of the cortex closer to the cell soma. Negativities are therefore often associated with a state of mobilization, while positivities are connected with a state of inhibition or consummation of the mobilization.

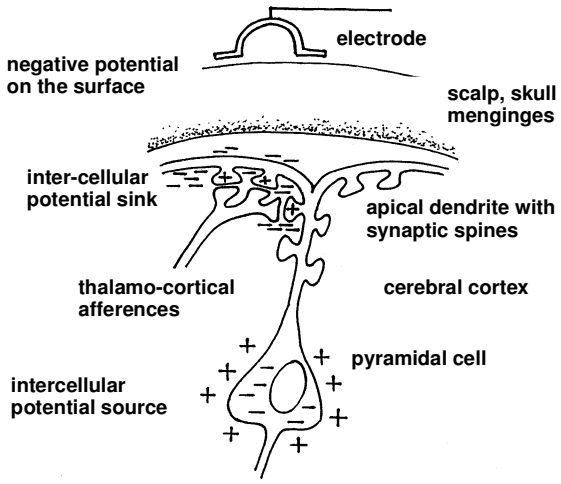

Figure IV-1: Ionic relations: Negativities and positivities in EEG. Adapted from Bösel (1996).

IV.2. THE ELECTROENCEPHALOGRAM (EEG)

The electric field described above can be measured with electrodes placed on the surface of the scalp. For a unipolar recording a difference in potentials between the standardized electrodes and a reference electrode is calculated. This reference electrode should be in a position at which a minimal amount of potential fluctuations due to brain activity are

expected, but which is also affected by the same external disturbances as the other electrodes, such as the electrical net. The influence of such external disturbances is thereby reduced, as they 'cancel out' up to a certain point when the potential difference is calculated.

The potential differences calculated for each electrode by this process are comparatively tiny (50-100μV) and must be amplified. Since in this process potential *differences* are amplified, the influence of external disturbances is again reduced.

For statistical evaluation the continuous EEG resulting from the above process must be digitalized, i.e. the continuous signal is regularly sampled at a frequency between 100 and 10,000Hz (or cycles per second) and thereby converted to a number of data points or samples for each electrode recorded.

In addition to external disturbances such as the aforementioned electrical net, radio waves and similar, there are internal so-called *artifacts* that are not produced by brain activity but recorded nevertheless. Among these are eye- and muscle artifacts such as eye-blinks, jerks, sneezes and coughs, resulting in rather large and short deflections of the EEG, and the slow but equally large and visible deflections caused for instance by sweating or excitement on the part of the subject. All these artifacts must be 'cut' or excluded from further processing of the EEG data, by automatic as well as manual rejection or scanning.

IV.3. THE ERP

There are two fundamental assumptions that must be made for the ERP-method to be a valid one for examining cognitive processes. The first is the assumption that similar stimuli are processed similarly not only by one (human) brain but by all (human) brains. In other words, one must assume that repeated presentation of the same type of stimulus leads to potentials that are similar to each other in time-course, form and distribution on the surface of all subjects' scalps: the ERPs or event-related potentials. However, even knowing precisely when the stimulus was presented and therefore where in the continuous EEG one should look for the reaction to said stimulus is not enough, as the ERPs have much smaller amplitudes than the basic EEG activity (between less than one and maximally 10μV for effects associated with language processing). This makes them impossible to isolate in the continuous EEG of one person. Assumption two, stating that the basic EEG -as opposed to the ERPs- is *stationary* and *ergodic*, or randomly distributed around a mean of zero, makes it possible to average all epochs containing the same type of stimulus into one average. First, the epochs for each subject for each electrode for each experimental condition are averaged, also called single-subject average, then these single-subject averages are reaveraged over all subjects for each electrode for each condition, also called grand-average (see Figure IV-2). Since the random basic EEG or noise, which is assumed not to be influenced by the stimulus, i.e. not *time-locked*, is averaged out by this process, ideally only the non-random process, the ERP or signal, is left in this grand average. This process works the better the more trials of the same type are averaged. To achieve a sufficiently good signal to noise ratio with linguistic material between 30 and 40 trials per condition are generally averaged over 15 to 20 subjects.

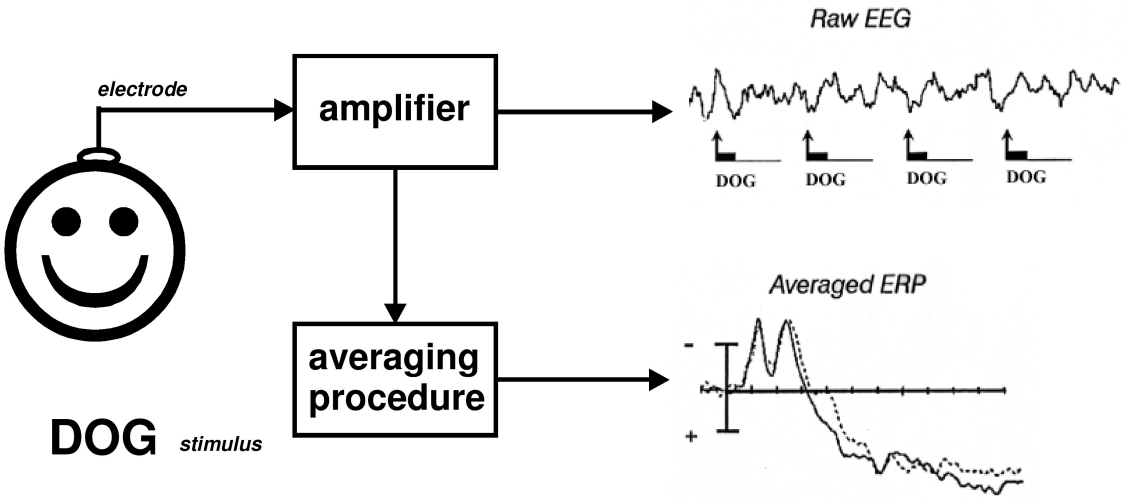

Figure IV-2: EEG acquisition and averaging procedure. Adapted from Hahne (1997) and Rugg & Coles (1995).

The amplitude of an ERP curve is calculated in the averaging process not relative to absolute zero (0μV), but relative to a baseline. The baseline is a window of 100 to 200 ms, located ideally directly prior to the presentation of the stimulus, for which means are calculated and subtracted from every data-point in the time window to be calculated into a grand-average, thereby pulling the ERPs onto each other in the area of the baseline[24].

Variations of the absolute values due to changes in resistance of single electrodes are thus equalized.

IV.4. CLASSIFICATION OF ERP COMPONENTS

ERPs are waveforms also known as components, which are mainly defined by four characteristica. The first, *polarity* (N for negative and P for positive), describes the direction of the deflection in the curve of an experimental condition relative to a baseline. The second, *latency*, denotes the point in time in milliseconds after the presentation of a stimulus at which the deflection roughly reaches its maximal amplitude (peak latency). These two 'dimensions' are used for the nomenclature of components, such as the N400, a negativity with a peak latency of 400ms post-stimulus. The third, *topography*, generally denotes the area of the skull where a component is found or where the component is particularly clearly defined. The fourth is *sensitivity to experimental manipulation*: in linguistic studies a component is not defined as such solely on the basis of the first three characteristica mentioned. The ERP curve for an experimental condition is not compared to zero μV, but to another experimental condition, a control. This control condition must be designed in such a way that it differs from the experimental or critical condition only with respect to the manipulation one is interested in. For linguistic studies, it is the differences between the critical condition and the control condition that are described by the above three characteristica. Theoretically a difference in one of these criteria is sufficient for a

[24] The baseline must therefore be free of variation due to experimental manipulation. This can be ascertained with baseline analyses, for which the original values for each condition for each electrode for each subject are statistically examined.

differentiation of two components. Practically, however, things are not that easy, since variation of all factors with the possible exception of polarity can be rather gradual. It is not impossible to subsume two effects with a latency difference of several hundred milliseconds into one component, such as the P600 with latency differences of 300ms. Differentiation between components is thus not clearly defined but more a case of orientation points on a continuum (Rösler, 1982).

Nevertheless, ERP components are usually separated into two groups according to latency and sensitivity, namely the *endogenous* and the *exogenous* components. Exogenous components are those with latencies of less than 100ms and are influenced primarily by physical properties of the stimulus such as modality and intensity. Endogenous components have a latency of more than 100ms and are influenced mostly by psychological factors such as expectation and instruction, making them the relevant group for cognitive experimentation.

IV.5. ADVANTAGES AND DISADVANTAGES OF ERPS

IV.5.1. Advantages

One of the main advantages of ERPs is the fact that the activity of the brain and thereby the processes taking place *during* presentation and processing of the stimuli can be observed directly and continuously with an extremely fine-grained time resolution. It is not necessary to deduce underlying processes, which at the time the measurement is taken are often already concluded, from secondary measurements such as reaction- or reading times. In contrast to classical on-line methods, a task whereby to judge the influence of the different experimental conditions is not even necessary, although in most ERP studies tasks are given nonetheless.[25] ERPs are also able to provide a more differentiated picture of language processing than classical on-line methods: while longer reaction times due to a semantic violation in the stimuli are as such difficult to distinguish as such from longer reaction times due to a syntactic violation, it is often possible to make such a qualitative distinction (and find out whether something is a semantic or syntactic process in the first place, as far as that distinction goes) in ERPs, as they influence the ERPs in different ways.

IV.5.2. Disadvantages

Disadvantages of the method can be found mainly due to the architecture of the brain. While clusters of pyramidal cells responsible for measurable potentials are arranged orthogonal to the cortex, the cortex is more often than not *not* lying parallel to the surface of the skull. This means that many potentials never reach the surface and with it the electrodes, or do not arrive at the electrode directly above the potential. Electrodes can also only pick up *open fields* or dipolar electric fields generated by cell clusters in which the cells are arranged in parallel. In cortical areas where the cells are not arranged thus, activation results in *closed fields* that are not measurable on the scalp. This exacerbates another problem of ERPs, namely the rather coarse-grained spatial resolution, limited also by the number and arrangement of electrodes on the scalp of the subject.

Another difficulty is the general assumption that components that have the same topographical properties but differing amplitudes are assumed to reflect the same underlying process. The variation is explained in terms of varying activational levels of a

[25] The purpose of tasks in ERP studies is to ascertain that the subjects read and understood the stimuli in the way the experimenter expected them to: that for instance sentences thought by the experimenter to be ungrammatical or unacceptable were perceived as such.

certain functional process: a logical and plausible but not at all proven assumption (Rugg & Coles, 1995; Hahne, 1997).

Following from the above points is the fact that it is not possible to conclude that a difference between two experimental conditions is due to the activity of one neuronal generator only, or that the activity measured on the scalp represents the entirety of the activity going on, or even that a lack of difference between conditions means that they are indeed the same. Similarly unknown is what precisely the functional meaning of ERP components is: the beginning or the end of a cognitive process or the point where a process is triggered?

The most common data processing method, the averaging, has its own set of disadvantages. First, even though an ERP component such as the N400 has characteristica that are roughly the same across experimental trials and subjects, these separate instances of the ERP are not completely identical: one subject might 'produce' an N400 with a peak latency of, say, 450ms and a duration of 250ms, while another shows the (presumably) same effect with a peak latency of 400ms and a duration of 300ms. This variability is called the *latency jitter*. Averaging all those slightly different effects into one grand average results in the visible components having generally longer duration and lower peak amplitudes.

Another drawback of the averaging method is the fact that the stimulus materials used to produce the 30 to 40 epochs per condition needed for reliable data must be as similar as possible, imposing very rigid limitations on the stimulus material itself, and making it by necessity rather monotonous. This monotony is often counteracted by using filler trials that are also intended to 'hide' the actual purpose of the experiment. If one is interested in discourse processing, however, a trial consists not only of the critical target sentence, but also of the preceding sentence(s) making up the discourse. This adds considerably to the on-task time for the subject, leaving little or no space for filler trials, since there are definite limits as to how long a subject can be asked to sit still and blink only on cue while wearing a fairly uncomfortable cap with electrodes (van Berkum, 2004).

In sum, while recording of ERPs and the interpretation of the results must be done with much care, ERPs are a very powerful and equally interesting way of looking at language processing while it is happening

V. LANGUAGE PROCESSING

In this chapter an overview of sentence and discourse processing theories will be given. Since every discourse must start with a single sentence, sentence processing is first.

V.1. SENTENCE PROCESSING

Most of the time understanding sentences is a fast, unnoticed, effortless, and automatic process assumed to be working along similar lines, i.e. without basic individual differences between processors of language (people)[26]. One of the few things there seems to be agreement on is that people understand language incrementally or word by word: they don't wait until the sentence currently being read or listened to is complete to start 'understanding' it, but incorporate every new information into a representation as it comes along. Yet precisely how this representation is organized, which information is used when and how dominant different structures of language are at what point in the parse has been much discussed and examined, producing a rather large number of parsing models. These models can, however, be separated roughly into two groups: modular and interactive. A comprehensive overview of parsing models may be found in Mitchell (1994).

V.1.1. Modular models

The so-called *syntax-first* models operate on the basic assumption that sentence processing is modular. According to these approaches, the process of understanding a sentence is split into separate sub-processes or modules with definite properties. Among these properties is that every module processes only certain information in a specific way, that the modules are arranged in a specific temporal order, and that later processes do not have any influence on earlier ones. Additionally, these models are localized in specific regions of the brain and work automatically and obligatorily (Fodor, 1983).

Within the framework of syntax-first models the parsing of a sentence takes place in (at least) two stages. In the first stage, or *first-pass parse*, a syntactic representation of the sentence is constructed. Afterwards semantic and contextual information is integrated into that syntactic structure.

One of the most well known modular models is the *Garden-Path Model* (Frazier & Fodor, 1978; Frazier, 1987a,b). Frazier assumes that the parser uses at first only information relating to word category and phrase structure to incrementally build a structural representation of the sentence. The parser always integrates new material in such a way that on the one hand as little syntactic structure as possible is projected (*Minimal Attachment*) and on the other incoming material is integrated into the phrase currently being built, instead of closing it and starting a new phrase or constituent (*Late Closure*).

Frazier's parsing model is serial, since it always pursues only one preferred structure at a time. Other syntax-first models, among them Gorrell's (Gorrell, 1995) or Inoue & Fodor's (Inoue & Fodor, 1995), propose that the parser also maintains less preferred structures. In contrast to the preferred structure these alternate representations might be less strongly activated, however.

If it turns out during the second stage that the preferred structure is not the correct one after all, reanalysis takes place. For serial models this means 'rearranging' the constructed syntactic structure. Parallel models can fall back onto a so far not preferred structure. In any

[26] This lack of individual differences is one of the basic assumptions one must make to be able to use the ERP method.

case only syntactic information is used to arrive at the first representation. Other sources such as semantic meaning and with it lexically coded properties such as the subcategorization frame of a verb or a preposition, or pragmatic and contextual information, are not even accessible until the second stage of processing. There are many empirical studies supporting the adoption of a syntax-first model that is modular at least with respect to the first structural representation of the input (but see section V.2.4.2).

V.1.2. Interactive models

Contrary to modular models, interactive models propose that more information than just word category has an influence on the construction of the initial phrase structure. Some very strongly interactive models even dispense entirely with a syntactic representation for language processing (Marslen-Wilson, 1980; Marslen-Wilson & Tyler, 1980, among others). Other interactive models, the so-called constraint-based parsers, make heavy use of lexical properties such as subcategorization information (Taraban & McClelland, 1988) or the frequency of certain constructions in language. This information is not accessible in the first-pass parse in modular models. Other, weakly interactive models (for instance Crain & Steedman, 1985; Altmann & Steedman, 1989; Steedman & Altmann, 1989) assume that discourse information has an influence on the representation of a sentence when an ambiguity is encountered. A more complex structure can here be preferred if it is more easily integratable than the simpler one, which would not be possible in a modular model.

V.1.3. Processing problems: ambiguity and reanalysis

There are of different types of problems that can occur during processing. If it turns out during the processing of a sentence that the representation constructed by the parser is incompatible with arriving material, reanalysis occurs. A reason for such a *misparse* can be the ill-formedness of the sentence, whether semantic of syntactic: the sentence contains a violation. In that case a reanalysis will be unsuccessful. The second reason for a misparse is an erroneous decision by the parser at an earlier point because of an ambiguity.

Ambiguities can be syntactic or semantic / pragmatic and either local or global. It depends on the nature of the ambiguity whether reanalysis is automatic and unnoticed or whether the automatic processing is aborted and the sentence ultimately only understood by conscious effort on the part of the language-processing party. Ambiguous sentences are also known as *garden path sentences*.

V.1.3.1. Violations

In the case of syntactically or semantically ill-formed sentences the parsing process is unsuccessful in every case, either automatically or consciously, since the violating element cannot be integrated into a felicitous representation of the sentence. Among others, such violations include phrase-structure violations such as in 1.a, violations of subcategorization 1.b or a word that does not fit at all 1.c[27]:

1.

a.	*Die Gans	wurde	im	<u>gefüttert</u>.		phrase structure violation
	the goose	was	in the	fed		(from Hahne, 1997, p. 125)

[27] In all examples in this work, the element on which an ambiguity is diagnosed (the critical element) will be underlined.

b. *Susie slept the toad. violation of subcategorization

c. *I ate two cows. semantic violation

In example 1.a, the ungrammaticality of the sentence is based on the phrase structure: only a noun phrase can follow a preposition. The verb 'gefüttert', *fed*, cannot be integrated, not being a noun phrase. In example 1.b, the phrase structure is felicitous, resulting in a representation in which the verb *slept* is transitive for syntax-first models. In the second parsing phase of these models, when subcategorization information is retrieved, the object *the toad* cannot receive case or a theta role, the verb being intransitive. The object cannot be integrated and the sentence violates the Theta-Criterion. Parsing models based on verb information or semantic content would also place this sentence in the 'ungrammatical' camp, but would not include the initial misanalysis of the verb. Processing of the third example also fails as soon as the meaning of the word *cows* is retrieved, as the semantic / pragmatic information pertaining to *cows* does not meet the requirements the verb *ate* has of its objects. A reanalysis of ungrammatical sentences is not successful, as they are irreparable[28].

V.1.3.2. Local ambiguities

A sentence is locally ambiguous if during processing an element can be integrated syntactically or semantically in more than one way, but this ambiguity is then resolved later on by additional material (*disambiguation*). In case of an ambiguity the parser can employ a number of strategies. In a modular model a decision would be made leading to the structurally simplest analysis, while in interactive models for instance prior (discourse) information and the frequency of certain structures can be the deciding factor. Reanalysis is necessary if it turns out later on that the chosen structure is incompatible with subsequent elements. For syntactic ambiguities this means either the projection of additional syntactic structure, such as in 2.a, or rearrangement of the structure already built 2.b. For semantic ambiguities a different meaning of the ambiguous element must be retrieved and integrated 2.c:

2.

a. I see [$_{CP}$ John did the dishes].

b. [Das sind die Professorinnen]$_i$, [$_{CP}$ die *e* die Studentin t_i gesucht hat/haben].
Those are the professors who the student (fem) looked for had(sing)/had(pl).

c. The comb is rather large if you consider that it's a bantam.

If the NP *John* in example 2.a is analyzed as the direct object of the verb, while in fact it is the subject of an embedded clause, as signified by the verb *did*, it must be reanalyzed and the entire embedded clause integrated as object of the verb *see*. This involves additional structure. In sentence 2.b, from Mecklinger, Schriefers, Steinhauer & Friederici (1995), the relative clause could initially be analyzed as a subject relative (*active-filler* strategy, Frazier, 1987a,b), as the article *'die'* in German is ambiguous between nominative and

[28] In the case of example 1.c there are of course possibilities of making it work out after all, for instance if there were a type of candy or dish known as a cow (see also section V.2.4.1). Without such a context, however, the sentence will be described as ungrammatical.

accusative as well as singular and plural. Upon encountering the singular auxiliary verb *'hat'*, it becomes clear that this strategy failed and it is in fact an object-relative clause. That means on the one hand, that the first article *'die'* is not the subject but the object. On the other hand the relative clause must be co-indexed not with a trace in Spec IP, but with a trace in the complement of V. This operation does not involve the projection of added structure as in example 2.a, but 'merely' the reassignment of traces. In example 2.c the parser decides on the base of the frequency of the different meanings of *comb* that the topic of conversation must be 'a toothed strip of rigid material for tidying and arranging the hair'[29]. This decision turns out to be wrong as soon as the word *bantam* is encountered. The other, more infrequent meaning of *comb* must be activated. The parser's decisions in case of semantic ambiguities are, apart from the frequency, also very dependent on the situation: If sentence 2.c was uttered during the chicken show at a farm fair, a misparse would be unlikely. A difference between reanalyses due to violations and those due to local ambiguities is that the latter are successful, since there is a well-formed structure available. In most cases of local ambiguity reanalysis is automatic and unnoticed.

V.1.3.3. Global ambiguities

Global ambiguities occur when an element can be integrated syntactically or semantically in more than one way, but there are no disambiguating pointers as to the correct structure later on in the sentence. Globally ambiguous sentences are well-formed.

Global semantic ambiguities

Global semantic ambiguities can occur with words that have two meanings, such as *bank*-financial institute and *bank*-edge-of-river, such as in 3. By itself, the sentence contains no hint as to the correct meaning.

3. I spent the entire day at the bank.

Global syntactic ambiguities

Global syntactic ambiguities occur when an element can be structurally 'incorporated' into the sentence in more than one way:

4. Die Sekretärin sah die Verkäuferin.
   The_{FEM} $\text{secretary}_{\text{FEM}}$ saw the_{FEM} $\text{salesperson}_{\text{FEM}}$.
   'The secretary saw the salesperson.' or 'The salesperson saw the secretary.'

This German example is ambiguous, since German is a scrambling language, allowing relative freedom as to the ordering of subject, verb and object. To add insult to injury, the feminine definite article *'die'* is ambiguous between nominative and accusative, so that the order can be either SVO or OSV. The parser could decide here that it is SVO based on a subject-preference, i.e. that the first NP in a sentence be the subject. In this sentence, as in other globally syntactically ambiguous structures occurring on their own, this and other strategies would not fail and there would be no reanalysis.

[29] …according to the Oxford English Dictionary & Thesaurus.

V.2. DISCOURSE PROCESSING

So far in this work, it was possible to simply introduce and discuss each current topic without too much distracting additional comment. In this chapter, dealing with discourse processing, this is not possible anymore for several reasons.

First of all, the method used here for experimentation, ERPs or evoked potentials, have been used almost exclusively for examining effects within single sentences, and therefore most effects found (see chapter VII) have been interpreted on that basis. It is not the case that researchers have simply been unwilling to expand the application of the method, either, as the small but rapidly growing pool of ERP studies on processing beyond sentence boundaries shows. The reasons lie more in a combination of the practical requirements of the method and the type of information it makes available. ERPs provide temporally very fine-grained data, and by virtue of a large base of previous research allow for an independent distinction of syntactic and semantic processes up to a certain point. The price to be paid for this richness of information is however rather high. As the data in the traditional method of analysis must be averaged, there must be a large number of trials for each condition, and the material in general has to be as carefully controlled as possible. This restriction is not at all helpful in studying discourse, which draws on all levels of human information processing, not just processes that could be argued to be more or less unconscious. An inference is most often based on more than the linguistic information available in the text, and in van Berkum's (2004; p. 231) words, 'comes awfully close to the comprehender's central system'.

Also, research attempting to distinguish automatic from controlled aspects of sentence processing has already shown that ERP correlates associated with later processing phases are quite susceptible to influences from outside the domain of 'pure' language processing. This led to most experimenters using additional tools to make sure that subjects did what they were intended to, such as judgment tasks, probe detections and comprehension questions during data acquisition, and questionnaires 'fishing' for possible strategies a subject might have employed after measurement. This problem is multiplied when studying discourse with ERPs: to get reliable data, one must be sure that differences between conditions are due only to one's experimental manipulation. If this manipulation rests on not only the subjects' grammatical competence, but many other things as well (discourse processing is often associated with what in German is called 'AHAZ: **a**lles **h**ängt mit **a**llem **z**usammen', translatable as: everything affects everything else) it is even more difficult to control.

Another problem with using ERPs in written text comprehension is that ERPs are a wonderful method for looking at the time-course of processing of single critical words or fairly short epochs. They are however not usually the method of choice for examining processes assumed to take longer than, say, one and a half seconds, as the fairly unnatural mode of serial word-by-word presentation can only be taken so far: a presentation rate of one word every two seconds would be guaranteed to leave subjects ample time to for instance think about the font color or the lighting in the acquisition room, and make it even more difficult for them not to blink or move.

The question then is: why use ERPs at all? The answer can be found in the basic properties of language processing: it is incremental. If one assumes that sentence processing is incremental, one cannot very well stop at the sentence boundary and declare that while the processing within a sentence is incremental, when processing a discourse incrementality stops for a moment while people (incrementally) process the second

sentence, i.e. hold the first one over until they have two complete sentences, to start constructing a discourse representation. Or can one? Fortunately, this question has already been answered in a number of ERP studies, discussed in chapter VII below, which demonstrate that people do indeed not wait for a sentence (or even the current proposition in complex sentences) to be complete to incorporate it into the discourse in its entirety, but integrate each word as it comes along (inferences: Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004; semantic expectation: Ditman, Holcomb & Kuperberg, 2005; information structure: Cowles, 2003; referential coherence: Yang & Perfetti, 2005; van Berkum, Brown & Hagoort, 1999a, van Berkum, Brown, Hagoort & Zwitzerlood 2003a). This pattern holds not only for the content words (mostly noun phrases) examined in the above experiments, but also for temporal connective ties, the only connective ties examined with ERPs so far (Münte, Schiltz & Kutas, 1998; Baggio, 2004). That (temporal) connective ties also elicit immediate ERP responses is particularly interesting, as these results make even a weakened 'on-and-off'-incrementality approach impossible – such as proposing that only content words are incorporated immediately – connective ties being discourse operators that only bring their semantic content to bear on said discourse level (but see chapter VIII for a number of caveats regarding this when it comes to temporal connective ties).

In sum, ERPs can be used to examine discourse processing, and increasingly have been used for this purpose. It would however be a sign of rather staggering arrogance (and criminal lack of diligence) to pretend that the few ERP studies examining discourse processing have charted white territory. Discourse processing has been examined with the entire arsenal of empirical methods at the disposal of researchers, resulting in a number of processing models, some of which will be described and discussed below. For the sake of brevity, the psycholinguistic approaches reviewed here will be restricted to what Foltz (2003) called *cognitive quantitative models of text and discourse processing*. These models he defines as "[…] providing quantitative predictions or explanations of discourse phenomena while using cognitively plausible mechanisms." (Foltz, 2003, p. 487). Regarding a text to be comprehended, this means that an *ideal model* would have to account for syntactic, semantic, pragmatic, and rhetorical factors. Properties of human information processing that would have to be included are coherence, cohesion, world knowledge, working memory, processing of metaphors, making of inferences, and knowledge of social rules of conversation. That is quite a tall, if not impossible order, and consequently current approaches tend to concentrate on only some of the above aspects (and leave others somewhat underspecified). First, however, two basically omnipresent aspects in research on text representation will be introduced.

V.2.1. Two general aspects

Sanders & Spooren (2001) identify three major themes in research on text representation common to most if not all models and approaches. These are the fact that the process of building a text representation is seen as dynamic, as changing with incoming information, secondly the internally complex nature of text representations, and thirdly the underspecification of mental representations. The first two aspects, and whether or not ERPs could be or are sensitive to them, will be addressed individually in the following sections.

V.2.1.1. Dynamic representations

The fact that it is possible for impatient conversation partners to finish the others' sentences, as well as the phenomenon of 'I-think-I-know-where-this-is-going' demonstrate

that people do not wait until the end of a sentence or text to start understanding it, that is to start building a representation of it. This means that on the one hand language and discourse comprehension are incremental processes, with the representation being changed and added to as new information arrives. On the other hand, incoming information is integrated into the *current* state of the representation, and can thereby only influence what is there already. This introduces the possibility of errors and reanalysis if a wrong decision is made in an ambiguous situation and later information conflicts with the current representation. That language comprehension is indeed an incremental process is widely accepted in formal theoretical as well as psycholinguistic models, and has been demonstrated many times in studies employing the full bandwidth of empirical methods invented so far (see Haberlandt (1994) for an overview excluding ERPs and neuroimaging methods, and chapter VIII for a modest attempt at doing the same for ERPs in discourse).

Dynamic representations and the effect of incoming on preceding material (and vice versa) is what the ERP method is about, and it need not be elaborated at this point anymore that ERPs indeed reflect just that.

V.2.1.2. Multiple representations

Many linguistic and psychological models assume that the text representation itself is not one structure being added to or altered, but consists of several levels of representation. These range from the basic input, the actual words in the sentences and the order in which they stand, over intermediate representations becoming more abstract and encompassing more information, up to and including the ultimate representation that includes the reader's knowledge about the world and assumptions made because of that knowledge. Minimally, a division is made between the microstructure, the actual text, and the macrostructure, often synonymous with the situation model or mental model of the discourse, which includes inferences already made as well as incorporated world knowledge: the gist, topic, upshot or theme of a text (Johnson-Laird, 1983; van Dijk & Kintsch, 1983). The microstructure is often subdivided into the surface code, a short-lived representation of the actual words in a text, and the textbase, containing the propositions expressed by the sentences and their interrelations (Sanders & Spooren, 2001). These two are the levels at which referential and relational coherence as well as bridging inferences are assumed to operate. The surface code and textbase can be empirically distinguished from each other (Fletcher & Chrysler, 1990). The memory for the surface code decays rather rapidly, in a matter of seconds under most circumstances (but see Zwaan & Singer, 2003, and Fletcher, 1994 for details). Memory for the textbase, i.e. the meaning of a sentence as opposed to its makeup, is more robust (Fletcher, 1994). Not all models adopt the mental model as a level of representation, or rather, there are models that did at first not go beyond the surface code and textbase, such as Kintsch & van Dijk's first version of the construction-integration model (Kintsch & van Dijk, 1978). That this is not enough can be seen in the following example from Sanford & Garrod (1998):

5. Harry put the wallpaper on the wall. Then he put his mug of coffee on the paper.

If only a surface code and textbase were constructed, the second sentence would not be odd at all: paper is connected to wallpaper by argument overlap (referential coherence), and the case is closed. The second sentence is, however, very marked: one can not put a mug of coffee onto a vertical surface. This is noticed *immediately*, providing evidence that a mental picture of the situation described is constructed at the same time as a locally operating textbase. In fact, example 5 could even be called a garden-path discourse. Van Dijk &

Kintsch (1983) as well as Zwaan & Radvansky (1998) list a number of reasons why the construction of a situation model or mental model must be assumed. Among these are the integration of information across multiple sentences (Hess, Foss & Carroll, 1995), the fact that similarities in comprehension performance across modalities (seeing, hearing, reading) must be explained (Gernsbacher, Varner & Faust, 1990), and the fact that expertise in a topic can outweigh poor reading skills, as shown in a very nice study with 3rd, 5th and 7th graders by Schneider & Körkel (1990). They presented texts about soccer and crossed reading level (3rd graders being worst and 7th graders best) with previously ascertained knowledge about soccer. Results showed that 3rd grade soccer experts recalled more of the gist of the text than 7th grade soccer novices. In other words expertise, when applicable to building a mental model during reading, is most helpful, irregardless of whether the actual reading was done with the help of an index finger or not. Another, rather entertaining, reason for the assumption of mental models stems from inter-language translation: as Zwaan & Radvansky note, a literal translation of the Dutch saying 'Verkoop de huid niet voordat je de beer geschoten hebt' would yield: 'Don't sell the skin before you've shot the bear.' While this is by no means unintelligible, a more correct translation would be 'Don't count your chickens before they're hatched', the surface code and textbase of which have but nothing to do with the Dutch original, except that both are constructed of words.

It is known that ERPs are sensitive to the felicitousness of the surface code, as witnessed by early syntactic effects such as the ELAN. The LAN, the N400 and the P600 show that they are also sensitive to the textbase, i.e. to semantic relations and co-reference. It will be shown in chapter VII that the method is also usable to estimate the current state of a situation model as reflected by the effect of said situation model on incoming material (N400). What ERPs can not tease apart are the different levels. Most research discriminating the separate levels has employed memory measures, such as verbatim recall when examining the surface code, and sentence matches and recall protocols for the textbase, all applicable only after subjects have already read the text. By definition, ERPs apply as words and sentences are read, a point at which the separate levels of discourse representation are necessarily present simultaneously[30]. This, in other words, is a domain in which ERPs can only provide secondary information, as a working hypothesis concerning which level of representation is being accessed must be present before effects can be interpreted.

V.2.2. Models of discourse representation

In the following sections, two current models of text and discourse representation will be introduced. Generally, models of discourse representation and comprehension can be classified according to their architecture: *production-system* and *connectionist*. Production-system architectures use rules to operate on the input, usually formulated as *if-then* rules (Anderson, 1993), which apply either serially or conjointly. Connectionist architectures represent language processing as a network of interacting units, all connected by varying levels of activation. Connection strength determines the influence each node has on the text representation.

Another central aspect of many models is that the dynamicity of the discourse representation is expressed in a cyclical nature: each new reading cycle, usually concurrent with new information being processed, changes the representation. They are also

[30] Think-aloud protocols, asking subjects to verbalize their thoughts as they read a text, might give insight into at least the situation model as it is being constructed, but would, coupled with ERPs, result in so many movement artifacts as to make the usage of the method in such a setting a complete waste of resources.

combinations of *bottom-up* and *top-down* processes: operations on the text itself are bottom-up, while the 'addition' of such things as inferences and world knowledge in general is a top-down process, as are predictions concerning what is coming next.

V.2.2.1. The Construction-Integration model

The construction-integration model is based on research by Kintsch and van Dijk in the last quarter century (Kintsch & van Dijk, 1978; van Dijk & Kintsch, 1983; Kintsch, 1988; Kintsch, 1998). It represents the comprehension of discourse as a two-stage cycling process of constructing propositional representations of the text from the surface code in the first phase and then integrating that textbase with prior knowledge in the second phase. The actual words of the text, the surface code, are first parsed into propositions. A proposition consists of a function (usually a verb or preposition) and its arguments, as demonstrated in example 6, taken from Kintsch, 1994):

6. Mary gave John a book but he lost it.
   a. GIVE[agent: MARY, recipient: JOHN, object: BOOK]
   b. LOSE[agent: JOHN, object: BOOK]
   c. BUT[GIVE[MARY, JOHN, BOOK], LOSE[JOHN, BOOK]

Propositions are constructed on the basis of information retrieved from the lexicon such as subcategorization frames of verbs. Note that co-reference, also called argument overlap, is resolved immediately (6.b). Also noteworthy is the fact that relational coherence, represented here by the subjunction *but*, triggers a more complex proposition incorporating its two arguments (6.c). Propositions are connected to each other into a network based on argument overlap, embedding of one proposition into another, as well as concepts from general knowledge associated with the propositions. Additional propositions not explicit in the surface code, such as bridging inferences, may be added as well. Connection strength is based on the amount of overlap or degree of association, with contradictory information having negative strengths. There may be elements ultimately unassociated with the discourse incorporated nevertheless, such as *bug-insect* in a text about spies. In other words, the textbase can contain incoherent as well as correct interpretations of the surface code: it is based on parallel processing. Which propositions are connected and / or added into the textbase is determined by working memory: only propositions concurrent in working memory (usually two: bridging inferences) are connected in this way.

In the following integration phase, thought of as a process of spreading activation, the stronger a connection or the more salient a proposition is to begin with, the more additional activation it receives. This 'weeds out' incoherent or contradictory elements. The model also assumes that the strongest propositions from the previous sentence(s) are maintained in working memory for the next construction cycle on new incoming material to have something to 'latch on to', a process also called the *leading-edge strategy* (van Dijk & Kintsch, 1978). Since only the most activated propositions are carried over, subsequently arriving material containing a referentially coherent element that refers to a discourse participant not part of one of those propositions results in the relevant proposition being reactivated if possible, or triggers an elaborative inference if reactivation is not possible anymore. Simultaneous to the construction-integration cycles on the surface code and textbase, a situation model, based on 'what we already know about similar situations' (van Dijk & Kintsch, 1983, p. 12) is retrieved and updated with the information coming in via surface code and textbase.

The CI Model incorporates both the incremental and dynamic aspects of text representation discussed above. The model also uses production-system and connectionist strategies, making its architecture a hybrid of both methods, albeit serially. Theories of inference generation incorporating ideas from the CI-model are the *minimalist hypothesis* put forward by McKoon & Ratcliff (1992), and the *constructionist* view of language processing (Graesser, Singer & Trabasso (1994), discussed briefly in section II.4.

V.2.2.2. The 3CAPS model

The 3CAPS model (Concurrent, Capacity-Constrained Activation-Based Production System, Just & Carpenter, 1992; Carpenter, Miyake & Just, 1994; Just, Carpenter & Keller, 1996) extends the influence of working memory on building a text representation. While the CI-model does not make very specific assumptions about the influence of capacity constraints, the 3CAPS model assumes that there is a limited amount of capacity available for processing and storage. The model is a true hybrid of production-system and connectionist architecture. There is a set of production rules (such as 'if the current word is a determiner you can expect to be processing a noun phrase'), that can and do increase the activation of elements in a network. An element can be a word, a proposition, a grammatical structure, or a concept activated from long-term memory. Production rules can fire repeatedly, and all rules can kick in simultaneously as well. There is a limited overall amount of resources available. At any time in processing, elements that did not receive sufficient activation can fall below a threshold and will thereby not be used for the building of a text representation. If the amount of activation needed for the next propagation cycle would exceed what is available, all activation is scaled back proportionately, in an 'across-the board percentage budget cut' (Just & Carpenter, 1992, p. 123). The result is pattern of activation changing with each incoming element.

The 3CAPS model is dynamic, changing with each incoming element, and allows for parallel processing, but it does not necessarily assume different levels of representation: simultaneously firing production rules can operate on what could be called the surface code, the textbase as well as the situation model. It can account for a number of observed individual differences: people with higher working memory capacity are able to keep more elements and thereby several possible interpretations sufficiently activated, while those with lower capacity have to restrict themselves, often to local relations in a text. For inference processes and ERPs, this was shown by St. George (1995) and St. George, Mannes and Hoffman (1997), who demonstrated that people with higher working memory capacity were able to draw elaborate inferences, while those with lower spans managed only the bridging inferences.

Another aspect that the 3CAPS model can account for is that working memory capacity does not only have an influence on what information remains available for processing, but also that added working memory load has an influence on the speed of processing: reading slows down at those points in a text that make added processing demands, more so for people with lower working memory than those with higher working memory. This has the immediate consequence that more complex operations take longer and are more resource-demanding for everyone, and that, in turn, can be and is reflected in ERPs.

In the Landscape model of reading (van den Broek, Risden, Fletcher & Thurlow, 1996; van den Broek, Young, Tzeng & Linderholm, 1998) ideas from the 3CAPS model are incorporated, such as the cyclical nature of reading and the limited memory capacity, as well as the basic connectionist architecture.

The landscape model also introduces an additional dimension, namely that of attention. Attending a particular concept or word can increase its activation, to the detriment of less

attended elements. Which elements receive added attention is determined by textual cues, such as function and relevance indicators ('It is important to note that…', 'To summarize…', 'Fortunately…'), which indicate that the author of a text considers the elements associated with the indicator to be of particular relevance. Co-reference and cataphors are another type of textual cues, as are typographical elements and text-structure cues.

V.2.3. Situation Models

In this section, a closer look will be taken at the situation model and the type of information it is assumed to encode, how it is structured and how it is proposed to change with incoming information. Constructing a coherent situation model is often seen as tantamount to comprehending a text (Zwaan & Radvansky, 1998). In that view, the question is not how people understand a text but how they construct such a coherent situation model.

Situation models have been investigated for roughly half a century now, research usually concentrating on one of the dimensions of space, time, causality, motivation and characters. Two of these dimensions, namely time and causality, will be discussed in more detail before a representation model incorporating all five is introduced.

V.2.3.1. Time and causality

Time is, due to its linearity, quite compatible with language. Events taking place one after another can simply be described consecutively, and in the absence of contrary temporal cues (such as *'before'*), that is the order in which they are interpreted as well. In fact, out-of-canonical-order events have to be marked with such a linguistic cue to avoid incoherence, and still incur added processing cost (Münte, Schiltz & Kutas, 1998). Tense marking is another tool by which time is encoded in language. Time cues are also used to separate events in text comprehension. In stories that either included a short time-shift (10 minutes) or a long shift (6 hours), subjects were faster and better at answering questions that referred to characters before the shift in the short time-shift condition (Anderson, Garrod & Sanford, 1983; Zwaan, 1996). This suggests that time cues may be used to 'parcel' events, with only those aspects carried over into the new parcel that are still relevant. In a short time-shift story about someone going shopping for instance, a store manager mentioned before the shift might be carried over, while in the same story with a long time-shift, the store manager could be 'dropped'.

Causal relations have been regarded as a central feature at least of narrative texts. There is evidence that readers routinely keep track of causes and consequences in narratives, and that 'understanding' a text centrally involves making causal connections. The making of these connections almost always involves world knowledge: to connect the two statements 'John dropped the ceramic bowl onto the stone floor' and 'the bowl broke', one has to know that ceramic is not flexible and will break if subjected to too much force. Fletcher (1994) assumes that causal connections are a property of the situation model, not only because making them involves world knowledge, but also because causal connections can link clusters of propositions, as can be seen in the following example taken from Fletcher (1994, p. 600):

7. The 750 pound orange and black cat walked into the bedroom and the burglar left very quickly.

This sentence contains six propositions, four pertaining to the cat and two to the burglar, which are linked by a causal relation: the entrance of the tiger causes the hurried departure of the burglar. Causal connections are however not necessarily made outside the domain of narrative texts. Fletcher, Chrysler, van den Broek, Deaton & Bloom (1995) have shown that causal connections improve recall of single sentences only if subjects were either explicitly instructed to make a causal connection or if the sentences were embedded in a narrative. Singer, Halldorson, Lear & Andrusiak (1992) showed that a question probing an element of world knowledge was answered faster if that element was needed to connect two previously read sentences, such as 'Does water extinguish fire?' after the two sentences 'Mark placed the bucket of water by the bonfire. The bonfire went out.', as opposed to 'Mark poured the bucket of water on the bonfire. The bonfire went out.'. Another interesting result was reported in a number of experiments by Keenan, Baillet & Brown (1984), Myers, Shinjo & Duffy (1987), and Duffy, Shinjo & Myers (1990). They first asked subjects to study sentence pairs that were either closely, intermediately or not causally related. Subjects were later presented with the first sentence of a pair as a recall cue for the second. Reading times for the second sentences in the second round were thought to be a measure of the ease of retrieval of the relevant model. The results were very interesting: the moderately related sentence pairs produced the fastest reading times for the second sentences, faster than either the closely related or the unrelated pairs. Myers et al. interpreted this to reflect the fact that in the intermediate condition, readers were both able to and needed to construct a bridging inference to connect the sentences. In the unrelated sentences, the subjects were unable to connect the sentences and in the closely related condition, subjects did not need to elaborate the textbase. Asking subjects to explicitly write down a connection between the two sentences in the first, the studying, round resulted in the disappearance of the recall advantage for intermediate pairs (Duffy et al. 1990). It seems that texts demanding more, but doable, work by the reader result in more salient situation models that are consequently better recalled.

V.2.3.2. The event-updating model

Zwaan & Radvansky (1998) review a number of experiments that show that equivalent propositional structures can lead to different behavioral responses (the 'soccer'-experiment discussed above), i.e. that depending on the goal and knowledge of the reader different situation models are built, and that readers keep 'at least five situational dimensions' in mind as they go through a text. These dimensions are time, space, characters, causation and motivation[31]. In the Event-indexing model (Zwaan, Langston & Graesser, 1995; Zwaan, Magliano & Graesser, 1995), all these dimensions play a role in building the situation model. The authors propose that the elements a situation models orders are mental representations of single events. Each separate event is centered around a verb, and each new event is decomposed into five indices, the dimensions mentioned above. Incoming events that share one or more indices with previous ones are easier to integrate into the model than discontinuous ones. The more indices are shared, for instance if a new event deals with the same people, at the same time and in the same place as a previous one, the easier integration is. Creating new indexes, as in the case of a discontinuity, is costly, as expressed by elevated reading times (Zwaan, Magliano & Graesser, 1995).

Zwaan & Radvansky distinguish between three separate stages or versions of a situation model: the *current model*, the *integrated model* and the *complete model*. The current model

[31] The authors do not limit the features of a situation model to these five, merely claim that these five definitely are included.

is the one that is constructed while a particular event is read. The integrated model is the one constructed by integrating previous current models up to the current sentence, and the complete model is what results after all the sentences or clauses have been read[32]. The process of integrating the current model into the integrated model is called *updating* by Zwaan & Radvansky.

There is some debate as to whether the updating process results in outdated information being completely purged from the integrated model or whether such outdated information can still be a part of the integrated model. According to what is called the *resonance* view of updating, taken among others by O'Brien, Rizella, Albrecht & Halleran (1998), incoming information resonates with all previous information, including outdated information (a lost object, a person that already left, no-longer valid goals etc.), and this can result in outdated information being reactivated and interfering with coherence. According to the *here-and-now* view, which is taken by Zwaan & Madden (2004) and Morrow, Greenspan & Bower (1987), among others, currently relevant information is much more easily accessible than older information. This means that in the here-and-now view, new information that is consistent with current information but inconsistent with older events can be integrated as effortlessly as new information that is consistent with current information *and* older information. In the resonance view, new information that is inconsistent with older information incurs higher processing cost.

The updating process is also influenced by what is called *foregrounding*, that being the process of a reader putting particular emphasis on one particular dimension, based on world knowledge or linguistic cues. If a sentence mentions a goal of a character ('Susie wanted to…') or contains an explicit cue regarding a particular dimension ('meanwhile…'), the information corresponding to that dimension in the integrated model is made more easily available 'further downstream' and results in readers paying particular attention to that dimension.

As the authors note, the event-indexing model still suffers from teething troubles[33]. It currently does not encode the temporal order of events or the direction of a causal relationship, and treats the dimension as discrete entities, which in some circumstances they simply cannot be, such as in example 8, taken from Zwaan & Radvansky (1998, p. 180):

8. Someone was making noise in the backyard. Mike had left hours ago.

The temporal information *hours ago* prohibits a causal connection between Mike and the racket in the backyard. Time and causality cannot be separated here.

Foregrounding, updating and connective ties

Despite these problems, the event-updating model looks very tasty for present purposes because it includes mechanisms that give connective ties a definite role in the construction of a situation model and thereby generate predictions, namely *foregrounding* and *updating*. Analogous to Gernsbacher (1990) and Givón (1992), Zwaan & Radvansky assume that connective ties are linguistic cues that are used in the construction of a situation model. A temporal connective tie such as *afterwards* is a possible cue that a new time frame, which is however connected to the old one, should be begun, while a causal connective tie such as *therefore* signals a close causal relation between two events. Moreover, connective ties have the effect of signaling *which* dimension it is that events share indices in, of

[32] The distinction between integrated and complete models appears to be based on external factors, such as a person knowing that there is more text to come, or that they are now done.
[33] It was also not intended as a complete account of situation model construction.

foregrounding or emphasizing that dimension and thereby make subsequent integrations easier. These assumptions are not qualitatively different from saying that connective ties predict or even force a certain type of inference, but they do give a clearer impression of the influence of connective ties on language processing as building instructions for a situation model (see also Fauconnier, 1994). Various studies have shown that connective ties serve to make comprehension easier, provided that the cue they give is valid. However, most studies of connective ties and situation model updating used sentence reading times or sentence probes as data sources (see chapter VI for a discussion of relevant behavioral and eye-tracking studies and chapter VIII for the few exceptions employing ERPs and functional magnetic resonance imaging (fMRI)). This means that they gathered data on complete propositions and events, not on the influence of single words on a situation model. ERPs on the other hand should provide more detailed information as to the triggering and execution of updates and the influence of foregrounding, i.e. connective ties in this case, on the situation model within a not-yet complete event.

V.2.4. Processing problems in discourse

Discourse processing deals with the understanding of more than one sentence. This means that processing problems can stem not only from the sentence currently being processed, but also from the influence of previous material on the current sentence, on the syntactic as well as the semantic analysis of the current sentence. To keep the discussion as coherent as possible, the processing problems addressed in the section on sentence processing (V.1.3) will be revisited, this time from the standpoint of discourse processing. There are also a few difficulties applicable only to discourse processing, which will be addressed as well.

V.2.4.1. Violations

Structural violations

In the case of phrase structure violations such as in example 9.a, the parsing process is unsuccessful in every case, either automatically or consciously. This happens regardless of whether the sentence stands alone or is part of a discourse, since the violating element cannot be integrated into a felicitous representation of the sentence, and discourse coherence is interrupted. Using an intransitive verb transitively is also ungrammatical in single sentences as well as in a discourse (9.b)[34].

9.

a.	*Die Gans	wurde	im	gefüttert.	
	the goose	was	in the	fed	(from Hahne, (1997), p. 125)
b.	*Susie slept the toad.				violation of subcategorization

Violations of antecedent binding however are dependent first on the type of referring element and secondly on the availability of other potential antecedents:

[34] Of course, it would be possible in a discourse to establish a verb with a different subcategorization frame, for instance to introduce the process or act of 'sleeping someone' in a science-fictional or magical (fantasy) context. However, as a regular consumer of such literature, the author of this work has found that for these occasions, other (more or less fortunate) linguistic tools are employed and the subcategorization frame of a known verb is not changed.

10.

a. *Susie was thirsty. Grandfather$_i$ made herself$_{*i}$ a cup of tea.

b. John$_i$ bought a lottery ticket. [The lady selling the tickets]$_j$ found that he$_{i/*j}$ had won the jackpot.

For violations of reflexive antecedent binding, previous discourse trivially plays no role, as the binding of a reflexive anaphor is a sentence-internal process, and if a valid antecedent is lacking in the current sentence, that, as they say, is that (example 10.a). The case of pronoun binding is somewhat different in a discourse. Standing alone, the second sentence in (10.b) is ungrammatical, as *the woman* can not be an antecedent for the pronoun. There is however an antecedent in the previous sentence, namely *John*. If the pronoun is analyzed as co-referent with *John*, the sentence is no longer ungrammatical.

Semantic violations

While structural violations, if pertaining to sentence-internal rules, cannot be influenced by previous discourse, semantic violations display the opposite pattern. It is the previous discourse that determines if a semantic violation is present or not[35]. It is possible to 'license' outright pragmatic violations by previous discourse:

11. The best vegan burritos can be bought at the corner store near where I live. The owner makes them himself and calls them cows. I ate two cows yesterday.

The previous discourse establishes *cow* as a name for an item of food, and hence eating two cows does not involve the physical impossibility of consuming roughly a metric ton of beef in 24 hours, as it would if the last sentence stood alone.

Conversely, what in a single sentence would not be a semantic violation can be one in a discourse:

12. This year we have a particularly hot summer. I've been freezing for days.

In vacuo the second sentence would not raise any eyebrows. The first sentence however establishes that keeping warm should not be a problem, and this makes the semantic content of the second sentence a violation, an example of incoherence due to discourse information.

V.2.4.2. Local ambiguities

Local syntactic ambiguities

The jury is still out on whether previous discourse can influence a parser's decision in the case of a local structural ambiguity. Strictly modular syntax-first models would predict that previous discourse has no influence and any decision is made on the basis of independent rules such as *Minimal Attachment* and *Late Closure*. Interactive models would predict that previous discourse can and does influence even the earliest decisions. There is evidence that for instance discourse-referential effects might be able to influence the first phase of phase-structure building by establishing a strong preference for a particular syntactic structure in the case of a relative-clause versus complement-clause ambiguity

[35] This is an oversimplification. See chapter 0 for a less roughshod discussion of semantic violations in discourse.

(such as 13, from van Berkum, Hagoort, & Brown, 1999a, van Berkum, Brown, Hagoort & Zwitzerlood, 2003a), to the point of counteracting *Minimal Attachment* and *Late Closure.*

13. The hippie told the friend that he… / ?there…

In the previous discourse, the NP *the friend* was either unambiguous (one-referent context), there being only one friend, or ambiguous, with two previously mentioned friends (two-referent context). The authors argued that in the one-referent context, the complement clause disambiguation should be the preferred one, basically because *the friend* was already unambiguous and therefore further elaboration of the NP by way of a relative clause should be unnecessary. For the two-referent context, the relative clause reading should be preferred, as this reading promises a disambiguation. In a modular syntax-first model, the relative clause reading would always be the preferred one.

Van Berkum, Hagoort & Brown (1999a) and van Berkum, Brown & Hagoort (1999b) reported effects for the dispreferred disambiguations, based on the previous discourse. The effect of discourse here would be in establishing a preference for a particular syntactic structure. This interpretation of the data precludes an assumption of a strictly modular syntax-first model *per se*, as the initial structure building, if modular, is an encapsulated process (Fodor, 1983), influenced by nothing but the word category of the input: the definition of a module according to Fodor rules out the possibility of a module being influenced by earlier processes.

There were some concerns as to possible strategy effects due to relatively slow serial presentation for these results, addressed in Brysbaert & Mitchell (2000), to which van Berkum and his colleagues replied in Brown, van Berkum & Hagoort (2000) and van Berkum, Hagoort & Brown (2000), (and see Mitchell, Corley & Garnham (1992) for self-paced-reading time evidence disagreeing with van Berkum et al.).

There is evidence that, on the one hand, word class does play a privileged role in sentence processing, as demonstrated in numerous studies that included outright word category violations in German (Friederici, Pfeifer & Hahne, 1993; Hahne, 1997; Hahne & Friederici, 1999; Hahne & Jescheniak, 2001; Hahne & Friederici, 2002; Friederici, Gunther, Hahne, Mauth, 2004; Rossi, Gugler, Hahne & Friederici, 2005). On the other hand, there is also evidence that individual differences can have a significant influence on which information is or can be used during language comprehension (Just & Carpenter, 1992).

Clearing up this question would, however, constitute much more than an additional dissertation. The admittedly cavalier treatment of the matter here is attributable to the fact that the present work concentrates on the processing of connective ties and their effect on the representation of discourse, and did not involve syntactic manipulations, all target sentences having the same unambiguous syntactic structure. Therefore, no claims can be made here in this debate.

Local semantic ambiguities

By definition, a local (semantic) ambiguity is an ambiguity that is resolved at a later point in the same sentence. In a discourse, a word with several possible meanings (a homograph in written material) could be said to be locally ambiguous either if the prior context provides no clue as to the correct meaning, or the sentence is the first one in a discourse, but later material in the same sentence does deliver the means to identify the correct reading for the first as well as the second variety. In both cases, the processing procedure would be analogous to that of an ambiguous word in a single sentence, and the

kind reader is referred to the appropriate section of processing problems in single sentences (V.1.3.2).

V.2.4.3. Global ambiguities

Global semantic ambiguities

At first glance, if previous context can license a semantic violation, prior discourse should make it possible to completely avoid selecting the 'wrong' meaning of a homograph. Things are, not surprisingly, not that simple. Previous discourse can have the effect of suppressing incorrect meanings of a ambiguous word faster than if there was no context, but only if it is sufficiently restricting. This 'context-advantage' is also dependent on the relative frequencies of the multiple readings of an ambiguous word. If the contextually inappropriate meaning of a word is as frequent as the appropriate meaning, the context serves to suppress the inappropriate meaning. If, on the other hand, the contextually inappropriate meaning is dominant, both that meaning and the subordinate reading are (initially) integrated (Duffy, Morris & Rayner, 1988; Rayner & Frazier, 1989; Simpson, 1994).

Global syntactic ambiguities

As discussed above, global syntactic ambiguities occur when an element can be structurally 'incorporated' into the sentence in more than one way, as in the following example, where the fact that German is a scrambling language, and the article *die* ambiguous between nominative and accusative, results in an ambiguity as to who saw whom:

14. Die Sekretärin sah die Verkäuferin.
    The_{FEM} $\text{secretary}_{\text{FEM}}$ saw the_{FEM} $\text{salesperson}_{\text{FEM}}$.
    'The secretary saw the salesperson.' or 'The salesperson saw the secretary.'

While in a stand-alone sentence the parser has to employ some sort of strategy to arrive at an interpretation, this might not be necessary in a discourse, since previous information can prevent an ambiguity, such as if the following sentences preceded example 14:

15.
   a. Es gab zwei Personen, die die Verkäuferin oft im Laden sah: eine Marktfrau und eine Sekretärin.
      'There were two people the salesperson saw often in the store: a market seller and a secretary.'
   b. Welche Person sah sie heute?
      'Which person did she see today?

The wh-question (15.b) establishes the expectation that one of the two objects of the first sentence will be the focus of the last sentence in the discourse (14), according to the parallel-function-strategy (Gordon & Scearce, 1995), leading to a possible avoidance of the incorrect subject-initial analysis of the last sentence. The qualification 'possible' is used for several reasons. Example 14, as it stands in written form, is still odd, even with the preceding discourse. It could be felicitous in spoken discourse if *die Sekretärin* received intonational focus, and in written discourse by the use of an it-cleft ('Es war die Sekretärin die die Verkäuferin sah', 'It was the secretary that the salesperson saw'). Secondly, this sort of syntactic ambiguity involves thematic processing, a truly complex field which has

recently been shown to constitute an alternative processing route to syntactic structure building (Bornkessel, 2002). Third, again, the present work did not examine syntactic or thematic processing and for the sake of brevity and global coherence, this discussion will have to be left at this unsatisfactory point.

V.2.4.4. Global incoherence

A processing problem exclusive to discourse occurs if the separate sentences that make up the text are grammatical, but the sentences have nothing to do with each other:

16. Wait for some of the stars to explode. Nature's sample space is often bigger than a conventional statistician would expect. The key step was the invention of printing.

The sentences in example 16 (taken from Pratchett, Stewart & Cohen, 1999, p. 76, 251, 315 respectively) are, taken separately, perfectly all right. Together however, they do not constitute a text, making it impossible to connect any two sentences or to construct a situation model without serious elaborative inferencing.

VI. CONNECTIVE TIES 2

The following section will discuss some studies examining the processing of connective ties that employed reading time, reaction time, recall, probe detection or eye-tracking methods. Studies that employed ERPs and fMRI are discussed in chapter VIII.

The studies presented here do not represent the entirety of published work on the processing of connective ties, but are considered by the author of the present work to illustrate four central questions:

1. How do connective ties affect the construction of a text representation in *coherent* texts?
2. What is the effect of connective ties in *incoherent* discourses, where the connective tie suggests or even enforces a relation that is not present?
3. Are different types of connective ties (causal, temporal and concessive) processed differently?
4. *When* is the information a connective tie imparts used in processing?

Question 1: connective ties in coherent discourses

There seems to be general agreement that connective ties facilitate the construction of a text representation in discourse. Caron, Micko & Thüring (1988) found for German that subjects were better at recalling the second sentence of an unrelated sentence pair, given the first sentence as a cue, when the sentence pair was connected by the causal connective tie *denn* (*because*), compared to the non-causal connective tie *und* (*and*), or no explicit connection at all. Subjects were given booklets with a sentence pair such as in 23 on each page (Example adapted from p. 311, translation to English by Caron et al.):

17. The priest was able to build the new church.
(*Denn* / *Und* / Ø) The computer had made a serious error.

The subjects had either 7.5, 15 or 30 seconds to study each pair of sentences[36]. After a 10 minute interval, in which subjects were prevented from rehearsing with the test of spatial ability, they were given the first sentence of each pair in random order as a recall cue for the second sentence. Results for the correct recalls showed that for both study times of 15 and 30 seconds, recall was much better for sentences connected with *denn* than for either *und* or no connective: ~40% correct recall for *denn* versus ~10% for each *und* and no connective tie. In the condition with 7.5 seconds study time, recall for causally connected sentences was also better, but not reliably so. Caron et al. repeated the experiment with only unconnected sentences and 15 seconds study time (supplementary experiment 1). This time subjects were told explicitly that there was a (causal) relation between the sentences that would aid them in recall if they found it. Recall percentages in this second experiment patterned as expected. Cued recall was better if subjects were told that there was a connection (about 35%) than if they were not. There was no difference between the causal connective condition from experiment 1 and the no-connective condition in which subjects were told that there was a relation from the supplementary experiment. In experiment 2, Caron et al. tested all four conditions with 15 seconds study time, (*denn*, *und*, 'instructional

[36] All of the resulting nine conditions (3 lexical connection x 3 study time) were between subject factors, with 9 subjects assigned to each group.

relation' and no connective) but used free recall instead of cued recall. Results showed that subjects recalled material from both clauses much better if the clauses were connected with *denn* (~70%) than in any of the other three conditions (between about 10% and about 40%). These results are discussed in answer to question 1 (above) despite the fact that the sentences used by Caron et al. could be classified as incoherent for the following reasons. First of all, the study time of 15 seconds provided ample opportunity for subjects to construct an elaborative inference, such as a building permit being erroneously granted in example 17. Secondly, subjects were not instructed to diagnose incoherence, as in a study by Ferstl & von Cramon (2001), discussed below. These results should therefore be interpreted not as showing the effect of connective ties in discourses with an underlying causal relation, but as showing the extent to which causal connective ties aid in or trigger elaborative inferences. Keeping that in mind, the results show that an explicit causal connection without instructions to find a causal relation has the same effect as instructions to construct a causal relation and no connective tie in the stimuli, provided that subjects have enough time to make a connection. This suggests that signaling or even enforcing a relation is indeed the function of causal connective ties.

In his experiment 5 (see also experiment 8), Townsend (1983) examined whether the order in which complex sentences containing a subjunctive connective tie are presented affects verbatim recall. There were six subjunctions used: *because*, *since*, *after*, *when*, *while*, and *before*. All subjunctions conjoined two simple sentences and were presented either with the main clause or the subordinate clause first. A noun phrase preceding the simple sentence introduced the subject of the target sentences (example taken from Townsend, 1983, p. 245):

18.

a. The Canary. It sang the song *because* it ate the seed.
b. The Canary. *Because* it ate the seed it sang the song.

Subjects studied each stimulus for 10 seconds. After six study-rounds, the initial noun phrases were presented in random order and subjects were asked to write down the corresponding target sentences as accurately as possible.

Results showed that recall for main-clause-initial targets was better for sentences containing *while*, *before*, and *when*, and to a lesser extent for *since*, while recall for targets containing *because* or *after* was better if the subordinate clause was presented first.

Townsend suggested that presentation of events out of cause-effect or first-second-event order results in poorer long term recall of the sentences. An additional factor for these results could have been the influence of the connective ties: *because* and *after* might be recalled worse in a main-subordinate representation because in that presentation, the external argument had to be kept active until the internal argument was read, and could only be evaluated then. For *when*, *while* and *before*, and to a lesser extent for *since,* this additional load was not present.

In sum, connective ties in coherent texts appear to aid the understanding of the text, especially if a (causal) relation is not immediate. At the same time, the presence of a connective tie seems to introduce a marked preference for the canonical order of events.

Question 2: connective ties in incoherent discourses

Murray (1997, experiment 2) showed that a connective tie must match the underlying relation in the discourse it stands in. Murray presented additive (*moreover*, *furthermore*, *also,* and *and*), causal (*therefore*, *so*, *thus* and *consequently*) and adversative connective ties

(*yet*, *nevertheless*, *however* and *but*) in sentences that did not contain the appropriate underlying relation[37]. Example 19.a shows an adversative and an additive connective tie in a causal situation, example 19.b a causal and an additive connective tie in an adversative context, and example 19.c a causal and an adversative connective tie in an additive context (material taken from Murray, 1997, p. 231):

19.

a. Manny needed to publicize the garage sale. *Moreover* / *However* he arranged for flyers to be made.
b. Ronny had little time to arrange for a surprise for his girlfriend's visit. *Also* / *So* he bought her a beautiful bouquet of flowers.
c. John responded to the department store's unethical hiring policies by writing his congressman. *So* / *Nevertheless* he decided to boycott the store.

Subjects read sentences with only additive, only causal or only adversative contexts. The sentences were presented self-paced line by line, such that a connective tie, if present, appeared at the end of the line.

Reading times showed that inappropriately placed connective ties resulted in longer reading times, regardless of connective ties or context, and always compared to the no-connective condition. Additionally, inappropriately placed adversative connective ties resulted in longer reading times than their also inappropriate 'colleagues' in the causal and additive contexts respectively. Murray suggested on the basis of this data that a connective tie, when processed, leads to expectations concerning the relation of the internal to the external argument, which is basically equivalent to stating that a connective tie must match the underlying relation in its discourse.

Ferstl & von Cramon (2001) showed for German in a sentence-reading time study[38] that the presence of cohesion in unrelated sentence pairs hinders in the detection of coherence breaks compared to sentence pairs that did not contain a cohesive element. Ferstl & von Cramon used causal, temporal, and instrumental connective ties, as well as referential cohesion (pronouns) and paired deictical sentential adverbs[39] as cohesive elements. Incoherent trials were constructed by exchanging the contexts of two coherent trials. Example 20 shows the materials used in the English translation provided by the authors (p. 328):

20. Context: Laura got a lot of mail today.

a. coherent targets:

Some friends had remembered the birthday.	non-cohesive
Her friends had remembered *her* birthday.	cohesive

b. Incoherent targets:

The palms were sweaty.	non- cohesive
Therefore, her palms were sweaty.	cohesive

[37] There were also trials that contained no connective tie at all.

[38] The sentence reading-time study was the pretest to an fMRI study. The fMRI results are discussed in chapter VIII.

[39] *'Yesterday* someone left the car lights on. *Today* the car doesn't start.': Two deictical sentential adverbs provide a time-frame for a discourse and can thereby act as relational coherence markers. A single deictical connective tie does not have this function (see experiment 1).

The stimuli were presented as a self-paced sentence reading time study. Subjects were asked to provide an acceptability judgment after each trial. Results for the error rates showed that slightly more mistakes were made in judging coherent trials, but error rates were very low overall (6.6%). The reading times for the targets, adjusted for sentence length, showed a strong interaction of coherence with the presence of cohesion. This effect was mostly due to the incoherent conditions, where cohesion massively hindered in the diagnosis of incoherence.

As can be seen in example 20.a, the two sentences were fairly closely related already without the cohesive elements. This might explain why the results for the reading times for the cohesive coherent target sentences were only descriptively shorter than the non-cohesive coherent targets. Since subjects were asked for a judgment, they were thereby encouraged to find a connection between sentences, whether cohesive or not.

Ferstl & von Cramon's results show that lexical cohesion is indeed taken 'at face value': if it is present, a reader assumes that it is present for a reason, namely that the relevant elements of a discourse are connected.

Question 3: different types of connective ties

In experiment 3, Caron, Micko and Thüring (1988) repeated their cued-recall experiment in French, using *parce que* (*because*), *et* (*and*), no connective, and *mais* (*but*), an adversative connective tie. Results showed that the concessive connective tie did not aid in cued recall in 7.5 and 15 seconds study time. In the 30-seconds study time condition, recall for the sentences with adversative connective ties improved significantly, but so did the proportion of inferential errors[40]. The interpretation for these results suggested by Caron et al. is that the construction of an elaborative *adversative* inference is more difficult than that of an elaborative *causal* inference, and that the resulting representations, despite demanding more work on the part of the subjects, were not coherent enough to facilitate cued recall. If one inserts *but* into the example in 17: 'The priest was able to build the new church, *but* the computer had made a serious error.', the impression is that the resulting connection has to be not only elaborative: if, for instance, a computer was used to calculate the static properties of the building, and it made an error, the finished church might be unstable. This is, however, a *predictive* inference, and 30 seconds are not likely to be enough to make it if subjects were at the same time trying to learn the sentences verbatim as instructed.

In his experiment 4, Townsend (1983) compared the connective ties *because*, *after*, *when*, *and*, *before*, and *although* in a semantic phrase match task. The connective ties were embedded in complex sentences, and the internal argument was identical in all six cases. The external argument was modified to accommodate the connective tie. Example 21 shows a target sentence felicitous for *after*, *when* and *although*, taken from Townsend, (1983, p. 242):

21. He tried not to be afraid *after* / *when* / *although* he felt cold fingers close around his neck.

The critical sentences were embedded into two stories of either 62 or 135 sentences length. Subjects read the stories sentence by sentence self-paced. After a sentence containing a connective tie, the button press resulted in a match phrase being presented

[40] Caron et al. do not mention exactly what constituted an 'inferential error'. Since they classified all trials as correctly recalled in which the second sentence was produced 'either literally or with changes in form that did not affect the meaning', p. 312, it can be inferred that any trials that did not meet these criteria were classified as inferential errors.

('squeezing his neck' in this case). Subjects were asked to indicate whether the target phrase was similar or dissimilar in meaning to any part of the preceding sentence. Results showed that reaction times to the match varied as a function of the type of connective tie in the critical sentences: if the critical sentence had contained either *because*, *after*, *when*, or *and*, reaction times to the match phrase were about equal (~2390ms). If the critical sentence had contained *before*, reaction times were longer (~2420ms), and for *although*, they were longest (~2480ms).

Townsend interpreted these results to show that the language processor organized the propositions of a sentence according to a causal or temporal pattern, and that the meaning of causal events is more accessible than the meaning of non-causal events, since he classifies *because*, *after*, *when* and *and* as allowing a causal interpretation, while *before* and *although* do not. First of all, judging from the one critical stimulus that Townsend provided as an example, *all* target sentences contained a fairly direct causal relation. As has been discussed above, causal relations also contain a temporal dimension. *Because*, *after*, *when* and *and* producing similar results in such contexts would then be expected. That *before* results in higher reaction times is also not surprising, as this connective tie would require a predictive inference for a coherent representation: 'He was not afraid *before* he felt…' implies that he *was* afraid afterwards. In the case of *although*, Townsend's interpretation that this connective tie does not allow for a causal relation is disagreed with here (see section III.4.2). Reaction times for matches to target sentences with *although* being longest could rest on the fact that the surprising outcome (not being afraid) that the concessive connective tie 'prepares' for is presented first, and not the one the match referred to[41]. This means that the processing of these sentences was highly complex. Since subjects had a maximum of 4 seconds for the critical sentences, it is likely that not all the implications were worked out by the time the match appeared.

Nevertheless, this study shows that in close causal situations temporal connective ties are just as felicitous as causal connective ties, i.e. that either dimension can be foregrounded, and that concessive connective ties appear to impose extra processing load.

In experiment 7, Townsend used adverbial connective ties instead of subjunctions as in experiment 4. Pairs of sentences were presented on a computer screen that were felicitous with any of the five connective ties *therefore*, *afterward*, *meanwhile*, *previously* and *however*, as well as no connective tie at all (example taken from Townsend, 1983, p. 250):

22. Harry began raising snakes on his farm. *Therefore*, kids visited the farm every day.

Subjects read the sentences self-paced. They were asked to construct a sentence that would be a coherent continuation of the story before they pressed the button to call up the next sentence. Results for the context sentences did not differ from each other across the conditions. Reading times for the target sentences displayed a pattern that was strikingly similar to that of the reaction times of experiment 4: in sentences with *therefore* and *afterwards*, subjects were fastest at reading and constructing a continuation. They were slowest for sentences containing *however*. Townsend suggests that a departure from a preferred cause-effect or first-second event order, as required for the connective ties *previously* and *however*, results in longer integration times. Since the subjects were asked to think of a continuation, i.e. make predictive inferences, it is difficult to tell whether the integration of the second sentence, or the required predictive inferencing is more difficult if a preferred causal or temporal chain is interrupted.

[41] In contrast to *despite that*, *although* takes the cause as its internal argument.

In sum, the results of the experiments by Caron, Micko & Thüring, and the ones by Townsend suggest that it is possible to foreground either the temporal or the causal dimension in causal situations, and that adversative and concessive connective ties are more difficult to process than 'straightforward' causal relations.

Question 4: The time-course of processing connective ties

Haberlandt (1982) found that if the last sentence in a short narrative started with a connective tie, such as in *'However*, the pilot made a safe landing', reading times for the phrase immediately following the connective tie (*the pilot*) were shorter compared to the non-connective condition. There was no effect found for the last phrase (*made a safe landing*). Millis & Just (1994) presented short discourses such as in 23:

23. The elderly parents toasted their only daughter at the party (. / *because*)
Jill had finally passed the exams at the prestigious university.

Presentation was word-by-word self-paced, and subjects were asked to determine whether a probe word (one of the verbs from the sentences) had occurred in the previous trial. Additionally, comprehension questions were presented at the end of each trial. In experiments 1, 2 and 4, probe recognition times for verbs from the first sentences were faster in the connective condition compared to the non-connective condition. The reaction times were faster and accuracy was higher for comprehension questions in the connective conditions as well. The results partially replicated the findings reported by Haberlandt, in that reading times for words in the second statements were consistently shorter in the connective condition, but only up to the last word. Reading times for the last words in the second statement were significantly longer in the connective condition compared to the non-connective condition. This pattern of results was found for the causal connective tie *because,* as well as the concessive connective tie *although*[42]. Facilitative effects of *because* on probe recognition and response times disappeared, however, when the causal relation between the statements was low[43].

Millis & Just interpreted this data to show that readers construct a representation of each statement separately and then possibly integrate the two at the end of the second sentence: their Connective Integration Model states that readers are less likely to construct a representation encompassing both statements in the absence of a connective tie. In other words, if a connective tie is present, readers simply assume that that connective tie states the intended interclause relation (type of inference), and wait with checking whether the relation truly holds until the end of the internal argument.

A problem concerning the stimuli used in the experiments by Millis & Just is that the presence of a connective tie was confounded with the two statements being one complex sentence. *Because* and *although* are subjunctions, and therefore all connective stimuli were rather long complex sentences, while non-connective stimuli were comprised of separate sentences. Deaton & Gernsbacher (in press), largely replicated the findings of Millis & Just, using non-causal connectives such as *and* or *then* as a comparison to *because*. They found

[42] The stimuli were altered (a negation was added) to accommodate *although* in experiment 4. Probe recognition and comprehension question data displayed the same pattern as for *because*.

[43] Millis & Just do not give an example of a low-related stimulus, making it hard to determine whether the statements contained a relation, just not a causal one, or whether the discourses were incoherent. The pattern of reading times for the last words, however, suggests that the discourses must have been incoherent, i.e. unrelated, as the same pattern was found when crossing cohesive / non-cohesive with coherent / incoherent conditions, see Ferstl & von Cramon, 2001, discussed above.

that a causal connective tie improves cued recall for the internal argument. Another result was that the connective tie is only an effective cue if the statements in the discourse were closely causally related. In not obviously causally related discourses, such as 24, there was no facilitation effect observed.

24. Susan called the doctor *because* the baby played in his playpen.

In an eye-tracking study, Traxler, Bybee and Pickering (1998) addressed Millis & Just's claim that integration of interclausal relationships (i.e. working out the relation signaled by the causal connective tie) is delayed until both arguments have been read. They compared the processing of causal and diagnostic sentences that contained the causal connective tie *because*. In an earlier study (Traxler, Sanford, Aked, & Moxey, 1997), it had been shown that diagnostic sentences are more difficult to process. Example (31) shows a diagnostic (25.a) and a causal sentence (25.b) with the connective tie *because*, taken from Traxler et al., p. 485:

25.

a. Heidi could imagine and create things *because* she won first prize at the art show
b. Heidi felt very proud and happy *because* she won first prize at the art show.

Traxler et al. classify sentences such as in 25.a as diagnostic since winning first prize at an art show is evidence, but not a cause for the ability to create and imagine. In the interpretation adopted in this work, sentence 25.a would be an instance of an opinion stated with a causal connective tie. Nevertheless, diagnostic sentences were shown by Traxler et al. (1997) to be more difficult to process. In the 1998 study, Traxler et al. used materials such as in 25 in an eye-tracking study to investigate whether the processing difficulties found for diagnostic sentences compared to causal sentences manifested themselves at the end of the second clause, as Millis & Just claimed, or at an earlier point. They separated the second clause of the target sentences into four regions: region 1 included the connective tie, region 2 the subject or in the case of pronouns the pronominal subject and the main verb, region 3 the main verb and object (except when the main verb was part of region 2), and finally region 4 included the last two words of the embedded clause or, if a prepositional phrase was the last constituent, the entire PP.

The data for regions 1 and 2 showed no difference between causal and diagnostic sentences. In region 3, diagnostic sentences resulted in longer first-pass fixations, subjects remained longer in the region (right-bounded time), and there were more regressions within region 3 and to earlier regions for diagnostic sentences compared to causal sentences. The total time, the sum of all fixations in region 3, was also higher for diagnostic than for causal sentences. Results for region 4 showed a similar pattern to that of region 3, although analysis of first-pass fixations and total time showed only trends, not reliable effects.

These results show that the processing difficulty in diagnostic sentences containing *because* manifested themselves well before the end of the second clause. Traxler et al. concluded that construction of interclausal relationships is incremental as well.

VI.1. CONNECTIVE TIES 2: SUMMARY

In general connective ties do appear to make the construction of a text representation easier (question 1, Caron, Micko & Thüring, 1988). They can however only fulfill this function if on the one hand the discourse is coherent in the first place (question 2, Ferstl &

von Cramon, 2001), and on the other the underlying relation between the two arguments matches, or at least does not counteract the semantic content of the connective tie (question 3, Townsend, 1983, Murray 1997). These conclusions were already reached in the theoretical discussion of connective ties, and the evidence from the behavioral and eye-tracking studies discussed above confirms them.

It is not quite clear if the information imparted by connective ties is used immediately or 'saved up' until the internal argument has been read completely (question 4, Millis & Just, 1994; Deaton & Gernsbacher, in press; Traxler, Bybee & Pickering, 1998). The data by Millis & Just suggest that a large part of the construction of the text representation is delayed until the end of the sentence. The data presented by Traxler et al. indicate, however, that relational coherence influences language processing immediately, similar to the processing of referential coherence, i.e. pronouns.

VI.2. ASPECTS TO BE EXAMINED 2

Some of the questions raised in the corresponding section III.5 have been answered at least in part by the studies discussed above. This section therefore has the function of revisiting each question, stating which aspects are now known, and which are still unanswered. Additionally, questions pertaining to language processing, which were not included in chapter III, will be added. 'Old' questions are marked with '•', (partial) answers with '3', and new, revised or still unanswered questions with '**?**'.

General questions

Questions common to all experiments were:

- Can empirical evidence be found for the theoretical distinction between connective ties and other elements that can occupy the same syntactic position, namely one-place (deictical) sentential adverbs (experiments 1, 2 and 3)?

✓ It appears that *in general*, connective ties have a distinct influence on language processing, their inclusion in discourses resulting in more coherent text representations.

? It is still not clear whether this supporting influence extends to single deictical sentential adverbs as well, or if two-place adverbial connective ties play a role distinct from on-place 'discourse operators'.

- Secondly, does the semantic content of the connective ties play a primary role, i.e. is the major distinction to be made indeed between 'connective' and 'non-connective' or instead between causal, temporal and concessive (experiments 3 and 4)?

✓ It seems that readers do attempt to connect two sentences in the form that the connective tie suggests.

? Again, it is not clear whether it is the semantic dimension (causal, temporal or concessive) playing the primary role, or the connective / non-connective aspect.

? It is still unclear when precisely the information provided by connective ties is used: there is some evidence that connective ties have an immediate influence on the integration of subsequent elements, but the end of the internal argument appears to play an important role as well. Experiments 2, 3, and 4 use ERPs to examine whether there is an immediate difference between connective ties and deictical sentential adverbs (experiments 2 and 3), and between different types of connective ties (experiments 3 and 4), as well as whether the integration of subsequent

elements in connective discourses differs from non-connective discourses, in coherent as well as incoherent discourses.

Causal connective ties versus non-connective elements

In experiments 1 and 2, the causal connective ties *deshalb* and *darum* are compared to temporal deictical non-connective elements (*gestern* and *vorhin*: *yesterday* and *just now*) in causally related and incoherent discourses. Experiment 1 employs a self-paced sentence reading time paradigm and experiment 2 uses the ERP-method. The question examined in both experiments, in addition to the first general question, is:

- What is the effect of a connective tie in incoherent discourses, where a causal connective tie signals a relation that is not present? A non-connective element would not enforce such a relation here. In other words: can evidence be found that causal connective ties do indeed enforce a causal relation?
- ✓ It has been shown that in unrelated (incoherent) discourses, cohesion is a hindrance, making processing difficult (Ferstl & von Cramon, 2001).
- **?** Whether this is true for connective ties compared to deictical sentential adverbs will be examined in experiment 1.

Causal versus temporal connective ties versus non-connective elements

In experiment 3, the temporal (*danach* and *hinterher*) and causal connective ties (*deshalb* and *darum*) were compared to each other and to temporal (*gestern* and *vorhin*) and non-temporal non-connective elements (*gern* and *lieber*: *gladly* and *rather*), all in coherent, causally, and thereby also temporally related situations. The questions examined in this study in addition to all general questions are:

- Is there a difference between causal and temporal connective ties in situations where both types of connective ties are felicitous?
- ✓ The studies by Townsend (1983) suggest that in such discourses there is no overall difference between the two types of connective ties. The methods used by Townsend, however, provided data pertaining to the finished text representation, not the processing of the connective ties themselves.
- **?** Therefore, experiment 3 examines whether the processing of the connective ties themselves and the integration of words subsequent to the connective ties also does not differ as a function of the temporal or causal connective tie.
- **?** If there is no difference between the connective ties, is the relevant distinction between connective and non-connective elements, i.e. do both types of connective ties differ in the same way from temporal and non-temporal sentential adverbs? This would suggest that foregrounding either of the two dimensions present in causally related situations is indeed felicitous.
- **?** If there is an immediate difference between temporal and causal connective ties, do temporal connective ties pattern with temporal non-connective elements, i.e. is the relevant distinction the one between causal and temporal semantic content?

Causal versus concessive connective ties

In the last experiment 4, causal connective ties (*deshalb* and *darum*) were compared to concessive connective ties (*trotzdem* and *dennoch*) in causally related situations. The outcome denoted in the second argument was either probable or improbable. Causal connective ties were felicitous with the probable outcomes, while concessive connective

ties were compatible with the improbable outcomes. The relevant questions, in addition to the last two general questions, were:

- Is there a difference between causal and concessive connective ties?
- ✓ The data by Millis & Just (1994, their experiment 4) suggests that there is no difference between causal and concessive connective ties. However, Millis & Just do not discuss or display separate analyses for causal and concessive connective ties. The data by Caron, Micko & Thüring (1988, experiment 3) and Townsend (1983) as well as Murray (1997) suggest however that there is a difference between causal and concessive connective ties.
- **?** Therefore, this question remains unanswered, and will be examined in experiment 4.
- **?** Is there evidence that causal and connective concessive ties are indeed found in complementary distribution in causally related discourse?
- **?** What happens if the end of the scale included in the internal argument is 'the wrong one'? Is the reaction equivalent to incoherent discourses for causal connective ties?

PART C: ERPS IN LANGUAGE PROCESSING

VII. PREVIOUS ERP RESEARCH

In this chapter, previous ERP studies of sentence and discourse processing will be introduced and discussed, after the processing model that was adopted as a working hypothesis is introduced.

VII.1. PICK A MODEL –ANY MODEL?

So far, it has been possible to sit on the fence where processing models, whether for sentence or discourse processing, were concerned. The subject matter under investigation here, the processing of connective ties, does not influence a number of issues central to the discrimination between models, whether developed for sentence- or discourse processing, and thereby cannot provide a basis on which to decide between them. As a working hypothesis, the parsing model developed by Friederici (Friederici, 1995, 1999, 2002) will be adopted, since it was developed in the context of ERP research. It is based on the work of Frazier, (1987a,b), and Gorrell (1995), among others, and is constructed as a modular syntax-first model involving three consecutive phases in the processing of a sentence.

In the first phase a syntactic representation of the sentence is constructed incrementally on the basis of word category information only. During this the parser pursues certain strategies that in case of ambiguities always results in the syntactically simplest structure being projected.

In the second phase semantic, but also additional syntactic properties such as subcategorization, number, gender or case of the current element is incorporated.

In the third and last phase of the parse the syntactic structure from the first and the information from the second phase are projected onto each other. Figure VII-1 shows a much simplified schematic of Friederici's (2002) model, including the ERP correlates associated with the three phases, which are introduced in section VII.2 below.

Phase 1	Phase 2		Phase 3
Identification of word category	Identification of lemma and morphologic information	Integration of semantic and morphosyntactic information	Processes of reanalysis and repair
ELAN (150-200ms)		LAN, N400 (300-500ms)	P600 (+/- 600ms)
time ⟶			

Figure VII-1: Model of sentence processing, adapted from Friederici (2002).

It may seem a bit odd to assume a modular parsing model dealing exclusively with the processing of single sentences in a work examining the processing of discourse, albeit the smallest discourse possible, two sentences. However, every discourse has to start with a single sentence and that first sentence must start with a single word. All subsequent words must be integrated into the current sentence as well as the current discourse, suggesting that the processes involved must at least to some extent be simultaneous and similar or even identical. As can be seen from the ERP-results of studies investigating discourse that will be discussed below, previous research on discourse processing has shown precisely that instead of finding ERP effects exclusive to discourse processing (see also Osterhout, Allen, McLaughlin & Inoue, 2002). It is therefore not totally illogical to assume that the

mechanisms proposed by Friederici's model might serve for incremental discourse processing as well. Furthermore, the discussion concerning at which point in the parse information other than word category enters the picture is based almost entirely on *syntactically* ungrammatical or ambiguous structures and often concerns the earliest phase of processing. The not unconvincing evidence supporting a modular syntax-first model rests on very early ERP effects, found in experiments involving single sentences with outright phrase-structure *violations*. Evidence speaking against a strictly modular syntax-first model involved syntactic ambiguities influenced by prior discourse, and reported late positivities, but no ELAN.

The structures examined in chapter IX do however not involve phrase-structure violations, are not even syntactically or semantically ambiguous at any point. Not only that: there was intentionally only one single syntactically unambiguous structure used for all target sentences in all four experiments, as the purpose was to examine the effect of connective ties on processing. Violations in the stimuli, if present, were of a semantic nature, information that is proposed not to be accessible until the second phase in syntax-first models. Therefore, the model developed by Friederici is used here *despite* the fact that there is good evidence that discourse information *can* influence the first-pass parse. If it is indeed the case that semantic information, does not influence the parse in the first phase, then there should be no effects within the time-frame of the first processing phase, i.e. prior to 200ms, found on any critical word in any of the three ERP-studies.

Friederici (2002) states that the ERP-correlate found in response to semantic anomalies, the N400, is a correlate of difficulties of integration into the context prior to the current word. The ERP studies on discourse discussed in this chapter show that this prior context does not only include the current sentence, but previous sentences as well as the current situation model and world knowledge.

Both the Construction-Integration Model and the 3CAPS Model of discourse processing also include this kind of information: the CI-Model in the construction of the textbase, and the 3CAPS Model in the production rules. Both models also assume that a situation model is constructed incrementally and in parallel. The models differ, however, with respect to the predictions they make as to how complex bridging inferences are made. The CI model, by operating 'automatically' on a fixed number of propositions, would predict that the fairly intricate integration of the internal argument of a concessive connective tie is no more complex or difficult than that of the internal argument of a causal connective tie. If a connective tie triggers a more complex proposition and concepts from world knowledge can be integrated into the textbase, then the fact that concessive connective ties 'choose' the more improbable outcomes of a causal relation should be no problem. The 3CAPS model, on the other hand, includes the possibility that more complex operations take longer, and that there might be more than one propagation cycle needed to calculate all relevant semantic and pragmatic relationships.

As to situation models, the event-updating model proposed by Zwaan & Radvansky (1998) will be used as a basis, since it includes more that one dimension, and one of the things investigated here was the interplay between foregrounding the causal *or* the temporal dimension in causally related situations.

VII.2. ERPS IN SENTENCE PROCESSING

In the following sections ERP components found in studies of sentence processing will be described. Since ERPs have been used to study language in general for over a quarter of a century, it is not possible to exhaustively list the ERP studies on language processing or

even pertaining to one particular aspect of linguistic experimentation. Studies mentioned here are therefore thought by the author to be representative for the aspect they are describing. Detailed expositions on the various components can be found in Kutas & van Petten (1994), Rugg & Coles, (1995), Hahne (1997), and Frisch (2000). The components described below are ordered according to the processing phase in Friederici's (2002) syntax-first modular model they are associated with.

VII.2.1. The first processing phase: ELAN

The ELAN (*Early Left Anterior Negativity*) is a negativity at left anterior sites with a peak latency of 100-300ms post stimulus. It has been found for phrase structure violations and for processing of elements of the closed class, for auditive stimuli (Hahne & Friederici, 1999; Hahne, 1997), see example 26.a, as well as visual stimuli (Neville, Nicol, Barss, Forster & Garrett, 1991), example 26.b. In the modular processing model described above it is associated with the first, automatic parsing step.

26.

a. *Die Gans wurde im gefüttert.
   The goose was in the fed.

b. *The scientist criticized Max's of proof the theorem.

In a study varying the frequency of phrase structure violations such as in 26.a Hahne (1997) showed that the ELAN, as opposed to the N400 or the P600 (discussed below) cannot be influenced by external factors. Irrespective of whether 20% or 80% of the stimuli contained phrase structure violations, the ELAN was found in both parts of the experiment. The P600 reported for the part of the experiment containing 20% violations was not found in the ERP data with 80% violations.

VII.2.2. The second processing phase: N400 and LAN

Correlates of the second processing phase are considered to be the N400 for semantic and pragmatic violations and integration problems and the LAN, found for morphosyntactic violations and added working memory load.

VII.2.2.1. The N400

The N400 is likely to be one of the most stable and frequently reproduced effects in ERP studies on language-processing. It was found by Kutas and Hillyard (Kutas & Hillyard 1980a, b), who contrasted sentences such as 27.a with sentences ending in a word that pragmatically did not fit (27.b).

27.

a. It was his first day at work.
b. *He spread the warm bread with *socks*.

The ERPs for the semantically ill-formed condition showed a bilateral centro-parietal negativity peaking at 400ms, strongest for the right hemisphere: the N400. Since the effect was not sensitive to physical manipulations such as font size, Kutas & Hillyard concluded that it must be language specific. It is not, however, specific to words, be they presented in

written or auditory form[44]. This was demonstrated by Nigam, Hoffman & Simons (1992), who found an N400 for a picture representing a semantically ill-formed continuation of a sentence such as (28).

28. I ate an apple and a ☎.

The effect has also been found in studies where the stimuli were presented using sign language (among others Kutas, Neville & Holcomb, 1987).

Kutas & Hillyard (1984) also demonstrated that not only words that could not be integrated into the sentence semantically, but also words that could be integrated but were unexpected showed an N400, albeit with a smaller amplitude than utterly mismatched words. The more unexpected a word was, the larger the amplitude of the N400. The degree of expected- or unexpectedness of a word in a given sentence is known as the *cloze probability*[45].

Additionally, Van Petten & Kutas (1991) found an N400 for every word in semantically correct sentences, with smaller amplitudes towards the end of the sentence. They interpreted this as the reflection of the rising cloze probability towards the end of a sentence for a given word, as the semantic context is more and more restricted by the words already known. Semantically incongruent words did not show a reduction in amplitude in relation to their position in the sentence, possibly due to their by definition very low cloze probability.

The N400 has also been found to be sensitive to semantic properties involving hypo- and hyperonym (Kounios & Holcomb, 1992) and the difference between abstract and concrete nouns in a sentence context (Holcomb, Kounios, Anderson & West, 1999)

The N400 in discourse

The N400 does however not only reflect difficult integration of a word into a single sentence: Van Berkum, Hagoort & Brown (1999c) found an N400 for words that were perfectly felicitous in the sentence they were embedded in, but incongruous when taken together with a preceding context sentence. This study as well as others will be discussed in greater detail in section VII.3.2.

Single words and the N400

Frequency

The N400 is also dependent on frequency effects not only absolutely but also within one experiment. During presentation of single words less frequent words show a larger N400 than highly frequent ones. Repeated presentation of a word with low frequency resulted in a reduction of the amplitude of the N400. These frequency effects have been found for words in sentence contexts as well: Van Petten & Kutas (1991) demonstrated that low frequency words standing at the beginning of a sentence showed a larger N400 than words with a high frequency in the same position. This frequency effect disappears however, if infrequent words or subordinate meanings of ambiguous words are primed by a preceding sentence (Van Petten & Kutas 1987a; see also Van Petten, 1995).

[44] The N400 found in experiments with auditory presentation differed from that found in visual presentation. The N400 found for auditory stimuli tended to have a smaller latency and a broader distribution.

[45] The distinction between an N400 in response to a semantic violation and an N400 due to low cloze probability rests in that a semantic *violation* is of a pragmatic nature (eating cars). Alternately, a semantically violating word would have a cloze probability of less than zero.

Priming

The N400 can also be influenced by semantic association and expectation. Studies presenting pairs of words found an N400 on the second word in those cases where the first and second words were not semantically associated, contrary to the expectation of the subject. An N400 was also found when the second word was a pseudo-word. For semantically related words pairs such as *doctor-nurse* no N400 was found. Non-words did also not show an N400 (Bentin, 1987).

Word class

Nobre & McCarthy (1994) found that words pertaining to the *open class* (the class of words containing nouns, verbs and adjectives and adverbs to which new words can be added) showed a larger N400 than words belonging to the *closed class* (prepositions, conjunctions, articles and pronouns). However, this finding may be doubtful due to the fact that closed-class words tend to be shorter, more frequent and more abstract than words of the open class (Frisch, 2000).

Underlying processes of the N400

Precisely which processes are reflected by the N400 is not completely clear. It could be a reflection of lexical retrieval, i.e. the mechanical look-up process of semantic properties. It could also be a reflection of the integration of that information into the linguistic context currently being processed. Lexical retrieval is viewed as automatic and obligatory while semantic integration is seen as controlled and can therefore be influenced.

Chwilla, Brown & Hagoort (1995) examined this question in a study presenting semantically related and unrelated word pairs by varying the task the subjects were asked to perform. One group had to make a lexical decision as to whether the second word in a pair was an actual word or a pseudo-word (deep processing), the other had to decide whether the words were presented in upper- or lower-case letters (superficial processing).

Since the reaction times for real words were the same as for pseudo-words for the group performing the physical task, Chwilla et al. could be sure that this group had indeed not processed the stimuli semantically.

An N400 was only found for unrelated word pairs for the group making the lexical decision task, suggesting that the N400 is to be associated more with later and controlled processes of integration than earlier automatic look-up processes.

Similar conclusions have been reached by other studies that either masked the target in a priming study and found a priming effect but no N400 (Brown & Hagoort, 1993) or degraded the stimuli by removing a third of the pixels, finding no influence of target degradation on the N400 for unrelated words (Holcomb, 1993).

In sum, the data suggest that the N400 can be associated with semantic processing and integration. Whether or not it is language specific is also undetermined. It is clear, however, that the critical stimulus must represent some sort of concept, be it a word, picture or face (Hahne, 1997).

VII.2.2.2. The LAN

While there is a general agreement that the N400 pertains to difficulties in the processing of semantic information, the nature of the LAN, a negativity with a peak at around 300 to 500ms found for left anterior sites, is much less clear.

Compared to the N400 not only the topography of the LAN is different, the LAN is also found for other violations or manipulations than the N400. Together with a P600 (discussed below) the LAN was found in visually presented studies examining morphosyntactic violations such as number agreement (29.a), violation of verb tempus (Kutas & Hillyard,

1983, P600 found for these stimuli was reported in Kutas & Van Petten, 1994), and violations of verb flexion for auditive presentation (Friederici, Pfeifer & Hahne, 1993), see example 29.b). Together with an ELAN the LAN was also found for phrase structure violations with auditive presentation by Friederici, Pfeifer & Hahne (1993), example 29.c).

29.

a. *All turtles have four leg and a tail.

b. *Das Parkett wurde bohnere.
The parquet was polish.

c. *Der Freund wurde im besucht.
The friend was in the visited.

Friederici (2002) associates the LAN with violation of morphosyntactic properties, which are retrieved in the second processing phase.

Another interpretation of the LAN is as a reflection of added working memory load (Coulson, King & Kutas, 1998; Kluender & Kutas, 1993; Kluender & Münte, 1998). Coulson et al. found a left anterior negativity together with a late positivity for stimuli such as 30.

30. *Every Monday he mow the lawn.

They interpreted the negativity as a reflection of added working memory load caused by the ungrammaticality of the verb *mow*, which lacks the correct flexion. Kluender & Kutas (1993) also reported left anterior negativities for all words between the moved constituent or filler *what* and the gap after the infinite verb, shown in examples 31.a and 31.b, which they also attributed to the added working memory load of 'holding the filler over' until the gap was encountered.

31.

a. *What do you suppose that…
b. What do you wonder who…

Underlying processes of the LAN

This attribution of left anterior effects to working memory load is difficult if a syntactic or morphosyntactic violation such as in example (30) is present at the same time, as the two effects are dissociable (see also Kluender & Münte, 1998). There is evidence for left anterior activation due to working memory loads, however, as example 31.a shows, for which the effect was found and which is syntactically well-formed. Münte, Schiltz & Kutas (1998) also found a sustained left-anterior negativity for sentences in which the temporal order of constituents contrasted with the conceptual order, but which contained no violation. This study will be discussed in detail in chapter VIII. In sum, there is evidence that the LAN is a reflection of morphosyntactic violations or incongruities, but that left anterior activity is also found for added working memory load.

VII.2.3. The third processing phase

VII.2.3.1. Late positivities

In addition to the (early) left anterior negativities there is another complex or group of components associated with processes of a syntactic nature, called late positivities. They are found at parietal and posterior sites with latencies of between 300 and over 1000ms post-stimulus. The probably most well known of these is the P600, found together with an ELAN for phrase structure violations for auditory presentation (example 32.a), taken from Hahne, 1997) as well as visual for presentation (example 32.b, Neville et al., 1991).

A P600 together with an LAN was found for morphosyntactic violations such as in 32.c, a biphasic pattern found also by a number of other studies (Kutas & Hillyard, 1983, P600 reported in Kutas & van Petten, 1994; Coulson, King & Kutas, 1998, among others).

For violations of subcategorization Osterhout, Holcomb & Swinney (1994) found a biphasic pattern: an N400, followed by a P600, example 32.d.

32.

a. *Die Gans wurde im gefüttert.
   The goose was in the fed.

b. *The scientist criticized Max's of proof the theorem.
c. *All turtles have four leg and a tail.
d. *The doctor forced the patient was lying.

The P600 occurs for ambiguous sentences as well. In sentences where the correct phrase structure was not the preferred one. Friederici, Hahne & Mecklinger (1996) reported a P600 as well as an N400 for the critical word:

33. *Das Metall wurde Veredelung von dem ...
    The metal was made/turned refinement of the …

Due to the fact that this component occurs for ambiguous sentences as well as ungrammatical ones it is usually associated with successful reanalysis as well as (unsuccessful) attempts to repair an ungrammatical structure during the third phase of processing. In this phase the information from the first (phrase structure) and the second phase (lexico-semantic information) are projected onto each other and integrated.

There is evidence that the complexity of the reanalysis necessary has an influence on the latency of the late positivity. Mecklinger, Schriefers, Steinhauer and Friederici (1995) compared subject-relative clauses to object-relative clauses. The relative clause was case-ambiguous and was thought to be analyzed first as subject relative (*active-filler strategy*, Frazier, 1987b), but is disambiguated on the last word of the sentence as an object relative. Mecklinger et al. also introduced a semantic bias for the verb, partly using verbs suggesting a certain relation between the NPs, such as 'geprüft', *examined*, instead of *looked for* in example 34, which has no such bias.

34. [Das sind die Professorinnen]$_i$, [$_{CP}$ die *e* die Studentin t_i gesucht hat/haben].
    Those are the professors [(who) the student$_{FEM}$ looked for had$_{SING}$ / had$_{PLURAL}$].

Subjects with short reactions times for the following question task showed a positivity with a peak around 345ms for object relative-clauses, irrespective of verb bias. Subjects with longer reaction times showed no such effect.

Based on these results Mecklinger et al. suggested that for reanalyses requiring no additional structure the lower complexity expresses itself in a lower latency of the positivity. Friederici (1999) proposed a connection between the difficulty of the diagnosis of whether or not a reanalysis is necessary and the complexity of the actual reanalysis: the latency of the positivity is dependent on the difficulty of diagnosis and the complexity of reanalysis expresses itself in the amplitude of the positivity.

P600: Automatic versus controlled process

The assumption that the underlying processes of the late positivities are of a controlled, not automatic, nature is supported by a number of studies. The occurrence of the component is can be influenced by the absolute frequency of syntactic violations within one experiment, as shown by Hahne (1997), experiment 2. She varied the frequency of syntactic phrase-structure violations such as in example 32 between 20% in one stimulus list and 80% in the other list. The stimulus list with 20% violations elicited a P600, while the list with 80% violations did not[46]. In addition to the frequency of violations, the task given to subjects during the experiment determines the occurrence of the P600 as well. In experiment 4, Hahne instructed the subjects to judge not grammatical acceptability, but semantic felicity of the same stimuli as in experiment 2, and to ignore syntactic errors. Results again showed no P600. A few years earlier, Osterhout & Mobley (1995) demonstrated this same phenomenon with reflexive anaphora that did not agree either in number (35.a) or gender (35. b) with the only possible antecedent in the stimuli sentences, the subject:

35.

a. The hungry guests helped himself to the food.
b. The successful woman congratulated himself on the promotion.

The stimuli were presented in a word-by-word fashion with a presentation time of 350ms (300ms ISI); subjects were asked to judge the acceptability of the sentences in experiment 1 and merely to read them in experiment 3. Results showed late positivities for both the reflexive-antecedent number- and gender-agreement conditions when subjects had to judge the sentences and no effects when they had been asked to only read them.

According to Hahne (1997) this supports the notion that the late positivities are a reflection of reanalysis and repair, i.e. that they are not exclusively triggered by the diagnosis of a syntactically false analysis only. In other words, for syntactic violations to elicit a P600, the syntactic violation must be perceived as such by the subjects and attempt to reanalyze or repair must be initiated. A study potentially demonstrating this (Osterhout & Mobley, 1995, experiment 2) will be discussed in detail in section VII.3.4.

P600 and P3b

One much discussed point is whether the P600 is 'merely' a variant of the P3b, a centro-parietal positivity with latencies between 300 and 800ms, depending on the complexity of the stimulus. The P3b occurs in response to attended, task-relevant stimuli, its amplitude varying in relation to subjectively perceived properties such as the probability of

[46] The ELAN was present in the ERPs for both lists, confirming the automatic and obligatory interpretation of this effect.

occurrence (the less frequent the larger), salience and informational content of the stimulus. It is seen as an indication of the process of actualization of a mental model (context-updating model, Donchin, 1979, 1981; Donchin & Coles, 1988). The similarities between the P3b and the P600, such as the similar topography and latency, are striking, not least because words making a sentence ungrammatical are generally a rare occurrence (Hahne, 1997) and therefore improbable as well as salient. The P600 has however been found for grammatical violations even when these were not task-relevant (Friederici, Steinhauer & Frisch, 1999; Hagoort, Brown & Groothusen, 1993). Additionally, the two components can at least partly be dissociated. Osterhout, McKinnon, Bersick & Corey (1996) presented three kinds of stimuli: correct sentences, sentences with a morphosyntactic violation (subject-verb-agreement), and sentences in which one word was written in all capitals. The subjects were instructed either to simply read the sentences or to judge them according to acceptability. Osterhout et al. found positivities for both types of violation, but with different topologies: the physical condition elicited a positivity with a left-hemispherical maximum, the agreement violation a positivity with a right-hemispherical maximum. Additionally, the reduction in amplitude found for both components when subjects were instructed merely to read was larger for the physical condition than the syntactic one. In a following experiment Osterhout et al. varied the probability of occurrence of a violation (20% versus 60%). While the amplitude of the positivity in the physical condition varied, this was not the case for the linguistic condition. In a third experiment Osterhout et al. presented an additional condition combining the two violations and found additive effects, leading them to the conclusion that the two effects were distinguishable and had different underlying neuronal generators.

This interpretation might also serve to explain the positivity found by Osterhout & Mobley (1995) in their third experiment, which included a subject-verb agreement violations such as in (36):

36. The elected officials <u>hopes</u> to succeed.

In experiment 1, this condition elicited an LAN and a P600. In experiment 3, with instructions only to read and not to judge, this condition showed only a much smaller late positivity, not the LAN. As the subject-verb number violation condition was relatively rare (a relation of one of these violations to six stimuli of different type, two of which contained anaphora-agreement violations), it could be argued that the positivity found in experiment 1 was a cumulative effect of a P600 and a P3b, with only the P3b component 'remaining' in experiment 3.

Another important factor concerning this discussion is the fact that a late positivity is not also associated with semantic violations. If the P600 is merely an unspecific 'surprise' effect, it should occur after semantic violations as well. As it does not, but rather seems to be tied to structural processes, it is less likely that the P600 and the P3b are identical. It is important to note, however, that although the two effects can be dissociated (see Osterhout et al., 1996), it is not always possible to do so in those cases where there are arguments for both views, similarly to the questions concerning the LAN (discussed above in section VII.2.2.2).

In sum, while it is not quite clear whether the P600 is language specific or just another member of the P300 family, it still reflects aspects of controlled language.

VII.2.3.2. Sentence end effects

It has been shown that in sentences containing semantic and / or syntactic violations not only the critical words themselves elicit ERP-effects, but that there are additional ERP-responses found on the final element of the sentences. A number of studies have reported widely distributed negativities in the N400 time-window with an anterior maximum in addition to a small posterior late positivity in response to syntactically anomalous sentence-final words (Münte, Heinze & Mangun, 1993; Rösler, Friederici, Pütz, & Hahne, 1993, Friederici, Pfeifer, & Hahne, 1993). In these cases, where the critical words were also the last words in the stimuli, a possible component overlap makes a differentiation of responses to violating words and responses to sentence-final elements difficult. There are also a number of studies where the critical word was not the sentence-final one, and which reported an N400-like (posterior) effect for sentence final nouns that were preceded by a syntactic anomaly. (Hagoort, Brown & Groothusen, 1993, McKinnon & Osterhout, 1996, Osterhout & Mobley, 1995; Osterhout, Bersick, & McLaughlin, 1997; Osterhout & Holcomb, 1992 and 1993). Osterhout (1997) proposed that these sentence-final negativities in response to syntactic anomalies reflect the semantic consequences of the syntactic violations: the negativity might be a response to the increased difficulty (or inability) to construct an integrative, 'message-level' semantic representation of the sentences. Sentence-final negativities are therefore often called 'sentence-wrap-up-effects'. Frisch (2000), reported negativities in response to sentence-final words preceded by *semantic* violations as well as syntactic violations, suggesting that not only syntactic violations make the construction of a semantic representation of a sentence difficult.

Osterhout (1997) additionally suggested that in those cases where the syntactically violating word was also the last one, a component overlap between an N400 and a P600 might have resulted in the negativity having a 'spurious' anterior distribution.

VII.3. ERPS IN DISCOURSE PROCESSING

Since connective ties influence many aspects of sentence- and discourse processing, this section will introduce a number of them on their own first, in experiments that did not include connective ties in the stimuli, before the impact of connective ties is discussed in chapter VIII. First, inference building in the processing of more than one sentence or proposition will be detailed. Secondly, a description of ERP studies examining the effects of coherence and semantic expectation in discourse will be given and the question of how local semantics, the discourse representation, and real-world knowledge interact will be addressed. The third section deals with studies that provide evidence for how fast a discourse representation can be changed to accommodate new information[47], and the phenomenon of semantic illusion. Fourthly, studies examining the effects of discourse-antecedent binding violations and ambiguities will be presented.

Finally, the studies presented in this chapter will be summarized in section VII.3.5 and the ERP-correlates found for the various aspects of discourse-processing will be discussed, as well as an attempt made to correlate them to possibly underlying processes in discourse comprehension. As before, the studies presented do not encompass the entirety of the data available, but are considered by the author to be representative of the aspect they investigate.

VII.3.1. Inference processes

While a word or sentence that blatantly does not fit into its sentence or has nothing to do with the rest of the discourse is obviously an example of incoherence, there are cases where the distinction between coherence and incoherence is much more difficult to make. In the case of elaborative inferences that are not necessary for the immediate understanding of the (otherwise coherent) text, the making of such an inference provides additional 'background' information. Not making this inference renders the text occasionally somewhat disjointed, but not totally incoherent or illogical. The question then is under which circumstances elaborative inferences are made at all. The most obvious answer would be: when there is time and leisure as well as the resources to do so[48]. One possible expression of 'resources' in language processing is the Reading Span (Daneman and Carpenter, 1980), thought to reflect individual differences in processing capacity.

The study that can probably claim to be the first to examine inference processes using ERPs was done by Marie St. George (St. George, 1995, and St George, Mannes & Hoffman, 1997). In her dissertation she examined the influence of individual difference in reading span while subjects read different types of paragraphs representing bridging inferences (37.a), elaborative inferences (37.b), word-based priming (37.c) and no inference at all (37.d). All paragraphs contained four sentences, the third of which was manipulated according to condition, while the last explicitly stated the inference that had or had not been made (examples adapted from St.George (1995), p.38):

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[47] This aspect is relevant for the processing of concessive connective ties that might 'prepare' for an unexpected outcome.

[48] Good examples of elaborative forward inferences that are routinely made are predictions made by the consumer of mystery novels as to whodunit or what happens in the next scene in financially challenged horror or thriller movies.

37.

a. Bridging Inference (necessary for connecting sentences two and three.)
Pam set the dining room table.
She forgot about the turkey in the oven.
The guests were disappointed with the ruined meal.
It was too bad the turkey burned.

b. Elaborative Inference (not necessary for comprehension of third sentence.)
Pam set the dining room table.
She forgot about the turkey in the oven.
Pam was disappointed when the argumentative guests ruined the meal.
It was too bad the turkey burned.

c. Word-Based Priming (control condition)
Pam set the dining room table.
She put the turkey in the oven.
Pam was disappointed when the argumentative guests ruined the meal.
It was too bad the turkey burned.

d. No Inference (sentence prior to target is irrelevant, making inference impossible.)
Pam set the dining room table.
She put the turkey in the oven.
The guests were outside playing badminton.
It was too bad the turkey burned.

The prediction was that while subjects with lower processing capacity are able to make only those inferences necessary for understanding the sentences, i.e. the bridging inferences, those with more processing capacity would be able to make the elaborative inferences as well. The last sentence explicitly stating the inference would therefore come as a bit of a surprise for the low reading span group but not the high span group. St. George et al. predicted this surprise to express itself in larger N400 components for the words of the last sentence of that condition for the low span group. The paragraphs were presented word by word with a presentation time of 300ms and an ISI (Inter-Stimulus Interval) of 300ms. After 10% of trials the subjects were asked to write down as much as they could recall of the previous paragraph.

As far as can be determined from the text, St. George separated the epochs corresponding to the words in sentence four into groups according to paragraph type and position in the sentence (first or second half). As the factor position did not result in any significant effects or interactions, it shall be disregarded here and any data is correspondent to *all* words in the last sentence averaged together.

The results for all subjects irregardless of reading span for the words of the fourth sentence separated by paragraph type showed a smaller N400 for the bridging condition (37.a) compared to the word-based priming- (37.c) and the no-inference condition (37.d). Separation by reading span showed that while the high-span readers exhibited no difference in N400 peaks between bridging (37.a) and elaborative inference (37.b), the low-span readers did (lower N400 peak for bridging than elaborative condition). According to St.George this indicated that the elaborative inference had not been made by the low-span readers. Similar analysis on the words of the third sentence showed no significant results. This is possibly due to the fact that only the third sentences of the elaborative and word-

based-priming conditions could be examined, as only they contained the same lexical material for sentence three. Also, the third sentences varied greatly with respect to syntactic complexity and length. Additionally, roughly half (count performed by E.B.) of the third sentences in those conditions contained a 'sub-inference', i.e. required the subject to draw an additional inference merely to understand that third sentence. This may have altered the ERPs for the word-based-priming condition to the point of masking any possible additional differences between this condition and the elaborative-inference condition. St. George and St. George et al. concluded that while bridging inferences, i.e. inferences necessary for the understanding of the connection between two sentences, are made automatically by all readers, individual differences in working memory capacity influence whether or not additional, not strictly necessary inferences can be executed.

First, it should be noted that these results are not an examination of inference processes as they are happening, as analysis of the third sentences –the point where an inference was being made or not– showed no results, but on the effect of an inference having been made or not *on priming* and *cloze probability*, i.e. the semantic and pragmatic fit of the words in the last sentence explicitly stating the (possible) inference. It remains, however, that the N400 is indeed an indicator for ease of semantic integration into the current discourse and that there is evidence for bridging inferences being automatic and obligatory for all.

A study examining the difference between causal predictive inferences and incoherent texts was presented by Kuperberg, Caplan, Eddy, Cotton & Holcomb, (2004). Subjects were asked to read three types of paragraphs and then rate them as to how related the final sentence was to the preceding two on a scale from one (most related) to two (intermediately related) to three (unrelated). The paragraphs were designed in three conditions, namely Contextually congruent (38.a), Inference (38.b), and Unrelated (38.c), referring to the 'fit' of the last sentence into the discourse:

38.

a. Contextually congruent
   Mark and John were having an argument. Mark began to hit John hard.
   <u>The next morning John had many bruises.</u>

b. Inference
   Mark and John were having an argument. Mark got more and more upset.
   <u>The next morning John had many bruises.</u>

c. Unrelated
   Mark and John were gambling at the casino. They won every game of blackjack.
   <u>The next morning John had many bruises.</u>

The authors predicted that if the ease of integration of a word into the current discourse is a reflection of the ease of the generation of inferences necessary for that integration, critical words (CWs), in the inference condition should elicit an N400, as should CWs in the unrelated condition. They did not make any predictions as to the amplitude differences between these two instances of the N400. The critical words were determined by asking twelve additional subjects to rate the relatedness of the final sentence and to indicate which word in that sentence had led to the decision. Approximately 50% of CWs were sentence-final. The authors do not indicate any more clearly precisely which words were the sentence-medial CWs.

Stimulus presentation was sentence by sentence for the first two sentences (3.4s, 100ms ISI) and word-by-word for the final sentence (500ms, 100ms ISI). Results by 'original condition' showed a bilateral N400 for CWs in the unrelated condition, but none for the inference condition. Re-averaging over the subjects' judgments produced a large bilateral N400 for those trials rated as unrelated and a smaller, right-lateralized N400 as well as an effect the authors interpreted as a late sustained positivity found at anterior sites starting at 850ms for the intermediately related condition compared to the other two conditions. This positive effect was present for sentence-medial as well as sentence final CWs, although the visual impression is that the effect is much smaller for sentence-medial CWs. This latter pattern of effects remained stable when the authors averaged only those epochs into one ERP-curve that had been rated by the subjects in accordance to the original condition, i.e. all contextually congruent trials that had been rated as 'most related', all inference trials rated as 'intermediately related' and so on. Kuperberg et al. interpreted these results such that semantic processing cost was not necessarily incurred during inference generation, but that an N400 does reflect semantic processing cost in a subset of 'inference-requiring scenarios'.

In contrast to the study presented by St. George and St. George et al. discussed above, Kuperberg et al. actually did examine inference processes per se. Concluding that the N400 is no indicator for the difficulty of an integration depending on relations between two sentences, as the data averaged by original conditions seems to show, might be a bit early, however. The average by original conditions suggests that subjects apparently effortlessly made the inferences necessary for firmly integrating the critical words of the third sentence into the discourse. Those inferences would, judging from the example materials, intuitively have to be classified as rather distal bridging inferences. Despite these two points, the lack of an N400 for the inference condition might merely show just how hard it is to make accurate predictions as to what discourse relation constitutes which kind of inference and whether or not this inference is actually made, since the averages over subjects' judgments, and especially those for the 'correctly judged' trials only, tell a different story. In this last case, where the authors' classification concurred with the subjects' judgments, there is a clear indication for the gradation of discourse relatedness proposed by the authors of the study, with the N400 indicating the difficulty of making a connection and thereby the difficulty of integration.

The second effect found for the intermediately related/inference condition is rather more difficult to interpret. The authors proposed that the late positivity might reflect the actual cost of inference generation in these scenarios. There are a few difficulties with that interpretation, which will be discussed in turn.

The first difficulty is what precisely to call that positivity. If it is indeed a positivity, it could basically only be a P3b or indication of the process of actualization of a mental model for attended and task-relevant stimuli (Donchin, 1979, Donchin & Coles, 1988). The other possibility, the P600, has not been found in association with semantic manipulations and Kuperberg et al.'s stimuli did not contain syntactic violations. The P3b, however, canonically has a centro-parietal distribution. Disregarding this, the interpretation of this effect as a P3b has some merits:

First, it seems logical to assume that, once it has been diagnosed that the current word does not quite fit into the discourse without further analysis, the 'next effect' so to speak reflects precisely that (re)analysis. The question then is why there was no indication of any attempt to make the unrelated condition 'work out' after all. Let's assume for present purposes that the subjects were aware that the unrelated condition was unrelated (as suggested by the judgment they were supposed to give and did give) and due to this did not

even attempt to make a connection, making it unnecessary to update or change the discourse representation. As the congruent condition would not require intensive updating, a P3b for the intermediately related condition only seems a workable interpretation.

There is, however, still the question of why the effect was larger for sentence-final CWs than for sentence-medial CWs. It is possible that the positivity was overlaid by an N400 for the next word for sentence-medial CWs in the intermediate condition. These next words would, presumably, be more difficult to integrate as well.

VII.3.1.1. Inference generation: summary

As the ERP-studies on inference processes discussed above demonstrate, the semantic expectancy, i.e. the amplitude of the N400 of an incoming word reflects whether or not an inference has been made (St. George et al.) as well as a connection having to be made (Kuperberg et al.). It is important to note, however, that the N400 is apparently not an indicator of inference generation as such. It is the fit of a word or concept being integrated into the *current* representation of the sentence, discourse and 'model of the world' that is reflected in the amplitude of this effect, which is of course influenced by any inferences or updates of that representation having been made *before* that word is encountered. With this interpretation of the N400, any necessary reanalysis of the current representation of a discourse would follow a difficult integration: If there are semantic or pragmatic indications that changing the representation is necessary, a possibly successful attempt of altering it to incorporate the new information will be made, as can be seen in section VII.3.2.3, which might be associated with a late positivity, reported for incongruous last words in a discourse (see Salmon & Pratt, 2002, and Sitnikova et al., 2003 below) as well as difficult inferences between sentences (Kuperberg et al., 2004).

VII.3.2. Coherence in discourse

As detailed in the previous section on inference processes, non-obvious connections between two sentences result in difficult semantic integration of subsequent words. Quite a few ERP studies did not examine inferences processes, but looked at words that did not fit with previous discourse at all or were semantically unexpected, but did not allow for an inference to establish a connection. The next sections will present a number of these studies, and also address the question of how the discourse representation and knowledge of the real world interact.

VII.3.2.1. Semantic violations in discourse

Possibly the first ERP study to present more than one sentence in one trial was done by St. George, Mannes & Hoffman (1994). In a very elegant experiment they asked subjects to read paragraphs of up two 15 sentences (maximally 163 words), taken from the studies by Bransford & Johnson (1972) and Dooling & Lachmann (1971). The sentences themselves were syntactically and semantically grammatical in all four experimental paragraphs. Without a title giving the subjects a theme or schema into which to integrate the sentences[49], i.e. without the wherewithal to identify what the text is about, also known as the *macrostructure* (Kintsch & van Dijk, 1983), the paragraphs were comprised of disconnected, semantically vague or downright incoherent propositions that have nothing to do with each other, as can be seen in example 39:

[49] This information is commonly gained from the title of a text or, failing that, the first sentence: 'Guess what that silly cat did now…'.

39. The procedure is actually quite simple. First you arrange things into different groups depending on their makeup. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step, otherwise you are pretty well set. It is important not to overdo any particular endeavor. That is, it is better to do too few things at once than too many. In the short run this may not seem important, but complications from doing too many can easily arise. A mistake can be expensive as well. The manipulation of the appropriate mechanisms should be self-explanatory, and we need not dwell on it here. At first, the whole procedure will seem complicated. Soon, however, it will become just another facet of life. It is difficult to foresee any end to the necessity for doing this task in the immediate future, but then one never can tell.

As soon as one knows what the text is about ("Procedure for washing clothes"), the separate, formerly disconnected sentences can be integrated into a discourse representation and a macrostructure can be formed. Without a title, a reader is left to form his own hypotheses what the topic could be[50], but will get no proof from the text.

St. George et al. (1994) presented the titled and untitled paragraphs in a word by word fashion with a presentation time of 300ms / 500ms ISI. Subjects read either only titled or only untitled paragraphs. St. George et al. found that the global incoherence in the untitled paragraphs resulted in larger N400s than the coherent, titled paragraphs, and concluded that the N400 not only reflects the semantic integration of a word within one sentence, but is also sensitive to global, discourse level semantic integration.

Van Berkum, Hagoort & Brown (1999c) examined the question whether an N400 elicited by a word incongruous in 'only' the current sentence is different from an N400 elicited by a word that fits into the current sentence but is made incongruous by preceding discourse. To this end they conducted two experiments. In experiment 1 they contrasted words that were anomalous due to information contained in a prior two-sentence discourse but perfectly felicitous in the current sentence (example 40.b, presented here in the English translation given by the authors) with words that were coherent in their carrier sentences as well as the previous discourse (40..a):

40. As agreed upon, Jane was to wake her sister and her brother at five o'clock in the morning. But the sister had already washed herself and the brother had even got dressed.

    a. Discourse-coherent word:
       Jane told the brother that he was exceptionally <u>quick</u>.

    b. Discourse-anomalous word:
       Jane told the brother that he was exceptionally <u>slow</u>.

The discourse was presented auditorily and the target sentences were presented visually word by word with a presentation time of 300ms / 300ms ISI. The ERPs for the discourse-anomalous words showed a large N400 with the classical morphology, time course and distribution. In experiment 2, van Berkum et al. presented the target sentences from experiment one without the discourse (41.a and b), mixed with sentences containing a word anomalous in that sentence alone (41.c and d). They argued that the lack of discourse (that

[50] Such as 'organizing research'. Bryan Jurish, p.c.

had been making the formerly discourse-anomalous words odd) should result in the N400 for the formerly discourse-anomalous words disappearing. At the same time the sentence-anomalous words should elicit the classical N400:

41.

a. Discourse-coherent word:
Jane told the brother that he was exceptionally quick.

b. Formerly discourse-anomalous word:
Jane told the brother that he was exceptionally slow.

c. Sentence-coherent word:
Gloomily the men stood around the grave of the president.

d. Sentence-anomalous word:
Gloomily the men stood around the pencil of the president.

Results for the sentence anomalous words showed a 'standard N400' (term used in the original text by van Berkum et al.). Contrary to expectations, the formerly discourse-anomalous words also showed a significant N400, even without the discourse making them anomalous in the first place. Van Berkum et al. accounted for this by saying that maybe they had not been entirely successful in ensuring that the discourse-anomalous words were as coherent as the discourse-coherent words in their carrier sentence, despite a preliminary sentence-completion task to evaluate the material used. This N400 was, however, significantly smaller than the one elicited by the discourse-anomalous words *with* discourse, showing that at least a substantial part of the N400 in experiment one was due to the target words being anomalous in discourse. A few years later, van Berkum, Zwitzerlood, Hagoort & Brown (2003b) repeated both these studies using spoken stimuli for the target sentences instead of written stimuli. While the N400 for discourse anomalous words (experiment 1) was reproduced as well as the N400 for sentence anomalous words (experiment 2), the smaller N400 for formerly discourse anomalous words disappeared. Van Berkum et al. concluded that since the N400 from experiment 1 had the same parameters as the one for sentence-anomalous words from experiment 2 (both 1999b and 2003b), both effects must be an N400. Consequently, the integration of a word into the current sentence appears to be the same process as integration of that word into the current discourse. Similar results for healthy older adults have been reported by Britz & Swaab (2005), who also presented sentence pairs of which the target sentences ended either in discourse coherent or incoherent words. The last words were congruous in their carrier sentence. These discourse conditions were compared to single sentences ending in either pragmatically felicitous or infelicitous words. The N400s found for both incongruous conditions, the discourse and the single-sentence condition, were comparable.

Salmon & Pratt (2002) also found similar N400 for incongruous last words in discourse and single sentences for auditory stimuli. Additionally, they reported a late positivity (peak latency 850ms, at the central site Cz) for both incongruent conditions, sentences and stories. They presented both the stories and the sentences consecutively to the same subjects in one experimental session, with the stories first.

The N400 as an indicator of semantic or pragmatic violations in discourse is not restricted to the integration of *words* into the discourse representation, be they written or

heard. West & Holcomb (2002), and Sitnikova, Kuperberg & Holcomb (2003) found an N400 for incongruous endings in picture stories (such as a picture of a girl on a bicycle after a story about the same girl running a race and falling down), and incongruous objects in movie clips of everyday occupations (a man getting ready to shave who reaches for an object and in the incongruous conditions ends up holding a rolling pin instead of a razor). Sitnikova et al. also reported a late posterior positivity for the incongruous conditions in addition to the N400.

In sum, these results show that semantic integration of new information into a sentence is influenced by prior discourse, and that for a discourse to be coherent a macrostructure must be available into which to integrate the separate sentences. The ERP correlate found for semantic integration and semantic violations in the above studies is very similar, if not identical, with that found in studies of single sentences, namely the N400. Some studies also reported late positivities in response to incongruent elements.

VII.3.2.2. Semantic expectation in discourse

In a study along similar lines as van Berkum et al.'s 1999b and 2003b first experiments, Federmeier & Kutas (1999a), see also Federmeier, McLennan, De Ochoa & Kutas (2002), provided another look at the N400 in discourse. They presented three types of two-sentence paragraphs. The first sentence 'set the scene', while the second sentence further constricted the context until pretty much only one word was possible as a felicitous continuation of the second sentence, as shown in example 42.a. The second condition, the within category violation, ended in a word from the same semantic category, but representing the wrong exemplar (42.b). The third condition, the between category violation, ended in a word from another semantic category, but still within the same higher semantic group, i.e. an hyperonym (42.c). All critical words occurred in each of the three conditions across the entire material.

42. They wanted to make the hotel look more like a tropical resort.
    a. So along the driveway they planted rows of palms.
    b. So along the driveway they planted rows of pines.
    c. So along the driveway they planted rows of tulips.

Data was recorded from 26 sites, presentation was word-by-word visual (500ms for the critical words). Results showed an N400 for the *between category* violation, and an N400 with a smaller amplitude (but still significant compared to the expected words) for the *within category* violations. On the basis of these findings Federmeier & Kutas suggest that integrating a word into the current sentence and discourse also draws on long-term memory knowledge, i.e. world knowledge, not only the immediate meaning of the word.[51]

Another study replicating the results found by Federmeier & Kutas is the one done by Ditman, Holcomb & Kuperberg (2005). They presented five-sentence paragraphs the first three of which were a list of true propositions. The fourth sentence restricted the context such that only one of the three possible fifth sentences was completely felicitous:

[51] Federmeier & Kutas replicated this study (Federmeier & Kutas, 1999b), this time presenting the stimuli either only to the left or the right visual field (i.e. right or left hemisphere, respectively) of their subjects. The results for the left hemisphere were compatible to the original study, while those for the right hemisphere showed equally large N400 effects for all unexpected last words, regardless of semantic category. They proposed that while incoming information is compared directly to the context in the right hemisphere (integrative processing), processing in the left hemisphere is more predictive: incoming information is compared to the semantic expectation built up by the context.

43. A ring is worn on a finger.
A bracelet is worn on a wrist.
A nightgown is worn to sleep.
Lisa's finger sparkled with the jewelry.

a. The ring was attractive.

b. The bracelet was attractive.

c. The nightgown was attractive.

The reasoning, similar to Federmeier & Kutas', was that *finger* and *jewelry* in the fourth sentence make only the correct continuation (43.a) possible, while the incorrect continuation (43. b) represented a concept from the same semantic category (jewelry), but the wrong exemplar. The control condition (43. c) resumed a word that had been mentioned before in the first three sentences, but not selected or reinforced by the fourth.

Results for the critical words in the fifth sentence showed a large N400 for the control condition, and a smaller N400 for the incorrect condition, compared to the correct continuations.

These findings, namely that previous discourse can impose strong expectations on upcoming information, hold not only for semantic expectations built up by semantic relations, as in the studies by Federmeier & Kutas and Ditman et al., but for expectations due to information structure as well. Gordon & Scearce (1995) formulated this idea as the *parallel function strategy*, which states that an anaphor is most likely related to an antecedent with the same grammatical function in a previous sentence, i.e. a subject pronoun to a subject in a prior sentence. Cowles (2003) showed that these preferences hold not only for anaphors but for referential discourse-old NPs as well in experiment 3.1b of her dissertation. She presented three-sentence paragraphs, such as in example 44:

44. Setup Context:
A queen, an advisor and a banker were arguing over taxes.
Who did the queen silence with a word, the banker or the advisor?

a. It was the banker that the queen silenced.

b. It was the queen that silenced the banker.

The first sentence set a scene that included three participants. The second sentence was a question in which one of the participants from sentence one 'did something' to one of the other two (44). As this sentence was formulated as an object question, the expectation induced was that one of the possible objects, in this case an advisor and a banker, would also be the object of the third sentence (44.a), the answer to the question (parallel function strategy). In the anomalous condition (44. b), this expectation was violated: instead of the expected word, i.e. one of the objects from the second sentence, the subject from the second sentence was placed in the topic position marked by the *it*-cleft. It is important to note that this semantic expectation is of a syntactic, or rather, information-structural nature: the third sentence answers the question 'correctly' as well, but places the wrong participant in the topic position (information packaging: Vallduví, 1992).

Cowles found an N400 for the critical word in the anomalous condition, suggesting that information structure can also influence semantic expectation of upcoming words in discourse.

To sum up, semantic expectation or cloze probability in discourse also appears to be correlated with the N400, similar to semantic violations in the previous section. Additionally, the syntactic structure of prior discourse can influence semantic expectations as well.

VII.3.2.3. Previous discourse versus real-world knowledge

The studies detailed in the previous section show that an already established text representation influences the semantic expectedness and integration of incoming words. It is also known that pragmatically incongruous words, i.e. words that in their sentence or discourse conflict with real-world knowledge, elicit an N400. The first question is which of the two, real-world knowledge or the already established discourse, takes precedence when the two conflict: when a new word fits into prior discourse but violates pragmatic real-world knowledge. The second question is what happens when incoming information is pragmatically appropriate in the current sentence but violates previous discourse on the other.

Nieuwland and van Berkum (2005a) addressed the first question by looking at animacy violations in a discourse. In their first experiment, they examined the situation of incoming information fitting into prior discourse but conflicting with pragmatic canonicity. Their stimuli material consisted of six-sentence stories in two versions. In the control version, a person was engaged in a conversation with another person (example 45). In the experimental version, called 'cartoon-like' by the authors, the second conversation partner was not a person but an inanimate object (example 45, underlined words). An example paragraph is shown in the English translation given by the authors:

45. Experimental paragraph: animate versus inanimate:
    a. Once upon a time a psychotherapist was consulted in her home office by a <u>yacht</u> / sailor with emotional problems.
    b. The <u>yacht</u> / sailor confided her that everything had gone wrong in life and started crying.
    c. The psychotherapist *consoled* the <u>yacht</u> / sailor by stating that everybody experiences these kinds of trouble every now and then.
    d. But the <u>yacht</u> / sailor doubted whether to continue outlining his problems to her.
    e. The psychotherapist *advised* the <u>yacht</u> / sailor to be honest not only with her, but especially with himself.
    f. At that moment the <u>yacht</u> / sailor cried out that he was absolutely terrified by water.

Nieuwland & van Berkum were interested not only in how the inanimate, pragmatically violating word *yacht* would be treated in sentences 45.a, 45.c and 45.e, but also whether a text representation 'legalizing' a pragmatic violation would support predictive processing, reflected by N400 amplitudes on the verbs in sentences 45.c and 45.e (cursive font), which do not select inanimate objects. The results of this study were very interesting: the first occurrence of an animacy-violating conversation partner elicited an N400, subsequent occurrences (sentences 45.c and 45.e) did not. Additionally, an N400 was found on the verb in sentence 45.c, but not for the verb in sentence 45.e.

In a second experiment Nieuwland and van Berkum examined the second question of whether prior discourse or pragmatic real-world knowledge takes precedence in a situation where the discourse had already legalized a pragmatic violation by four previous mentions. An incoming word violated the established discourse representation but was congruent with real world knowledge (46.b). An example of an experimental paragraph is given here in the English translation provided by the authors:

46. A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that.

    a. Discourse-congruent condition (locally anomalous):
    He was <u>in love</u>, and by the sound of it, this was definitely mutual.

    b. Real-world-congruent condition (locally plausible):
    The peanut was <u>salted</u>, and by the sound of it, this was definitely mutual.

    c. Continuing sentence:
    He was seeing a little almond.

Results for the critical words showed an N400 for the locally anomalous condition that was congruent with the real world (46.a), compared to the discourse incongruent word that was however locally plausible (46.b).

The above results suggest that a discourse representation, once established, can override real-world knowledge. The representation must however, first be established: The N400 for the first occurrence of the anomalous word in Nieuwland & van Berkum's first experiment shows that until a discourse representation legalizing real-world pragmatic violations has been established, the real world does rule the roost.

VII.3.2.4. Semantic integration and expectation in discourse: summary

The interesting aspect of these results is that semantic relations and cloze probability 'work' on the discourse level as well, and, just like semantic violations and cloze-probability effects within one single sentence, are sensitive to rather fine-grained distinctions. As with the studies by van Berkum et al, the violations in Federmeier & Kutas' study were diagnosable only if semantic information stemming from discourse prior to the critical sentence as well as general world knowledge were available at the same time as the 'naked' semantic and pragmatic properties of the critical word on its own. These points may seem trivial at first glance, but they are not. The results discussed above do expand on the classical interpretation of the N400: while it is possible to argue that an N400 found for *rock* in *John ate a rock* is due to the fact that the verb *eat* selects, well, edible things as its complement[52], a relation that can be described by a number of lexico-semantic features such as [+edible], a similar explanation is difficult for the studies above. In van Berkum et al.'s studies, there is no single selector, nothing that could be converted to a priming study using only two words at a time, to be found in the materials that could account for the

[52] This interpretation of course also depends on world knowledge, pertaining to what is edible and what isn't in one's world. However, this sort of knowledge can most likely be assumed to be present before the complete acquisition of transitive verbs.

effects found. It is rather a complex model of the situation or discourse, not one single word, that provides the features selecting felicitous continuations. The syntactic structure of previous discourse can influence semantic expectation as well (Cowles, 2003).

The study by St. George et al. demonstrated that it is vital for comprehension to be able to coordinate sentences in a discourse with a macrostructure, or global semantic model. The study by Ditman et al. showed that it is however not sufficient for a concept to have merely been mentioned before to be a part of this semantic discourse structure. It must have been kept actively discourse-relevant by subsequent information to be able to influence the semantic expectancy of following words (but see section VII.3.3.2 for evidence that not even that is sufficient).

As to the interaction between discourse and the real world, it seems that an established discourse representation can override world knowledge to the point of making pragmatically congruous words that are incongruent in the current discourse anomalous.

VII.3.3. Updating the situation model

The obvious question resulting from Nieuwland & van Berkum's experiments on the conflicts between real-world knowledge and the discourse representation is how quickly that discourse representation can be altered once incoming information indicates the need.

In Nieuwland and van Berkum's first experiment, the diagnosis of a pragmatic anomaly and the indication that the discourse representation was not congruent with pragmatic canonicity occurred on the same word. In that one as well as the second study by Nieuwland & van Berkum (2005a) the change of the discourse representation was also done by 'habituation': the canonicity violation was simply repeated until the subjects got used to it, i.e. incorporated the oddity into the model.

But what takes place when a previously occurring word already carries information that would legalize such an anomalous word if it was integrated quickly enough and the discourse representation altered accordingly just as quickly? The lack of an N400 for the critical word in the third sentences in Nieuwland and van Berkum's first experiment suggests that by that time, two sentences and one additional occurrence of the anomalous word later, the discourse representation has been altered to accommodate a conversation between a psychotherapist and a yacht. The studies detailed in the next two sections will present some data restricting this relatively wide window, but also raising new questions.

VII.3.3.1. Here-and-now?

One possibility is that the discourse representation is changed as soon as the need arises. In that case, the question is *how fast* such an alteration is accomplished.

Fischler, Bloom, Childers, Roucos & Perry (1983) presented very short and simple declarative sentences containing two nouns that were either semantically related (47.a and 48.b) or not (47.b and 48.a). The declarations were either true (47) or false (48) and either contained a negation (47.b and 48.b) or did not (47.a and 48.a):

47. True sentences:
    a. An apple is a fruit.
    b. An apple is not a weapon.

48. False sentences:
    a. An apple is a weapon.
    b. An apple is not a fruit.

The stimuli were presented visually, subject and auxiliary together and predicate separately, at 175ms presentation time and 800ms ISI. Of particular interest for present purposes are the conditions 47.b and 48.b, where the negation should have the effect of altering the discourse representation such that 'weapon' is a felicitous continuation in the true sentence and conversely make 'fruit' anomalous in the false statement.

Fischler et al. found an N400 on all semantically unrelated critical words, regardless of the truth value of the sentence or the presence of negation.

Kounios & Holcomb (1992) found similar results for stimuli along the same lines that included three types of quantifier: *all*, *some* and *no*. In that study, the element potentially legalizing a semantic violation occurred at the beginning of a simple sentence, with the verb intervening between the two NPs. Kounios & Holcomb also varied the type of semantic relation between the first and second NP, either presenting a semantic category followed by a congruous or incongruous exemplar (49) or an exemplar followed by a congruous or incongruous category (50):

49. Category–Exemplar:
    a. All animals are *dogs / *apples.
    b. Some animals are dogs / *apples.
    c. No animals are *dogs / apples.

50. Exemplar–Category:
    a. All dogs are *animals / *fruit.
    b. Some dogs are animals / *fruit.
    c. No dogs are *animals / fruit.

The stimuli were presented visually, with 550ms presentation time for the subject segment (*All dogs are*), 300ms ISI and 300ms presentation time for the predicate (*animals*). Subjects were asked to judge truthfulness at the end of each trial.

Unfortunately, the authors did not show averages showing quantifier by truth value for the predicate. However, there is an interesting result for the subject segment. Exemplars in sentences beginning with *some* and *no* (b and c examples) showed greater right-hemispherical negativities than those beginning with *all* between 300 and 500ms compared to categories. Exemplars beginning with *no* showed a greater negativity between 500 and 800ms as well. First it should be noted that all sentences beginning with *all* required the reader to give a 'false' statement (indicated by the starred predicates in examples 49.a and 50.a) at the end of the trial. It is probably fairly safe to assume that subjects noticed this relatively quickly and consequently did not pay close attention to the rest of the sentence. Trials beginning with *some* or *no*, however, did require the subjects to process the quantifier to be able to judge the sentence correctly, as the quantifier did not serve as a predictor of truth value here[53]. There were also no semantic violations present at this point in the trial. It could be that these negativities are an indication of the process of activating possible properties of exemplars, with the *no* condition being the more complex, as

[53] But see Noveck & Posada (1998) for a critical investigation into the properties of 'some'.

indicated by the second negativity. In other words, these effects could be an indication of discourse-representation construction.

Analogous to Fischler et al.'s experiment, unrelated predicates in Kounios & Holcomb's study produced an N400 compared to the related NPs regardless of quantifier type[54], indicating that whether an alteration of semantic expectations for the predicate had been initiated or not, that change was not completed in time.

Van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort (2005) provided further evidence that alterations to the discourse structure, in this case semantic expectations induced by prior discourse, take some time. They presented 2-sentence discourses in which the first sentence induced a strong semantic expectation as to the final noun in the second one. Van Berkum et al.'s critical condition violated this expectation by presenting a final noun phrase that did not fulfill this expectation. This noun phrase consisted of an indefinite determiner, an adjective and a noun. The gender inflection of the adjective indicated whether or not the following noun would be the preferred one (51.a) or not (51.b), as shown in the English translation given by the authors:

51. Context:
The burglar had no trouble locating the family safe.

a. Target consistent with expectations:
Of course, it was located behind a *big*-$Ø_{NEU}$ but unobtrusive $painting_{NEU}$.

b. Target inconsistent with expectations:
Of course, it was located behind a *big*-e_{COM} but unobtrusive $bookcase_{COM}$.

The stimuli were presented auditorily, with a range of between 390 and 1290ms (mean 707ms) between the onset of the inflection on the adjective and the onset of the noun. No task was given. Results showed a very early positivity between 50 and 250ms from the onset of the inflection[55] as well as an N400 in response to the inconsistent condition. It seems that the morphosyntactic information indicating a non-preferred continuation carried by the inflection was either not sufficient to influence the strong semantic expectation built up by the context or, alternately, the discourse representation could not be changed in time (~707ms) to accommodate continuations other than the preferred one, as expressed by the N400.

The interpretation of the N400 as not being sensitive to contextual information is not an option anymore. That leaves as only other possible interpretation of the above three studies the following notion: although the offending words were ultimately 'legalized', as indicated by the high accuracy of judgments in truth verification studies, there was not enough time for that legalization to 'take', as demonstrated by the N400 on the next element in the stimuli for the true statements involving negation or the non-preferred continuations, and the lack of that effect in the false or preferred conditions. It is also possible that the complexity of a necessary alteration plays a role in the speed with which an adjustment to the discourse representation can be made. One word later (Fischler et al.) or two words

[54] The N400 was also generally larger for exemplars in predicate position, greatest for unrelated exemplars.
[55] Van Berkum et al. did not claim this effect to be an indication of very early discourse-influence, but argued that subtle changes in intonation on the root of the adjectives might have alerted subjects that an unexpected continuation was to follow: addition of the inflectional ending altered the syllabic structure of the adjectives.

later, respectively 850ms (Kounios & Holcomb), is apparently too soon for relatively complex operations on the discourse structure to have been completed.

That the *time* required for such processes might be only very little longer that 850ms can be seen in a study of negative and positive polarity items (NPIs and PPIs) such as *jemals*, (*ever*), and *durchaus*, (*certainly*) respectively, that require a downward entailing licenser such as negation (NPIs) or are anti-licensed by negation, i.e. ungrammatical when c-commanded by negation (PPIs). Brehm (2000), and beim Graben, Drenhaus, Saddy, Brehm & Frisch (submitted) examined the processing of *ever* and *certainly* in sentences that either contained a possible licenser as first element or did not (examples for the study with simple sentences given here in translation from German):

52. Licensed NPI, anti-licensed PPI:
    a. *No* student was ever punctual.
    b. *No* student was *certainly punctual.

53. Unlicensed NPI, grammatical PPI:
    a. *A / One*[56] student was *ever punctual.
    b. *A / One* student was certainly punctual.

Stimuli were presented visually with a presentation time of 400ms and 100ms ISI, with subjects asked to provide a grammaticality judgment after each trial. ERP-results showed an N400 for unlicensed negative polarity items and a late positivity for anti-licensed positive polarity items. An unlicensed NPI is 'unsaveable', while an anti-licensed PPI could potentially be reanalyzed by scoping it higher than the offending negation, arriving at a reading along the lines of 'There was no student who was guaranteed to be punctual', which might account for the different effects found. The lack of an N400 for the *licensed* NPIs (52.a) as well as the positivity for the *anti-licensed* PPIs (52.b) suggests that a whole second was sufficient for alterations to the discourse structure to have been completed, only 150ms more than in Kounios & Holcomb's study. However, the effects found by Brehm and beim Graben et al. might also be an indication of an alteration of the discourse representation of a different *type* than a switch between real-world and comic book conditions or a real-world truth evaluation: the licensing of a negative polarity item as well as the conditions under which a positive polarity item is felicitous have an obligatory, structural character[57], i.e. the need to be licensed might be 'hardwired' into the lexico-semantic representation of negative polarity items, as opposed to whether or not a peanut can dance or a yacht be depressive, and this fact might account for the rapidity of the discourse representation alteration: the negative polarity items were present in 50% percent of the trials, and the presence or absence of negation at the beginning of the sentence was task-relevant for the subsequent grammaticality judgment. In sum, it can be said that while the discourse structure obviously can be altered, the time course and triggering of such alterations is still unclear, but the process appears to take longer than 850ms, and, even if initiated, might not be actually performed until the end of the current sentence.

[56] The German 'ein' is ambiguous between the indefinite determiner ('a') and the numeral one.

[57] Licensing of polarity items is generally defined in terms of syntactic relations: A suitable licenser must *c-command* an NPI, while a PPI cannot be in the scope of negation (Ladusaw, 1980).

VII.3.3.2. Maybe later: Semantic illusion

There is, however, an entirely alternative hypothesis: It might be that the altering of a discourse structure is, so to speak, not a process undertaken lightly. Considering that incorrect, unexpected or uninformative as well as downright incoherent statements are a relatively regular occurrence in everyday life, it could be that radical changes to the discourse representation are only made once there is irrefutable evidence that this is necessary, in the form of more than one obvious discrepancy between the representation and the new input.

An indication that the language processing system might allow for or rather, temporarily ignore glitches is given by the phenomenon of semantic illusion (see Sanford & Sturt, 2002 for an overview). Certain conditions such as a strong semantic bias towards a particular word in a discourse, a semantic relation between a congruous and incongruous continuation (illustrated in example 54 taken from Erickson & Mattson, 1981) or an already established discourse relation can lead to a listener or reader missing evidence that something is wrong.

54. How many animals of each sort did Moses put on the ark?

Since Moses and Noah are semantically related, and the name is not in a prominent position, many people do not notice the fact that it was Noah, and not Moses, who built and populated the ark.

Hoeks, Stowe & Doedens (2004), presented stimuli such as in 55, comparing coherent sentences (55.a) to sentences with a thematic role violation but a strong semantic relation (the classical roles were 'traded', 55.b) and thematic role violations with no semantic relation (55.c):

55.

a.	Het brood	weerd	door de bakkers	gebakken.
	The bread	*was*	*by the bakers*	*baked.*
b.	Het brood	heeft	de bakkers	gebakken.
	The bread	*has*	*the bakers*	*baked.*
c.	Het brood	heft	de bakkers	bedreigd.
	The bread	*has*	*the bakers*	*threatened*.

Stimuli were presented word-by-word with 240ms presentation time and 240ms ISI. Subjects were asked to provide a plausibility judgment after each trial. The unrelated animacy violation (55.c) elicited an N400. Contrary to expectations, the semantically related animacy violation condition (55.b) did not elicit an N400, but a late positivity starting some 700ms after presentation of the critical last word. The fact that the subjects only temporarily missed the evidence that something was wrong can be seen in the low error rates for plausibility judgments for this condition: 11%. Kolk, Chwilla, van Herten & Oor (2003) replicated these results, also finding no N400, but a late positivity for thematic role violations resulting (56.b) from trading canonical roles, with stimuli such as in (Kolk et al., p. 9) :

56.

a.	De stroper	die	op de vossen	joegen…
	The poacher	who	on the foxes	hunted…
b.	De vos	die	op de stropers	joegen…

The fox that on the poachers hunted…

Stimuli were presented word-by-word with 345ms presentation time and 654ms ISI. Subjects were asked to make a plausibility judgment after each trial.

Nieuwland & van Berkum (2005b) provided further evidence for semantic illusion in discourse in an auditory ERP study. They set up a context in which two people (in this case a check-in clerk and a tourist at an airport) talked about an inanimate object (a suitcase). In the last sentence, the check-in clerk either addressed the tourist (coherent continuation, 57.a) or the suitcase (incoherent continuation, 57.b):

57.

a. The woman then told the tourist that she thought he looked really trendy.
b. The woman then told the suitcase that she thought he looked really trendy.

Nieuwland and van Berkum expected an N400 on the critical word –provided that the anomaly was noticed immediately– and were surprised to find a late positivity for the anomalous condition instead, starting around 600ms, peaking around 100ms and diminishing until the end of the sentence, with a strong bilateral posterior maximum. Similarly to the studies by Hoeks et al. and Kolk et al., the incoherent critical word was highly semantically related to the correct option: *tourist-suitcase*, *bread-baker*, *fox-hunter*, and in Nieuwland & van Berkum's study discourse-relevant and not new, which might have resulted in a temporary 'good-enough'-semantic fit (Nieuwland & van Berkum). The nature of the late positivity is difficult to pinpoint, as the incoherent critical word was not only odd (P3b?) but also constituted a thematic role violation (P600?).

Note that in these studies there was no indicator of an upcoming oddity prior to the violating words.

VII.3.4. Discourse-referential processes

The argumentation that the N400 reflects the difficulty of integration of an incoming word into the current representation of the discourse fits well into a model of sentence processing that associates the N400 with the second processing phase, where semantic information of the current word is integrated. However, what happens if the semantic content of the word currently being integrated *is* information as to the structure of the discourse representation or even an indication that that representation has to be altered? Both types of cohesion discussed in section II.2, pronouns and connective ties, as well as determiners (section II.3.2) need the current sentence or discourse to be interpretable. These words indicate the structure of the discourse or problems with same not (only) by possibly not fitting into the current representation, or violating it, but also by conveying *structural* information that something is wrong or 'how to go on from here'.

VII.3.4.1. Discourse-antecedent binding: violations

After having found only a late positivity for reflexive-antecedent number and gender violations, Osterhout & Mobley (1995) wanted to determine whether this positivity was due to a violation of the binding principle A as such, or due to the agreement violation resulting from an infelicitous attempt to bind the reflexive to a 'disagreeing' antecedent. Binding principle A states that reflexives *must* be bound within their governing category (Chomsky, 1980, 1981a, 1982, 1986a) or, failing that, be syntactically ungrammatical. Binding of reflexives to clause-mate antecedents is considered to be obligatory. Osterhout & Mobley

presented stimuli that included a pronoun in an embedded clause that could not be bound to the subject of the matrix clause due to a gender violation (58):

58. The aunt heard that she / he had won the lottery.

While an anaphoric reflexive and its antecedent must be clause-mates, pronouns on the other hand must be free within their own clause (Binding Principle B). This means that they *can* have an antecedent in the same sentence, provided that it is a complex sentence consisting of more than one proposition.

The pronoun in example 58 would be anomalous only if it and the antecedent are perceived to be co-referential. However, this resulting anomaly would, according to Osterhout & Mobley, not constitute a violation of antecedent binding, as no binding principles are violated: a pronoun must merely be free within its governing category, which is the case. The results for this study showed a posterior late positivity for the anomalous pronouns. The data was then separated into two groups on the basis of the acceptability judgments: group one, consisting of eight subjects, had rarely (mean 7%) judged the gender mismatch sentences as acceptable, group two, consisting of four subjects, did have the tendency to judge these sentences as acceptable (mean 63%). Both groups together judged the nonviolating sentences to be acceptable 90% of the time, while the overall mean of 'acceptable'-judgments for the violating sentences was 24%. The ERPs for group one showed a late positivity similar in time course and distribution to the one found for reflexive-antecedent agreement violations in study 1. ERPs for group two displayed no such positivity, but an anterior negativity between 500 and 800ms post-stimulus. Since there were only four subjects in this group, this data should, as Osterhout & Mobley noted, be treated with caution.

Münte, Szenkuti, Wieringa, Matzke & Johannes (1997) presented two sentences, the first of which contained a potential antecedent for the subject pronoun in the second:

59.	Der Opa hat zwei Maikäfer$_i$ gefunden.	Sie$_i$	brummt laut	beim Fliegen.
	Grandpa has two june$_i$ bugs found.	*She/They$_i$*	*hums loudly*	*when flying.*

The German pronoun '*sie'* is ambiguous between feminine singular and feminine plural as well as ambiguous between all three genders within the plural. If the pronoun in the second sentence is bound to the antecedent '*two june bugs'*, the only possible explicit antecedent, then the following verb constitutes a number agreement violation, being unambiguously singular.

Münte et al. found an anterior negativity and a late positivity on the verb, the first word where an antecedent-mismatch could be diagnosed. The interesting aspect of these results is that, although pronouns do not have to be bound to anything that has been explicitly mentioned, an attempt to do so is apparently made in discourse if it is possible, and also if is not (see also Osterhout & Mobley, 1995). That antecedent binding is what has taken place here is shown by the for morphosyntactic violations of subject-verb-agreement classic ERP-pattern found on the verb: an anterior negativity and a late positivity. If the pronoun had not been bound to the plural antecedent, there would have been no agreement violation, as it could in that case have easily been interpreted as a new, previously unmentioned singular discourse participant.

Such a treatment of the pronoun as a free variable could be precisely what the small group of subjects in Osterhout & Mobley's study (above) did. The ones that did not show the late positivity in response to the potential gender violation may simply have not even

attempted to bind the pronoun to the only possible antecedent but so to speak 'invented' one right away.

Another possible case of a late positivity in response to a perceived syntactic violation in discourse, namely a violation of an indefinite determiner introducing a new discourse participant (Hawkins, 1978; Heim, 1983), is found in a study presented by Yang & Perfetti (2005). One of their conditions comprised a short discourse in which a referent was introduced per indefinite NP in the first sentence (60). The second sentence then started with the same NP, either in definite (60.a) or indefinite form (60. b):

60. Context:
Leaving Heinz Chapel, Ross almost ran into a bridesmaid dressed entirely in teal.

a. The bridesmaid said, “Excuse me, sir, but have you seen the groom?”.
b. A bridesmaid said, “Excuse me, sir, but have you seen the groom?”.

At first glance, the indefinite determiner in the second sentence does not constitute a violation of any sort: it could simply be another new referent being introduced. Second sentences starting with an indefinite determiner were, however, *always* followed by the same noun as in sentence one, that being 'bridesmaid' in this case. Moreover, this condition was the only one in which an indefinite determiner stood at the beginning of the second sentence: all other three conditions (the last two will be discussed in section VII.3.4.2) started with the definite determiner *the*. This means that upon encountering the indefinite determiner, subjects knew what would follow: an ambiguity as to whether or not it was the same bridesmaid as in sentence one or a different one, unmentioned up to that point. The stimuli were presented word-by-word self paced (300ms, 500ms SOA), so the subjects had ample time to apply strategies. Yang & Perfetti do not display reading time data, which could show whether the subjects spent more time on indefinite determiners. If subjects bound the indefinite NP to the possible antecedent, a definiteness violation resulted. If on the other hand the indefinite determiner was taken to be introducing a new bridesmaid, that new bridesmaid had to be 'invented' on the spot. Both processes appear somewhat analogous to Osterhout & Mobley's second experiment on pronouns: subjects that had attempted to bind the pronoun to the gender-disagreeing antecedent showed a P600, subjects that did not attempt to bind (as far as it is possible to tell), showed a frontal sustained negativity in Osterhout & Mobley's study.

ERP effects found on the indefinite determiner in sentence two in Yang & Perfetti's study were a negativity at central and frontal sites between 300 and 600ms *and* a positivity at right parietal sites (T4 is shown in the poster) between 300 and 600ms. Whether it would be possible to break the data down into two groups with differing processing strategies, analogous to Osterhout & Mobley (1995), is not known, so the data will be interpreted as a whole. Two different interpretations present themselves here.

If subjects attempted to bind the indefinite NP to its indefinite discourse antecedent, the frontal negativity could either be a failed attempt to locate a suitable antecedent, i.e. a working memory LAN, or an expression of the definiteness violation resulting from an attempt to bind, speculatively making it a morphosyntactic LAN. The late positivity would then be a correlate of a perceived syntactic violation, namely a P600.

If, on the other hand, subjects introduced a new bridesmaid, the anterior negativity might be an indication of a failed attempt to find a possible antecedent, i.e. a working memory LAN, and the subsequent positivity a correlate of the updating process of integrating a new bridesmaid. In this case the late positivity would be P3b.

It is not possible to decide between these two options. The distribution of the positivity argues more for a P600, which would make this another instance of syntactic relations playing a role between sentences as well as within one sentence.

VII.3.4.2. Discourse antecedent binding: preferences and ambiguities

Antecedent violations in discourse appear to be associated with a late positivity and possibly a left anterior negativity. The following studies deal with ERP correlates of antecedent selection (ambiguities and preferences) in discourse.

Van Berkum, Brown & Hagoort (visual stimuli 1999a, auditory stimuli van Berkum, Brown, Hagoort & Zwitzerlood, 2003a) presented paragraphs where, in the last sentence, a word was either referentially unique (61.a) or ambiguous (61. b), as established by the previous discourse (cursive NPs). An example of the experimental paragraphs is given here in the English translation provided by the authors:

61.

a. Just as the elderly hippie had lit up a joint, he got a visit from *a friend and a nephew*. Even though *his friend* had had quite a few drinks already, and the nephew had just smoked quite a lot of pot already, they insisted on smoking along.
The hippie warned the friend that…

b. Just as the elderly hippie had lit up a joint, he got a visit from *two friends*. Even though *one of his friends* had had quite a few drinks already, and *the other one* had just smoked quite a lot of pot already, they insisted on smoking along.
The hippie warned the friend that...

The referentially ambiguous condition constitutes no antecedent violation or semantic violation, but for the reader or listener it poses the problem of having to choose one of the two possible antecedents, as the definite determiner *the* indicates that one of the two previously mentioned friends is the object of conversation.

Results showed an anterior negativity for the ambiguous condition starting around 300ms for visual and 300-400ms for auditory stimuli, apparently reflecting the difficulty of finding an antecedent (or the search itself).

The experiment by Yang & Perfetti (2005), partially discussed in the previous section, varied four different antecedents and four different NPs in the target sentence:

62.

a. Explicit antecedent:
Leaving Heinz Chapel, Ross almost ran into *a bridesmaid* dressed entirely in teal.
The bridesmaid said, “Excuse me, sir, but have you seen the groom?”.

b. Frame antecedent:
Leaving Heinz Chapel, Ross almost ran into *a wedding party* dressed entirely in teal.
The bridesmaid said, “Excuse me, sir, but have you seen the groom?”.

c. Indefinite NP:
Leaving Heinz Chapel, Ross almost ran into *a bridesmaid* dressed entirely in teal.
A bridesmaid said, “Excuse me, sir, but have you seen the groom?”.

d. Zero antecedent:
Leaving Heinz Chapel, Ross almost ran into *a jogger* dressed entirely in teal.
The bridesmaid said, "Excuse me, sir, but have you seen the groom?".

Processing of the indefinite target-sentence NP (example 62.c) was probably influenced by strategy effects, making the determiner the critical word, and a possible definiteness violation. This condition is discussed in section VII.3.4.1. The other three conditions differed only with respect to the nature of the possible antecedent for the definite NP *the bridesmaid*, making the noun the critical word: In example 62.a the antecedent is an indefinite variant of the target NP. In example 62.b the context-sentence antecedent for the definite NP was a semantic frame that felicitously included the definite NP, as bridesmaids are usually a part of a wedding party. In the last condition (example 62.d) the definite article in the target sentence also marks the NP as discourse-old, but the only possible antecedent is incongruous.

Stimuli were presented visually, word-by-word self-paced (300ms, 500ms SOA), with a true-false comprehension question after each trial. There were no differences between the three conditions (Frame antecedent, Explicit antecedent and Zero antecedent) on the determiner. Results for the subsequent noun showed a left anterior negativity for the explicit condition (62.a), where the other two did not differ from each other, and an N400 for both Frame- and Zero antecedent conditions (62.b, 62.d). Both effects were significant from a rather early point onwards (120ms), again suggesting strategy effects. As far as can be determined Yang & Perfetti presented all four conditions of each block of lexical material to each subject, 120 experimental passages total, 30 for each of the four conditions, plus 60 filler passages. This would make it theoretically possible for a subject to recognize a context repeating itself the third or fourth time. Regardless of this, the two different effects found suggest two different underlying processes: the left anterior negativity for the Explicit condition (F7 is shown in the poster) could be a working memory effect, reflecting the search for or the reactivation of the antecedent or possibly even a successful binding process. The N400 for the Frame and Zero antecedent conditions most likely reflects the difficulty of semantic integration of the target noun.

Streb, Rösler & Henninghausen (1999) compared the processing of pronouns to that of proper names in a two-sentence discourse, crossing that factor with parallel and non-parallel discourse structures. Their stimuli consisted of a context sentence introducing two participants via proper names, one in subject- and one in object position. The target sentences referred to one of those participants, either with same syntactic position as before (example 63) or in a different one (example 64), and either as another instance of the proper name (63.a and 64.a) or in the form of a pronoun (63.b and 64.b). An example of the stimulus material is provided here in an English translation:

63. Parallel structures:

a. Proper name target:
Peter visits Julia in the hospital. There Peter has asked the doctor a question.

b. Pronoun target:
Peter visits Julia in the hospital. There he has asked the doctor a question.

64. Non-parallel structures:

a. Proper name target:
Peter visits Julia in the hospital. There the nurse has shown Peter the room.

b. Pronoun target:
Peter visits Julia in the hospital. There the nurse has shown him the room.

The first question was if and how the additional processing required to bind the pronoun to its antecedent would express itself in the ERPs. The second question concerned the parallel function strategy (Gordon and Scearce, 1995): as that strategy would lead subjects to prefer an anaphor to have the same syntactic role in the target sentence as in the context, a mismatch here should result in more difficult semantic integration. Streb et al. varied whether the subject or the object of the context sentences is referred to either in parallel or non-parallel targets, to exclude strategy effects, but do not report any effects pertaining to this. For the sake of brevity, only one example, the subject-reference, is shown here.

Stimuli were presented word-by-word visually, with a presentation time of 250ms and 250ms ISI. Subjects were asked to answer a true / false question after each trial.

Results for proper names versus pronouns showed a LAN and a later N400 for the pronouns. The LAN could be seen as another instance of a discourse-antecedent search, i.e. a working memory effect, although Streb et al. also discuss the fact that pronouns are closed class words. An anterior negativity as well as an N400 for closed- versus open class words has been found in previous studies (Neville, Mills & Lawson, 1992; Van Petten & Kutas, 1991). However, the LAN has been found as a correlate of working memory load associated with discourse antecedent search or (successful) binding in the studies discussed above as well. Moreover, it can be argued that a proper name such as *'Peter'* is not open-class in the same sense as the common noun *table*: in formal semantics, proper names refer to individuals, while common nouns refer to sets. The N400 found for the pronouns is therefore not necessarily a correlate of open- versus closed class differences. The ERPs for the non-parallel structures yielded an N400 compared to the parallel structures, reflecting the more difficult semantic integration in non-parallel target sentences, as predicted by the parallel function strategy.

Cowles (2003) tested whether the informational structure of previous discourse can also influence the processing of a noun phrase in a target sentence. She compared contrastive focus (65) to informational focus (66):

65. Contrastive focus context
    a. A butcher, a chef and a specialist were in the kitchen of a posh restaurant.
    b. They had started up the business together.
    c. It was successful, but they were very busy.
    d. All of them wanted everything to be perfect, but only one had time to stop and taste the soup.
    e. Which one tasted the soup?

66. Informational focus context
    a. The kitchen of a posh restaurant was filled with people trying to get orders filled.
    b. Near the door was a butcher and another person.
    c. A group of cooks was clustered around a stove, including a chef and a specialist.
    d. There was a pot of soup in the corner that was almost ready to be served.
    e. Did anyone taste the soup?

67. Target sentence
After a moment, the butcher tasted the soup.

In the contrastive focus condition (65), the first sentence (65.a) introduced three discourse participants via noun phrases, always together and conjoined in subject position, to establish all three with the same informational status. The next two sentences elaborated the scene (65.b, 65.c). If the participants were mentioned again, it was always with a third-person plural pronoun. The fourth sentence (65.d) separated one participant out, but without explicitly stating which one. The fifth sentence (65.e) was always a question in the form of 'Which one did X'. This lead to the subject NP in the target sentence (67) being the focus and having to be chosen from a finite, small set of possible choices (*butcher*, *chef*, *specialist*).

In the informational focus condition, the first sentence (66.a) set a scene with lots of people. The next two sentences (66.b, 66.c) mentioned all of the participants as if simply describing a larger scene, but without introducing any of them in a more prominent way than the others or constructing a contrastive set. The fourth sentence (66.d) was included to make the following question (66.e) sensible. This question always took the form of 'Did anyone do X', designed so that the target sentence answer (67) did not require a single person to be the focus. In the filler items, the target sentence answer to such a question was often 'No one did X', to prevent subjects from having the expectation that the answer would always mention a single participant.

The context was presented as a paragraph on the screen, while the target was presented self paced word-by-word with a presentation time of 200ms and a SOA of 500ms.

In the averages over the entire target sentence, Cowles found a sustained anterior negativity between 300 and 1100ms for the contrastive condition (65), roughly for the first two to three words of the target sentence. A central positivity from 200 to 700ms post-stimulus for the target word (*butcher*) was marginal in the sentence average, but reached significance in the one-word average. Both effects occurred for the contrastive condition.

Cowles interpreted the LAN as a working memory effect, elicited by the subjects' need to keep the contrastive set of participants, or alternately the unfilled role introduced by the question in sentence (65.e) in mind. The late positivity was seen as a P3b, a correlate of updating a mental model or matching the *butcher* in the contrastive target condition to the correct discourse referent, i.e. picking the right discourse antecedent. In the informational focus condition, the subjects had no need to either remember all the participants or make such a match, as they were not led to expect that one of the participants would occur in the target sentence in the first place.

VII.3.4.3. Discourse antecedents: summary

It seems that discourse-referential processes display the full spectrum of ERP correlates of the second and third processing phases: perceived syntactic violations of pronoun binding result in a late positivity (Osterhout & Mobley, 1995, Yang & Perfetti, 2005 and possibly Münte, Szenkuti, Wieringa, Matzke & Johannes, 1997), that in some cases could be interpreted as a P3b, while in others the nature of the stimuli argues more for a P600. Even in the absence of any syntactic violation whatsoever, a reordering of discourse antecedents or the process of matching a referent with the correct antecedent elicited a P3b (Cowles, 2003). Ambiguities concerning the correct antecedent or the search for a referent are associated with (left) anterior negativities, that, again, in some cases could indeed be morpho-syntactic LANs, in the cases where the (left) anterior negativity is associated with possible syntactic violation, but not even in those cases the situation is quite clear (see

Yang & Perfetti, 2005). In others the circumstances speak more for the working memory effect-version of that effect (van Berkum, Brown & Hagoort, 1999a and van Berkum, Brown, Hagoort & Zwitzerlood 2003a; Yang & Perfetti, 2005; Streb, Rösler & Henninghausen, 1999; Cowles, 2003). This anterior negativity appears to be dependent on the possible antecedent (whether ultimately felicitous or not) being mentioned verbatim as a single entity at some point in the discourse, however, as the Frame antecedent condition in Yang & Perfetti's study did not show a LAN. Difficult semantic integration of a word that has been involved in a discourse antecedent relationship also elicited an N400 (Yang & Perfetti, Frame antecedent condition, and Streb et al., non-parallel structures). The study by Streb et al. also shows that the syntactic positions of anaphors and antecedents play a role in the ease with which a relation can be established.

The interesting aspects of these results are that (left) anterior negativities as well as late positivities can be elicited by *inter*-sentential processes, not just within one sentence. There is also the possibility of discourse influencing syntactic analysis (see also the debate concerning discourse influences on syntactic ambiguities: van Berkum, Brown, & Hagoort 1999a,b; Brysbaert & Mitchell, 2000, van Berkum, Brown & Hagoort, 2000; Brown, van Berkum & Hagoort, 2000; van Berkum, 2004), although since in many cases an argument for a P3b can be made, claiming the relevant late positivities as correlates of syntactic processing is not possible.

VII.3.5. Tabular summary of studies discussed in section VII.3

In this section, the studies discussed in section VII.3 will be summarized in Table VII-1. The order of presentation follows the previous discussion. For each study, the following information will be specified[58]: examples of stimulus material, language of stimulus material, number of subjects, modality of stimulus presentation, task given to the subjects, relevant results, and supplementary comments.[59]

Table VII-1**:** Summary of the studies discussed in chapter VII.3.

Study	Stimuli	L[60]	N[61]	Modality[62]	Task	Results	Comments
Inference Processes							
St.George (1995); St. George, Mannes & Hoffman (1997)	Bridging Elaborative Word-Priming No Inference 4 sentences: Inference on 3rd sentence, target (sent. 4) stated inference.	E	33	Visual word-by-word 300 / 300 ISI	Reading, Recall in 10% of trials	Target sentence: -All subjects: smaller N400 for a vs. c and d -Low Read. Span: smaller N400 for a vs. b -High Read. Span: no diff. a vs. b	-Effect of inference having been made or not on semantic expectation of words in target sentence
Kuperberg, Caplan, Eddy, Cotton & Holcomb (2004)	a. Congruent b. Inference c. Incongruent 3 sentences, inference on sentence 3 (target).	E	15	Visual Target: word-by-word 500 / 100 ISI	Judgment: Relatedness of target to context 1: most rel. 2: intermed. 3: unrelated	Correctly judged trials only: -bilateral N400 for c vs a -smaller N400 -ant late positivity for b vs a	-Effect of inference being made or not on sem. expectation of words in target sentence. -pos. larger at sent.-final words
Coherence: semantic violations							
St. George, Mannes & Hoffman (1994)	titled versus untitled short texts 77 to 163 words, 6 to 14 sentences untitled: missing macrostructure	E	29	Visual word-by-word 300 / 500 ISI	Paper-and-pencil recall	N400 for words in untitled paragraphs	Between subject: Subjects read either only titled or only untitled paragraphs

[58] As far this information is available: n/a = not available

[59] This method of summarizing a rather large amount of data is taken from the dissertation of Hahne (1997).

[60] Language: E = English, G = German, D = Dutch.

[61] N = number of subjects.

[62] For visual presentation the duration of word presentation and the inter-stimulus-interval (ISI) or the stimulus onset asynchrony (SOA) for the target sentences is given in milliseconds.

Study	Stimuli	L	N	Modality	Task	Results	Comments
Salmon & Pratt (2002)	List 1: 3 sentences CW in 3rd sent. a. disc.-coherent b. disc.-anomal. List 2: Single sentences c. sent.-congruous d. sent-anomalous	E	18	auditory	Semantic judgment	-N400 for anomal. cond. b and d -centro-parietal late positivity for anomal.: b and d	-Lists 1 and 2 presented consecutively -ERPs for the four conditions shown separately
West & Holcomb (2002)	Picture stories w/ a. congruous endings b. incongruous endings	(E)	16	Visual Serial pictures 1500 / 300 ISI	Coherence judgment	-N400 for incongruous endings	
Sitnikova, Kuperberg & Holcomb (2003)	Movie clips of everyday processes w/ a. congruous objects b. incongruous objects	(E)	16	Visual Continuous length 7 to 26s	Coherence judgment	-N400 for incongr. objects -post. late positivity for incongruous	
Coherence: semantic expectation in discourse							
Federmeier & Kutas (1999a)	2-sentence disc. Restricting cloze-prob. for last word in target CWs in target sentence a. congruous b. right sem category, wrong exemplar c. wrong sem. category	E	18	Visual 200 / 300 ISI CWs 500ms	Recall at end of session	-N400 for wrong sem. cat. © vs congruous (a) -smaller N400 for right sem. cat but wrong exemplar (b) vs congruous (a)	
Ditman, Holcomb & Kuperberg (2005)	5-sentences 1-3 introducing 3 objects and their use, 4 primes one object. 5 (target) CW: a. primed object b. unprimed object but correct sem. category c. unprimed object, wrong sem. category	E	16	Visual word-by-word	Judgment of whether CWs in target had been referred to in sentence 3	CWs (sentence-medial): -N400 for unprimed © vs primed (a) -smaller N400 for unprimed but correct sem. cat (b) vs primed (a)	LAN for final words cond. c in second half of experiment.
Cowles (2003) Experiments 3.1a and 3.1b	3 sentences 1: introduces 3 people 2 : object-wh question placing one participant in subject and 2 in object-position. 3: it-cleft placing one participant in object-position: a. expected (object from sent.2) b. unexpected (subject from sentence 2)	E	3.1a 16 3.1b 14	Target Visual Self-paced 200 / 500 SOA	Occasional True / false question	-N400 for unexpected (b)	-Experiment 3.1a repeated: effects on words in target sent. prior to critical word. These effects disappeared in 3.1b. -semantic expectation due to syntactic structure

Study	Stimuli	L	N	Modality	Task	Results	Comments
Previous discourse versus real-world knowledge							
Nieuwland & van Berkum (2005A) Exp. 2	6-sentence discourse with 4 repeated animacy violations prior to target (dancing peanut in love). Target sentence either: a. real-world plausible, disc. anomalous: The peanut was salted… b. disc. plausible, locally anomalous: The peanut was in love…	D	N/a	auditory	N/a	-N400 for condition a (real-world plausible, discourse anomalous	
Altering the discourse structure							
Fischler, Bloom, Childers, Roucos & Perry (1983)	True sentences: a. An apple is a fruit. b. An apple is not a weapon. False sentences: c. An apple is a weapon d. An apple is not a fruit.	E	8	Visual 175 / 800 ISI	True / false judgment	-N400 for all semantically unrelated targets (apple-weapon), regardless of truth value or presence of negation.	
Kounios & Holcomb (1992)	Category–Exemplar: All animals are *dogs / *apples. Some anim. are dogs / *apples. No anim. are *dogs / apples. Exemplar–Category: All dogs are *anim. / *fruit. Some dogs are anim. / *fruit. No dogs are *anim. / fruit.	E	12	Visual subject segment: 500ms predicate 300ms ISI 300ms	True / false judgment	-N400 for unrelated predicates regardless of quantifier. -Exemplars: right-hemisph. negativities for 'some' and 'no' 300 - 500ms. - negativity for 'no' 500 -800ms	-strategy for 'All'-sentences: always false. -no average for quantifier by truth value for the predicate. -850ms between quantifier and predicate
Van Berkum, Brown, Zwitzer-lood, Kooijman & Hagoort (in press)	Sentence-pairs. Context: The burglar had no trouble locating the family safe. -Expected target: ...was …behind a big painting: groot schilderij -Unexpected target: …was…behind a big bookcase: groote boekenkast	D	24	auditory	listening	-positivity 50-250ms for unexpected inflection -N400 for unexpected noun	-390 to 1290ms (mean 707ms) between inflection on adjective and noun onset.

Study	Stimuli	L	N	Modality	Task	Results	Comments
Brehm (2000), beim Graben, Drenhaus, Saddy, Brehm & Frisch (submitted)	Licensed NPI / Anti-lic. PPI: a. No...ever… b. *No…certainly… Unlicensed NPI / Grammat. PPI c. *A…ever… d. A…certainly…	G	20	Visual word-by-word 400 / 100 ISI	Acceptab. judgment	-no N400 for licensed NPI -late positivity for anti-licensed PPI	-1000ms between (anti)-licenser and target -licensing of syntactic nature?
Semantic Illusion							
Hoeks, Stowe & Doedens (2004),	Thematic role 'trade': a. Het brood weerd door de bakkers gebakken. b. Het brood heeft de bakkers gebakken. c. Het brood heft de bakkers bedreigd.	D	24	Visual word-by-word 240 / 240 ISI	plausibility judgment	-N400 for c vs a -no N400 for b vs a. -late positivity for b vs a	
Kolk, Chwilla, van Herten & Oor (2003)	Thematic role trade: a. De stroper die op de vossen joegen… b. De vos die op de stropers joegen…	D	40	Visual word-by-word 435 / 645 ISI	plausibility judgment	-no N400 for b vs a. -late positivity for b vs a.	
Nieuwland & van Berkum (2005B)	Conversation about inanimate object. Continuations were: -a. Coherent: The woman … told the tourist that… -b. Anomalous: The woman … told the suitcase that …	E?D ?	N/a	auditory	N/a	-no N400 for anomalous continuations -bilateral posterior positivity 500 – 1600ms	
Discourse-antecedent binding: violations							
Osterhout & Mobley (1995), Exp. 2	The aunt heard that she / *he had won the lottery.	E	12	Visual 350 / 300 ISI	Acceptab. judgment	-All subjects: late positivity 300-900ms for gender-violating pronoun -'binding'-group: centro-posterior late positivity only -'non-binders': anterior negativity only (300-900ms)	-'binders' (8 subjects) rarely judged violation as acceptable (7%) -'non-binders' (4 subjects) judged as acceptable (63%)
Münte, Szenkuti, Wieringa, Matzke & Johannes (1997)	Der Opa hat zwei Maikäfer$_i$ gefunden. Sie$_i$ *brummt beim Fliegen laut.	G	12	Visual word-by-word 300 / 700 ISI	Questionnaire after session	-ant.negativity -late positivity for singular verb in violating cond.	-S-V-agreement

Study	Stimuli	L	N	Modality	Task	Results	Comments
Yang & Perfetti (2005)	2 sentences, referent for target-sentence NP in 1st sentence: definite target: [a bridesmaid] …the bridesmaid indefinite target (violation) [a bridesmaid] …a bridesmaid	E	16	Visual Self-paced word-by-word 300ms / 300 SOA	N/a	-central +anterior negativity for 'a' -late positivity for 'a' (at T4), 300-600ms	-indefinite article always followed by same noun as in context: strategy effect -N400 or LAN? -P600 or P3b?
Discourse-antecedent binding: ambiguities and preferences							
Van Berkum, Brown & Hagoort, 1999a, exp. 1, visual stimuli; van Berkum et al. 2003a: auditory stimuli	Unique discourse referent: …a friend and a nephew… Ambiguous discourse referent: …two friends… Target: The hippie told the friend…	D	99a: 24 03A: 24	1999a: Target sentence: Visual word-by-word 300 / 300 ISI 2003a: auditory	Reading Listening	-sustained anterior negativity starting at 300ms - sustained anterior negativity starting at 300-400ms	
Yang & Perfetti (2005)	Explicit antecedent: [a bridesmaid]… …the bridesmaid Frame antecedent: [a wedding party]… … the bridesmaid Zero antecedent: [a jogger]… … the bridesmaid	E	16	Visual Self-paced word-by-word 300ms / 300 SOA	N/a	-LAN for Explicit vs Frame + Zero -N400 for Frame + Zero	-Very early effects: Strategy? -subjects saw all four versions of each paragraph
Streb, Rösler & Henning-hausen (1999)	2 sentences, proper name referents. Proper name vs pronoun in 2nd, Parallel vs non-parallel syntactic structures	G	16	Visual Word-by-word 250 / 250 ISI	Yes / No comprehen. questions for each trial	-LAN + N400 for pronouns -N400 for non-parallel structures	-N400: open- versus closed-class-effect?
Cowles (2003), experiment 3.2	6 sentences, 1-5 introducing 3 participants in either: a. contrastive focus b informational focus. Target noun in 6 one of the participants (word 5)	E	14	Target Visual Self-paced 200 / 500 SOA	Occasional True / false question	-sustained anterior negativity for first 2-3 words in target for contrastive -positivity 300-1100ms on target noun for contrastive	

VII.3.6. ERP-correlates of discourse processing

In the following section the ERP effects found for the various aspects of discourse processing discussed in this chapter, and these ERP-correlates' underlying processes, will be addressed in turn. As there is no possible way in which the phrase structure of a sentence can be violated by previous discourse, the following discussion concerns the second (N400 and LAN) and the third (late positivities) processing phases only.

VII.3.6.1. The second processing phase: The N400

Integrating the meaning of a new word into the current representation of a discourse appears to be much the same process as integrating a word into a sentence presented in isolation. Cloze probability and semantic violations in discourse reliably express themselves in an ERP-effect with the same latency, polarity, topography and sensitivity to experimental manipulation as in single sentences: the N400 (Salmon & Pratt, 2002; Van Berkum, Hagoort & Brown, 1999c; van Berkum, Zwitzerlood, Hagoort & Brown, 2003b; Britz & Swaab, 2005). Seeing as how a single sentence is the potential start of a discourse, and, as long as only one sentence is present, the semantic representation of the current discourse is identical to the semantic representation of this sentence, this is not yet news. There are however several ways in which previous discourse can influence the semantic expectancy and pragmatic fit of a word, and with it the N400, that are not apparent in isolated sentences:

Previously made inferences

An inference, i.e. a connection that has already been made between two previous sentences, results in higher cloze probabilities, i.e. lower N400 amplitudes for the words in a sentence explicitly stating the inference (St. George, 1995; St. George, Mannes & Hoffman, 1997).

Difficulty of a subsequent inference

The N400 also reflects how obvious a connection that will later be made between two statements is: the more obscure the connection and with it the lower the cloze probability of an incoming word, the larger the N400 (Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004).

Lack of a discourse structure

If, in a collection of vague sentences, the information of what the text is about is missing, a discourse structure ordering the semantic content of the separate sentences cannot be constructed. This leaves the confused addressee to fend for himself, and results in a large N400 for the words in that text, as the incoming words can be integrated into their current sentence, the microstructure, but not the superordinated macrostructure (St. George, Mannes & Hoffman, 1994).

Previous discourse

Information in earlier sentences can change the cloze probability of a new word that is otherwise quite felicitous in its current sentence (Salmon & Pratt, 2002; Britz & Swaab, 2005; van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort, 2005), eliciting an N400 for discourse-incongruous words. This effect is apparent not only for scalar opposites such as *fast-slow* (van Berkum, Hagoort & Brown, 1999c; van Berkum, Zwitzerlood, Hagoort & Brown, 2003b), but also for degrees of semantic relatedness (Federmeier & Kutas, 1999a; Ditman, Holcomb & Kuperberg, 2005). It also holds for incongruous non-verbal discourse in picture stories (West & Holcomb, 2002) and movies (Sitnikova, Kuperberg & Holcomb, 2003), as well as the syntactic structure of the previous discourse (Streb, Rösler &

Henninghausen, 1999; Cowles, 2003), and the lack and possibly also the accessibility of a discourse antecedent for a noun in a definite noun phrase (Yang & Perfetti, 2005).

Changes in the discourse structure

A real-world pragmatic violation can be accommodated in contexts such as a fairy tale or a comic-book-like setting through an override of pragmatic canonicity by the discourse representation. The first time such a violation occurs in a discourse it is treated as such (N400), but subsequent repetitions result in the N400 disappearing. This holds not only for semantic integration of current words, but also for the processing of verbs (Nieuwland and van Berkum, 2005A, experiment 1). Once a pragmatically odd context has been accommodated, integration of a word referring to the real state of things is in turn treated as a violation (Nieuwland and van Berkum, 2005A, experiment 2), eliciting an N400. The exact conditions under which such a change can be is triggered and how quickly it is accomplished are not clear, but appear to either take longer than 850ms or not be completed until the end of the sentence is reached (Fischler, Bloom, Childers, Roucos & Perry, 1983; Kounios & Holcomb, 1992; Brehm, 2000; beim Graben, Drenhaus, Saddy, Brehm & Frisch (submitted); van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort, 2005).

Underlying processes of the N400

The underlying processes of the N400 in discourse also seem much the same as those in isolated sentences, as is implied by referring to the centro-posterior negative deflection found for integrating a word into the discourse as an N400 throughout the previous chapter. It is a correlate of later, controlled processes of integration of the current word, namely the cloze probability and semantic and pragmatic fit of same. What that word is being integrated into, however, is a little more complex in the processing of more than one sentence or proposition: previous discourse takes precedence over the current sentence; for initial semantic violations, pragmatic canonicity is dominant, while for subsequent violations the altered discourse structure wins the day. The uniting factor of these three interactions is *the discourse structure already built* when the new word is encountered. Into this representation the semantic and pragmatic content of the word is integrated, and mismatches and difficulties at that point are reflected by the occurrence and amplitude of the resulting N400.

VII.3.6.2. Is there a connection? The LAN

LANs occur in single sentences containing a morphosyntactic subject-verb agreement violation, often together with a late positivity. They have also been found in connection with pronoun-antecedent binding and discourse-antecedent binding, in other words in complex sentences and two separate sentences, in cases where the antecedent was either obvious (Streb, Rösler & Henninghausen, 1999; Cowles, 2003, experiment 3.2; Yang & Perfetti, 2005, Explicit condition), obvious but non-preferred (Cowles, 2003, experiment 3.1b) or ambiguous (van Berkum, Brown & Hagoort, 1999a; van Berkum, Brown, Hagoort & Zwitzerlood, 2003a). In contexts where a co-reference would result in an agreement violation, a LAN is found in cases where there are possible arguments that subjects did not even attempt to bind but took the referring NP to be co-referent with a new, as yet unmentioned, antecedent (Osterhout & Mobley, 1995, experiment 2; Yang & Perfetti, 2005, indefinite condition). It should be noted that in both these cases there are questions concerning either the reliability and homogeneity of the data and / or the possible presence of strategy effects. The most striking aspect of LANs in discourse-antecedent binding, however, is that the effect is not generally associated with a subsequent late positivity as the morphosyntactic LAN is, even in the case of potential morpho-syntactic discourse

violations (with the one possible exception of Yang & Perfetti, 2005, indefinite condition). Since the binding operations in discourse are intuitively of a more optional nature than the bare necessity of a verb agreeing with its noun, in other words since a discourse will end up disjointed or incoherent, but the current sentence will not be downright ungrammatical if a connection is not made, this is not surprising.

In view of these points it can be argued that a LAN in discourse processing is an instance of the working-memory-load variant of this correlate. Most circumstances under which it has been found indeed constitute situations where the discourse antecedent was either not unique, involved an extra processing step in the form of agreement-'checking' in a previous sentence (pronouns), or potentially had to be invented on the spot, processes that would definitely involve extra work for the working memory. As the LAN has been found in connection with undisputed working-memory processes not involving co-reference in discourse (Münte, Schiltz & Kutas, 1998, discussed in the next chapter, and Cowles, 2003, experiment 3.2), this association seems the more likely.

If the LAN in discourse is indeed a correlate of added working memory load, the question is what underlying processes it reflects in discourse. The options are:

- the search for an antecedent,
- finding an antecedent,
- the diagnosis of that the antecedent 'will do',
- the diagnosis of that the possible antecedent is in fact not the right one,
- and, lastly, the incorporation of an entirely discourse-new antecedent.

These possibilities would be very hard to dissociate, but it remains that LANs occur when there is evidence that two sentences or propositions can be explicitly connected.

VII.3.6.3. Late positivities in discourse

While the interpretation of the N400 in discourse is fairly straightforward, and that of the working-memory LAN only somewhat less so, late positivities in discourse-processing present a thoroughly mixed bag of evidence and possible interpretations. The first question is whether late positivities in discourse are syntax-related. In studies where there was no syntactic violation by any means, the answer is obviously negative (Sitnikova, Kuperberg & Holcomb, 2003; Cowles, 2003; Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004). In these studies, it is likely that the late positivity found is a reflection of updating a situation model, in other words: a P3b. In other studies, the presence of a potential syntactic violation depended on the subjects perceiving it as such (Osterhout & Mobley, 1995, experiment 2; Salmon & Pratt, 2002; Nieuwland & van Berkum, 2005B; Yang & Perfetti, 2005, indefinite condition; see also the debate concerning discourse influences on syntactic ambiguities: van Berkum, Brown & Hagoort, 1999a,b; Brysbaert & Mitchell, 2000, van Berkum, Brown & Hagoort, 2000; Brown, van Berkum & Hagoort, 2000; van Berkum, 2004; among others).

For this latter group of publications there are arguments for classifying the late positivity found as a correlate of syntactic processing, although for some there are also aspects pointing more towards a P3b.

In the case of studies examining inferences and discourse coherence, however, there is simply no way of defending the late positivity as a syntactic effect. Such a doomed attempt is unnecessary, anyway, as there are alternatives, namely the P3b. With the exception of the anterior late positivity found for the inference condition in Kuperberg, Caplan, Eddy, Cotton & Holcomb (2004), the late positivities found had a posterior or centro-posterior

distribution and they occurred in response to stimuli that were unusual, and relevant to the task of understanding verbal or non-verbal discourse.

The interpretation of the P3b as a correlate of updating a situation model serves well as an explanation of the underlying processes in these studies, as the model concerned would be the representation of the discourse. The weaker claim, that of associating the centro-posterior positivities with surprise effects induced by prior discourse, whether semantic or syntactic, cannot be dismissed either. Whatever the underlying processes of the late positivity found in the absence of any syntactical violation, it remains that it can be elicited by discourse processing, at least, to misquote Osterhout & Hagoort (1999, p. 2) and Frisch (2000), "…to an interesting degree".

VIII. CONNECTIVE TIES 3

To the best of the author's knowledge, there are only two ERP studies that explicitly examined the processing of connective ties, all looking at temporal connective ties (Münte, Schiltz & Kutas, 1998; and Baggio, 2004). There are a few that consistently included connective ties in their stimuli (Schmitt, Lamers & Münte, 2002; Koornneef, Waaijer & van Berkum 2002; Swaab, Camblin & Gordon, 2004; van Berkum, Zwitzerlood, Bastiaansen, Brown & Hagoort, 2004), but as the same connective ties were here present in all conditions, no direct conclusions can be drawn concerning their influence on processing on the basis of these data. Therefore, a study that employed fMRI (Ferstl & von Cramon, 2001) will be included in this section as well. For studies employing reaction time, reading time and eye-tracking methods, the kind reader is referred to chapter VI.

Münte, Schiltz & Kutas (1998) used ERPs to examine the processing of the temporal connective ties *before* and *after*, using stimuli such as in example (Münte, Schiltz & Kutas, 1998, p. 71):

68.

a. *After* [the scientist submitted the paper]$_{t1}$, [the journal changed its policy]$_{t2}$.
b. *Before* [the scientist submitted the paper]$_{t2}$, [the journal changed its policy]$_{t1}$.

Both 68.a and b describe a sequence of two events, t1 and t2. In 68.a, the linear order of the input is the same as the conceptual order, i.e. what happened first is stated first. In 68.b by contrast, the linear order is reversed. This reversal is marked with the temporal connective tie *before*, as it must be, since without the connective tie that reversed order of events could not be expressed. Münte et al. investigated whether the information provided by the connective tie would be made use of immediately, or whether the necessary reordering of the two clauses would be delayed until the end of the sentence. They presented the stimuli visually word by word, with a presentation time of 200ms and 500ms ISI, to 24 subjects. After each trial, subjects were asked to indicate via a button press which of the two subclauses had occurred first in time.

Results showed that the ERPs for the *before*-sentences, the condition in which the linear order did not coincide with the conceptual order, were more negative than the control condition at left frontal sites (working-memory-LAN). This difference emerged at 300ms post-stimulus, and continued throughout the entire complex sentence. The onset of the effect at 300ms suggests that the ERP effect was triggered by the connective tie, as the next word was presented at 700ms, 400ms after emergence of the effect. The amplitude of the LAN was also correlated with the working memory span of the subjects: participants with high working memory span showed a higher amplitude of the effect that participants with low working memory span.

Münte et al. suggested on the basis of these data that the information imparted by the connective tie *before* is used immediately in language processing, i.e. that the impact of the connective tie on the text representation is calculated at once, and not delayed until the end of the sentence. It should be noted that the information the connective tie *before* provides is also of a structural nature: *before* signals that its internal argument occurred after its external argument. Since the internal argument 'arrives' first, it is possible that a reader or hearer must hold the meaning of that internal argument over in working memory, until the external argument is parsed, to be able to construct a coherent text representation or situation model. Concessive connective ties, by contrast, would not require such structural

operations on the situation model. This is not an argument against the 'discourse-consequences' of *before* being made use of immediately, au contraire, but it is suggested here that the effect found, the sustained anterior negativity, might be an expression of structural operations on the text representation being 'prepared' as soon as the need for such is diagnosed. This, in turn, suggests that connective ties do have a privileged status where the text representation is concerned, as the studies discussed in section VII.3.3.1 showed that at least in the case of negation, such structural operations take some time, more than 300ms post-stimulus.

Baggio (2004) proposed that the LAN found by Münte et al. was not due to an *obligatory* conceptual reordering of the *before*-sentences, but a task effect. Since subjects were asked to indicate after each trial which event had occurred first, the participants might have undertaken the explicit reordering only because they knew that this information would be needed for the task. Additionally, Baggio proposed that the event-order is not the only relevant difference between *before* and *after*. According to Baggio, the temporal connective tie *after* is veridical (conjunctive), asserting the truth of both its arguments, while *before* does not necessarily do so:

69. Max died *before* he saw his grandchildren.

In example 69, taken from Baggio (2004), p. 41, Max's death prevents him seeing his grandchildren. In other words, the connective tie *before* indicates the falsity of the internal argument, and there is a causal relation between the two arguments: Max's death is the reason for his not seeing his grandchildren. In consequence, a sentence containing *before* forces a reader or hearer to perform a veridicality-check, i.e. to determine whether there is a causal relation between the events, with the occurrence of the first event preventing the occurrence of the second. Baggio investigated these questions in an ERP study, using materials such as the following, translated from Baggio, 2004, p. 43[63]:

70.

a. *After* the man had finished reading, the woman closed the book.
b. *After* the goalie had grabbed the ball, the forward scored a goal.
c. The woman closed the book *after* the man had finished reading.
d. The forward scored a goal *after* the goalie had grabbed the ball.
e. *Before* the woman had closed the book, the man finished reading.
f. *Before* the forward had scored a goal, the goalie grabbed the ball.
g. The man finished reading *before* the woman closed the book.
h. The goalie grabbed the ball *before* the forward had scored a goal.

In the situations described in 70.a, c, e, and g, the occurrence of the first event (the internal argument) does not prevent the occurrence of the second: someone finishing reading is no reason for someone else being unable to close the book. In sentences 70.b, d, f, and h, by contrast, the first event does prevent the second: a goalie getting hold of the ball is usually the end of an offensive move in soccer. If standing in sentences with *after*, which is veridical, these situations are marked (70.b and d). In sentences with *before*, which allows for one of its arguments being false, they are not (70.f and h). Baggio did not ask his

[63] Many thanks to Marije Michel for providing exact translations of Baggio's Dutch material, as the author's grasp of that language is embarrassingly shaky.

24 subjects to do anything but read the sentences presented word-by-word, with a presentation time of 300ms and an ISI of 600ms.

Baggio investigated the following hypotheses:

1. Is the conceptual reordering the cause of the LAN found by Münte et al.? If so, a comparison of 70.a and b to 70.c and d should produce an LAN for 70. c and d: '*After* p,q' versus 'p *after* q' should yield results identical to Münte et al.'s data, since the ordering of events for 'p *after* q' is identical to that of '*before* q,p'.
2. Does *before* trigger a veridicality check? If so, then a comparison of 70.a and b to 70.g and h should yield an effect for 70.g and h, as the differing veridicality characteristica of *before* and *after* are the only difference between these sentences: the event order is the same.
3. Does an underlying causal relation play a role? If it does, then there should be a difference between 70.a and b and 70.g and h respectively: there is no evaluation of a possible causal relation necessary for understanding 70.g, in contrast to 70.h.

There were three time-windows examined: 600-3000ms, corresponding to the first clause, 4200-6600ms, corresponding to the second clause, and 6600-7400ms, the sentence-final period. Baggio did therefore not examine the connective ties themselves, as the onset of the connective tie, if in sentence-initial position, was at 0ms, and at 3000ms if in sentence-medial position. The results were the following:

Hypothesis 1: there was no (left) frontal effect for out-of-order *after*-sentences (70. c and d), but a right-posterior negativity (at P8 only) for these conditions in the sentence-final epoch. A comparison of '*after* p,q' and '*before* q,p' sentences (70.a and b versus 70.e and f), the closest correlates of Münte et al.'s materials, also failed to replicate the LAN.

Hypothesis 2: there was no statistically reliable main effect between *after* (70.a and b) and *before* (70.g and h) in in-event-order sentences.

Hypothesis 3: there was a reliable bilateral anterior negativity for the causally marked *after*-condition (70. b) compared to the situation that did not involve a causal relationship (70.a), for the second clause and the sentence-final epoch. The *before*-sentences involving a causal relationship (70.h) were reliably more negative at a right-pre-frontal site (Fp2), and more positive at parietal (P3, Pz, P4) and right-occipital sites (O2) when compared to the *before*-sentences that did not involve a 'mandatory' causal relation (70.g) in all three time windows[64].

Baggio concluded that the left-frontal effects found by Münte et al. were largely due to the task given to the subjects. There was also no evidence for *before* automatically triggering a veridicality check in all cases.

However, the results reported for hypothesis three suggest an alternative interpretation. An examination of the materials used shows that the situations involving causal relations between the clauses (70.b, d, f, and h) are somewhat odd with the connective ties. According to the properties of temporal connective ties such as *after* identified here (section III.4.3.4), there can be no event intervening between the events denoted in the internal and external arguments that is of equal or greater duration. Speculatively, this constraint could apply to the temporal connective tie *before* as well. For instance, as noted above, a goalkeeper getting hold of the ball usually ends that offensive by the opposing team. The only way to preserve coherence in these sentences would be to postulate an

[64] Effects for Pz and O2 were marginal for the first clause (600-3000ms poststimulus), as was the effect for P4 for the sentence-final epoch (6600-7400ms). For this comparison, effects for the first clause cannot be attributed to the connective tie, as it occupied a position between the clauses (strategy effect?). The effects for the second clause (4200-6600ms) can however be influenced by the connective tie.

intervening event, such as the goalkeeper fumbling the ball or an unmentioned additional run at the goal, an indirect temporal relation that the connective ties do not appear to condone. Baggio's results reported under hypothesis three above speak for this interpretation: The sentences of type 70. b (*after* in causal situations) elicited a negativity for the second clause and the sentence-final epoch, while the sentences of type 70.h did so as well, but additionally showed a posterior positivity. The negativities might be a reflection of a working-memory effect related to this mild incoherence, while the positivity might indeed reflect a (failed) veridicality-check.

To summarize, the studies by Münte et al. (1998) and Baggio (2004) suggest that temporal connective ties do have an immediate effect on language processing. However, the contrast found by Münte et al. appears to be a strategy effect and not a response triggered by the connective tie per se. This was shown by Baggio, who did not find parallel results for analogous comparisons. Whether strategy or not, the effect found by Münte et al. was still triggered by the connective tie. Baggio's data also suggests that readers are sensitive to the influence of temporal connective ties on the felicity of underlying causal relation before the end of the second clause (*before* was sentence-medial in the comparison of causally unmarked and marked situations: 70.h versus 70.g).

In an fMRI study, Ferstl & von Cramon (2001) compared the processing of two-sentence discourses containing lexical cohesion (connective ties, pronominal co-reference, and paired deictical sentential adverbs) to discourses that were non-cohesive. They crossed this experimental factor with coherence, by switching the contexts of two coherent discourses, thereby obtaining incoherent pairs. An example of their material is shown below, the translation provided by Ferstl & von Cramon, p. 328:

71. Context: Laura got a lot of mail today.
    a. Coherent targets:
       Some friends had remembered the birthday. — non-cohesive
       Her friends had remembered *her* birthday. — cohesive
    b. Incoherent targets:
       The palms were sweaty. — non- cohesive
       Therefore, her palms were sweaty. — cohesive

For the cohesive targets, the lexical cohesion signaled that the two sentences were directly related, a misleading signal in the cohesive incoherent condition. For the non-cohesive conditions, coherence or incoherence had to be diagnosed by inferencing alone, making the establishment of coherence in coherent trials more difficult, but the diagnosis of incoherence in incoherent trials easier, as there was no explicit cohesion interfering.

A behavioral pretest (discussed in chapter VI) had shown that cohesion in coherent discourses aided in the task of establishing coherence, while cohesion in incoherent discourses hindered the diagnosis of that incoherence, as expressed in rather longer reaction times to the coherence judgment.

In the fMRI study, the 120 critical German sentence pairs were pseudo-randomized with 30 control trials. These control trials consisted of sentences comprised of illegal non-words [65]. Half of the control sentences were printed in all upper case letters, and half in upper- and lowercase letters. The non-word sentences were combined in pairs so that in 15 trials,

[65] An illegal non-word is a word that has no meaning and does not confirm to phonemic or orthographical rules of the language in question: ‘nfaks’. A legal non-word is simply one that does not have a meaning associated with it (an obscure hunting term).

context and target had the same letter case pattern and in 15 trials context and target had different letter case patterns. The target sentences were all split into two displays, line-breaks coinciding with phrase boundaries where possible. Contexts were split only if the sentences were long enough to warrant this, otherwise they were presented in one display. Presentation time per display was 2 seconds. After the stimulus displays, subjects were asked to give a yes / no coherence judgment for the critical trials and to indicate whether the letter case pattern was the same or different between context and target in the control trials. Total time per trial was 20 seconds, and 12 subjects were tested.

After ascertaining that the control condition was felicitous as a baseline (there was no activation in the visual control cortex after subtracting the baseline from the language trials), Ferstl & von Cramon first compared the cohesive to the non-cohesive conditions. Apart from bilateral activation in the vicinity of the frontal eye fields (BA 6), which Ferstl & von Cramon attributed to the fact that the cohesive trials were one word longer than the non-cohesive trials, there was no activation found.

A comparison of the coherent to the incoherent conditions produced the unexpected result of the coherent, not the incoherent, condition showing greater activation in two areas of the median wall of the left hemisphere. There was activation in posterior cingulate and inferior precuneal areas (BA 31 and BA 23). The much more prominent anterior activation was located in BA 9 and 10, the anterior-most extension of the frontomedian area that was activated in all language conditions. The interaction between coherence and cohesion yielded activation in BA 44 (Broca's Area) for the two conditions thought to be more difficult, i.e. coherent / noncohesive and incoherent / cohesive.

A comparison of the two coherent conditions showed small activations for the coherent / cohesive condition in the left supramarginal gyrus (BA 40) and the intraparietal sulcus (BA 39/7). For the incoherent trials, the cohesive condition yielded activation in the left inferior frontolateral cortex. Ferstl & von Cramon concluded that the significant interaction between coherence and cohesion was due to added processing demands (the misleading cohesion) in the incoherent / cohesive condition.

Additional analyses of homologous left- and right-hemispherical Regions of Interest confirmed that the activation in the left hemisphere was significantly greater than in the right hemisphere. The effects for coherence were also shown to be mainly driven by activation in the frontomedian wall of the left hemisphere.

Ferstl & von Cramon did not find evidence for special involvement of the right hemisphere in inference processes which has been found in other studies (St. George, Kutas, Martinez & Sereno, (1999), among others). They attributed this to the fact that their material did not contain confusing or erroneous material that was not task-relevant: the subjects were never at a loss about 'what to do' with the incoherent material, and Ferstl & von Cramon propose that the resources in the right hemisphere are only activated under such circumstances. Speculatively, the task-relevance of incoherence might also account for the overall greater activation for coherent instead of for incoherent trials. As soon as the incoherence was diagnosed, there was no further work needed, such as the construction of a situation model. Ferstl & von Cramon confirmed with the coherent conditions that the posterior cingulate and adjacent precuneal areas in the left hemisphere are involved in these processes.

More interestingly for present purposes, Ferstl & von Cramon showed that cohesion in general is taken seriously by the language processor: there was significantly more activation for the incoherent / cohesive condition than the incoherent / noncohesive condition, reflecting added processing costs.

In sum, the three studies discussed here show that connective ties and cohesion do have an effect on language processing. More specifically, connective ties are taken as an explicit hint to how the discourse is to be 'put together'. A violation of such a clue is costly (Ferstl & von Cramon, 2001). The results reported by Münte, Schiltz & Kutas (1998) suggest that the information provided by temporal connective ties can be made use of immediately, in this case for task-relevant demands. Baggio additionally showed that the processing of temporal connective ties is sensitive to their fit into underlying causal relations.

VIII.1. ASPECTS TO BE EXAMINED 3

This section again has the function of integrating 'new' results into the questions asked, reformulating those for which at least partial answers have been found, and determining which questions are still open. As before, 'old' questions are marked with '•', (partial) answers with '3', and new, revised or still unanswered questions with '**?**'.

General questions

Questions common to all experiments were:

- Can empirical evidence be found for the theoretical distinction between connective ties and other elements that can occupy the same syntactic position, namely one-place (deictical) sentential adverbs (experiments 1, 2 and 3)?

✓ It appears that *in general*, connective ties have a distinct influence on language processing, their inclusion in discourses resulting in more coherent text representations.

? It is still not clear whether this supporting influence extends to (deictical) sentential adverbs as well, or if two-place adverbial connective ties play a role distinct from on-place 'discourse operators'.

- Secondly, does the semantic content of the connective ties play a primary role, i.e. is the major distinction to be made indeed between 'connective' and 'non-connective' or instead between causal, temporal and concessive (experiments 3 and 4)?

✓ It seems that readers do attempt to connect two sentences in the form that the connective tie suggests. Baggio's (2004) as well as Murray's (1997) data shows that mismatches between the connective tie and the underlying relation result in processing difficulties.

? Again, it is not clear whether it is the semantic dimension (causal, temporal or concessive) playing the primary role, or the connective / non-connective aspect.

? It is still unclear *when* precisely the information provided by connective ties is used: there is some evidence that connective ties can have an immediate influence on the integration of subsequent elements (Münte, Schiltz & Kutas, 1998), but the end of the internal argument appears to play an important role as well. Experiments 2, 3, and 4 use ERPs to examine whether there is an immediate difference between connective ties and deictical sentential adverbs (experiments 2 and 3), and between different types of connective ties (experiments 3 and 4), as well as whether the integration of subsequent elements in connective discourses differs from non-connective discourses, in coherent as well as incoherent discourses.

Causal connective ties versus non-connective elements

In experiments 1 and 2, the causal connective ties *deshalb* and *darum* are compared to temporal deictical non-connective elements (*gestern* and *vorhin*: *yesterday* and *just now*) in

causally related and incoherent discourses. Experiment 1 employs a self-paced sentence reading time paradigm and experiment 2 uses the ERP-method. The question examined in both experiments, in addition to the first general question, is:

- What is the effect of a connective tie in incoherent discourses, where a causal connective tie signals a relation that is not present? A non-connective element would not enforce such a relation here. In other words: can evidence be found that causal connective ties do indeed enforce a causal relation?

✓ I has been shown that in unrelated (incoherent) discourses, cohesion is a hindrance, making processing difficult (Ferstl & von Cramon, 2001).

? Whether this is true for connective ties compared to deictical sentential adverbs will be examined in experiment 1. Whether processing difficulties manifest themselves on immediately subsequent elements after a violating connective tie, i.e. before the end of the sentence and the presence of the entire internal argument, will be examined in experiment 2.

Causal versus temporal connective ties versus non-connective elements

In experiment 3, the temporal (*danach* and *hinterher*) and causal connective ties (*deshalb* and *darum*) were compared to each other and to temporal (*gestern* and *vorhin*) and non-temporal non-connective elements (*gern* and *lieber*: *gladly* and *rather*), all in coherent, causally-, and thereby also temporally related situations. The questions examined with ERPs in this study in addition to all general questions are:

- Is there a difference between causal and temporal connective ties in situations where both types of connective tie are felicitous?

✓ The studies by Townsend (1983) suggest that in such discourses there is no overall difference between the two types of connective ties. The methods used by Townsend, however, provided data pertaining to the finished text representation, not the processing of the connective ties themselves.

? Therefore, experiment 3 examines whether the processing of the connective themselves and the integration of words subsequent to the connective ties also does not differ as a function of the temporal or causal connective tie.

? If there is no difference between the connective ties, is the relevant distinction between connective and non-connective elements, i.e. do both types of connective ties differ in the same way from temporal and non-temporal sentential adverbs? This would suggest that foregrounding either of the two dimensions present in causally related situations is indeed felicitous.

? If there is an immediate difference between temporal and causal connective ties, do temporal connective ties pattern with temporal non-connective elements, i.e. is the relevant distinction the one between causal and temporal semantic content?

Causal versus concessive connective ties

In the last experiment (4), causal connective ties (*deshalb* and *darum*) were compared to concessive connective ties (*trotzdem* and *dennoch*) in causally related situations. The outcome denoted in the second argument was either probable or improbable. Causal connective ties were felicitous with the probable outcomes, while concessive connective ties were compatible with the improbable outcomes. The relevant questions, in addition to the last two general questions, were:

- Is there a difference between causal and concessive connective ties?

✓ The data by Millis & Just (1994, their experiment 4) suggests that there is no difference between causal and concessive connective ties. However, Millis & Just do not discuss or display separate analyses for causal and concessive connective

ties. The data by Caron, Micko & Thüring (1988, experiment 3) and Townsend (1983) as well as Murray (1997) suggest on the other hand that there is a difference between causal and concessive connective ties. Münte, Schiltz & Kutas used complex sentences starting with *because* and *although* as filler material, but do not report any analysis on their distractors.

? Therefore, this question remains unanswered, and will be examined in experiment 4.

? Is there evidence that causal and connective concessive ties are indeed found in complementary distribution in causally related discourse?

? If concessive connective ties 'select' unusual and surprising outcomes, is this selection process initiated on the connective tie itself, i.e. do concessive connective ties trigger an immediate update of the current situation model?

? What happens if the end of the scale included in the internal argument is 'the wrong one'? Is the reaction equivalent to incoherent discourses for causal connective ties?

PART D: EXPERIMENTAL PART

IX. THE EXPERIMENTS

IX.1. EXPERIMENT 1: PILOT STUDY

IX.1.1. Questions

It has been shown in a number of studies that the presence of connective ties in coherent discourses aids in the drawing of a bridging inference and thereby in establishing a coherent text representation and situation model (Haberlandt, 1982; Townsend, 1983; Caron, Micko & Thüring, 1988; Ferstl & von Cramon, 2001), while it hinders the detection of coherence breaks in incoherent sentence pairs (Murray, 1997; Ferstl & von Cramon, 2001). In other words, there is evidence that the semantic content of connective ties is taken at face value, that the type of inference a connective tie signals is the one assumed to exist between the two arguments of a connective tie.

There is a general consensus that bridging inferences, connections between two adjacent sentences, are made obligatorily in language processing and that causal relations play an important role in the drawing of such inferences (McKoon & Ratcliff, 1992; Graesser, Singer & Trabasso, 1994). On the other hand, Fletcher, Chrysler, van den Broek, Deaton & Bloom (1995) have shown that causal inferences are not necessarily made outside the domain of narrative texts if there are no explicit instructions to make a causal connection.

It has also been proposed in chapter III (Pasch, Braußе, Waßner, & Herrmann, 2003) that there is a qualitative difference between adverbial connective ties and sentential (deictical) adverbs, since connective ties can explicitly connect two sentences, which sentential adverbs can not. This difference, if present, should be apparent in a direct comparison of the processing of connective versus non-connective two-sentence discourses.

The purpose of this first study was to determine if the effects found in their pilot study by Ferstl & von Cramon (2001, chapter VI) could be reproduced with the by necessity rather more monotone stimulus material design demanded by ERP studies, and to examine whether deictical elements do indeed not behave like connective ties and can therefore serve as a contrast element to the connective ties in the ERP stimuli. Only one type of connective tie was examined in this study, namely causal connective ties.

IX.1.2. Stimulus materials

The stimulus materials for this study had the following pattern:

32 causally related context-target discourses were constructed. The target sentences appeared in two versions: once with one of the two causal connective ties *deshalb* or *darum* as initial word (*therefore* or -more colloquially- *that's why* in English), and once with one of the deictical sentential adverbs *gestern* or *vorhin* (*yesterday* and *recently*, both referring to a point in time in the past) as first word, as shown in Table IX-1. The incoherent conditions were produced by switching the contexts of two coherent blocks of lexical material, analogous to the strategy used by Ferstl & v. Cramon (2001). There were a total of 128 sentence pairs, with 32 pairs for each of the four conditions connective coherent (A), non-connective coherent (B), connective incoherent (C) and non-connective incoherent (D). The complete list of materials used for this study can be found in Appendix A.

Context	**Der Herd war kaputt**. *The stove was broken.*
Coherent targets	
A connective target	**Deshalb machte Berta Rohkost zum Abendbrot**. Therefore made Berta crudités for dinner.
B non-conn. target	**Gestern machte Berta Rohkost zum Abendbrot**. Yesterday made Berta crudités for dinner.
Incoherent targets	
C connective target	**Deshalb kaufte Klaus Dünger im Baumarkt**. Therefore bought Klaus fertilizer at the hardware store.
D non-conn. target	**Gestern kaufte Klaus Dünger im Baumarkt.** Yesterday bought Klaus fertilizer at the hardware store.

Table IX-1: Example of stimulus materials used in experiment 1.

All target sentence had the same syntactic structure, as shown below:

1.	Deshalb	machte	Berta	Rohkost	für das Abendbrot.
	conn/ non-conn element	V	Name	Obj	PP.

The two connective elements and the two non-connective elements were combined in all four possible variations over the 32 blocks of lexical material, each variation occurring equally often. Since it has been found that a reading time effect may occur not on the target itself, but one element 'down the line', an additional sentence was constructed. This addition was meant as an extension of the target, so the content was always coherent with the target. The additional sentences for the example above are shown in Table IX-2:

Additions	
for coherent targets	**Das Essen war lecker.** *The food was tasty.*
for incoherent targets	**Die Tüte war schwer.** *The bag was heavy*.

Table IX-2**:** Extensions for coherent and incoherent targets.

The study was designed as a self-paced sentence-reading design with a sentence match as additional task for the subjects. This task was chosen to ensure that reading time effects found were due only to the differing connectivity and coherence of the stimuli, and not to a strategic diagnosis of coherence or incoherence, as possible rehearsal processes for the target or the extension should be present in all four conditions. As a match either the target itself or the extension was presented again, either exactly the same or with one word

altered, namely a noun, verb or adjective, equally distributed across all conditions, but never the connective tie. The altered match stimuli for the coherent material in Table IX-1 and Table IX-2 are shown in Table IX-3, words altered for this trial are underlined:

Match sentences for the targets	
for connective targets	**Deshalb machte Berta <u>Salat</u> zum Abendbrot**. Therefore made Berta salad for dinner.
for non-conn. targets	**Gestern machte Berta <u>Salat</u> zum Abendbrot.** Yesterday made Berta salad for dinner.
Match sentences for the extensions	
coherent targets	**Das Essen war <u>fade</u>.** The food was tasteless.
incoherent targets	**Die Tüte war <u>riesig</u>.** The bag was huge.

Table IX-3: Sentence match: Altered match stimuli.

IX.1.3. Hypotheses and predictions

Since the measurement used was sentence-reading time, there can be no predictions made as to the time-course of the processing of connective ties. The experiment investigates the general interaction between causal connective ties and coherence, and the influence of a relatively shallow sentence matching task on the proposed automatic and obligatory character or the drawing of bridging inferences. Keeping that in mind, the hypotheses for this first experiment are the following:

I. **The context**: The connective ties were the first element of the targets, i.e. sentence-initial to the second sentences in each trial. Therefore no systematic effects for the context sentences, first in each trial, should be found, since the context sentences were identical between conditions for each block of lexical material, and provided no information as to which condition was to follow.

II. **Coherence**: The coherent conditions should make an automatic causal inference and a coherent text representation possible, while the incoherent conditions were causally unrelated. Therefore, the incoherent conditions should yield longer reading times and longer reaction times and possibly higher error rates than the coherent conditions.

III.a. **Connectivity; coherent conditions**: If connective ties aid in establishing coherence, while deictical sentential adverbs do not do so, the reading- and reaction times for the connective coherent condition (A) should be shorter than the reading times for the non-connective coherent condition (B).

III.b. **Connectivity; incoherent conditions:** If connective ties hinder the in diagnosis of incoherence, i.e. if an attempt is made to connect two unrelated sentences according to the relation signaled by the connective tie, and this attempt is not made automatically for deictical sentential adverbs, then the reading and reaction times for connective incoherent trials (C) should be longer than the reading times for non-connective incoherent trials (D).

IV. **Automaticity of bridging inferences and task**: If the drawing of (causal) bridging inferences is obligatory and automatic, the relatively shallow task of a sentence match

should have no influence on the result pattern for the coherent conditions, contrary to the results reported by Fletcher, Chrysler, van den Broek, Deaton & Bloom (1995).

IX.1.4. Method

IX.1.4.1. Randomization and presentation

The 128 sentence pairs with extensions, 32 for each of the four conditions, were split into four lists such that only one sentence pair from each material block with the same context sentence was present in any one list. Each list contained 32 sentence pairs with extensions, 8 for each of the four conditions. The four lists were then mixed with 80 filler trials, arriving at a rate of about two filler trials to each critical trial. The resulting 112 trials per list were distributed over four experimental blocks of 28 sentences per list each, pseudo-randomized to assure that between 7 and 9 critical trials, of which between one and 3 critical trials were of each of the four conditions, occurred per experimental block. The four pseudo-randomized versions were then reversed, resulting in a total of 8 lists. The sentence matches were equally distributed over the lists as well, so that the same number of correct and incorrect target- and extension matches occurred per list, and so that no more than two consecutive trials had the same expected answer (correct or incorrect).

The experiment was programmed using ERTS (Experimental RunTime System, Version 3.05; Beringer, 1996), installed on an IBM-compatible Pentium I PC. Stimuli were presented self-paced sentence by sentence centered on a 17" Belinea Monitor, blue on a gray background. Eight practice trials were presented first to familiarize the subjects with the task. Figure IX-1 shows the time course of one trial:

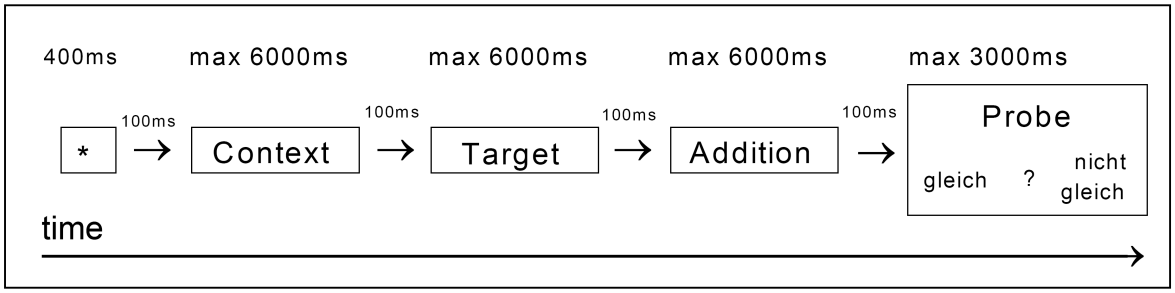


Figure IX-1: Trial structure for experiment 1.

Subjects read first the context, then the target, followed by the extension, each presented for maximally 6000ms or until the subject requested the next sentence in a trial by pressing the space bar. After subjects read the extension and pressed the space bar the match sentence appeared on the screen with the response picture underneath: '*GLEICH ? NICHT GLEICH*', (THE SAME ? NOT THE SAME). Subjects had 3000ms in which to respond by pressing either the left or the right shift-key. The orientation of the response picture was reversed for half of the subjects, equally distributed over experimental versions. If no response was registered within that time, the feedback '*Antwortzeit ist abgelaufen*', (Response time has passed) was displayed on the screen. No other feedback was given. Duration of the experiment was 40 minutes, including pauses between the four experimental blocks, the length of which was determined by the subjects.

IX.1.4.2. Subjects

48 students from Potsdam University, of whom 11 were male, participated in the study. Subjects were randomly assigned to one of the eight experimental versions, a total of six per version, so that every trial was read a total of twelve times. All had normal or corrected to normal vision and had learned German as their only first language. Their ages were between 19 and 30 years, mean age 23. Participation was paid either with 5 Euro or with course credit.

IX.1.4.3. Statistical analysis

The behavioral data was evaluated using the Statistical Package for Social Sciences (SPSS), Version 12.0 for Windows. Variance Analyses (ANOVAs) were performed for the error percentages as well as the reaction and reading times.

Error rates were calculated as the percentage of responses not in accordance with the expected response for each trial. Missed responses, i.e. no response within the time limit set were counted as errors.

Reaction times and reading times were evaluated on the basis of correct responses only. The percentage of trials excluded for experiment 1 is equivalent to the error percentages.

The statistical evaluation for experiment 1 was done using a 2-by-2 design with the factors coherence (2 COHER: coherent versus incoherent) and connectivity (2 CONN: connective versus non-connective), as shown in Table IX-4:

		Coherence (COHER) coherent	incoherent
Connectivity (CONN)	connective	**(A) conn coher**	**(C) conn incoher**
	non-connective	**(B) non-conn coher**	**(D)non-conn incoher**

Table IX-4: ANOVA design for statistical evaluation of experiment 1.

Except in the case of specific hypotheses the procedure for statistical analysis was strictly hierarchical. This means that interactions were resolved only in those cases were superordinated interactions were at least marginally significant ($p < .10$). Main effects were only interpreted if no significant interaction involving that experimental factor was present and if the effect was significant with $p < .05$. Single comparisons between conditions were calculated with an F-statistic (one-factorial ANOVA with two levels).

IX.1.5. Results

IX.1.5.1. Reading times

Shown in Figure IX-2 are three bar graphs displaying the reading times for the contexts, the extensions, and the targets in ms:

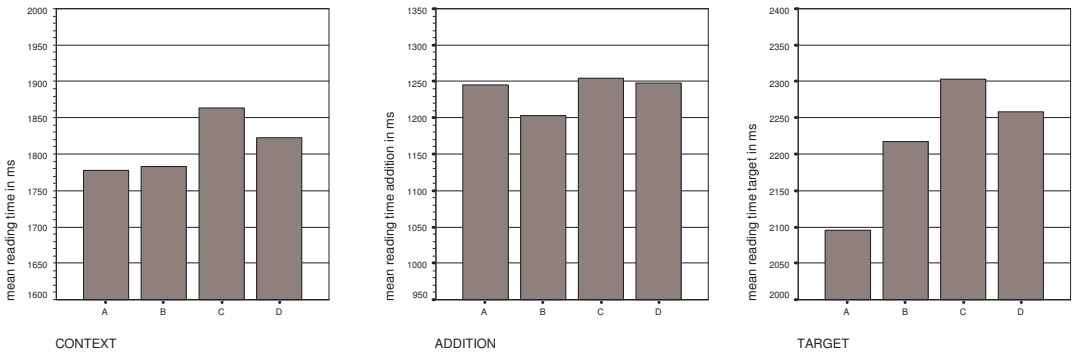


Figure IX-2: Mean reading times in ms for the context, addition, and target, exp. 1. N = 48.

Table IX-5 shows the mean reading times and standard deviations (in ms) for the context, target and additions:

	context (reading times in ms)		**target** (reading times in ms)		**addition** (reading times in ms)	
condition	**mean**	**std.**	**mean**	**Std.**	**mean**	**std.**
A: conn coher	1778	500	2095	598	1245	318
B: non-conn coher	1782	464	2217	636	1203	302
C: conn incoher	1864	566	2304	696	1255	335
D: non-conn incoher	1883	510	2259	620	1248	326

Table IX-5: Means and standard deviations for the context, target and additions. N = 48.

Analysis of the reading times for the context with the ANOVA design showed no significant effects or interactions ((COHER ($F(1,47)=3.1$, $p=.1$), CONN ($F(1,47)<1$), COHER x CONN ($F(1,47)<1$)).

Analysis of the reading times for the extensions following the target showed no significant effects or interactions (all $p>.2$).

Analysis of the reading times for the target yielded a significant effect for coherence ($F(1,47)=12.96$, $p=.001$), due to shorter reading times for the coherent conditions compared to the incoherent conditions. There was no effect for connectivity ($F(1,47)=1.91$, $p>.15$), but an interaction of coherence with connectivity (COHER x CONN ($F(1,47)=7.96$, $p<.05$)).

This interaction was resolved by examining single comparisons.

The comparison A versus B (connective coherent versus non-connective coherent) showed a significant effect for connectivity (CONN ($F(1,47)=11.65$, $p=.001$), due to shorter reading times for connective coherent trials compared non-connective coherent trials. The comparison C versus D (connective incoherent versus non-connective incoherent) did not show an effect for connectivity ($F(1,47)=1$). The main effect for connectivity in the global

analysis was therefore due to the difference between the connective and non-connective condition in the coherent trials.

Comparison of conditions A and C (connective coherent versus connective incoherent) yielded a significant effect for coherence COHER ($F(1,47)=19.61$, $p<.001$), due to shorter reading times for connective coherent compared to connective incoherent trials. The comparison B versus D (non-connective coherent versus non-connective incoherent) did not show an effect for coherence ($F(1,47)<1$).

IX.1.5.2. Sentence match

Figure IX-3 shows the reaction times on the sentence match in ms and the error rates on the match in percent. Averaging over only the four experimental conditions and not separating additionally by probe type (target or additional sentence) and whether or not the match was indeed a match or slightly altered was possible, since match type and response type were equally distributed over the four experimental conditions.

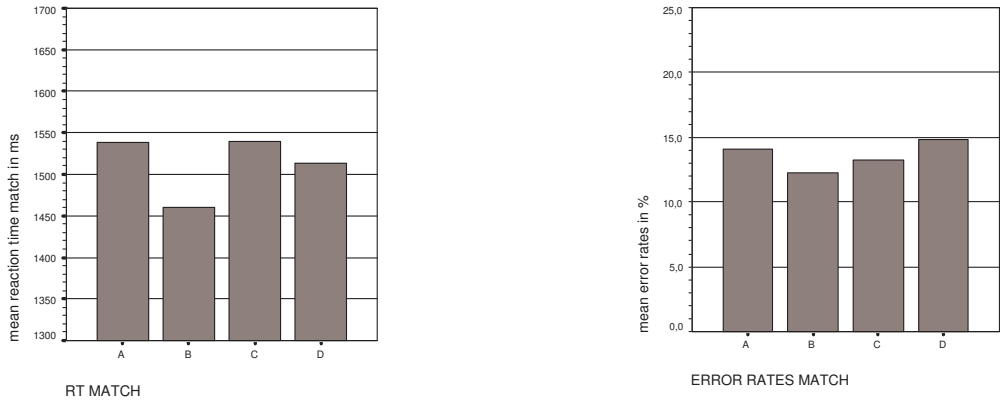


Figure IX-3: Mean reaction times (ms) and error rates (%) for sentence match. N = 48.

Table IX-6 shows mean values and standard deviations for the reaction times (in ms) and error rates (in percent) for the sentence match task:

	Reaction times match (in ms)		**Error rates match (in %)**	
condition	**mean**	**std.**	**mean**	**std.**
A: conn coher	1538	258	14.1	14
B: non-conn coher	1461	255	12.2	11.4
C: conn incoher	1539	264	13.2	13.5
D: non-conn incoher	1513	249	14.9	11.7

Table IX-6: Means and standard deviations, for the reaction times and error rates. N = 48.

Analysis of the reaction times for the match showed no effect for coherence ($F(1.47)=1.45$, $p>.2$), but a significant effect for connectivity CONN ($F(1,47)=7.82$, $p<.05$), reaction times for connective trials being longer than for non-connective trials. There was no interaction between coherence and connectivity ($F(1,47)=2.32$, $p=.14$). Analysis of the error rates showed no effects or interactions (all $F(1,47)<1$).

IX.1.6. Discussion experiment 1

First, there were no effects found for the reading times of the context sentences, showing that the manipulation was felicitous in that respect (hypothesis I). There were also no differences found for the reading times of the additional sentences, suggesting that processes of inference drawing between context and target and the influence of the connective ties were already concluded. Alternately, subjects very probably realized that the additions provided no further information, i.e. never resolved a possible prior coherence break between context and target. Consequently, they might not have paid closer attention to them than the sentence match task warranted. This explanation is the more probable, as the reaction times showed that connectivity did have an influence on the sentence match task, suggesting that not all inference processes were concluded.

Error rates on the sentence match were low (overall mean 13.2%), and did not differ between conditions, showing that the subjects' accuracy on the task was not influenced by the coherence or connectivity. It was postulated in hypothesis II that incoherence might lead to higher error rates, which was not the case.

The reading times showed the expected pattern, that of connective ties having a reliable influence on coherence, and of coherent trials yielding reliably shorter reading times than incoherent trials (supporting hypothesis II). This effect was due to the difference between the connective conditions A and C, not to an only descriptively present difference between the non-connective conditions. The reading times for the connective coherent condition (A) was reliably shorter than the reading time for the non-connective coherent condition (B), but the expected opposite effect, that of the connective incoherent condition (C) yielding longer reading times than the non-connective incoherent condition (D) was again only present descriptively (hypothesis III.a being supported and hypothesis III.b rejected).

It is assumed here that the sentence matching task did not trigger analysis processes beyond the automatic and obligatory ones, in contrast to the plausibility judgment used by Ferstl & von Cramon (2001). The different tasks were the only substantial difference between the two studies.

The lack of a difference between the incoherent conditions is hence likely to be an effect of the task. Ferstl & von Cramon used a plausibility judgment as a task, with the consequence that the diagnosis of (in)coherence was task-relevant. This diagnosis was not task-relevant in the present study, and therefore the hindering effect of a connective tie in an incoherent discourse did not have as much of an influence in this study as in Ferstl & von Cramon's. In other words, as soon as subjects realized that something was wrong, the automatic inferencing processes were most likely aborted, but in contrast to Ferstl & von Cramon's study there was no conscious reanalysis triggered to make sure that the discourse was indeed incoherent. This explanation is supported not only by the fact that Ferstl & von Cramon *did* find reliable differences between incoherent conditions in their study, and the present study did not. Ferstl & von Cramon did also *not* find reliable differences between the coherent conditions, which this study did. Subjects in this study did not have to make sure that the coherent discourses were coherent, and therefore the influence of the connective ties in these discourses was not overlaid by the task-induced process of 'double-checking' the coherence of the non-connective coherent trials.

The reaction-time data for the sentence match showed that reaction times for connective trials were longer than for non-connective trials, and that coherence had no influence on this effect. These –at first glance surprising –results can be interpreted as follows. If only automatic processes were accessed, then the presence of a connective tie must have triggered processes beyond inferencing (present in all conditions) that were not concluded

by the time the sentence match task 'came around', and which thereby intruded on the task. The most likely candidate for such processes is the influence of the connective ties on the underlying discourse relation and the felicity of the resulting text representation.

In sum the present data supports the following conclusions:

a. Causal connective ties have an aiding influence on automatic causal inference processes in coherent discourses, as previously concluded by Townsend (1983) and Caron, Micko & Thüring (1988).
b. Deictical sentential adverbs do not have that supporting influence, are therefore non-connective and can serve as contrast elements to connective ties in ERP studies.
c. The drawing of causal bridging inferences is indeed an obligatory and automatic process (this being evidence against Fletcher et al.'s conclusion that causal relations are not necessarily kept track of outside narrative text, and supporting the event-indexing model (Zwaan, Langston & Graesser, 1995, Zwaan, Magliano & Graesser, 1995, see also Zwaan & Radvansky, 1998), as well as both the inference models proposed by McKoon & Ratcliff (1992) and Graesser, Singer & Trabasso (1994) but:
d. The diagnosis of incoherence is not automatic and obligatory, and an attempt to integrate an incoherent sentence into the text representation (an elaborative inference) is not made, regardless of the presence of a connective tie, if not task-relevant.

Taking the present data together with the results by Ferstl & von Cramon, it can also be concluded that the information (causal) connective ties provide is made use of by default in the construction of a text representation and situation model.

IX.2. EXPERIMENT 2

IX.2.1. Questions

Experiment 2 was designed to investigate the time-course of the processing of causal connective ties. Prior evidence from self-paced reading studies (Haberlandt, 1982; Millis & Just, 1994), as well as eye-tracking studies (Traxler, Bybee and Pickering, 1998), discussed in chapter VI and ERP studies (Münte, Schiltz & Kutas, 1998; Baggio, 2004, chapter VIII), have reported largely contradictory results, finding evidence that connective ties are processed immediately as well as evidence that the influence of connective ties expresses itself at the end of the discourse. Experiment 1 has shown that in coherent texts, the information provided by connective ties aids in the construction of a text representation at some point. Sentence reading times are however not the medium of choice for investigating incremental language processing within one sentence. In experiment 2 therefore, the design from experiment 1 was used, this time in an ERP study with visual word-by-word presentation.

IX.2.2. Stimulus materials

The stimulus materials used in the pilot study (experiment 1) were also used for experiment 2, with an additional 48 blocks of lexical material, making a total of 80 blocks or 320 sentence pairs of lexical material, each in the same four conditions as for experiment 1: connective coherent (A), non-connective coherent (B), connective incoherent (C) and non-connective incoherent (D), resulting in a total of 320 sentence pairs, with 80 pairs in each of the four conditions. Each connective tie resp. deictical sentential adverb also occurred a total of 80 times. In contrast to experiment 1, no extension or additional sentence after the target was included. An example block of lexical material is shown in table Table IX-7, the two critical words in each target, first word and object, underlined:

Context	**Der Herd war kaputt**. *The stove was broken.*
Coherent targets	
A connective target	**Deshalb machte Berta Rohkost für das Abendbrot**. Therefore made Berta crudités for the dinner.
B non-conn. target	**Gestern machte Berta Rohkost für das Abendbrot**. Yesterday made Berta crudités for the dinner.
Incoherent targets	
C connective target	**Deshalb kaufte Klaus Dünger in der Markthalle**. Therefore bought Klaus fertilizer at the store.
D non-conn. target	**Gestern kaufte Klaus Dünger in der Markthalle.** Yesterday bought Klaus fertilizer at the store.

Table IX-7: Example of lexical material used in experiment 2.

All target sentence had the same syntactic structure, as shown below:

2.	Deshalb	machte	Berta	Rohkost	für das Abendbrot.
	conn/ non-conn element	V	Name	Obj	PP.

Since it was crucial that there be only one particular word in the target sentence on which an incoherence could be diagnosed for certain, namely the object, and that there would be no possibility for the subjects to be sure whether a sentence pair was incoherent or not before this point, only 10 different verbs were used eight times each, all selected for being non-causal and semantically rather 'vanilla-flavored'. The list of verbs used is shown in example 3.

3. Verbs used in experiment 2

'beschaffte'	3rd pers. Pl., past tense;	***'got, procured'***
'machte'	3rd pers. Pl., past tense;	***'made, produced'***
'kaufte'	3rd pers. Pl., past tense;	***'bought'***
'verwendete'	3rd pers. Pl., past tense;	***'used'***
'besorgte'	3rd pers. Pl., past tense;	***'got, procured'***
'benutzte'	3rd pers. Pl., past tense;	***'used'***
'suchte'	3rd pers. Pl., past tense;	***'looked for'***
'wählte'	3rd pers. Pl., past tense;	***'chose'***
'bestellte'	3rd pers. Pl., past tense;	***'ordered'***
'organisierte'	3rd pers. Pl., past tense;	***'organized'***

Care was also taken to ensure that all context-target pairs were coherent without the sentence-final prepositional phrase, again to make the diagnosis of an incoherence only possible on the object. As with experiment 1, all possible combinations of one of the two connective elements with one of the two deictical elements was used equally often. Additionally, care was taken to distribute those combinations equally among the eight occurrences of each of the ten different verbs. The complete stimulus materials for experiment 2 can be found in Appendix B.

IX.2.3. Hypotheses and predictions

I. First of all, according to Friederici's (2002) model of language processing, incoherence should not be diagnosable in the first phase of processing. There are therefore no effects pertaining to the experimental manipulation prior to 200ms predicted.

Beyond that, there were three points of interest for experiment 2: The first word of the target sentence, the object of the target sentence and the sentence-final epoch (the prepositional phrase), which will be addressed in turn, the first word first.

II.a. **Connective versus non-connective elements:** If the information provided by connective ties is used immediately, there should be systematic differences between the connective and the non-connective conditions on the first word of the target sentences, with a latency corresponding to the second processing phase, namely 300+ms. As to the expected ERP-effect, possible choices are restricted to those not correlated to syntactic processing, since it is the semantic content of the connective ties that should have an influence and there were no syntactic manipulations,

ambiguities or violations. One possibility would be an N400, reflecting a more difficult semantic integration of the connective ties compared to the non-connective elements. The other option is a LAN. LANs have been found correlated with the processing of temporal connective ties (Münte, Schiltz & Kutas, 1998; Baggio, 2004), and with processes involving discourse-antecedents (see section VII.3.4). Since it has also been argued here that connective ties assign a role to their external argument, and this role had to be assigned 'retroactively' in the present experiment, incurring added processing cost, a LAN seems the more likely effect to be found.

II.b. ***Deshalb* versus *darum* and *gestern* versus *vorhin*:** Since both connective ties were causal adverbial connective ties, their semantics being compatible[66], they should not differ from each other. The two deictical elements should also not differ from each other, both denoting a point in time in the past.

III.a. **The object –Coherence:** The object is the first element in the target sentences on which a possible incoherence could be diagnosed. If an incoherence is present, the integration of the object should be difficult, as it constitutes a semantic / pragmatic violation in the discourse. Semantic violations in discourse have been found to be correlated with a larger N400 on the violating element (see section VII.3.2), which consequently is the effect predicted for the objects in incoherent target sentences. It is important to note that the target sentences in and of themselves were semantically perfectly felicitous. A semantic violation was present only if subjects attempted to integrate the two sentences into a discourse representation incrementally.

III.b. **The object –Connectivity:** If connective ties influence the semantic expectancy of subsequent elements in the sentence, as is postulated by defining causal connective ties as choosing likely outcomes of a situation and excluding other possible outcomes (section III.4.1), the N400 for the object should also be modulated according to the presence or absence of a connective tie: it should be larger for connective incoherent targets compared to non-connective incoherent targets, as the connective tie here signals a relation that is not present, which a deictical element does not. Conversely, in the coherent conditions, the N400 for the object in the non-connective condition should have a larger amplitude than the N400 for the connective condition, as the supporting influence of the connective ties is not present in the non-connective condition.

IV. **Sentence-final integration processes**: It has been found in previous studies that violations elicit negativities on the sentence-final element, even if the violation occurred prior to this word (Frisch, 2000, see also section VII.2.3.2). Osterhout (1997) proposed that these ERP-effects reflect the increased difficulty (or inability) to construct an integrative, 'message-level' semantic representation of the sentences. For the incoherent conditions in the present study, this difficulty would result not from the current sentence, but the entire text representation and the situation model. Negativities on sentence-final elements have been found in ERP-studies of discourse (Ditman, Holcomb & Kuperberg, 2005). A sentence-final negativity is hence predicted for those conditions in which the construction of a situation model (the 'message-level' semantic representation) is difficult or impossible, namely the incoherent conditions. It is also possible that this sentence-final negativity is influenced by the presence of a connective tie in a way analogous to the N400 for the object of the target sentences. If connective ties aid in the construction of a situation model in coherent discourses, and hinder that process in incoherent discourses, the

[66] German dictionaries list *deshalb* as a synonym for *darum* and vice versa.

effect should be smallest for the connective coherent condition (A), and successively larger for the non-connective coherent condition (B), the non-connective incoherent condition (C), and largest for the connective incoherent condition (D).

IX.2.4. Method

IX.2.4.1. Randomization

The 320 sentence pairs described above were distributed over two stimulus lists, each with a total of 160 sentence pairs, 40 pairs for each of the four conditions. The similar lexical material of one stimulus material block was split among the two lists, such that only two sentence pairs - in all possible combinations of the four conditions in groups of two - of one stimulus material block were in any one list, i.e. such that no subject read all four sentence pairs of one lexical block.

Each list of 160 sentences was then pseudo-randomly split into four experimental blocks of 40 sentences each, such that the four conditions occurred roughly equally often in each of the four experimental blocks (between 9 and 11 times per condition per 40-sentence block). There was a gap of minimally 40 trials between sentence pairs with the same lexical material in the context or the target. The sentence pairs within one experimental block were also pseudo-randomized, such that no more than two sentence pairs of the same condition, and no more than three either coherent (conditions A and B) or incoherent (C and D) sentence pairs were presented in a row, to avoid effects of familiarization.

The two lists of four experimental blocks each were then reversed, resulting in four versions.

IX.2.4.2. Presentation

All sentence pairs were presented in light gray on a dark blue background in a phrase-by-phrase fashion (NPs and PP together) with a fixed presentation time of 450ms and an inter-stimulus interval (ISI) of 100ms. All stimuli were centered on a 19” Belinea Monitor.

Both the context sentence and the target were preceded by a fixation point: '*' for the context and '+' for the target, each presented for 1000ms and followed by a pause (blank gray screen) of 500ms. There was a pause of 1000ms between context and target. After the last word of the target sentence there was a pause of 500ms, followed by the response picture showing the word '*sinnvoll'* ('makes sense') on one side of the screen and '*sinnlos'* ('makes no sense') on the other, equidistant to a question mark in the middle. The response picture was presented until the subject gave an acceptability judgment per button press, maximally 3000ms. If the subject did not respond within 3000ms, a feedback picture ('*Antwortzeit ist abgelaufen*', response time has passed) was presented. No other feedback was given. The orientation of the response picture (*sinnvoll* on the left or the right) was varied between subjects, equally distributed across experimental versions. 1000ms after the subjects' button press, or 1000ms after the maximum response time the fixation star for the next trial was shown. Figure IX-4 shows the time course of the target sentences:

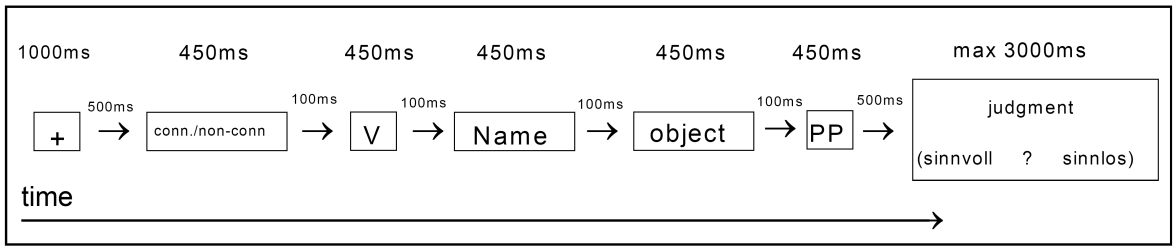


Figure IX-4: Time course of presentation for target sentences in experiment 2.

Subjects were instructed not to move and only to blink between trials. At the beginning of the experiment 12 practice trials were shown to familiarize subjects with the presentation, the task and the 'blinking routine'. After the practice trials the four experimental blocks were presented. There were pauses between the blocks, the length of which were determined by the subject, although a minimum length of one minute and a maximum length of five minutes was ensured. Total on-task time for the subjects was between 45 and 55 minutes, duration of the entire experiment was one and a half hours, maximally two hours.

IX.2.4.3. Subjects

28 subjects, 9 of whom were male, ranging in age between 20 and 34 years (mean age 24.0) participated in the experiment. None had participated in experiment 1. All were right-handed, had reported no left-handed immediate family members, had normal or corrected-to-normal vision and had learned German as their only first language. Participation was paid either with 15 Euro (E 7.50 per hour) or with course-credit. Subjects were assigned to one of the four experimental versions pseudo-randomly (the male subjects were purposely assigned), so that each version was used six times.

IX.2.4.4. EEG- and data recording

The following procedure for data recording was used for all three ERP-experiments.

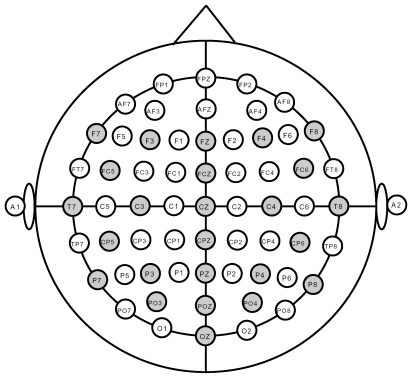


Figure IX-5: Electrode positions according to the extended 10-20 system. Positions used in the studies presented here are shaded gray.

The EEG was recorded with shielded AgAgCl-Electrodes fixed in elastic caps (EasyCap) from the following positions according to the American Electrographic Society's extended 10-20-System (Sharborough et al., 1991): F7, F3, FZ, F4, F8, FC5, FCZ, FC6, T7, C3, CZ, C4, T8, CP5, CPZ, CP6, P7, P3, PZ, P4, P8, PO3, POZ, PO4, and OZ, see also Figure IX-5. C2 was used as ground electrode. The mastoids (A1 and A2) were used as reference electrodes, with A1 serving as reference during recording. After recording the data was re-referenced over the mean of A1 and A2 (linked-mastoid rereference). Eye artifacts were recorded with an electrooculogram (EOG): two electrodes were fixed at the outer edges (canthus) of

the left and right eyes to record horizontal eye-movements (EOGH), and two electrodes were fixed above and below the right eye to record vertical eye movements (EOGV). All impedances were brought and kept below 3kΩ during recording. The data from all channels was recorded with a 32-channel PORTI-32/MREFA TMS-Amplifier and digitalized at 250Hz, while subjects were seated in a separately grounded SIEMENS pure-iron shielding cabin. No online filters were used during recording. Data was recorded on an IBM-compatible Pentium I using Xrefa (Novagk, 1998). Stimulus presentation and marking of relevant points (setting of triggers) was done with ERTS (Experimental Run Time System, Beringer, 1996), installed on an IBM-compatible Pentium PC connected to the EEG-recording PC. Subject responses were recorded with the ERTS ExKey Keyboard Logic System (BeriSoft Corporation, Beringer, 1996).

IX.2.4.5. Data preparation

The method of data analysis described below was applied to all three EEG experiments, varying only with respect to the choice of experimental factors used in the ANOVAs and the time windows chosen for analysis.

Behavioral data

Error rates were calculated as the percentage of responses not in accordance with the expected response for each trial. Missed responses, i.e. no response within the time limit set were counted as errors.

Reaction times were evaluated on the basis of correct responses only. The percentage of trials excluded for evaluation of the reaction times corresponds to the error percentages.

EEG data

The EEG-data was processed using the EEProbe software package (version 3.1-9, © Max-Planck-Institute of Cognitive Neurosciences ANT Software b.v.) for Linux.

Only artifact-free trials with correct responses were included in the analyses. Subjects whose data sets contained less than a minimum of 55% artifact-free trials with correct responses for one or more conditions were excluded from the analysis. Artifacts were excluded first automatically and then scanned again by hand by the author. Automatic rejection used the Standard-Deviation rejection method with a sliding window of 200ms: all trials where either the EOGH or the EOGV channel deviated by more than 40μV from the sliding-window mean were excluded.

The critical epochs were averaged by condition by electrode, first for each subject separately and then over all subjects. The time window from –200 to 0 ms relative to the onset of the critical stimulus was used as a baseline.

There were two grand-averages calculated for experiment 2. The first was time-locked to the onset of the first word of the target sentences with an epoch of 1500ms included (the first word, the verb and the beginning of the proper name). EEG-epochs for this average were sorted according to the first word, namely *deshalb*, *darum*, *gestern* and *vorhin*. The totals of trials per condition excluded due to incorrect responses or artifacts from this lexical average were: 10.5% for the condition *deshalb*, 7.9% for the condition *darum*, 11.0% for the condition *gestern* and 8.7% for the condition *vorhin*, overall mean 9.5%.

The second grand average was time-locked to the onset of the object of the target sentence, also with a duration of 1500ms, encompassing the object, the prepositional phrase, and the post-target pause until 150ms before the presentation of the response picture. EEG epochs were sorted according to the conditions A through D. The totals of trials per condition excluded from the object average due to incorrect responses or artifacts were: 15.9% for condition A, 16.1% for condition B, 14.6% for condition C and 12.2% for

condition D, overall mean 14.7%. No subjects were excluded from evaluation, as all 28 recorded data sets contained at least 55% artifact-free trials with correct responses for each of the conditions under examination.

For presentation a 9Hz lowpass filter was applied to the grand-averages; the statistical analyses were performed on the unfiltered data.

IX.2.4.6. Statistical analysis

The behavioral data was evaluated using the Statistical Package for Social Sciences (SPSS), Version 12.0 for Windows. Variance Analyses (ANOVAs) were performed for the error percentages as well as the reaction times.

EEG data was evaluated using the SAS System for Windows, release 8.02. Variance Analyses (ANOVAs) were performed for amplitude means by time window by condition. Time windows for analyses were determined on the basis of previous studies and visual inspection. Except in the case of specific hypotheses the procedure for statistical analysis was strictly hierarchical. This means that subordinated interactions or main effects were resolved only in those cases were superordinated interactions were at least marginally significant ($p < .10$). Main effects were only interpreted if no significant interaction involving that experimental factor was present and if the effect was significant with $p < .05$. Single comparisons between factorial levels or conditions were calculated with an F-statistic (one-factorial ANOVA with two levels). Calculations of effects with factors involving more than one degree of freedom were corrected using the Huyn & Feldt method (1970). As they were not of interest, main effects for topographical factors or interactions between such are not reported.

The statistical evaluation for the time-window of the first word of the target sentence (the two connective ties respectively deictical elements) in experiment 2 was done using a 2-by-2 design with the factors connector (2 CONN: connective versus non-connective) and item (2 ITEM: *deshalb* versus *darum* and *gestern* versus *vorhin*), as shown in Table IX-8:

		Item (ITEM)	
Connector (CONN)	connective	**deshalb**	**darum**
	non-connective	**gestern**	**vorhin**

Table IX-8: ANOVA Design for the experimental factors, first word, experiment 2.

Since the point of including the factor ITEM was to determine whether the two connective ties respectively the two deictical elements indeed behaved the same, only those two comparisons, i.e. *deshalb* versus *darum* and *gestern* versus *vorhin* were calculated, and only reported if the superordinated interaction of CONN x ITEM was at least marginally significant.

The statistical evaluation for the object time-window in experiment 1 was done using a 2-by-2 design with the factors coherence (2 COHER: coherent versus incoherent) and connector (2 CONN: connective versus non-connective), as shown in Table IX-9.

		Coherence (COHER)	
		coherent	incoherent
Connector (CONN)	connective	**(A) conn coher**	**(C) conn incoher**
	non-connective	**(B) non-conn coher**	**(D)non-conn incoher**

Table IX-9: ANOVA Design for the experimental factors, object, experiment 2.

Analyses of the ERP data was done separately for the lateral electrodes and the midline.

For the statistical analysis of the lateral electrodes for ROIs (regions of interest) were defined: left anterior, right anterior, left posterior and right posterior. Table IX-10 and Figure IX-6 show the defined ROIs and the electrodes used:

	left hemisph. left anterior	**right hemisph.** right anterior
Anterior	**F7, FC5, F3**	**F4, FC6, F8**
Posterior	left posterior **P7, CP5, P3**	right posterior **P4, CP6, P8**

Table IX-10**:** Lateral Regions of Interest (ROIs)

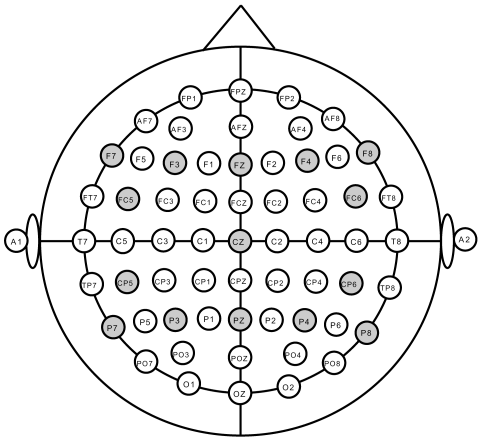


Figure IX-6: Electrode positions used for Statistical Analysis (shaded gray).

For the analysis of the midline the electrodes FZ, CZ and PZ were included. The topographical factors used for the lateral analyses were region (2 REG: Anterior and Posterior) and hemisphere (2 HEMI: left- and right- hemispherical). The two levels of the variable Region included six anterior and six posterior electrodes, the two levels of the variable Hemisphere included six left- and six right-hemispherical electrodes, thereby completely crossing the factors region and hemisphere (see also Table IX-10).

- The ANOVA design for the lexical average (the first word) of the lateral electrodes was **REG (2) x HEMI (2) x CONN (2) x ITEM (2).**
  The topographical factor for the midline was electrode (ELEC: FZ, CZ, PZ), resulting in an ANOVA design of **ELEC (3) x CONN (2) x ITEM (2)** for the first word.

- The ANOVA design for the object window of the lateral electrodes was **REG (2) x HEMI (2) x COHER (2) x CONN (2)**.
  The topographical factor for the midline was electrode (ELEC: FZ, CZ, PZ), resulting in an ANOVA design **ELEC (3) x COHER (2) x CONN (2)** for the object of the target sentence.

IX.2.5. Results: behavioral data

Figure IX-7 shows a bar graph displaying the reaction times and the error rates for the plausibility judgment task by condition, and Table IX-11 shows the mean values and standard deviations.

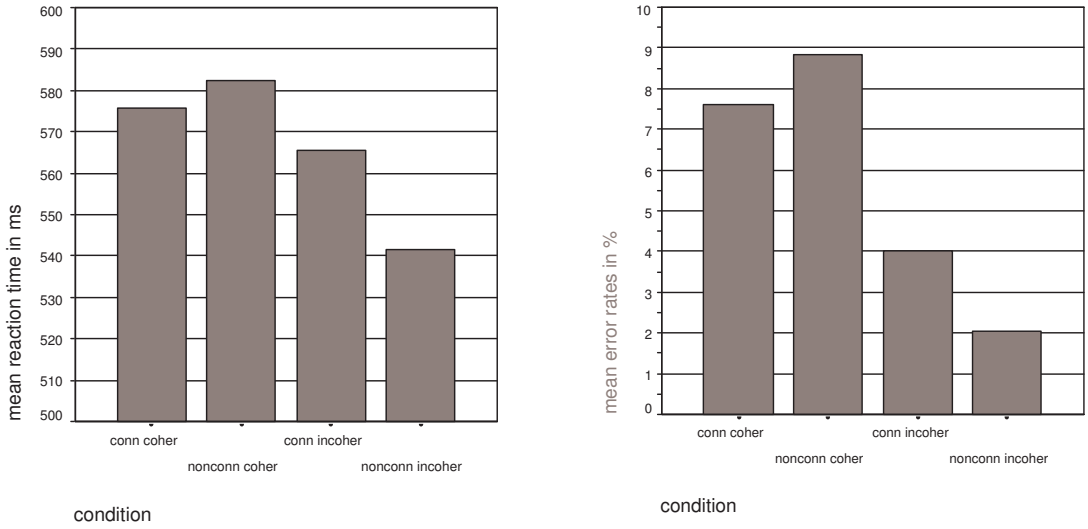


Figure IX-7: Mean reaction times (left, in ms) and error rates (right, in %), exp.t 2. N = 28.

	Error rates (in %)		Reaction times (in ms)	
condition	**Mean**	**Std.**	**mean**	**Std.**
A: connective coherent	7.7	4.2	576	208
B: non-conn coherent	8.9	5.7	583	196
C: connective incoherent	4	4.1	565	237
D: non-conn incoherent	2.1	1.9	546	243

Table IX-11: Means and standard deviations, reaction times and error rates, exp. 2. N = 28.

Analysis of the error rates showed a significant effect for coherence COHER ($F(1,27)=27.43$, $p<.001$), no effect for connectivity ($F(1,28)<1$), and a significant interaction COHER x CONN ($F(1,28)=8.25$, $p<.01$).

The single comparison A versus B yielded no effect for connector ($p>.15$).

The single comparison C versus D showed a significant effect for connector CONN ($F(1,28)=5.51$, $p<.05$).

The comparisons A versus C and B versus D both yielded a significant effects for coherence COHER ($F(1,28)=11.13$, $p<.005$) and COHER ($F(1,28)=102.46$, $p<.001$).

Analysis of the reaction times showed no effect for coherence ($F(1,28)=3.46$, $p=.07$), no effect for connector ($F(1,28)=2.18$, $p>.15$), but a significant interaction COHER x CONN ($F(1,28)=7.02$, $p=.01$).

The single comparison A versus B showed no effect for connector ($F(1,28)<1$).

The comparison C versus D did yield an effect for connector ($F(1,28)=11.47$, $p<.005$).

The comparison A versus C showed no effect for coherence ($F(1,28)<1$), while the comparison B versus D did (COHER ($F(1,28)=5.52$, $p=<.05$).

IX.2.6. Results: ERP-data

IX.2.6.1. The first word: lexical average

To examine whether the connectors themselves were processed differently from the deictical expressions the data was averaged by lexical item.

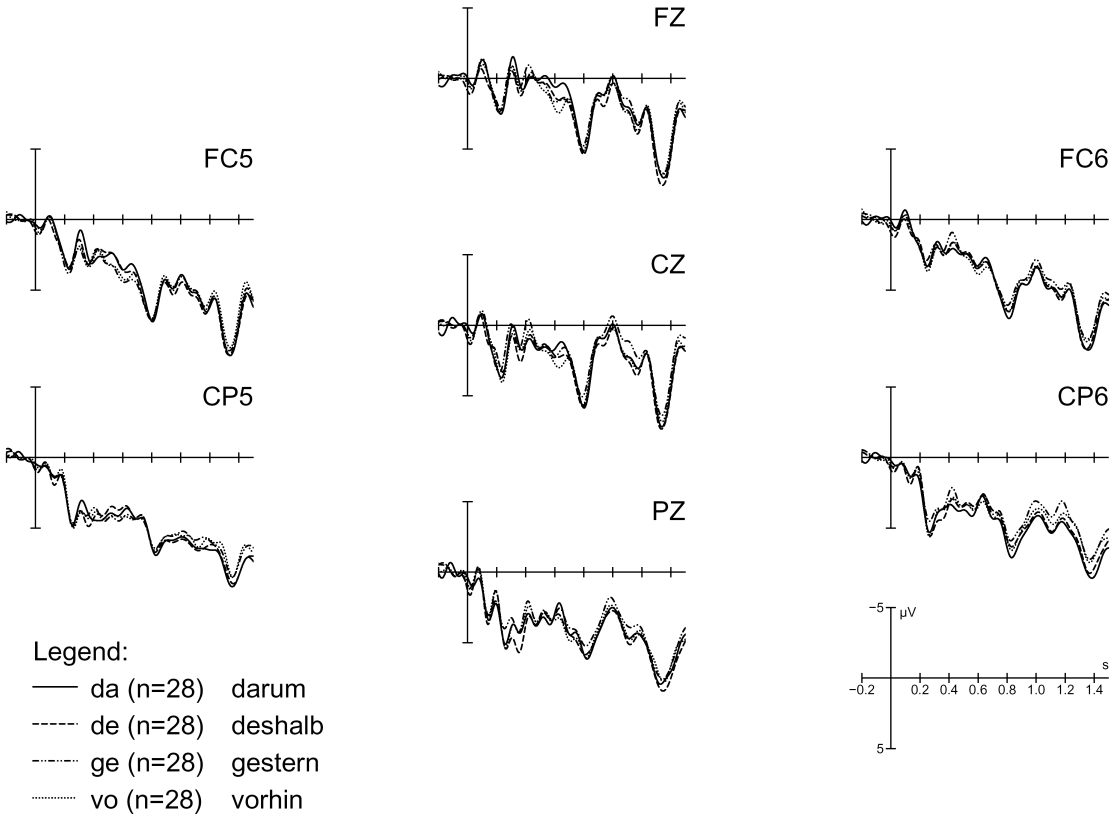


Figure IX-8: ERP grand-averages, first word, experiment 2. N = 28.

Figure IX-8 shows the ERP averages for the first word of the target sentence, averaged for each of the four connectors / deictical expressions from –200ms to 1500ms relative to the onset of the first word at 0ms, with a baseline from –200 to 0ms. Only artifact-free and correctly answered trials were included. Negative voltages are plotted up. Shown are the three midline electrodes and one electrode from each of the four lateral ROIs. Between 500ms and 650ms a negativity of both connectors relative to the deictical expressions can be seen for left hemispherical electrodes, clearest at the left anterior site FC5.

Starting at 1000ms another negativity, this time for the deictical expressions, can be found at lateral posterior sites, especially right posterior. Grand averages for all recorded electrodes for this epoch can be found in Appendix E.

Lexical average: baseline analysis

The window –200 to 0ms relative to the onset of the first word was examined with the ANOVA design to make sure that no systematic effects were present prior to presentation of the stimulus.

Statistics for the midline electrodes showed no significant main effects or interactions. Statistics for the lateral electrodes showed an interaction REG x HEMI x CONN x ITEM (F (1,27) =3.06. p=.09). Resolution of the four-way interaction by the factor REG showed an interaction HEMI x CONN x ITEM for anterior electrodes (F(1,27) =4.46, p=.044), but none for posterior electrodes (F(1,27)<1). Resolution of the three-way-interaction for the anterior sites by the factor HEMI showed no interaction CONN x ITEM either left- or right anterior (both (F(1,27)<1)).

Since there were no main effects involving either the factor CONN or the factor ITEM the window was used as a baseline.

Lexical average: the first negativity (500 to 650ms) midline analysis

Table IX-12 shows the global statistical analysis for the midline electrodes in the time-window from 500 to 650ms.

Global ANOVA	F-value	p-value
CONN	F(1,27)<1	
ITEM	F(1,27)<1	
ELEC x CONN	F(2,54)=2.89	p=.06
ELEC x ITEM	F(2,54)<1	
CONN x ITEM	F(1,27)=1.73	p=.2
ELEC x CONN x ITEM	F(2,54)=1	p=.35

Table IX-12**:** Global ANOVA for the midline, 500-650ms, first word, exp 2. N=28.

Resolution of the interaction ELEC x CONN by the factor ELEC showed no effect for CONN either in FZ (F(1,27)=2.96, p>.05), CZ or PZ ((F(1,27)<1) for both CZ and PZ).

Lexical average: the first negativity (500 to 650ms) lateral analysis

Table IX-13 shows the global statistical analysis for the lateral electrodes in the time-window from 500 to 650ms.

Global ANOVA	F-value	p-value
CONN	F(1,27)=2.25	p=.15
ITEM	F(1,27)<1	
REG x CONN	F(1,27)=3.02	p=.09
HEMI x CONN	F(1,27)=2.92	p=.1
REG x ITEM	F(1,27)=1.43	p=.24
HEMI x ITEM	F(1,27)<1	
CONN x ITEM	F(1,27)<1	
REG x HEMI x CONN	F(1,27)=3.77	p=.06
REG x HEMI x ITEM	F(1,27)=1.61	p=.2
REG x CONN x ITEM	F(1,27)=2.61	p=.12
HEMI x CONN x ITEM	F(1,27)<1	
REG x HEMI x CONN x ITEM	F(1,27)<1	

Table IX-13: Global ANOVA for lateral ROIs, 500 to 650ms, first word, exp 2. N=28.

Resolution of the interaction REG x CONN by the factor REG showed no effect for connector either for anterior (F(1,27)=3.64, p>.05) or posterior electrodes (F(1,27)<1). Resolution of the interaction HEMI x CONN, however, showed an effect for CONN for left-hemispherical electrodes (F(1,27)=4.21, p=.05), resulting from a negativity of both

connected conditions compared to deictical conditions, visible in Figure IX-8 for left anterior electrodes.

Resolution of the three-way interaction REG x HEMI x CONN by the factor REG showed nothing for anterior electrodes ($F(1,27)<1$), but an interaction HEMI x CONN for posterior sites ($F(1,27)=5.40$, $p<.05$). Resolution of this interaction by the factor HEMI showed no effect for CONN either left- ($F(1,27)=2.26$, $p=.14$) or right posterior ($F(1,27)<1$).

Lexical average: the second negativity (1000 to 1500ms) midline analysis

Table IX-14 shows the global statistical analysis for the midline electrodes in the time-window from 1000 to 1500ms.

Global ANOVA	F-value	p-value
CONN	F(1,27)=1.24	p=.28
ITEM	F(1,27)<1	
ELEC x CONN	F(2,54)<1	
ELEC x ITEM	F(2,54)<1	
CONN x ITEM	F(1,27)=1.6	p=.22
ELEC x CONN x ITEM	F(2,54)<1	

Table IX-14**:** Global ANOVA for the midline, 1000 to 1500ms, first word, exp 2. N=28.

There were no significant effects of interactions found in this window for the midline electrodes.

Lexical average: the second negativity (1000 to 1500ms) lateral analysis

Table IX-15 shows the global statistical analysis for the lateral electrodes in the time-window from 1000 to 1500ms.

Global ANOVA	F-value	p-value
CONN	F(1,27)=3.53	p=.07
ITEM	F(1,27)<1	
REG x CONN	F(1,27)=3.88	p=.06
HEMI x CONN	F(1,27)=1.99	p=.17
REG x ITEM	F(1,27)=1.08	p=.31
HEMI x ITEM	F(1,27)=1.18	p=.29
CONN x ITEM	F(1,27)<1	
REG x HEMI x CONN	F(1,27)=2.91	p=.1
REG x HEMI x ITEM	F(1,27)<1	
REG x CONN x ITEM	F(1,27)<1	
HEMI x CONN x ITEM	F(1,27)<1	
REG x HEMI x CONN x ITEM	F(1,27)<1	

Table IX-15: Global ANOVA for lateral ROIs, 1000 to 1500ms, first word, exp 2. N=28.

Resolution of the interaction REG x CONN by the factor REG showed an effect for CONN for posterior ($F(1,27)=8.12$, $p<.01$), but not for anterior sites ($F(1,27)<1$). Similarly, resolution of the three-way-interaction REG x HEMI x CONN by the factor REG showed an interaction HEMI x CONN for posterior ($F(1,27)=4.98$, $p<.05$), but not for anterior ROIs ($F(1,27)<1$). Resolution of the posterior interaction HEMI x CONN by the factor HEMI produced nothing for left posterior electrodes ($F(1,27)=3.51$, $p=.07$), but an effect for connector for the right-posterior electrodes ($F(1,27)=10.52$, $p<.01$), due to a more negative

curve of the two deictical conditions compared to the conditions involving lexical connectors.

IX.2.6.2. The object

The following Figure IX-9 shows the averaged curves for the four experimental conditions A (connective coherent), B (non-connective coherent), C (connective incoherent) and D (non-connective incoherent) for the time window of –200ms to +1500ms from the onset of the object of the target sentence at 0ms, with a baseline from –200 to 0ms. Shown are three midline electrodes and one electrode from each of the four lateral ROIs. Negative voltages are plotted up.

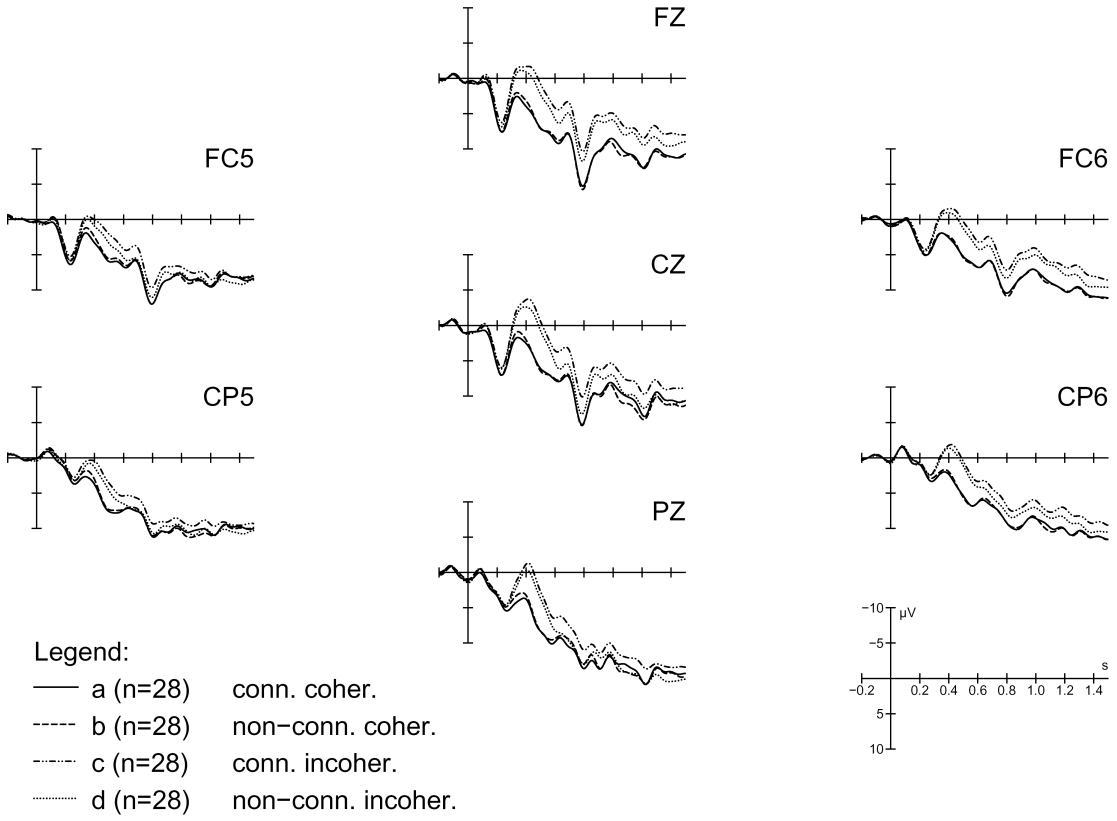


Figure IX-9: ERP grand-averages. object, experiment 2. N = 28.

Between 300ms and 700ms a negativity of both incoherent conditions can be seen, largest for central and right-lateral electrodes. This distribution resembles an N400. There seems to be no difference between the coherent conditions (A and B); the incoherent connective condition (C), however, shows a slightly larger negative deflection compared to the incoherent non-connective condition (D). Starting around 800ms and continuing until the end of the window another negativity is visible for right-frontal and central electrodes, a distribution in accordance with a sentence-end-negativity (SEN). For anterior central and right anterior electrodes, the N400 appears to be augmented by the SEN, or alternately the N400 continues as a sustained negativity until the end of the averaged window. Grand averages for all recorded electrodes for this epoch can be found in Appendix E.

Baseline analysis

The baseline window (-200 to 0ms relative to the onset of the object) was examined with the ANOVA design to make sure that no coherence effects were present prior to the presentation of the object.

Statistics for lateral electrodes showed a significant interaction HEMI X COHER ($F(1,27)=4.33$, $p<.05$) and a significant interaction REG X HEMI X COHER X CONN ($F(1,27)=6.16$, $p<.05$).

Resolution of the two-way interaction showed no effect for coherence either left- or right-hemispherically: ($F(1,27)<1$) for both.

Resolution of the four-way interaction showed no effect for posterior ROIs ($F(1,27)<1$), but a significant interaction HEMI X COHER x CONN ($F(1,27)=6.1$, $p<.05$) for anterior ROIs. No effects were found for COHER X CONN either anterior left or anterior right: ($F(1,27)<1$) for both.

Since there were no main effects involving experimental manipulation, this time window was used as a baseline.

The first negativity (300 to 700ms) midline analysis

Table IX-16 shows the global statistical analysis for the midline electrodes in the time-window from 300 to 700ms.

Global ANOVA	**F-value**	**p-value**
COHER	F(1,27)=93.82	p<.0001
CONN	F(1,27)=2.71	p=.11
ELEC x COHER	F(2,54)=8.1	p<.01
ELEC x CONN	F(2,54)<1	
COHER x CONN	F(1,27)=6.88	p<.05
ELEC x COHER x CONN	F(2,54)<1	

Table IX-16**:** Global ANOVA for the midline, 300 to 700ms, object, exp 2. N=28.

Resolution of the interaction ELEC x COHER by the factor ELEC showed significant main effects for COHER for all three midline electrodes: FZ COHER ($F(1,27)=82.65$, $p<.0001$), CZ COHER ($F(1,27)=85.95$, $p<.0001$) and PZ COHER ($F(1,27)=74.51$, $p<.0001$), due to a negativity of both incoherent conditions compared to coherent conditions.

The interaction COHER x CONN was resolved by examining single comparisons between conditions. Condition A versus B (coherent conditions) showed neither a main effect nor interactions for the factor connector. Condition C versus D (incoherent conditions) showed a main effect for connector ($F(1,27)=19.12$, $p<.001$). This was due to a more negative curve of the condition C (connective incoherent) compared to condition D (non-connective incoherent), as can be seen in Figure IX-9.

Examination of the comparison of conditions A versus C for the factor coherence showed effects for coherence ($F(1,27)=74.81$, $p<.0001$) and an interaction ELEC x COHER ($F(1,27)= 3.12$, $p=.08$). Resolution by the factor ELEC showed effects for coherence in all three midline electrodes: FZ ($F(1,27)=57.67$, $p<.0001$), CZ ($F(1,27)=74.53$, $p<.0001$) and PZ ($F(1,27)=61.28$, $p<.0001$), due to a more negative curve for condition C compared to condition A.

Comparison of condition B with condition D showed a main effect for coherence ($F(1,27)=42.97$, $p<.0001$) and an interaction ELEC x COHER ($F(1,27)= 4.16$, $p<.05$). Resolution by ELEC also showed effects for all three midline electrodes: FZ COHER

(F(1,27)=31.53, p<.0001), CZ COHER (F(1,27)=40.95, p<.0001) and PZ COHER (F(1,27)=30.47, p<.0001). These effects were also due to a negativity of the incoherent condition D compared to the coherent condition B.

The first negativity (300 to 700ms) lateral analysis

Table IX-1 shows the global statistical analysis for the lateral electrodes in the time-window from 300 to 700ms.

Global ANOVA	F-value	p-value
COHER	F(1,27)=74.61	p<.0001
CONN	F(1,27)=2.6	p=.12
REG x COHER	F(1,27)=1.02	p=.32
HEMI x COHER	F(1,27)=20.55	p=.0001
REG x CONN	F(1,27)<1	
HEMI x CONN	F(1,27)<1	
COHER x CONN	F(1,27)=7.28	p<.05
REG x HEMI x COHER	F(1,27)=2.09	p=.16
REG x HEMI x CONN	F(1,27)<1	
REG x COHER x CONN	F(1,27)<1	
HEMI x COHER x CONN	F(1,27)=2.7	p=.11
REG x HEMI x COHER x CONN	F(1,27)<1	

Table IX-17**:** Global ANOVA for lateral ROIs, 300 to 700ms, object, exp 2. N=28.

Resolution of the interaction HEMI x COHER by the factor HEMI showed effects for COHER for the left-hemispherical as well as the right-hemispherical electrodes ((F(1,27)=41.33, p<.0001) and (F(1,27)=80.03, p<.0001), respectively), due to a more negative curve of both incoherent conditions (C and D) compared to the coherent conditions A and B.

The interaction COHER x CONN was resolved by examining single comparisons between conditions. The comparison A versus B showed no main effects for or interactions involving the factor CONN (all p>.3). The comparison C versus D showed a main effect for connector (F(1,27)=16.43, p<.001), due to a more negative curve for condition C compared to condition D. The comparison A versus C showed a main effect for coherence (F(1,27)=63.38, p<.0001) and an interaction HEMI x COHER (F(1,27)=14.4, p<.001). Resolution by the factor HEMI showed effects for coherence for the left (F(1,27)=47.15, p<.0001) as well as the right hemisphere (F(1,27)=69.41, p<.0001).

The comparison B versus D showed a main effect for coherence (F(1,27)=34.5, p<.0001) and an interaction HEMI x COHER (F(1,27)=15.63, p<.001). Resolution by the factor HEMI showed effects for coherence for both hemispheres (left hemisphere: (F(1,27)=11.32, p<.01) and right hemisphere: (F(1,27)=6.2, p<.05). These effects as well as the effects found for the comparison A versus C are due to the negativity of both incoherent conditions compared to the coherent ones.

The second negativity (800-1500) midline analysis

Table IX-18 shows the global statistical analysis for the midline electrodes in the time-window from 800 to 1500ms.

Global ANOVA	F-value	p-value
COHER	F(1,27)=28.69	p<.0001
CONN	F(1,27)=8.23	p<.01
ELEC x COHER	F(2,54)=29.05	p<.0001
ELEC x CONN	F(2,54)=1.25	p=.29
COHER x CONN	F(1,27)=2.19	p=.15
ELEC x COHER x CONN	F(2,54)<1	

Table IX-18**:** Global ANOVA for the midline, 800 to 1500ms, object, exp 2. N=28.

Resolution of the interaction ELEC x COHER by the factor ELEC showed a main effect for coherence for FZ (F(1,27)=80.6, p<.0001) as well as CZ (F(1,27)=14.54, p<.001), but none for PZ (F(1,27)=3.67, p=.06) This was due to a negativity for both incoherent conditions (C and D) compared to coherent conditions A and B, visible for frontal and central electrodes. Since the earlier negativity (the N400) was significant for the electrode PZ as well, these results suggest the presence of two separate ERP effects.

The second negativity (800-1500) lateral analysis

Table IX-19 shows the global statistical analysis for the lateral electrodes in the time-window from 800 to 1500ms.

Global ANOVA	F-value	p-value
COHER	F(1,27)=11.87	p<.01
CONN	F(1,27)=4.37	p<.05
REG x COHER	F(1,27)=3.67	p=.07
HEMI x COHER	F(1,27)=9.41	p<.01
REG x CONN	F(1,27)<1	
HEMI x CONN	F(1,27)<1	
COHER x CONN	F(1,27)=2.24	p=.15
REG x HEMI x COHER	F(1,27)=2.8	p=.11
REG x HEMI x CONN	F(1,27)<1	
REG x COHER x CONN	F(1,27)<1	
HEMI x COHER x CONN	F(1,27)<1	
REG x HEMI x COHER x CONN	F(1,27)=2.19	p=.15

Table IX-19**:** Global ANOVA for lateral ROIs, 800 to 1500ms, object, exp 2. N=28.

Resolution of the interaction REG x COHER by the factor REG showed an effect for coherence for anterior (F(1,27)=9.32, p<.01) as well as posterior electrodes (F(1,27)=7.02, p=.01). Resolution of the interaction HEMI x COHER showed an effect for coherence for the right (F(1,27)=16.63, p<.001) but not the left hemisphere (F(1,27)<1). These effects were due to a negativity of the incoherent conditions for right-hemispherical, but not left-hemispherical electrodes in this time window. Resolution of the interaction REG x HEMI x COHER by the factor REG showed an interaction HEMI x COHER for the anterior ROIs (F(1,27)=6.84, p=.01) as well as the posterior region (F(1,27)= 8.93, p<.01). Resolution of these interactions by the factor HEMI showed an effect for coherence for the right anterior and posterior ROIs ((F(1,27)=17.71, p<.001) and (F(1,27)=12.23, p<.01), respectively), but

nothing for the left hemispherical ROIs ((F(1,27)<1 in both cases). Since the analysis of the earlier negativity showed reliable effects for both hemispheres, which the ANOVAS for this later time-window do not, the data again suggests the presence of two separate ERP effects.

IX.2.7. Discussion experiment 2

IX.2.7.1. Behavioral data

The low overall error rates show that the subjects were able to read the stimuli well and perform the task asked of them, as well as that the subjects' judgments coincided with those predicted by the experimental manipulation.

Since a plausibility judgment was used, diagnosis of an (in)coherence was task-relevant. Consequently, the pattern of responses was analogous to that found by Ferstl & von Cramon (2001) in their pretest: the incoherent conditions showed reliably longer reaction times for the connective condition (C) compared to the non-connective condition (D), and there was no effect for connectivity in the coherent conditions (A versus B). The former is proposed to be an expression of the hindering influence of the connective tie in the diagnosis of incoherence, while the latter is argued to be due to subjects' need to reassure themselves of the coherence of the non-connective coherent trials, thereby raising the reaction time for that condition and masking the influence of the connective tie. These results also support the hypothesis that instructions to construct a relation trigger conscious inference processes (Fletcher, Chrysler, van den Broek, Deaton & Bloom, 1995), also see experiment 1.

The generally longer reaction times for the coherent trials are speculatively attributed to not yet concluded inference processes and the construction of a situation model intruding on the judgment: while subjects appear to have been fairly certain of their judgment in the incoherent trials, the judging of the coherent trials required a coherent and complete text representation and situation model, the construction of which was not concluded at judgment time.

IX.2.7.2. ERP data

There were no effects prior to 200ms found for the lexical average or the object of the target sentences. These results therefore provide no data speaking against a syntax-first model of processing (Friederici 2002, hypothesis I).

The first word

Although the contrasts between the connective ties and the deictical elements are visually very subtle, they are nonetheless reliable: the connective elements differ from the non-connective ones at left-hemispherical electrodes, while there are no contrasts between either the two connective ties or the two deictical sentential adverbs (hypothesis II.b). The difference found was also present before the onset of the N1 P1 complex for the following matrix verb, suggesting that it indeed pertained to the first word itself. The distribution of the effect, namely left-hemispherical with an anterior maximum argues against an N400 and for a LAN (hypothesis II.a). This ERP-effect has been found as a correlate of working-memory processes pertaining to temporal connective ties (Münte, Schiltz & Kutas, 1998, see also Baggio, 2004). There was no re-ordering of events involved in the present study, but the presence of a connective tie was nevertheless task-relevant, again arguing for an interpretation of the effect as a LAN. It could therefore be a correlate of integrating the external argument into the text representation as a cause, i.e. the assignment of the role of

CAUSE to the context. Neither of the two non-connective conditions showed this effect, despite the fact that if a coherent relation was going to be present between context and target, it was always a causal relation. This indicates that the effect was indeed a correlate of the processing of connective ties, and that the information provided by connective ties is made use of immediately.

The second effect found also provides tentative evidence in support of the above claim. It has been shown (Haberlandt, 1982; Millis & Just, 1994) that reading times for elements subsequent to a connective tie are read faster than if there is no connective tie present. Millis & Just attributed this to the integration of the internal argument into the text representation or situation model being delayed until the internal argument was complete. Traxler, Bybee & Pickering (1998) showed that processing problems arising from difficult integration of elements subsequent to a connective tie appear well before the end of the internal argument. The present results support Traxler et al.'s claim that interclausal relations are computed immediately. The second effect found was a right-posterior contrast between the connective and the non-connective elements. It occurred in the time window of the main verb and the proper name in the target sentences, with a latency of 450ms after the presentation of the main verb in the target sentences. The two non-connective elements showed a more negative ERP curve, and there was no influence of lexical item. The distribution of the effect is similar to that of an N400, being right-lateralized with a parietal maximum. If a connective tie aids in the construction of a text-representation, then the absence of a connective tie should result in added integration costs, which this possible N400 might reflect.

In sum, the above results for the first word of the target sentences could be argued to support the claim that the processing of discourse is incremental and immediate, i.e. that interclausal relationships are computed immediately and not delayed, and that (causal) connective ties indeed influence the drawing of inferences and denote a two-place relation, in contrast to deictical sentential adverbs. There are, however, two caveats regarding these claims, which will be addressed in turn.

First, both connective ties have also been argued to have a co-referential aspect (see section III.2.2). LANs have been found as a correlate of discourse-referential processes (section VII.3.4.2: Streb, Rösler & Henninghausen, 1999; Cowles, 2003, experiment 3.2 and 3.1b; Yang & Perfetti, 2005, Explicit condition; van Berkum, Brown & Hagoort, 1999a; van Berkum, Brown, Hagoort & Zwitzerlood, 2003a). This interpretation of the effect found here, as a correlate of antecedent-binding, weakens the possible claim of the LAN as a correlate of the processing of interclausal relations. However, even if the LAN is an expression of antecedent-binding, the antecedent for the connective ties is still the *entire* external argument, in other words the claim is not weakened 'by much', but these two possible underlying processes are indeed confounded.

Secondly, and much more critically, both connective ties had a causal semantic content, while both non-connective elements were temporal. It is therefore possible that all the effects found for the first word and subsequent elements were an expression of different processing of causal versus temporal semantic content, not of connective versus non-connective elements. This is critical despite the fact that causal relations contain a temporal aspect as well, and foregrounding either the causal or the temporal aspect should be possible. The fact that the behavioral data displays a pattern of results largely analogous to that found by Ferstl & von Cramon, who used several type of cohesion including causal and temporal connective ties, and whose non-connective conditions did not include temporal deictical elements, suggests that the results found do pertain to the contrast of connective versus non-connective elements. Moreover, the underlying relation between

contexts and targets was causal in all cases[67], indicating that a foregrounding of the *temporal* dimension should have incurred added processing costs on the first word, especially since one of the two temporal adverbs, namely *gestern* (yesterday), could have been taken to refer to a point in time prior to the occurrence of the event denoted in the external argument. Nevertheless, the confound is present, and the problem will be addressed by experiment 3.

The object

Because of the massive confound discussed above, any conclusions made here and in the discussion of sentence-end effects are speculative. The results for the object-average of the target sentences are discussed at this point already to avoid utter confusion in the discussion of experiment 3.

First of all, there were no effects prior to 200ms found for the average of the object window. These results therefore also provide no data speaking against a syntax-first model of processing (hypothesis I).

Incoherence resulted in a large negative deflection with an onset at 300ms, a peak amplitude at precisely 400ms, and a broad distribution: an N400. This effect was found for both incoherent conditions (hypothesis III.a). In the case of the non-connective incoherent condition, the violation pertained exclusively to the discourse, not the current sentence. The character of the N400 as a reflection of difficult integration of a word into not only the current sentence, but into the text representation constructed up to that point is therefore supported, as is the incremental nature of not only sentence- but also discourse processing, as suggested by previous studies (St. George, Mannes & Hoffman, 1994; St. George, 1995, St. George, Mannes & Hoffman, 1997; Federmeier & Kutas, 1999a; van Berkum, Hagoort & Brown, 1999c; Salmon & Pratt, 2002; van Berkum, Zwitzerlood, Hagoort & Brown, 2003b; Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004; Britz & Swaab, 2005; van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort, 2005; Ditman, Holcomb & Kuperberg, 2005).

Although the difference was visually very subtle, the N400 for the connective incoherent condition was reliably larger than that for the non-connective incoherent condition (hypothesis III.b). If the relevant contrast between the two conditions was indeed that between connective and non-connective discourse, the obvious conclusion is that of the more difficult integration for the connective condition being due to the influence of that lexical element. In this condition, a relation is signaled by the connective tie that is not present. The larger amplitude of the effect could therefore reflect that a connective tie is taken at face value, that an attempt to find the relation it signals is made mandatorily, and consequently that connective ties trigger inference processes in accord with their semantic content. An attempt to integrate the violating word in the non-connective incoherent condition is obviously made as well, but here there is no connective tie to make things worse than they are already.

The opposite effect, that of the non-connective coherent condition resulting in a larger N400 compared to its connective counterpart, was not found, and the respective part of hypothesis III.b must hence be rejected: apparently, a causal connective tie does not aid in the integration of subsequent words in coherent discourses with an underlying causal relation. The task given to the subjects, the plausibility judgment, does not provide any mitigating circumstances here. The diagnosis of coherence being task-relevant should have resulted in more 'work' being done by the subjects in the non-connective coherent trials, and

[67] A fact that subjects very probably realized fairly early on.

should therefore have amplified integration costs, not reduced them. What might have reduced integration costs for the object in this condition, however, is that there was a close underlying causal relation present in *all* coherent trials, and the search for a causal relation was therefore made as a default. A possible, but rather speculative explanation for the lack of contrast between the coherent conditions might hence be that connective ties only have a supporting influence if there is, so to speak, something to influence, i.e. if there is the possibility of a different relation than the one implied by the connective tie.

Sentence-final integration processes

There was a reliable sustained negativity with an anterior maximum for both incoherent conditions for right-hemispherical electrodes (SEN) in the time window of the sentence-final element, which was influenced by the presence of a connective tie, being larger for the connective incoherent condition than the non-connective incoherent condition (hypothesis IV). It is possible that the effect is a continuation of the N400 discussed above. Alternately, it is possible that the SEN had an onset latency in the time window of the N400 and thereby augmented the N400 at the anterior electrodes. The second option is the likelier one, given that all target sentences had the same syntactic structure and that the last element presented, the prepositional phrase, never resolved a violation. The data for the right-hemisphere make no distinction between the two effects possible, but the data for the left hemisphere and the midline electrodes indicate the presence of two separate ERP-responses. The earlier effect does not continue at the central posterior electrode PZ, nor for the left hemisphere, in the latter time window. It shall therefore be assumed here that the two effects are distinct, being an N400 in response to the violating object and a sentence-final integration effect (SEN).

An SEN has been found in previous studies in response to a semantic violation occurring prior to the final element (Frisch, 2000, experiment 2, see also Ditman, Holcomb & Kuperberg, 2005). According to Osterhout (1997) the effect is a correlate of the difficulty of constructing a coherent 'message-level' semantic representation of a sentence containing a violation. This interpretation indicates the presence of additional integrative processes at the end of sentences, supported in the case of connective ties by the data reported by Millis & Just (1994), but see Haberlandt (1982) and Traxler, Bybee and Pickering (1998) for a different view and evidence to the contrary. It seems that the question of when interclausal relationships are computed is not one of *either* immediately *or* at the end of a sentence, but that both positions have a claim. In the present study, the occurrence of the N400 on the violating element itself suggests that interclausal relations are at least to a large part computed immediately, otherwise a diagnosis of the incoherence on the object would not be possible. The SEN could then be a reflection of semantic or pragmatic reanalysis attempts. In the context of the event-indexing model (Zwaan, Langston & Graesser, 1995, Zwaan, Magliano & Graesser, 1995, see also Zwaan & Radvansky (1998); Gernsbacher (1990) and Givón (1992), the SEN found here could be seen as a correlate of an (unsuccessful) attempt to construct a final situation model. The presence of a connective tie then added insult to injury for the connective incoherent condition C: the connective tie signaled a relation that was not present, further hindering the construction of an integrated situation model.

IX.2.8. Experiment 2: summary

Due to the problem identified above, a summary discussion of experiment 2 will be delayed until the confound between causal and temporal semantic content is investigated further.

IX.3. EXPERIMENT 3

IX.3.1. Questions

The main motivation for experiment 3 was to examine whether the contrasts found in experiment 2 were due to a difference in processing between connective and non-connective elements or between the causal and temporal semantic content of said lexical elements.

Secondly, the experiment will investigate the claim that causal situations contain a temporal dimension (section III.4.1.2), and that both dimensions are kept track of during processing, as proposed by the event-indexing model (Zwaan, Langston & Graesser, 1995; Zwaan, Magliano & Graesser, 1995; Zwaan & Radvansky, 1998). If causal situations do contain a temporal element, then foregrounding of either the causal or the temporal dimension by means of an appropriate connective tie ought to not lead to added integration costs.

Additionally, the task-relevance of connective ties was removed in experiment 3 by presenting only coherent discourses. This was done to ensure that any potential differences between connective and non-connective elements found were due to that contrast and not to the connective ties providing hints as to how to complete the task.

IX.3.2. Stimulus materials

A total of 640 sentence pairs were constructed, using the material from experiment 2. Each of the four conditions connective causal (CC), connective temporal (CT), non-connective temporal (IT) and a non-connective non-causal filler condition (F) was represented 160 times. Care was taken that each context-target pair was coherent with either a causal or a temporal connective tie, i.e. that the event denoted in the external argument, the context, of each pair could be temporally concluded by the time the event denoted in the internal argument takes place (see also section III.4.3.5 on temporal connective ties in causal situations). A block of lexical material with the four conditions is shown Table IX-20:

Context	**Das Auto war auf dem Sandweg steckengeblieben.** The car had gotten stuck on the sandy path.
Connective targets	
CC connective causal	**Darum beschaffte Niklas Kies für die Auffahrt.** Therefore got Niklas gravel for the driveway.
CT connective temporal	**Danach beschaffte Niklas Kies für die Auffahrt.** Afterwards got Niklas gravel for the driveway.
Non-connective targets	
IT non-conn. temporal	**Gestern beschaffte Niklas Kies für die Auffahrt.** Yesterday got Niklas gravel for the driveway.
F non-conn. non-temp.	**Gern beschaffte Niklas Kies für die Auffahrt.** Gladly got Niklas gravel for the driveway.

Table IX-20**:** Example of lexical material used in experiment 3.

All target sentence had the same syntactic structure, as shown in example 4:

4.	Darum	beschaffte	Niklas	Kies	für die Auffahrt.
	conn/ non-conn element	V	Name	Obj	PP.

Two lexical elements were chosen for each of the four categories: *deshalb* and *darum* as causal connective elements, both synonymous with *therefore*; *danach* and *hinterher* as temporal connective elements, both synonymous with *afterwards*; *gestern* (yesterday) and *vorhin* (recently) as non-connective temporal elements; *gern* (gladly) and *lieber* (rather) as non-connective non-temporal filler elements[68].

The same 10 verbs from experiment 1 were used 16 times each, despite the fact that no effects for coherence were expected. As before, every possible combination of four (one from each condition) of each of the eight elements was used equally often with every one of the ten verbs. The complete stimulus material for experiment 3 can be found in Appendix C.

IX.3.3. Hypotheses and predictions

I. Analogous to experiment 2, there are no effects pertaining to the experimental manipulation prior to 200ms predicted.

As in experiment 2, there were three points of interest: the first word of the target sentences, the object of the target sentences, and the sentence-final prepositional phrase.

II.a. **The first word; connective versus non-connective**: If the effects observed in experiment 2 were due to a contrast between connective and non-connective elements, there ought to be no difference between the causal and the temporal connective ties at left and / or left anterior electrodes, but both should differ from the non-connective temporal condition.
There should also be the same contrast between connective and non-connective elements present that was found in experiment 1: a LAN.

II.b. **The first word; causal versus temporal elements**: If the effects found in experiment 2 were due to a contrast between causal and temporal elements, there should be no difference between the temporal connective and the temporal non-connective condition. Both should however differ from the causal connective condition.
Since the causal connective ties elicited a LAN in experiment 2, the same effect would be expected for the causal connective ties in this experiment.

II.c. **Task-relevance of connective ties**: If the effects observed on the first word of the target sentence in experiment 2 were due to the connective ties being task-relevant, then all differences between the connective conditions and the non-connective temporal condition should disappear in this experiment.

III. **The object; influence of connective ties**: If it is possible to foreground either the temporal or the causal dimension in an underlying causal relation, then the N400 amplitude for the object should not be influenced by the type of connective tie.
If both types of connective ties aid in the construction of a text representation, then the amplitude of the N400 on the object for the connective conditions should be smaller than that for the non-connective temporal condition.

[68] This condition is termed 'filler' since the ideal completion of the paradigm would have been a non-connective *causal* pair of words. However, despite a very thorough search no causal elements could be found that were not connective at the same time.

IV. **Sentence-end effects**: There were no violations present, so at first glance there ought to be no negativities found between conditions on the sentence-final element. Kuperberg, Caplan, Eddy, Cotton & Holcomb, (2004), however, found a late sustained *positivity* on the last element in coherent discourses for the condition in which the causal relation between two sentences was not immediate but had to be inferred, which Kuperberg et al. interpreted to be a correlate of inference generation (situation model updating: see also Donchin, 1979, Donchin & Coles, 1988). While the foregrounding of the temporal dimension of causal relations should be felicitous, it is also possible that precisely that foregrounding results in the other dimensions, in this case the causal one, being underspecified or temporally ignored until the end of the sentence. The event-updating model makes no predictions in that respect (see section V.2.3.2). If it is the case that foregrounding of one dimension *backgrounds* other dimensions, and if it is also true that both causal and temporal dimensions play a role in causally related sentences, then a backgrounding of the causal dimension in both temporal conditions should result in the causal relation having to be evaluated at the end of the sentence, incurring an update of the situation model, and possibly eliciting a positivity.

IX.3.4. Method

IX.3.4.1. Randomization and presentation

A probe detection task (every trial) combined with occasional comprehension questions (25% of the trials) was used. To this end a single word was presented following the last element of the target sentence, a verb, proper name, adjective or noun with equal frequency. Neither the connective ties nor the non-connective elements were used as probes. The subjects' task was to indicate by button press whether or not this word had occurred in the sentence pair just read. In 50% of the trials the expected answer was 'true'.

It has been shown that very shallow tasks lead to subjects not constructing a text representation (Schallert, 1976, Till & Walsh, 1980). The comprehension questions ('Was something done to the driveway?' in the example above) were included to ensure that subjects did indeed read the material for comprehension, not just pay attention to the content words to complete the task, but were not evaluated.

The correct and incorrect probes were distributed equally among the four experimental conditions, while the comprehension questions were distributed equally not only over the conditions but also over correct and incorrect probes.

The 640 sentence pairs were split among four lists such that only one pair from each block of lexical material was present in any list, and such that the number of occurrences of each condition, the number of correct and incorrect probes occurring for each condition, and with them the comprehension questions, as well as the number of times each connective or non-connective element occurred, were distributed equally. The four lists were then pseudo-randomly split into four experimental blocks of 40 trials each, such that each experimental condition, probe-condition, comprehension-question type and lexical type of connector occurred roughly equally often per experimental block (between 9 and 11 per experimental condition, of which between 4 and 6 for each connective or non-connective element; between 18 and 22 for correct and incorrect probes each and between 4 and 6 for each right and wrong comprehension question).

Care was taken that no more than two trials of the same condition, no more than two trials with the same expected probe answer, no more than one trial with the same

connective or non-connective element and no more than two trials with a comprehension question occurred consecutively.

The four lists of four experimental blocks each were then reversed, making a total of eight experimental versions.

The presentation procedure and the equipment used was the same as for experiment 2, differing only with respect to the response picture used: *kam vor* and *kam nicht vor*, equidistant to a question mark in the middle ('occurred' and 'did not occur'). In 75% of the trials the fixation point for the next sentence pair followed after a blank screen of 1000ms duration. In 25% of the trials the probe was followed by a comprehension question presented as an entire sentence on the screen above the response picture 'JA' and 'NEIN' ('yes' and 'no') equidistant to a question mark in the middle. The question was presented for maximally 6000ms or until the subject responded per button-press.

If no response was registered within that time to the probe or the question, the 'too-late-feedback' was given. No other type of feedback was used.

1000ms after the maximal response time for the question or the subjects' button press the fixation point for the next sentence was presented.

Figure IX-10 shows the time course of the target sentences without comprehension question.

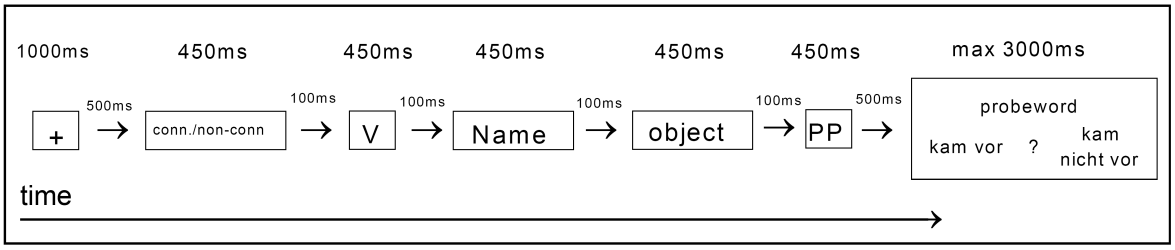


Figure IX-10**:** Time course of one target sentence for experiment 3.

Subjects were instructed not to move and only to blink between trials. At the beginning of the experiment 12 practice trials were shown to familiarize subjects with the presentation, the task and the 'blinking routine'. There were pauses between blocks, the length of which was determined by the subject. Total on-task time for the subjects in this experiment was between 50 and 60 minutes, the total duration of a session varied between one hour and 45 minutes, and two and a half hours.

IX.3.4.2. Subjects

22 students of Potsdam University participated in the experiment, of whom 5 were male. Their ages ranged between 19 and 32 years, mean age 22.4 years. None had participated in either experiment 1 or 2. None were left-handed or had reported left-handed immediate family members. All had normal or corrected-to-normal vision and had learned German as their only first language. Participation was paid with either 15 Euro or with course-credit.

IX.3.4.3. EEG- and data recording

The recording equipment, stimulus presentation equipment and electrode configuration were the same as used for experiment 2.

IX.3.4.4. Data preparation

Behavioral data

Only the reaction times and error rates for the probe answers were calculated and reported, as only 40 out of 160 trials for each subject contained a comprehension question.

Error rates were calculated as the percentage of responses to the probe not in accordance with the expected response for each trial. Missed responses, i.e. no response within the time limit set were counted as errors.

Reaction times were evaluated on the basis of correct responses only. The percentage of trials excluded from the analysis of the reaction times corresponds to the error percentages.

EEG data

The software and procedures for artifact-rejection and averaging were the same as for experiment 2. Only artifact free and correctly answered trials were included in the analysis. Correctness was determined by the probe-answer.

The total of trials excluded from the analysis of the first word of the target sentence (connective tie resp. deictical element / filler) due to artifacts or incorrect responses was: 15.8% for condition CC, 18.1% for condition CT, 14.1% for condition IT and 16.6% for condition F, overall mean 16.1%. The total of trials excluded from the analysis of the object of the target sentence due to artifacts or incorrect responses was 13.4% for condition CC, 14.4% for condition CT, 12.9% for condition IT and 13.6% for condition F, overall mean 13.6%. 2 subjects were entirely excluded from evaluation because more than 45% of trials were rejected due to artifacts for one or more condition, resulting in a total of 20 data sets for experiment 3.

For presentation a 9Hz lowpass filter was applied to the grand-averages; the statistical analyses were performed on the unfiltered data.

IX.3.4.5. Statistical analysis

Since all hypotheses formulated for this experiment concern differences between the two connective conditions and the temporal non-connective condition, the filler condition is included in the overall analyses, but pairwise analyses of the two non-connective conditions were not made or reported, except for the baseline analyses.

The statistical evaluation for the first word of the target sentence as well as the object in experiment 2 was done using a 2-by-2 design with the factors connector (CONN: connective versus non-connective) and temporal properties (TEMP: temporal versus non-temporal), as shown in Table IX-21:

		Properties of Connective Tie (TEMP)	
		causal	temporal
Connector (CONN)	connective	**(CC) causal conn.**	**(CT) temp. conn.**
	non-connective	**((F) filler)**	**(IT) temp non-conn.**

Table IX-21: ANOVA Design for the experimental factors in experiment 3.

Analyses of the ERP data were done separately for the lateral electrodes and the midline.

For the statistical analysis of the lateral electrodes the same four ROIs (regions of interest) as in experiment 2 were defined: left anterior, right anterior, left posterior and right posterior.

For the analysis of the midline the electrodes FZ, CZ and PZ were included. The topographical factors used for the lateral analyses were region (2 REG: anterior and

posterior) and hemisphere (2 HEMI: left- and right- hemispherical). The two levels of the variable region included six anterior and six posterior electrodes, the two levels of the variable hemisphere included six left- and six right-hemispherical electrodes, thereby completely crossing the factors region and hemisphere (see also Table IX-10).

- The ANOVA design for the first word and the object of the target sentence for the lateral electrodes was **REG (2) x HEMI (2) x CONN (2) x TEMP(2).**
- The topographical factor for the midline was electrode (ELEC: FZ, CZ, PZ), resulting in an ANOVA design **ELEC (3) x CONN (2) x TEMP(2)** for the first word and the object.

IX.3.5. Results: behavioral data

Figure IX-11 shows the error rates and the reaction times for the probe detection task.

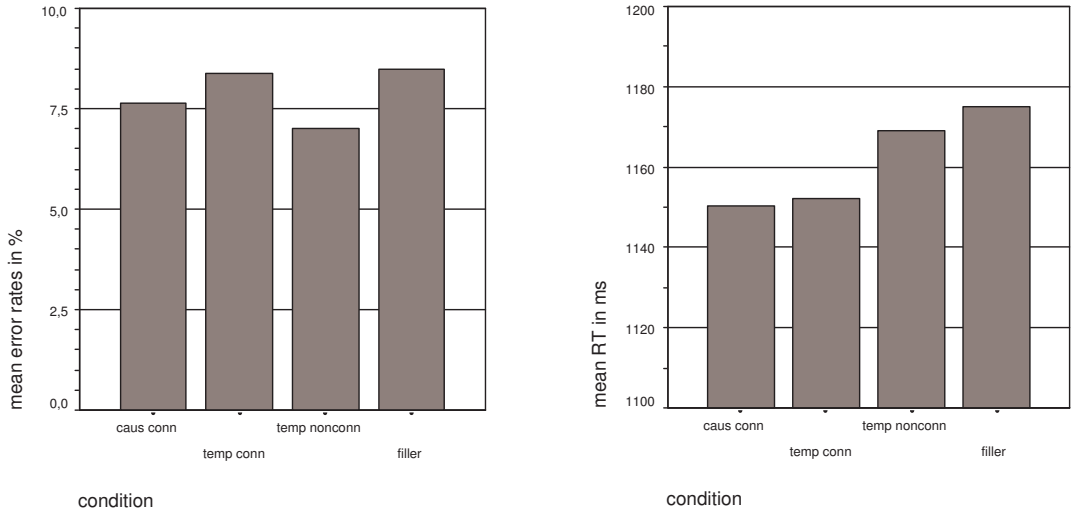


Figure IX-11**:** Error rates and reaction times, experiment 3. N = 20.

Table IX-22 shows the mean values and the standard deviations of the error rates and the reaction times for the probe detection task.

	Error rates (in %)		Reaction times (in ms)	
condition	**mean**	**Std.**	**mean**	**Std.**
CC: causal connective	7.6	3.3	1150	179
CT: temporal connective	8.4	5.3	1152	165
IT: temporal non-connective	7	4.1	1169	199
F: filler	8.5	4.6	1175	195

Table IX-22**:** Means and standard deviations, error rates and reaction times, exp. 3. N = 20.

Analysis of the error rates showed no significant effects or interactions (all $p>.25$).

Analysis of the reaction times showed a significant main effect for connectivity CONN ($F(1,19)=7.28$, $p=.01$), due to the longer reaction times for the two non-connective conditions compared to the two connective conditions. There was no effect for temporal versus non-temporal conditions ($F(1,19)<1$) or interaction between connectivity and connector type ($F(1,19)<1$).

IX.3.6. Results: ERP data

IX.3.6.1. The first word

Figure IX-12 shows the ERP averages for the first word of the target sentence, averaged for each of the four conditions from –200ms to 1500ms relative to the onset of the first word at 0ms, with a baseline from –200 to 0ms. Shown are the three midline electrodes and one electrode from each of the four lateral ROIs. Negative voltages are plotted up.

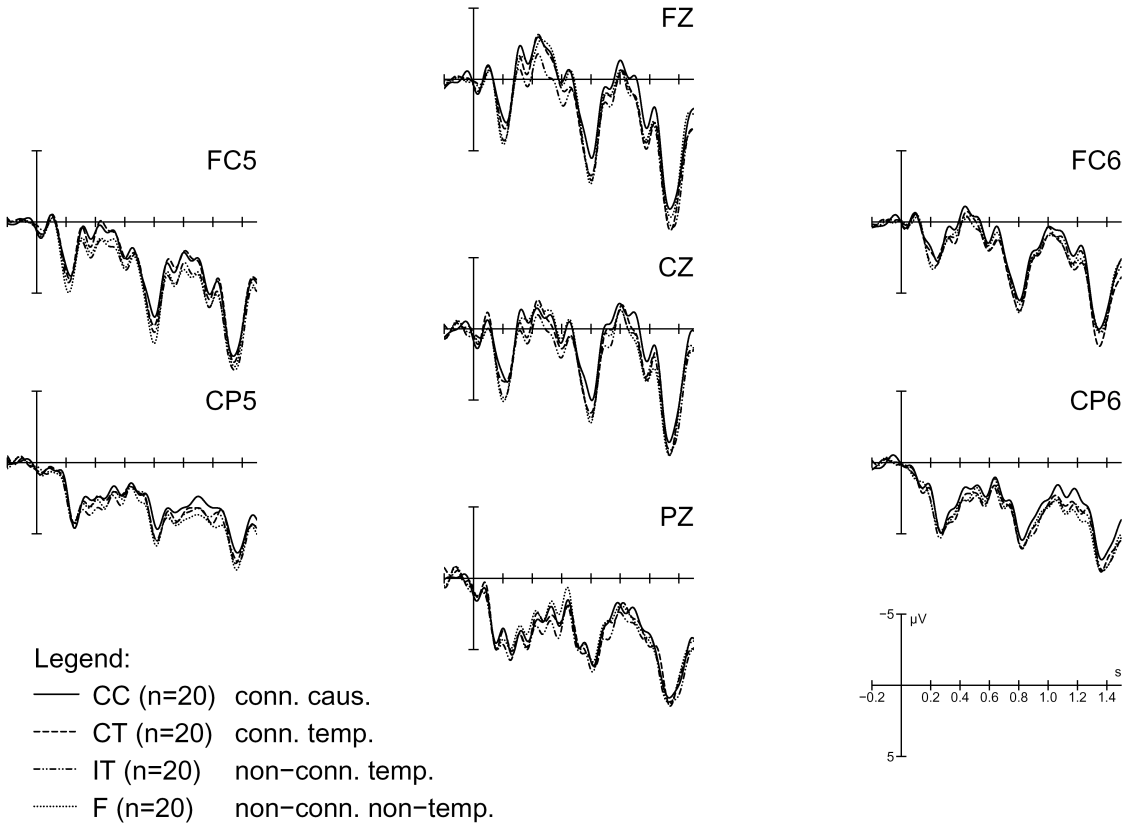


Figure IX-12**:** ERP grand averages, first word, experiment 3. N = 20.

Between 300ms and 600ms at left anterior sites (FC5) a negativity of both connectors relative to the non-connective temporal expression and the filler condition can be seen. Between 900 and 1100ms, the same contrast is visible for the same electrode. Grand averages for all recorded electrodes for this epoch can be found in Appendix F.

Baseline analysis

The window –200 to 0ms relative to the onset of the first word was examined with the ANOVA design to make sure that no systematic effects were present prior to presentation of the stimulus.

Statistics for the midline electrodes showed no significant main effects or interactions (all $p>.1$).

Statistics for the lateral electrodes showed an interaction HEMI x TEMP ($F(1,19) = 4.9$, $p<.05$). Resolution of this interaction by the factor HEMI showed no effects for TEMP either left- or right-hemispherically (both $F(1,19)<1$).

Since there were no significant main effects involving experimental manipulation, the window was used as a baseline.

The first negativity (300 to 600ms) midline analysis

Table IX-23 shows the statistical analysis for midline electrodes for the time-window 300 to 600ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)<1	
TEMP	F(1,19)=2.23	p=.15
ELEC x CONN	F(2,38)=1.25	p=.29
ELEC x TEMP	F(2,38)<1	
CONN x TEMP	F(1,19)=2.79	p=.11
ELEC x CONN x TEMP	F(2,38)<1	

Table IX-23**:** Global ANOVA for the midline, 300 to 600ms, first word, exp. 3. N=20.

There were no significant main effects or interactions for the midline electrodes for this time window.

The first negativity: (300 to 600ms) lateral analysis

Table IX-24 shows the global statistical analysis for the lateral electrodes in the time-window from 300 to 600ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)=3.33	p=.08
TEMP	F(1,19)<1	
REG x CONN	F(1,19)=1.17	p=.29
HEMI x CONN	F(1,19)=3.64	p=.07
REG x TEMP	F(1,19)<1	
HEMI x TEMP	F(1,19)<1	
CONN x TEMP	F(1,19)=1.64	p=.21
REG x HEMI x CONN	F(1,19)<1	
REG x HEMI x TEMP	F(1,19)<1	
REG x CONN x TEMP	F(1,19)<1	
HEMI x CONN x TEMP	F(1,19)<1	
REG x HEMI x CONN x TEMP	F(1,19)<1	

Table IX-24**:** Global ANOVA for lateral ROIs, 300 to 600ms, first word, exp. 3. N=20.

Resolution of the interaction HEMI x CONN by the factor HEMI showed a significant main effect for CONN ($F(1,19)=4.89$, $p<.05$) for the left hemisphere, due to more negative curves of the conditions involving connective ties (CC and CT), compared to the conditions without connective ties (IT and F), as visible in Figure IX-12. There was no effect for CONN for the right hemisphere ($F(1,19)=1.47$, $p=.24$).

The second negativity (900 to 1100ms) midline analysis

Table IX-25 shows the statistical analysis for midline electrodes for the time window 900 to 1100ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)=1.29	p=.27
TEMP	F(1,19<1	
ELEC x CONN	F(2,38)<1	
ELEC x TEMP	F(2,38)<1	
CONN x TEMP	F(1,19)=1.38	p=.25
ELEC x CONN x TEMP	F(2,38)<1	

Table IX-25: Global ANOVA for the midline, 900 to 1100ms, first word, exp. 3. N=20.

There were no significant main effects or interactions for the midline electrodes for this time window.

The second negativity (900 to 1100ms) lateral analysis

Table IX-26 shows the global statistical analysis for the lateral electrodes in the time-window from 900 to 1100ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)=2.23	p=.15
TEMP	F(1,19)<1	
REG x CONN	F(1,19)<1	
HEMI x CONN	F(1,19)=3.44	p=.08
REG x TEMP	F(1,19)=1.34	p=.26
HEMI x TEMP	F(1,19)<1	
CONN x TEMP	F(1,19)=1.08	p=.31
REG x HEMI x CONN	F(1,19)<1	
REG x HEMI x TEMP	F(1,19)=1.4	p=.25
REG x CONN x TEMP	F(1,19)<1	
HEMI x CONN x TEMP	F(1,19)<1	
REG x HEMI x CONN x TEMP	F(1,19)<1	

Table IX-26**:** Global ANOVA for lateral ROIs, 900 to 1100ms, first word, exp. 3. N=20.

Resolution of the interaction HEMI x CONN by the factor HEMI showed an effect for CONN for the left hemisphere (F(1,19)=4.18, p=.05), due to more negative curves for the conditions involving lexical connectors (CC and CT) compared to the conditions without lexical connectors (IT and F). There was no effect for the right hemisphere (F(1,19)<1).

IX.3.6.2. The Object

The following Figure IX-13 shows the averaged curves for all four experimental conditions for the time window of –200ms to +1500ms relative to the onset of the object of the target sentence at 0ms, with a baseline from –200 to 0ms. Shown are three midline electrodes and one electrode from each of the four lateral ROIs. Negative voltages are plotted up.

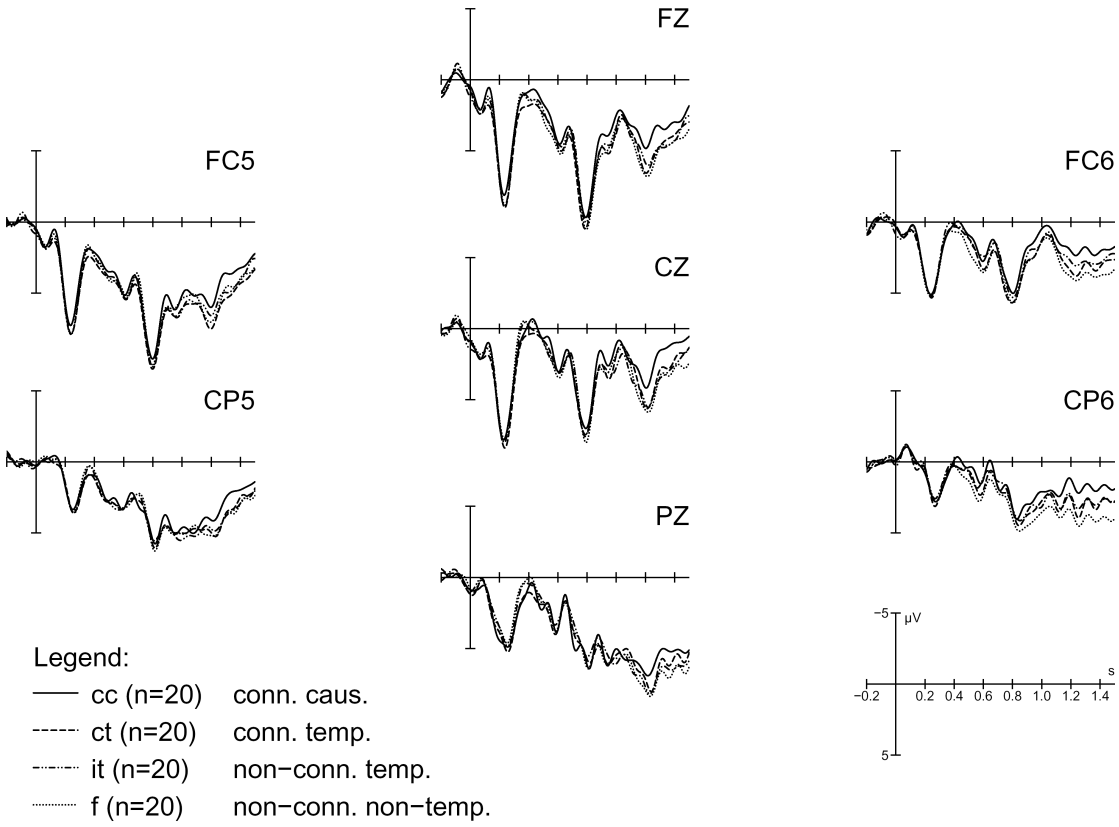


Figure IX-13**:** ERP averages, object, experiment 3. N = 20.

Between 300 and 500ms a negative deflection of the three conditions CC (connective causal), IT (non-connective causal) and F (filler) compared to CT (connective temporal) can be seen, largest for frontocentral electrodes. This effect, however, was not reliable either between 300 and 500ms or in smaller windows (all p>.1).

Starting at 1100ms and continuing until the end of the window contrast between the connective causal condition (CC) and connective temporal condition (CT) and the non-connective temporal condition (IT) is visible, largest for frontocentral and right-hemispherical electrodes. Grand averages for all recorded electrodes for this epoch can be found in Appendix F.

Baseline analysis

The window –200 to 0ms relative to the onset of the object was examined with the ANOVA design to make sure that no systematic effects were present prior to presentation of the stimulus.

Statistics for the midline electrodes showed an interaction CONN x TEMP ($F(1,19)=3.17$, $p=.09$). This interaction was resolved by examination of single comparisons.

Examined were the comparisons CC versus CT (connective causal versus connective temporal), IT versus F (non-connective temporal versus the filler condition), CC versus IT (connective causal versus non-connective temporal) and lastly CT versus IT (connective temporal versus non-connective temporal). There were no main effects or interactions involving experimental factors found for any of these single comparisons (all p>.2).

Statistics for the lateral electrodes showed an interaction REG x CONN x TEMP ($F(1,19)=5.52$, $p<.05$). Resolution by the factor REG did not produce an interaction CONN x TEMP either for anterior ($F(1,19)=1.33$, $p=.26$) or posterior electrodes ($F(1,19)=2.32$, $p=.14$).

Since there were no significant main effects involving experimental manipulation, the window was used as a baseline.

The late negativity (1100 to 1500ms) midline electrodes

Table IX-27 shows the statistical analysis for midline electrodes for the time window 1000 to 1500ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)=5.51	p=.03
TEMP	F(1,19)=2.26	p=.15
ELEC x CONN	F(2,38)<1	
ELEC x TEMP	F(2,38)<1	
CONN x TEMP	F(1,19)<1	
ELEC x CONN x TEMP	F(2,38)<1	

Table IX-27**:** Global ANOVA for the midline, 1100 to 1500ms, object, exp 3. N=20.

The main effect for connector was apparently the only reliable difference between conditions in this time window.

The late negativity (1100 to 1500ms) lateral electrodes

Table IX-28 shows the statistical analysis for lateral electrodes for the time window 1000 to 1500ms.

Global ANOVA	F-value	p-value
CONN	F(1,19)=6.2	p=.02
TEMP	F(1,19)=3.67	p=.07
REG x CONN	F(1,19)<1	
HEMI x CONN	F(1,19)=3.55	p=.08
REG x TEMP	F(1,19)<1	
HEMI x TEMP	F(1,19)<1	
CONN x TEMP	F(1,19)=1	
REG x HEMI x CONN	F(1,19)<1	
REG x HEMI x TEMP	F(1,19)<1	
REG x CONN x TEMP	F(1,19)<1	
HEMI x CONN x TEMP	F(1,19)<1	
REG x HEMI x CONN x TEMP	F(1,19)<1	

Table IX-28**:** Global ANOVA for the lateral ROIs, 1100 to 1500ms, object, exp 3. N=20.

Resolution of the interaction HEMI x CONN by the factor HEMI showed nothing for the left hemisphere ($F(1,19)=1.92$, $p=.18$), but a significant main effect for CONN for the

right hemisphere ($F(1,19)=8.81$, $p<.01$), due to a contrast between connective conditions (CC and CT) and non-connective conditions (IT and F).

The global difference between connective and non-connective conditions appears be the only reliable contrast in this time window.

IX.3.7. Discussion experiment 3

IX.3.7.1. Behavioral data

The overall low error rates showed that the subjects had no trouble reading the sentences or performing the task asked of them. Presence or absence of a temporal or causal connective tie also had no influence on subjects' accuracy in the probe detection task. The reaction times suggest that in the absence of a connective tie, subjects had more difficulty deciding whether the probe word had occurred in the previous trial. This might be due to uncompleted inference processes intruding on the task, but even if so, this intrusion had no effect on the subjects' accuracy.

IX.3.7.2. ERP data

There were no effects found prior to 200ms poststimulus found for either the first word or the object of the target sentences. These results therefore also provide no data speaking against a syntax-first model of processing (Friederici 2002, hypothesis I).

The first word

The contrast found on the first word of the target sentences was the same as in experiment 1 with respect to lateralization, peak latency and polarity: a LAN of the connective conditions compared to both non-connective conditions. There was no influence of connector-type between the connective conditions, nor a contrast between temporal and non-temporal elements for the non-connective conditions. Hypothesis II.a is therefore supported, while hypothesis II.b must be rejected: the contrast in experiment 2 was due to a difference in processing between connective and non-connective elements, not between temporal and causal elements. Why the effect is larger and has a notably shorter onset latency in this study is somewhat difficult to explain, but a reason might lie in the nature of the materials. Since half of the trials in experiment 2 contained incoherent material, subjects might have put additional effort into understanding the context to be able to judge coherence quickly later on. This added memory load could have intruded on the effect found for the first word, but would not have been present in experiment 3.

The contrast found in experiment 2 was also not due to the connective ties being task-relevant (see Münte, Schiltz & Kutas, 1998 compared to Baggio, 2004), since the connective ties in experiment 3 provided no information that was relevant to the probe detection. Hypothesis II.c is therefore also rejected.

An interesting contrast between the results from experiment 2 and those from experiment 3 is that there was a second effect found for the non-connective conditions on the verb of the target sentence in both experiments, but in experiment 2 it was a right-posterior negativity for the non-connective conditions, while in experiment 3 it was a left-hemispherical negativity for the connective conditions. In experiment 2, the effect was attributed to added integration costs for elements subsequent to the first word in the non-connective conditions. In this study, the effect seems to be a second LAN in response to the connective conditions.

The object

Despite the fact that there were visual differences between the conditions in the window between 300 and 500ms after presentation of the object, these contrasts were not reliable. It is therefore concluded that foregrounding either the causal or the temporal dimensions in a short discourse with an underlying causal relation is possible, or at least has no influence on the integration of elements of the internal argument prior to the end of the sentence (hypothesis III). Similarly to the lack of a difference between the coherent conditions in experiment 2, there was no difference between connective and non-connective discourses on the object in experiment 3, i.e. integrating the objects in non-connective discourses was no more difficult than integrating those in connective discourses. The relevant part of hypothesis III is therefore rejected.

Sentence-end effects

The effects found on the sentence-final elements in this experiment seem to be a contrast between the connective and the non-connective conditions. There were no violations present in the materials, and so interpreting the contrasts found as SEN-effects seems counterintuitive. The other possibility stated in hypothesis IV, that of a positivity for the more demanding conditions, seems more promising, but there is a general question that must be discussed first: how can the proposal be defended that more difficult end-of-sentence processes alternately elicit negativities or positivities, if positivity it be? The answer might lie in the processes that took place before the end of the sentence. In the cases where end-of-sentence effects were interpreted as negativities, there had been a prior syntactic or semantic violation in the relevant conditions (Osterhout & Holcomb, 1992, 1993; Hagoort, Brown & Groothusen, 1993, McKinnon & Osterhout, 1996, Osterhout & Mobley, 1995; Osterhout, Bersick, & McLaughlin, 1997; Frisch 2000). In the study by Kuperberg, Caplan, Eddy, Cotton & Holcomb, (2004), however, there was no outright violation, whether semantic or syntactic, but the contrasting condition arguably involved additional end-of-sentence integration, as the integrated situation model was needed for completing the task of judging how related the previous two sentences were. It might be that coherent discourses elicit anterior positivities on the sentence-final elements as a correlate of updating and integrating the situation model, while sentences or discourses that contained a violation do not, but elicit a correlate of semantic integration difficulties, an SEN. The only way to tell these two effects apart is the presence or absence of violations prior to the last element in a sentence. Moreover, since the positivity would be elicited by what in experiments examining violations are the control conditions, the two effects would always occur in response to different conditions, but at the same point in the parse in experiments contrasting coherent with incoherent discourses, such as experiment 2. This makes a distinction of the two effects, if they are indeed separate, nearly impossible.

If the effects found are positivities, then the following, somewhat speculative and only partial, interpretation is possible. While foregrounding the temporal or the causal dimensions does not have an influence on the integration of elements prior to the sentence-final one, it does influence the construction of an integrated situation model, a process that would by definition occur at the end of a discourse. By foregrounding the temporal dimension with a *non-connective* temporal element, which the clearly temporal but non-connective deictical elements might have done, the elements prior to the last one(s) might be fully integrated only with respect to that dimension, and other dimensions present backgrounded until the end of the sentence. If a connective tie is used on the other hand, and connective ties do indeed signal that the relation denoted by them is the only one

present in the respective discourse, there would have been no additional evaluation at the end of the sentence for either the causal or the temporal connective conditions.

IX.3.8. Experiments 2 and 3: summary

One important finding in experiment 2, supported by the results of experiment 3, is that the theoretical distinction between connective ties and (deictical) sentential adverbs is supported by empirical evidence. Connective ties are processed differently from other elements standing in the same syntactic position. By the same token, it can be said that deictical elements are non-connective, providing support for the distinction made between connective ties and deictical elements in the HdK (Pasch, Braußе, Waßner, & Herrmann, 2003). The effect found for connective ties, a LAN in both experiments, suggests that added working memory load was incurred. The underlying processes of this effect could either be attributed to the connective tie triggering the integration of the context into the text representation as a cause, respectively first event (t1), or to the also present co-referential characteristica of the connective ties. The second major result of both experiments argues more for the former possibility: the information imparted by connective ties influences the integration of subsequent elements. The effects found for the verbs of the target sentences are somewhat contradictory between the experiments, suggesting added integration costs for non-connective conditions in experiment 2 and added working memory load for the connective conditions in experiment 3. The results for the objects of the target sentences on the other hand paint a fairly clear picture. While a felicitous connective tie did not influence the integration of that element, a misleading one resulted in added difficulties, difficulties that would not have occurred if the external argument had not been integrated as the cause of the internal argument. This supports the notion that language processing is indeed incremental with respect to the text representation as well as the sentence representation, as shown by the previous ERP studies on discourse discussed in section VII.3.

That it might *not* be 'turtles all the way down'[69], or incrementality all the way up in this case, is indicated by the effects found on the sentence-final prepositional phrases. In experiment 2, both incoherent conditions were more negative than the coherent conditions. This effect was taken to be a correlate of the difficulty or inability to integrate the violating sentence into a final (integrated) situation model. In experiment 3, the non-connective conditions were argued to be more positive than the connective conditions. This latter effect being a negativity of the connective conditions instead was discussed, but rejected as there was no violation present prior to the last elements presented. If the contrast found was a positivity for the two non-connective conditions, then it might indicate that the final evaluation of dimensions present in a discourse beyond the foregrounded temporal one was not undertaken until the end of the second sentence for non-connective conditions, in other words that the end of a sentence or discourse plays a prominent role for the construction of an integrated situation model (Zwaan, Langston & Graesser, 1995; Zwaan, Magliano & Graesser, 1995; Zwaan & Radvansky, 1998, see also the data presented by Millis & Just, 1994).

[69] This is the punch-line of an old Hindu joke, to be found in Pratchett, Stewart & Cohen (1999), pp. 51.

IX.4. EXPERIMENT 4

IX.4.1. Questions

All connective ties examined so far signaled relations that Townsend (1983) refers to as 'preferred cause-effect or first-second event order', in other words in the temporal relations the first event was read first, and in causal relations the cause was read first. Townsend reported that the inclusion of concessive connective ties such as *although* and *however* in his materials resulted in longer reaction times to a task. He attributed this to concessive connective ties not allowing for a causal relation between the arguments. This conclusion has been disagreed with here (see section III.4.2.4). Concessive connective ties do not only allow for a causal relation between arguments, they imply that such a relation is present. The difference to causal connective ties is that concessive connective ties signal unusual or surprising outcomes of a situation.

In experiment 4, concessive connective ties were compared to causal connective ties. Both types of connective ties signal a causal relation, but the felicity of possible outcomes differs depending on which type of connective tie is used. This difference has been expressed in section III.4.2.6 as a contrast between the probabilities of possible outcomes: causal connective ties are felicitous with probable outcomes of a situation while concessive connective ties are felicitous with improbable outcomes of a situation. For this interpretation, it had to be assumed that there is a difference between causally unrelated outcomes and related outcomes not 'condoned' by the connective tie.

Experiment 4 therefore investigated whether there is evidence for the postulated difference between improbable and impossible outcomes.

A second motivation for experiment 4 was to examine whether the fact that concessive connective ties 'announce' a surprising outcome has immediate consequences for processing on the concessive connective tie itself and on subsequent elements in the internal argument before the end of the sentence. If Townsend's interpretation is correct, and readers have a preference for straightforward causal relations, then concessive connective ties should differ from causal connective ties.

Whether there is a difference between causal and concessive discourses is also influenced by how quickly a situation model can be altered as well as *when* it is altered to accommodate surprising outcomes. Previous ERP research has shown that even if an element directly prior to a pragmatically violating one would have legalized the violation, the amplitude of the N400 for the subsequent element indicated that the legalizing element had not been incorporated into the situation model to the extent that it could influence the semantic expectation or cloze probability of the current element (Fischler, Bloom, Childers, Roucos & Perry, 1983; Kounios & Holcomb; 1992; Van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort, 2005). Other studies in which there were intervening elements between the signaling element and the critical word found that the legalizing word had apparently 'done its job' or been incorporated (Brehm, 2000; beim Graben, Drenhaus, Saddy, Brehm & Frisch, submitted). The speed with which such a potential alteration of the current situation model can be accomplished is also influenced by the complexity of the changes needed (Just & Carpenter, 1992), as well as the closeness of the semantic relation between the violating word and the correct continuation (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B).

IX.4.2. Stimulus materials

A total of 640 sentence pairs were constructed, using the materials from experiment 2 and 3. Each of the four conditions causal coherent (A), concessive coherent (B), causal incoherent (C) and concessive incoherent (D) was represented 160 times. A block of lexical material with the four conditions is shown in Table IX-29:

Context	**In der Einladung wurde um formelle Kleidung gebeten.** The invitation requested formal dress.
Coherent targets	
A causal coherent	**Darum kaufte Sonja Lackschuhe in der Stadt.** Therefore bought Sonja patent leather shoes in town.
B concessive coherent	**Trotzdem kaufte Sonja Turnschuhe in der Stadt.** Nevertheless bought Sonja jogging shoes in town.
Incoherent targets	
C causal incoherent	**Darum kaufte Sonja Turnschuhe in der Stadt.** Nevertheless bought Sonja jogging shoes in town.
D concessive incoherent	**Trotzdem kaufte Sonja Lackschuhe in der Stadt.** Nevertheless bought Sonja patent leather shoes in town.

Table IX-29: Example of stimulus materials, experiment 4.

All target sentence had the same syntactic structure, as shown in example 5:

5.	Darum	kaufte	Sonja	Lackschuhe	in der Stadt.
	caus./concess. conn. tie	Verb	Name	Object	PP

Two lexical elements were chosen for each of the two categories: *deshalb* and *darum* as causal connective elements, both synonymous with *therefore*; *trotzdem* and *dennoch* as concessive connective elements, both synonymous with *nevertheless*.

The objects in each block of lexical material were chosen to represent semantic opposites, such as formal versus casual in the example in Table IX-29. The incoherent examples were constructed by switching the objects around between the two coherent conditions. In the incoherent conditions the outcomes denoted were thereby not impossible, but improbable given the context.

The same 10 verbs from experiment 2 were used 16 times each, to ensure that diagnosis of the incoherence was not possible until the object of the target sentence was read. As before, every possible combination of two of each of the four connective elements was used equally often with every one of the ten verbs. The complete stimulus materials for experiment 4 can be found in Appendix D.

IX.4.3. Hypotheses and predictions

I. Analogous to experiments 2 and 3, there are no effects pertaining to the experimental manipulation prior to 200ms predicted.

As in experiments 2 and 3, there were three points of interest: the first word of the target sentences, the object of the target sentences, and the sentence-final prepositional phrase.

II.a. **The first word; causal versus concessive connective ties**: If the LAN observed in experiments 2 and 3 was due to a contrast between connective and non-connective elements, then there should be no difference between the causal and the concessive conditions at left and / or left anterior electrodes.

II.b. **The first word; influence of concessivity**: If the concessive connective ties trigger an update of the situation model immediately, then a corresponding ERP effect should occur for the two concessive conditions. The correlate of a situation model update according to Donchin (1979) and Donchin & Coles (1988) is a late posterior positivity (P3b). This is the effect predicted for the concessive connective ties.

III.a. **The object; coherence**: If the connective ties influence the cloze probability of the object, then the two incoherent conditions should yield a larger N400 than the coherent conditions.

III.b. **The object; semantic illusion**: Alternately, it is possible that the close semantic relationship between the correct and incorrect objects results in the incoherence not being diagnosed or not eliciting an N400. Previous studies have found a late positivity for violations closely semantically related to the correct continuation (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B). If the close semantic relationship between the violating object and a correct continuation leads to the subjects not diagnosing the violation immediately, then a late positivity for the incoherent conditions is expected.

III.c. **The object; concessive connective ties:** If the concessive connective ties do not trigger an immediate update of the situation model, then the pattern of responses for the two concessive conditions should be reversed: a larger N400 for the coherent condition compared to the incoherent condition.

IV. **Sentence-end effects**: There were semantic violations present in the stimuli, so the respective conditions, namely both incoherent ones, should elicit sentence-end negativities (SEN).

IX.4.4. Method

IX.4.4.1. Randomization and presentation

As a coherence judgment was again felicitous in this design, this task was chosen. The 640 sentence pairs were split into four lists of 160 sentence pairs each, with only one pair from each material block per list. Each list was then pseudo-randomly split into four experimental blocks of 40 trials each, such that each condition, the two expected types of judgment, and the four connective ties occurred roughly equally often in each experimental block of 40 trials: between 9 and 11 trials per condition, between 19 and 21 trials for each type of expected answer and between 4 and 6 occurrences of each connective tie.

Care was taken to ensure that no more than two trials of the same condition, no more than two trials with the same expected answer and no more than one trial with the same connective element occurred consecutively. The four resulting randomized lists were then each reversed, resulting in a total of eight experimental versions.

Presentation was the same as for experiment 2. Figure IX-14 shows the time course of the target sentences:

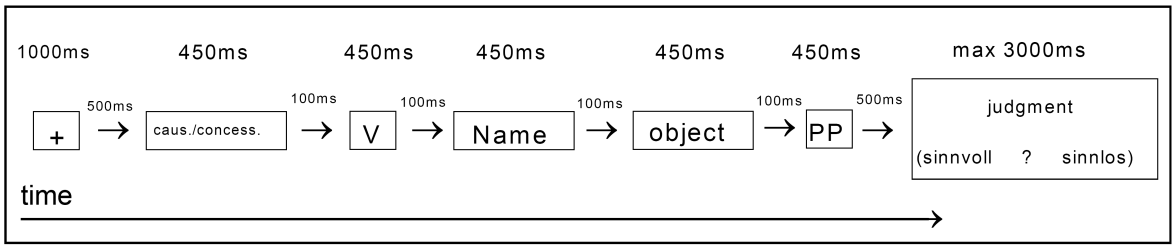


Figure IX-14: Time course of the target sentences, experiment 4.

The subjects were instructed not to move during experimental blocks and only to blink in the interval between a response and the fixation point for the next trial. There were 12 practice trials to familiarize the subjects with the task and the 'blinking-routine'.

Between the four experimental blocks pauses were interjected the length of which were determined by the subject, although a minimum duration of one and a maximum duration of five minutes was aimed for by the experimenter. Total on-task time for experiment 4 was between 45 and 55 minutes, total duration of a session between one and a half hours and two hours.

IX.4.4.2. Subjects

26 students from Potsdam University participated in this study, of whom 4 were male. None had participated in any of the previous studies 1, 2 or 3. All were right-handed, had normal or corrected-to-normal vision and had learned German as their only first language. Their ages ranged between 18 and 31 years, mean age was 26.1 years. Participation was paid with either 15 Euro or with course-credit.

IX.4.4.3. EEG- and data recording

The recording equipment, stimulus presentation equipment and electrode configuration were the same as used for experiment 2.

IX.4.4.4. Data preparation

Behavioral data

Error rates were calculated as the percentage of responses not in accordance with the expected response for each trial. Missed responses, i.e. no response within the time limit set were counted as errors.

Reaction times were evaluated on the basis of correct responses only. The percentage of trials excluded from evaluation of the reaction times corresponds to the error percentages.

EEG data

The software and procedures for artifact-rejection and averaging were the same as for experiment 2.

There were two grand-averages calculated. The EEG-epochs for the first word of the target sentence were sorted by lexical element. The epochs for the object of the target sentences were averaged by the four conditions described above.

Only artifact-free and correctly answered trials were included in the analysis. The totals of trials excluded from the analysis for the first word of the target sentence due to incorrect responses or artifacts were: 18.6% for the condition *deshalb*, 17.3% for the condition

darum, 21.7% for condition *trotzdem* and 23.3% for condition *dennoch*, overall mean 20.2%.

The total of trials excluded from the analysis of the object of the target sentence was: 16.1% for condition A, 27.6% for condition B, 24.5% for condition C and 22.2% for condition D, overall mean 22.6%. The relatively high percentage of rejections in this experiment is due not to a high frequency of artifacts but to the error rates.

4 data sets were excluded from analysis due to more than 45% incorrectly answered trials in one or more condition, resulting in a total of 22 data sets in this experiment.

For presentation a 9Hz lowpass filter was applied to the grand-averages; the statistical analyses were performed on the unfiltered data.

IX.4.4.5. Statistical analysis

The procedure for the statistical analysis of experiment 4 was analogous to the procedure for experiment 2, only varying with respect to the experimental factors and time windows chosen for analysis.

The statistical evaluation for the time-window of the first word of the target sentence (the causal resp. concessive connective ties) in experiment 4 was done using a 2-by-2 design with the factors connector (2 CONN: connective causal versus connective concessive) and item (2 ITEM: *deshalb* versus *darum* and *trotzdem* versus *dennoch*), as shown in Table IX-30:

		Item (ITEM)	
Connector (CONN)	causal	**deshalb**	**darum**
	concessive	**trotzdem**	**dennoch**

Table IX-30: ANOVA Design for the first word in experiment 4.

The statistical evaluation for the object time-window in experiment 4 was done using a 2-by-2 design with the factors coherence (2 COHER: coherent versus incoherent) and connector (2 CONN: causal versus concessive), as shown in Table IX-31:

		Coherence (COHER)	
		coherent	incoherent
Connector (CONN)	causal	**(A) causal coherent**	**(C) causal incoherent**
	concessive	**(B) concessive coher.**	**(D) concess. incoher.**

Table IX-31: ANOVA Design for the object in experiment 4.

The Regions of Interest (ROIs) defined for this experiment were the same as for the experiments 2 and 3 (see also Table IX-10).

The electrodes selected for statistical analysis for the midline were also the same as for experiments 2 and 3: FZ, CZ, and PZ.

- The ANOVA design for the lexical average (the first word) of the lateral electrodes was **REG (2) x HEMI (2) x CONN (2) x ITEM (2).**
  The topographical factor for the midline for the lexical average was electrode (ELEC: FZ, CZ, PZ), resulting in an ANOVA design **ELEC (3) x CONN (2) x ITEM (2)** for the first word.

- The ANOVA design for the object window of the lateral electrodes was **REG (2) x HEMI (2) x COHER (2) x CONN (2).**
  The topographical factor for the midline was electrode (ELEC: FZ, CZ, PZ), resulting in an ANOVA design **ELEC (3) x COHER (2) x CONN (2)** for the object of the target sentence.

IX.4.5. Results: behavioral data

IX.4.5.1. Error rates and reaction times by condition

The two bar graphs and the table below show mean error rates (in %) and mean reaction times (in ms) for the four experimental conditions in experiment 4.

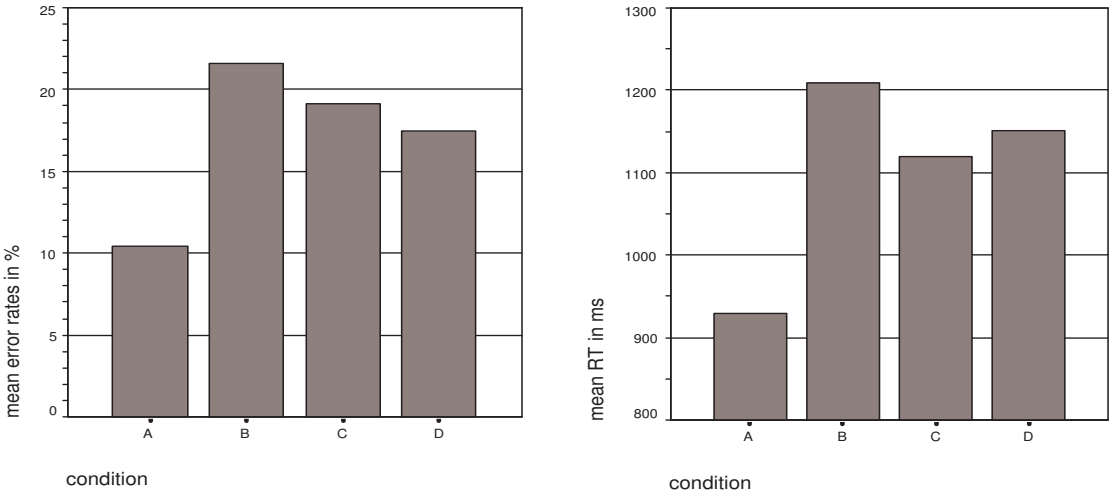


Figure IX-15: Mean error rates and reaction times, experiment 4. N = 22.

	Error rates (in %)		Reaction times (in ms)	
condition	**mean**	**Std.**	**mean**	**Std.**
A: causal coherent	10.5	6.6	928	355
B: concessive coherent	21.6	11.6	1209	437
C: causal incoherent	19.1	9.4	1119	430
D: concessive incoherent	17.6	9.3	1152	425

Table IX-32: Means and standard deviations, error rates and reaction times, exp. 4.

Analysis of the error rates showed no main effect for COHER ($F(1,21)=1.17$, $p=.3$), but a significant effect for CONN ($F(1,21)=8.14$, $p=.01$) and an interaction COHER x CONN ($F(1,21)=14.64$, $p=.001$). Examination of single comparisons showed an effect for CONN for the comparison A versus B ($F(1,21)=24.95$, $p<.001$). The comparison C versus D yielded no effect ($F(1,21)<1$). The comparison A versus C showed an effect for COHER ($F(1,21)=14.84$), $p=.001$), while the comparison B versus D was not significant for COHER ($F(1,21)=1.79$, $p=.2$).

Analysis of the reaction times showed a main effect for COHER ($F(1,21)=6.15$, $p=.02$) and a main effect for CONN ($F(1,21)=14.72$, $p=.001$) as well as an interaction COHER x CONN ($F(1,21)=18.83$, $p<.001$). Examination of single comparisons showed a significant effect for CONN for the comparison A versus B ($F(1,21)=24.42$, $p<.001$), but none for the

comparison C versus D (F(1,21)<1). The comparison A versus C yielded a significant effect for COHER (F(1,21)=23.96, p<.001), but there was no such effect for the comparison B versus D (F(1,21)=2.08, p=.17).

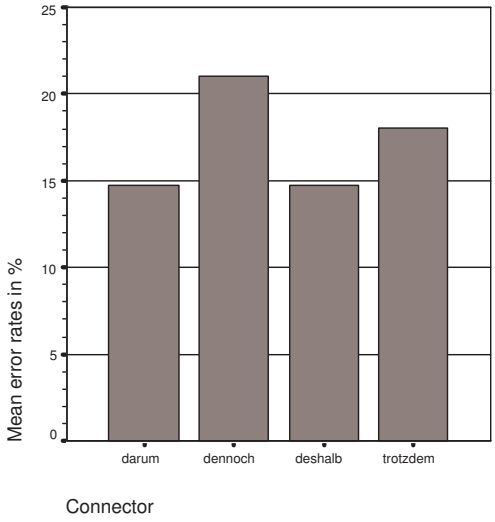
IX.4.5.2. Error rates by connective tie

Table IX-33 shows the mean error rates and standard deviations for each of the four connective ties used. Figure I-16 shows the error rates (in %).

	Error rates (in %)	
condition	**mean**	**Std.**
darum	14.8	5.8
deshalb	14.8	7.5
trotzdem	18.1	6.7
dennoch	21	11.6

Table IX-33: Error rates for the connective ties, exp 4.

Figure IX-16: Error rates (in %), conn. ties, exp. 4. →



Analysis of the error rates for the connective ties showed a reliable contrast between causal and concessive connective ties (CONN (F(1,21)=8.14, p=.01). There was no effect for lexical item, *darum* versus *deshalb* or *trotzdem* versus *dennoch* (ITEM (F(1,21)=1.21, p=.26), nor an interaction between connector type and lexical item (CONN x ITEM (F(1,21)=1.18, p=.29)..

IX.4.6. Results: ERP data

IX.4.6.1. The first word

Figure IX-17 shows the ERP averages for the first word of the target sentence, averaged for each of the four lexical conditions from –200ms to 1500ms relative to the onset of the first word at 0ms, with a baseline from –200 to 0ms. Shown are the three midline electrodes and one electrode from each of the four lateral ROIs. Negative voltages are plotted up.

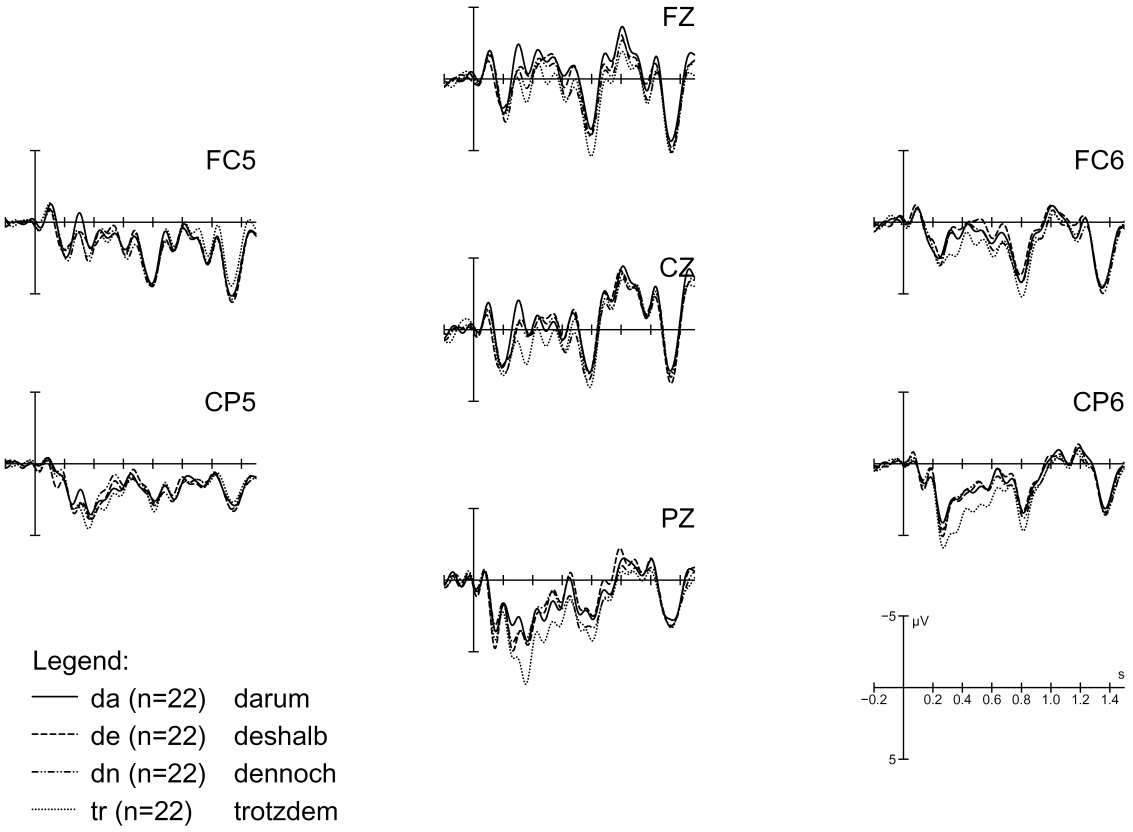


Figure IX-17: ERP grand averages, first word, experiment 4. N = 22.

Between 300 and 700ms, one of the concessive conditions (*'trotzdem'*) shows a more positive curve compared to all other conditions. This is especially noticeable for centro- and right-posterior electrodes. Between 700 and about 800ms, another small positivity, this time for both concessive conditions, is visible at PZ, see also Figure IX-18 below. Grand averages for all recorded electrodes for this epoch can be found in Appendix G.

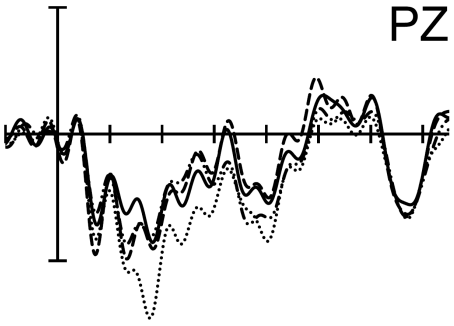


Figure IX-18: ERP grand averages, first word, electrode PZ, experiment 4. N = 22.

Baseline analysis

The window –200 to 0ms relative to the onset of the first word was examined with the ANOVA design to make sure that no systematic effects were present prior to presentation of the stimulus. Statistics for the midline electrodes showed no significant main effects or interactions (all p>.2). Statistics for the lateral electrodes showed an interaction REG x HEMI x CONN (F (1,21) =4.07, p=.06). Resolution of this interaction by the factor REG showed no effects for HEMI x CONN either for the anterior or the posterior ROIs (both p>.25). Since there were no significant main effects for or interactions between experimental factors, the window was used as a baseline.

The positivity for *trotzdem* (300 to 700ms) midline electrodes

Table IX-34 shows the analysis for the midline for the time window 300 to 700ms.

Global ANOVA	F-value	p-value
CONN	F(1,21)=6.18	p=.02
ITEM	F(1,21)=2.74	p=.11
ELEC x CONN	F(2,42)<1	
ELEC x ITEM	F(2,42)=1.23	p=.3
CONN x ITEM	F(1,21)=2.18	p=.15
ELEC x CONN x ITEM	F(2,42)=3.18	p=.07

Table IX-34: Exp. 4; Global ANOVA for the midline, 300 to 700ms, first word, exp 4. N=22.

Resolution of the interaction ELEC x CONN x ITEM by the factor ELEC showed no interaction CONN x ITEM for the electrodes FZ and CZ (all p>.2), but a significant interaction CONN x ITEM for the electrode PZ (F(1,21)=9.88, p<.01).

Examination of the single comparisons for PZ showed no effect for ITEM for the comparison *deshalb* versus *darum* (the causal connectives) with all p>.4, but a significant effect for ITEM for the comparison *trotzdem* versus *dennoch*: (F(1,21)=9.53, p<.01). This effect was due to a more positive curve of the condition *trotzdem* at PZ.

The positivity for *trotzdem* (300 to 700ms) lateral electrodes

Table IX-35 shows the analysis for lateral electrodes for the time window 300 to 700ms.

Global ANOVA	F-value	p-value
CONN	F(1,21)=5.86	p=.02
ITEM	F(1,21)=3.06	p=.1
REG x CONN	F(1,21)<1	
HEMI x CONN	F(1,21)=1.12	p=.3
REG x ITEM	F(1,21)=5.1	p<.05
HEMI x ITEM	F(1,21)<1	
CONN x ITEM	F(1,21)=2.48	p=.13
REG x HEMI x CONN	F(1,21)<1	
REG x HEMI x ITEM	F(1,21)<1	
REG x CONN x ITEM	F(1,21)=1.51	p=.2
HEMI x CONN x ITEM	F(1,21)=4.34	p=.05
REG x HEMI x CONN x ITEM	F(1,21)<1	

Table IX-35: Exp. 4: Global ANOVA for the lateral ROIs, 300 to 700ms, first word, exp 4. N=22.

Resolution of the interaction REG x ITEM by the factor REG showed no effect for ITEM for anterior ROIs (F<1) but a significant effect for ITEM for posterior ROIs (F(1,21)=7.37, p=.01).

Resolution of the interaction HEMI x CONN x ITEM by the factor HEMI showed no interaction CONN x ITEM for left-hemispherical ROIs ($F<1$), but a significant interaction for right-hemispherical ROIs ($F(1,12)=5.07$, $p<.05$).

Examination of single comparisons showed no effects for or interactions between factors involving experimental manipulations (all $F(1,21)<1$) for the right-hemispherical ROIs for the comparison *deshalb* versus *darum* (the causal conditions). The comparison *trotzdem* versus *dennoch* showed an effect for ITEM for the right-hemispherical ROIs ($F(1,21)=6.38$, $p<.05$) and an interaction REG x ITEM ($F(1,21)=7.80$, $p=.01$).

Resolution of this interaction by the factor REG showed no effect for ITEM for the right anterior ROI ($p>.2$), but a significant effect for ITEM for the right posterior ROI ($F(1,21)=11.46$, $p<.005$), due to a more positive curve of the concessive condition *trotzdem* in that area. As with the analysis of the midline electrodes for this window, these results show that the any effects for CONN in the overall analysis are due to a more positive curve of the condition *trotzdem* at posterior and right-posterior ROIs and not to a systematic difference between causal and concessive conditions.

The second positivity, 700-800ms, midline analysis

Table IX-36 shows the statistical analysis for the midline between 700 and 800ms.

Global ANOVA	**F-value**	**p-value**
CONN	$F(1,21)=3.88$	$p=.06$
ITEM	$F(1,21)<1$	
ELEC x CONN	$F(2,42)<1$	
ELEC x ITEM	$F(2,42)=1.17$	$p=.2$
CONN x ITEM	$F(1,21)<1$	
ELEC x CONN x ITEM	$F(2,42)<1$	

Table IX-36: Exp. 4; Global ANOVA for the midline, 700 to 800ms, first word, exp 4. N=22.

Despite the fact that there was no interaction between electrode and connector type, analyses for the separate electrodes were examined, since the positivity was visually present at PZ only.

Statistics for the anterior electrode FZ showed no effects, with all $p>.1$. The electrode CZ did not yield any effects either, with all $p>.2$. At the electrode PZ, a significant effect for connector type was found, with CONN ($F(1,21)=7.06$, $p=.01$). There was no effect for item, nor an interaction between connector type and item, both $F<1$. These results were due to a more positive deflection of both concessive conditions at the posterior electrode PZ in this time window.

The second positivity, 700-800ms, lateral analysis

Table IX-37 shows the statistical analysis for the lateral ROIs between 700 and 800ms.

Global ANOVA	F-value	p-value
CONN	F(1,21)=3.74	p=.07
ITEM	F(1,21)<1	
REG x CONN	F(1,21)<1	
HEMI x CONN	F(1,21)=1.6	p=.22
REG x ITEM	F(1,21)<1	
HEMI x ITEM	F(1,21)<1	
CONN x ITEM	F(1,21)<1	
REG x HEMI x CONN	F(1,21)=1.2	p=.29
REG x HEMI x ITEM	F(1,21)<1	
REG x CONN x ITEM	F(1,21)<1	
HEMI x CONN x ITEM	F(1,21)=3.27	p=.08
REG x HEMI x CONN x ITEM	F(1,21)=2.29	p=.15

Table IX-37: Exp. 4; Global ANOVA for the lateral ROIs, 700 to 800ms, first word, exp 4. N=22.

Resolution of the three-way interaction HEMI x CONN x ITEM by the factor hemisphere yielded no interaction CONN x ITEM for the left or the right hemisphere (both p>.2).

Since there were no specific hypotheses regarding the lateral ROIs in this time window, there were no further analyses calculated.

IX.4.6.2. The object

The following Figure IX-19 shows the averaged curves for all four experimental conditions for the time window of –200ms to +1500ms relative to the onset of the object of the target sentence at 0ms, with a baseline from –200 to 0ms. Shown are three midline electrodes and one electrode from each of the four lateral ROIs. Negative voltages are plotted up.

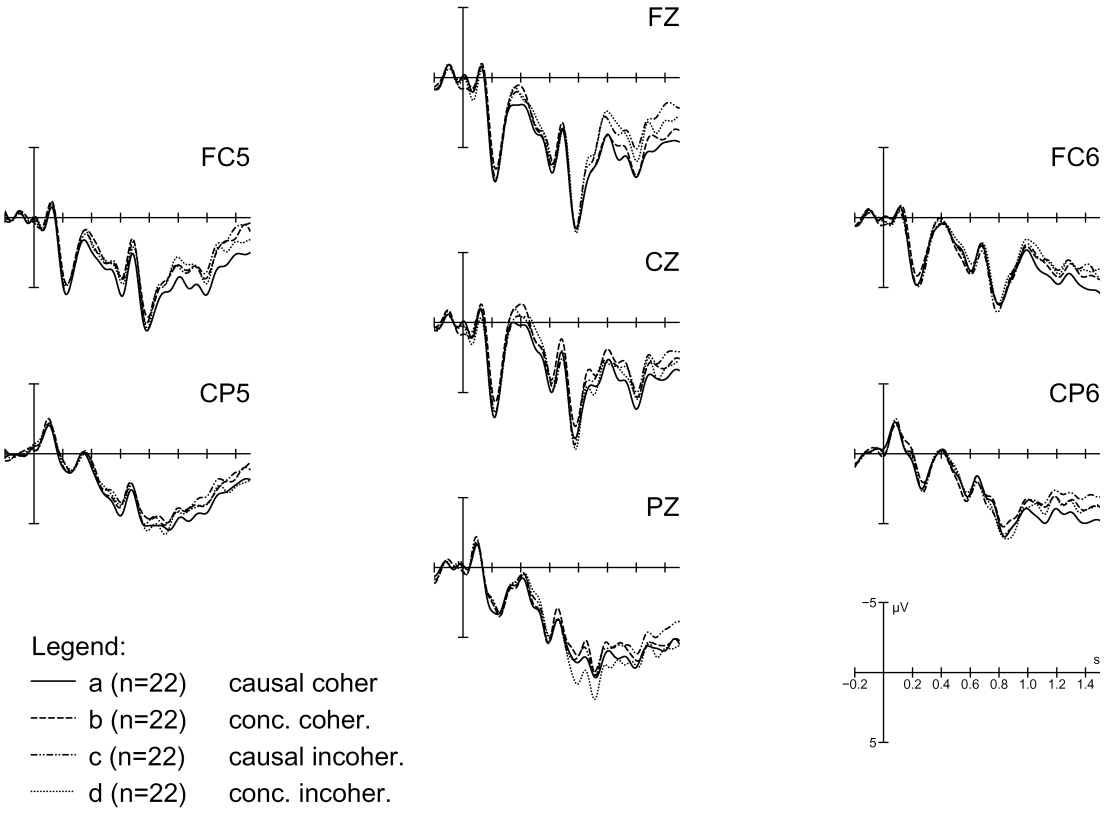


Figure IX-19: ERP grand-averages, object; exp. 4, N = 22.

Between 300 and 500ms a more negative curve of all conditions except causal coherent is visually present at FZ. Between 750 and about 1000ms, a positivity for the condition D (concessive incoherent) is visible for the posterior electrode PZ. Starting around 850ms, the incoherent conditions and for lateral electrodes also the concessive coherent condition show more negative curves than the causal coherent condition. This is most visible for frontal electrodes.

Figure IX-20 shows the averaged curves for the same time window for the two posterior ROIs:

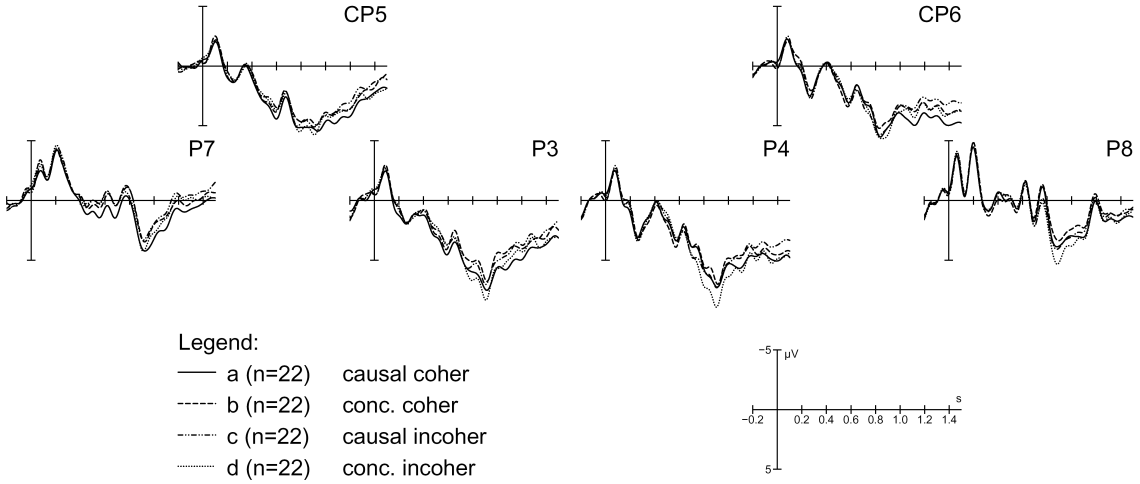


Figure IX-20: ERP grand-averages, posterior ROIs, object; exp. 4, N = 22.

Grand averages for all recorded electrodes for this epoch can be found in Appendix G.

Baseline analysis

The window –200 to 0ms relative to the onset of the first word was examined with the ANOVA design to make sure that no systematic effects were present prior to presentation of the stimulus. Statistics for the midline electrodes showed no significant main effects or interactions (all p>.12). Statistics for the lateral electrodes showed an interaction REG x HEMI x COHER (F (1,21) =3.46, p=.08). Resolution of this interaction by the factor REG showed no effect for HEMI x COHER for either the anterior ROIs (F(1,21)<.1), or the posterior ROIs (F(1,21)=2.86, p=.11).

Since there were no significant main effects for or interactions between experimental factors, the window was used as a baseline.

The first negativity (300-450ms), midline analysis

Table IX-38 shows the statistical analysis for the midline between 300 and 450ms.

Global ANOVA	**F-value**	**p-value**
COHER	F(1,21)<1	
CONN	F(1,21)=1.74	p=.2
ELEC x COHER	F(2,42)<1	
ELEC x CONN	F(2,42)=2.25	p=.12
COHER x CONN	F(1,21)<1	
ELEC x COHER x CONN	F(2,42)=1.27	p=.3

Table IX-38: Exp. 4; Global ANOVA for the midline, 300 to 450ms, first word, exp 4. N=22.

There were no reliable effects or interactions found for the midline in this time window.

The first negativity (300-450ms), lateral analysis

Table IX-39 shows the global statistical analysis for the lateral electrodes in the time-window from 300 to 450ms.

Global ANOVA	F-value	p-value
COHER	F(1,21)<1	
CONN	F(1,21)=1.95	p=.2
REG x COHER	F(1,21)<1	
HEMI x COHER	F(1,21)<1	
REG x CONN	F(1,21)=1.9	p=.2
HEMI x CONN	F(1,21)=1.21	p=.3
COHER x CONN	F(1,21)<1	
REG x HEMI x COHER	F(1,21)=1.12	p=.3
REG x HEMI x CONN	F(1,21)<1	
REG x COHER x CONN	F(1,21)<1	
HEMI x COHER x CONN	F(1,21)=2.4	p=.14
REG x HEMI x COHER x CONN	F(1,21)<1	

Table IX-39: Global ANOVA for the lateral ROIs, 300 to 450ms, object, exp 4. N=22.

There were no effects or interactions found for the lateral ROIs in this time window.

The positivity for D (750-1050ms), midline analysis

Table IX-40 shows the global statistical analysis for the midline electrodes in the time-window from 850 to 1050ms.

Global ANOVA	F-value	p-value
COHER	F(1,21)<1	
CONN	F(1,21)<1	
ELEC x COHER	F(2,42)=10.1	p<.0005
ELEC x CONN	F(2,42)=1.79	p=.19
COHER x CONN	F(1,21)=1.78	p=.2
ELEC x COHER x CONN	F(2,42)=7.09	p<.001

Table IX-40: Global ANOVA for the midline, 750 to 1050ms, object, exp 4. N=22.

Resolution of the interaction between electrode and coherence by the factor coherence yielded a reliable effect for coherence for the electrode FZ (F(1,21)=4.81, p<.05), due to the contrast between coherent and incoherent electrodes at FZ in that time window. There was no effect for coherence at CZ (F(1,21)<1) or PZ (F(1,21)=1.8, p=.2).

Resolution of the three-way interaction ELEC x COHER x CONN by the factor ELEC showed no interaction COHER x CONN at FZ (F(1,21)<1) or CZ (F(1,21)=2.28, p=.15), but a reliable interaction between the two factors at PZ (F(1,21)=4.9, p<.05).

This interaction was resolved by examining single comparisons between conditions for the electrode PZ.

The comparison A versus B (coherent conditions) showed no effect for connector type (CONN (F(1,21)<1). The comparison C versus D (incoherent conditions) did yield a reliable effect for connector type (CONN (F(1,21)=4.72, p<.05), due to a more positive curve of the concessive incoherent condition D compared to the causal incoherent condition C. The comparison A versus C (causal coherent versus incoherent) showed no effect for coherence at PZ (COHER (F(1,21)<1). The comparison B versus D (concessive coherent versus incoherent) yielded a reliable effect for coherence (COHER (F(1,21)=5.7, p<.05), due to a more positive curve for the concessive incoherent condition D compared to the

concessive coherent condition B. These results reflect the visual impression that the concessive incoherent condition D shows a positive deflection at the posterior electrode PZ in this time window.

The positivity for D (750-1050ms), lateral analysis

Table IX-41 shows the global analysis for the midline from 850 to 1050ms.

Global ANOVA	F-value	p-value
COHER	F(1,21)<1	
CONN	F(1,21)<1	
REG x COHER	F(1,21)<1	
HEMI x COHER	F(1,21)=2.35	p=.14
REG x CONN	F(1,21)=2.27	p=.15
HEMI x CONN	F(1,21)<1	
COHER x CONN	F(1,21)=1.36	p=.26
REG x HEMI x COHER	F(1,21)<1	
REG x HEMI x CONN	F(1,21)<1	
REG x COHER x CONN	F(1,21)=10.56	p<.005
HEMI x COHER x CONN	F(1,21)=1.16	p=.3
REG x HEMI x COHER x CONN	F(1,21)=1.34	p=.26

Table IX-41: Global ANOVA for the lateral ROIs, 750 to 1050ms, object, exp 4. N=22.

Resolution of the three-way interaction REG x COHER x CONN by the factor region showed no interaction COHER x CONN for anterior electrodes (F(1,21)<1), but a reliable interaction between coherence and connector type for posterior ROIs (COHER x CONN (F(1,21)=4.85, p<.05). This interaction was resolved by examining single comparisons between conditions for the posterior region.

The comparison A versus B (coherent conditions) showed no effect for connector type or interaction involving that experimental factor (all p>.17). The comparison C versus D (incoherent conditions) showed no effect for connector type or interaction involving that experimental factor (all p>.13). The comparison A versus C (causal coherent versus incoherent) yielded an interaction between hemisphere and coherence for the posterior ROIs (HEMI x COHER (F(1,21)=6.19, p<.05)). Resolution of this interaction by the factor hemisphere showed no effect for coherence for either the left- or the right-posterior ROI (all p>.14). The comparison B versus D (concessive coherent versus incoherent) showed a reliable effect for coherence (COHER (F(1,21)=6.05, p=.02) for posterior ROIs.

The second negativity (850-1500ms) midline analysis

Table IX-42 shows the global statistical analysis for the midline electrodes in the time-window from 850 to 1500ms.

Global ANOVA	F-value	p-value
COHER	F(1,21)=1.31	p=.26
CONN	F(1,21)<1	
ELEC x COHER	F(2,42)=7.09	p<.005
ELEC x CONN	F(2,42)=1.11	p=.33
COHER x CONN	F(1,21)=2.63	p=.12
ELEC x COHER x CONN	F(2,42)=1.07	p=.34

Table IX-42: Exp. 4; Global ANOVA for the midline, 850 to 1500ms, object, exp 4. N=22.

Resolution of the interaction ELEC x COHER by the factor ELEC showed an effect for COHER for FZ (F(1,21)=10.89, p<.005) but none for CZ or PZ (F(1,21)<1). This was due

to a more negative curve for both incoherent conditions (C and D) compared to coherent conditions A and B, visible for FZ.

The second negativity (850-1500) lateral analysis

Table IX-43 shows the global statistical analysis for the lateral electrodes in the time-window from 800 to 1500ms.

Global ANOVA	F-value	p-value
COHER	F(1,21)=1.84	p=.19
CONN	F(1,21)<1	
REG x COHER	F(1,21)=3.95	p=.06
HEMI x COHER	F(1,21)<1	
REG x CONN	F(1,21)=1.89	p=.18
HEMI x CONN	F(1,21)<1	
COHER x CONN	F(1,21)=4.57	p<.05
REG x HEMI x COHER	F(1,21)<1	
REG x HEMI x CONN	F(1,21)<1	
REG x COHER x CONN	F(1,21)=2.17	p=.16
HEMI x COHER x CONN	F(1,21)<1	
REG x HEMI x COHER x CONN	F(1,21)=3.72	p=.07

Table IX-43: Exp. 4; Global ANOVA for the lateral ROIs, 850 to 1500ms, object, exp 4. N=22.

Resolution of the interaction REG x COHER by the factor REG showed a marginal effect for COHER for the frontal ROIs (F(1,21)=4.09, p=.056), and nothing for the posterior ROIs (F(1,21)<1).

The global interaction COHER x CONN was resolved by examining single comparisons.

The comparison A versus B yielded a reliable effect for connector type (CONN (F(1,21)=4.31, p=.05). There were no interactions between the factor CONN and any topological factors (all p>.16). The comparison C versus D showed an interaction of region by connector type (REG x CONN (F(1,21)=3.04, p<.1), with all other p>.2. Resolution of this interaction yielded nothing for either the anterior or the posterior ROIs, with all interactions F<1, and all p>.08 for connector type CONN. The comparison A versus C yielded an effect for coherence (COHER (F(1,21)=6.74, p=.02). There were no interactions between the factor COHER and any topological factors (all p>.14). The comparison B versus D showed an interaction between region and coherence (REG x COHER (F(1,21)=7.59, p=.01). Resolution of this interaction yielded no effect for coherence either for the anterior or the posterior region (all p>.17).

Resolution of the interaction REG x HEMI x COHER x CONN showed an interaction HEMI x COHER x CONN for anterior ROIs (F(1,21)=2.87, p=.1), but none for posterior ROIs (F(1,21)<1).

Resolution of the anterior interaction HEMI x COHER x CONN by the factor HEMI showed an interaction COHER x CONN for the left anterior ROI (F(1,21)=3.31, p=.08), but none for the right anterior ROI.

To further examine the interaction COHER x CONN for the left anterior electrodes, single comparisons were calculated. The comparison A versus B (causal coherent versus concessive coherent) yielded a significant effect for CONN for the left anterior electrodes (F(1,21)=6, p<.05), due to a more negative curve of the concessive coherent condition (B) compared to condition A. The comparison C versus D (causal incoherent versus concessive incoherent) showed no effect for CONN (F(1,21)<1) for left anterior electrodes. The

comparison A versus C (causal coherent versus causal incoherent) yielded a significant effect for CONN for the left anterior electrodes ($F(1,21)=14.27$, $p=.001$), due to a more negative curve of condition C (causal incoherent) compared to condition A. The comparison B versus D (concessive coherent versus concessive incoherent) showed no effect for CONN ($F(1,21)<1$) for left anterior electrodes.

These effects reflect the visual impression that all conditions except A (causal coherent) describe a more negative curve at left anterior sites starting from around 850ms and lasting until the end of the averaged window (1500ms).

IX.4.7. Discussion experiment 4

IX.4.7.1. Behavioral data

Both the error rates and the reaction times show that contrary to expectations not the concessive incoherent condition D, but condition B (concessive coherent) was the most difficult one. Additionally, the data indicate that all conditions in which the underlying relation was not straightforward (B) or in which it was violated (C and D) were more difficult than the causal coherent condition A.

The conclusion that the task was too difficult or the material too confusing would be premature, however, since the error rates for all conditions as well as the connective ties themselves stayed well below the chance level of 50%, the concessive coherent condition B and the concessive connective tie *dennoch* being worst with 21.6% and 21% respectively.

The higher error rates for the concessive conditions were not due only to *dennoch*, either, as there was no difference between *trotzdem* and *dennoch*.

The hypothesis that the semantic content of the connective ties played no role whatsoever also has to be rejected. If the subjects had merely superficially matched the semantic content of the target to the situation denoted in context, and thereby ignored the connective ties, then the condition D should have been no more difficult than the condition A, both trials containing the same lexical material except for the connective tie.

This shows that subjects were indeed able to read and understand the materials and perform the task asked of them.

IX.4.7.2. ERP data

Again, there were no effects pertaining to the experimental manipulation prior to 200ms found. Experiment 4 therefore also does not indicate that discourse information influences the earliest phase of processing (hypothesis I).

The first word

There was no difference observed between the two types of connective tie used in this experiment at left anterior sites, the region in which a LAN for connective compared to non-connective elements had been found in experiments 2 and 3. It is therefore possible to conclude that the LAN observed in the two previous studies was indeed an effect pertaining to the difference between connective and non-connective elements (hypothesis II.a).

The first contrast that was found between causal and concessive conditions was not present for both concessive connective ties, but only for trials starting with *trotzdem*. The positivity found had a right-parietal distribution, resembling a P600 more than a P3b (Osterhout, McKinnon, Bersick & Corey, 1996). There were, however, no syntactic manipulations or violations in the stimuli. Proposing the P600 to be a correlate of language-related situation model updates, which could tentatively be argued to be of a structural nature, is a claim that will not be made here. Declaring the effect to be a P3b (Donchin,

1979, Donchin & Coles, 1988), is not only the safer, but also the more logical option. This raises the question of what this effect reflects, or more precisely, why it occurred only for *trotzdem* and not for *dennoch*, at least at first, since the second, but much smaller positivity, to be discussed below, was also present. There are two options, each of which will be discussed in turn.

The first possibility is that the P3b is indeed an indication of a situation model update for the condition *trotzdem*, related to the concessive semantic content of the word. The problem with this interpretation is that it would then be difficult to explain why *dennoch* did not show the same effect at the same time. One potential explanation for *dennoch* not to be processed the same as *trotzdem* right away would be to postulate that subjects were not aware of the meaning of *dennoch*, or misunderstood it. The second positivity argues against this option. The questionnaires filled out by the subjects after the sessions also gave no indication of this, nor did the behavioral data. Moreover, subjects were prompted to ask questions after the practice trials, and none requested information on *dennoch*. The frequencies of the two words are also roughly equal: 67 per million written words for *dennoch* and 51 for *trotzdem* according to the WebCelex Corpus for written German[70]. It is therefore unlikely that the (in)frequency of *trotzdem* led to the observed effect or that subjects were not aware of the meaning of *dennoch*, especially as an extremely infrequent word at the beginning of a sentence has been shown to elicit an N400, not a late positivity (Van Petten & Kutas, 1991).

The second possibility is that the P3b is not a correlate of a situation model update as such, i.e. not related to the semantic content of the word, but merely a reaction to a subjectively infrequent but task-relevant stimulus, an 'oddball effect' (Duncan-Johnson & Donchin, 1977; Tueting, Sutton, & Zubin, 1970). This is not utterly far-fetched, because the condition *trotzdem* was the only one in which the first word of the target started with a 'T', with 25% probability of occurrence, compared to 75% probability of occurrence for a 'D', the letter with which all of the other first words started [71].

The second effect found for the first word of the target sentences was a small but reliable positivity at the electrode PZ for both concessive conditions, where the condition *dennoch* appears to join its concessive colleague *trotzdem*. There was no influence of lexical item found for this effect. It is proposed here that this small positivity is a P3b indicative of a situation model update, an integration of the semantic content of *trotzdem* and *dennoch*, as predicted in hypothesis II.b. The small amplitude and duration of the effect might be due to the influence of the much larger previous oddball effect, the underlying processes of which may have served to make the condition *trotzdem* more salient for the moment. Alternately, the earlier positivity for *trotzdem* might have been a combination of an oddball effect and a situation model update, with the more salient physical features of *trotzdem* emphasizing the effect. It is not possible at this point to completely distinguish the two proposals, but the semantic content of both concessive conditions appears to have been evaluated upon encountering the concessive connective ties at this point in the parse already. This suggests that readers do make immediate use of the fact that concessive connective ties announce unusual or suprising outcomes (Stede, 2004). The latency of the effect, namely roughly 700ms after presentation of the connective ties, is somewhat earlier than the tentative time-span identified for situation model updates in section VII.3.3.1, namely 1 second, but

[70] The written lemmata-corpus for Celex is based on a German newspaper. Since newspapers are known to be written in a different register than standard narrative text, an additional, somewhat 'dirty' hit-count for the connective ties was performed on http://www.Google.de. The results were: ~3.8 million for *dennoch*, and ~3.16 million for *trotzdem*, reflecting roughly the same pattern as the Celex database.

[71] Thanks to Bryan Jurish, for bringing this to the author's attention.

similarly to the study by Brehm (2000), and beim Graben, Drenhaus, Saddy, Brehm & Frisch (submitted), the making of an update to the situation model was task-relevant. In other words, it is still possible that immediate updates to the situation model in discourse are not automatic, but must be triggered. A variation of the present study in which the connective ties are not task relevant would provide more information here, but in the end the occurrence of the effect in the first place shows that concessivity did have an influence.

The object, or: the missing N400

Despite the visual contrasts, there were no reliable differences between the four conditions present in the time window of the N400 after presentation of the object, indicating that the connective ties had no influence on the cloze-probability of the object, as there was no N400 found for the incoherent conditions. Hypotheses III.a has to be rejected.

These findings are especially surprising for the condition C, the incoherent causal condition, since the incoherent element had been shown to elicit an N400 for the causal connective condition in experiment 2, and the incoherent causal condition was thought to be the 'easier' one of the two incoherent conditions. The lack of N400 for this condition also does not seem to be a case of semantic illusion (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B), or, if it was, then there was no subsequent positivity. Hence, hypothesis III.b must be rejected for the causal incoherent condition. It is unclear why there was no indication of a more difficult semantic integration for the causal incoherent condition at this point in the target sentence. It is conceivable that the fact that the outcome denoted by the object in this condition was not clearly impossible is responsible for the lack of contrast between the causal conditions. Alternately, influences across conditions may have played a role here, since there were concessive relations in the stimuli, and the object in condition C would have been felicitous with a concessive connective tie.

In hypothesis III.c, it was postulated that if the semantic content of the concessive connective ties is not integrated, the concessive conditions should display a pattern opposite to that of the causal conditions. The incoherent concessive condition D does indeed not show an N400, in accordance with hypothesis III.c, but the converse effect, that of the coherent concessive condition B elicing an N400, is also not present. Since the causal incoherent condition C did not elicit an N400 either, it is likely that more than the semantic and pragmatic fit of the object into the text representation had an influence on the ERP responses at this point.

The most probable explanation for the general lack of semantic integration effects in this time window does seem to be cross-conditional interference, a definite shortcoming of experiment 4: both incoherent conditions would have been coherent, and the coherent conditions would have been incoherent with the other respective connective tie, a fact that probably served to make reading very difficult at this point for the subjects. The 3CAPS Model (Just & Carpenter, 1992; Carpenter, Miyake & Just, 1994; Just, Carpenter & Keller, 1996) predicts that processing difficulties lead to added working memory demands and slower processing on the part of the subjects, possibly leading to an incoherence in condition C at least not being diagnosed or 'dealt with' immediately.

The object: the positivity of the concessive incoherent condition

The concessive incoherent condition D did also not show an N400 on the object of the target sentence, but there was a reliable positivity compared to the other conditions at centro-posterior sites. It is tempting to group this effect with the late positivity found in the studies on semantic illusion (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B), but it must then be explained why the

causal incoherent condition C did not elicit a similar positivity. A difference between the causal and the concessive incoherent conditions is that in the concessive incoherent condition there *is* something in the previous material that in the framework of the 3CAPS Model could have resulted in the activation of the object (or its incoherence) being raised to the point that it did not fall below the threshold when the general difficulty of the material resulted in too much processing demand. The concessive connective tie might have led to the diagnosis of the incoherence on the object not being completely ignored. The late positivity might be an indication that subjects did notice that not all was well in the concessive incoherent condition *before* the end of the sentence, and, by the same token, that the semantic content of the concessive connective ties did influence processing incrementally, as already suggested by the small positivity found for the two concessive connective ties. The positivity for D on the object could hence be a correlate of reanalysis of the text representation.

Sentence-end effects

There was a reliable difference between coherent and incoherent conditions for the prepositional phrase, the end of the target sentences, at the centro-anterior electrode FZ and the left-anterior ROI. This effect could be a SEN, but it did not show the same distribution as the sentence-end effect found for the incoherent conditions in experiment 2, namely a right-anterior-, but instead a left-anterior maximum, suggestive of a working-memory LAN. Hence hypothesis IV has to be rejected with respect to the effect found, but not with respect to a general contrast between coherent and incoherent conditions.

At the electrode FZ, the effect was not influenced by connector type, suggesting that subjects were aware at this point of which conditions made sense and which did not. Analysis of the left-anterior ROI on the other hand showed a pattern of negativities that was strikingly similar to the reaction times and error rates in the judgment task: all conditions except the 'easiest one', the causal coherent condition A, were reliably more negative and there were no differences between the three conditions according to the statistical design. As has been noted above, if subjects had simply fallen back on a preferred causal relation between the two sentences and completely ignored the connective ties, there should have been a contrast between conditions C and D, namely condition D *not* eliciting a negativity. Subjects did therefore indeed integrate the semantic content of the concessive connective ties. The fact that there were no indications of more difficult semantic integration on the object suggests that the update to the text representation –necessary for comprehending a concessive relation –was not fully made until the last element presented. It is not clear whether in the case of the concessive conditions this delay was due to the concessivity per se, but the lack of an N400 for the causal incoherent conditions suggests that the generally high complexity of the material, i.e. the probable cross-conditional interferences, played a weighty role. A final judgment as to whether the implications of concessive connective ties are indeed calculated immediately will hence have to be delayed until a comparison is made between concessive connective ties and non-connective elements, or possibly between concessive and temporal connective ties.

IX.4.8. Experiment 4: summary

Experiment 4 suffered from one problem: the ease of diagnosis of a coherence or incoherence of the target sentences was very probably influenced by the fact that just that coherence or incoherence would have been reversed if the other type of connective tie had been present. Diagnosis of coherence was task-relevant, and the type of connective tie was central to whether a target was coherent or not. Consequently, the stimuli made very high

processing demands of the subjects, which was reflected in the much higher error rates in this experiment compared to the previous two ERP studies reported here.

The added complexity is certain to have influenced the speed with which an incoherent element was diagnosed as such, and therefore any conclusions made here are rather tentative, because it is not clear to which extent differences between causal and concessive connective ties are due to that contrast per se. Since the additional processing demands can be argued to have affected all conditions equally, however, there are a few things that can safely be said.

First of all, there was no difference between causal and concessive conditions on the first word of the target at left anterior sites. This indicates that the difference found there between connective and non-connective elements in experiments 2 and 3 was indeed a reflection of just that contrast, a point which will be elaborated further in the general discussion below.

There was a positivity found for the concessive connective tie *trotzdem* on the first word of the target sentences, i.e. the connective tie itself. Since there was no indication that subjects were not aware of the semantic content of the other concessive connective tie *dennoch*, and the two elements occur with roughly equal frequency in WebCelex, and precisely equal frequency within experiment 4, the effect was attributed to the physically infrequent occurrence of a target-initial word beginning with 'T', as opposed to 'D' for the other three target-initial words.

The second effect found for the first word of the target sentences, the small positivity for the concessive conditions, suggests that the semantic content of the concessive connective ties was evaluated at once.

That the semantic content of the connective ties did play a role in the incremental processing of the target sentences was not indicated by N400 amplitudes on the object; there were no differences between the three conditions evaluated in the window between 300 and 500ms after presentation of the object. This lack of effects was argued to be due to the generally high processing cost of the stimuli, which masked any differences present between conditions at that point in the parse. Alternately, the close semantic relation between correct and incorrent continuations on the object might have served to mask the violation. There was an indication that the incoherence was at least noticed in the concessive incoherent condition, since that condition showed a late positivity, similar to the effects found in previous ERP studies of semantic illusion. It is thinkable that the semantic content of the concessive connective tie served to make that violation more prominent, or at least salient enough to trigger a reanalysis of the text representation.

If the general problems in this experiment had not been present, the lack of evidence for semantic integration problems on the object would provide evidence for a difference between causally unrelated outcomes and causally related outcomes that are however highly improbable given the semantic content of the connective tie. As the problems were there, however, this stage of the parse does not clearly speak for this assumption, but there is also no reason to completely reject the hypothesis.

There were clear indications of reanalyses of the text representations and the situation models at the end of the target sentences. All conditions in which the semantic content of the targets did not map easily onto a preferred causal relation, either due to a violation or due to a surprising outcome, showed evidence of difficulty (condition B) or inability (conditions C and D) to integrate the violating sentence or unusual outcome into a final (integrated) 'message-level' semantic representation (Osterhout, 1997), or situation model.

X. GENERAL DISCUSSION AND OUTLOOK

The four experiments reported in this work were intended to provide an exploratory investigation of the processing of connective ties.

One of the central questions was whether connective ties differ from non-connective elements in and of themselves, if evidence can be found that the theoretical distinction between connective and non-connective elements suggested by Pasch, Braße, Waßner, & Herrmann, (2003) has 'cognitive reality'.

The second aspect that was investigated was when precisely the information a connective tie imparts is used. In other words, does a connective tie influence the parsing process according to its semantic content straight away, or is the presence of the connective tie 'merely' a signal that there is a direct relation between the sentences, but the exact kind of relation is not evaluated until the end of the sentence? This point includes the question of whether the relation that a connective tie signals (discussed in sections II.2.2 and III.4) has an impact on the type of inference that readers attempt to make between two sentences, i.e. if the connective tie enforces a certain type of relation.

Each of these questions, and the evidence found in the above four studies concerning them, if any, as well as possibilities for further investigation will be discussed in turn in this section.

X.1. ARE CONNECTIVE TIES SPECIAL?

In all three experiments investigating the difference between connective and non-connective elements, namely experiments 1, 2, and 3, there were clear differences between connective and non-connective conditions. This suggests that connective ties are indeed processed differently from non-connective elements right from the word 'go', and that the information connective ties impart is made use of immediately. The same conclusion was already reached in a number of previous studies (Haberlandt, 1982; Caron, Micko & Thüring, 1988; Millis & Just, 1994; Ferstl & von Cramon, 2001), but the present studies do provide additional information: the distinction between 'connective' and 'non-connective' appears to also hold for the difference between connective ties and deictical sentential adverbs made in the HdK ('Handbuch der deutschen Konnektoren', Pasch, Braße, Waßner, & Herrmann, (2003). In other words, the separation into connective and non-connective elements made therein is reflected in language processing as well, and there is evidence for a distinction between one-place and two-place discourse relations.

X.2. ARE CONNECTIVE TIES INTEGRATED IMMEDIATELY?

There were differences between connective and non-connective discourses, as well as between different kinds of connective discourses, at several points in the target sentences. The first was the target initial word, the connective tie or non-connective element. The second point of interest was the object of the target sentences, an element prior to the end of the sentence on which possible contrasts between coherent and incoherent discourses, as well as between different types of connective discourses, were examined. The third critical period was the end of the sentence, where the influence of (in)coherence on the construction of an integrated semantic representation of the discourse (situation model) and the impact of connective ties on (in)coherence was examined. The following sections will proceed through these three points in the target sentences one after the other.

X.2.1. The first word

There were two effects found on the first words of the target sentences: an LAN, for all comparisons between connective and non-connective elements, and a late positivity for the comparison between causal and concessive connective ties. These effects, and their implications for the processing of connective ties, are discussed in turn below.

X.2.1.1. What does the LAN reflect?

The effect found on the first words of the target sentences was a LAN for all connective conditions compared to all non-connective conditions in experiments 2 and 3, and a lack of contrast between the two types of connective ties in that region in experiment 4. This immediate effect was not due to the connective ties being task-relevant, as proposed by Baggio (2004). In experiment 3, the effect appeared despite the fact that the semantic content of the connective tie had no impact on the task given to the subjects. It was also not elicited by a morphosyntactic violation (Kutas & Hillyard, 1983; Friederici, Pfeifer & Hahne, 1993; Coulson, King & Kutas, 1998; Frisch, 2000), as there was none present. This absence of a violation points to underlying working-memory processes, for which an LAN has been found, not only in stand-alone sentences (Kluender & Kutas, 1993; Kluender & Münte, 1998), but also in discourse processing (Münte, Schiltz & Kutas, 1998; van Berkum, Brown & Hagoort, 1999a; van Berkum, Brown, Hagoort & Zwitzerlood, 2003a; Cowles, 2003; Yang & Perfetti, 2005). With the exception of the study by Münte et al., the LAN-effects found in previous ERP studies of discourse were associated with the binding of elements to appropriate discourse-antecedents, or a search for an antecedent. In the present studies, an argument can be made for the effect to be a reflection of such an antecedent-search. A number of the connective ties used in the present studies had a co-referential aspect: one of their morphemes was a definite determiner. Use of a definite determiner in discourse signals that the mentioned entity is discourse-old (Hawkins, 1978; Heim, 1983). Applied to connective ties, this definite determiner might trigger a binding of the connective element to an appropriate antecedent, and thereby elicit a LAN, but there is a deciding difference between co-referential noun phrases and connective ties. In the case of noun phrases, there is one element, also a noun phrase, that serves as antecedent. In the case of connective ties, the antecedent is the entire external argument, the situation denoted by the context in the above experiments.

It is also thinkable that the LAN was elicited by the process of integrating the context into the text representation in the role that the respective connective ties assign to their external argument. This would involve fairly detailed semantic analysis of the connective ties and the external argument, i.e. the activation of world knowledge pertaining to the situation denoted in the context, and the LAN should then have reflected differences between the semantic types of connective ties, which it did not. More specifically, if the causal connective ties had triggered predictions pertaining to possible outcomes, the LAN in experiment 3 in response to causal connective ties should have differed from the LAN in response to temporal connective ties, which only denote that the event described in the external argument is over: an arguably simpler relation. Additionally, there was no difference in LAN amplitudes between causal and concessive connective ties in experiment 4, also indicating that the LAN is not a reflection of the evaluation of the external argument.

There is, however, an intermediate position which will be adopted here, namely that of the LAN reflecting an assignment of the respective role to the external argument, possibly triggered by the co-referential morpheme, and influencing the processing of subsequent

elements, but not including an immediate semantic evaluation. A possible way to investigate whether the LAN is a reflection of such a process would be to contrast complex connective ties with semantically equivalent variants that do not contain a determiner, for instance *darum* versus *folglich* for causal connective ties, *danach* versus *später* for temporal connective ties, and eliminating the added complexity from experiment 4 by for instance comparing only concessive coherent and incoherent conditions, as one of the concessive connective ties used, *dennoch*, also does not contain a determiner.

On the basis of the present data, however, it can only be concluded that the LAN reflects processes of the integration of the first sentence as the external argument of a two-place relation signaled by the connective ties, i.e. of antecedent searching and binding, similar to the results found for noun phrases by the previous studies mentioned above.

X.2.1.2. What about the little positivity?

There were no indications that the differing semantic type of connective ties was reflected in the ERPs for causal or temporal connective ties. There was a contrast between causal and concessive connective ties on the first word in experiment 4. What causal and temporal connective ties have in common, and what separates them from the concessive connective ties, is that both the causal and the temporal connective ties used here represent a straightforward, fairly easily calculated relation between the two sentences, which concessive connective ties do not. Encountering a causal or temporal connective tie did not demand preparation for something unexpected. Hence, it appears that Townsend's (1983) proposal that readers have a preference for such canonical relations in discourse is supported. This preference does not mean, however, that readers blindly impose such a relation, as shown in experiment 4 as well as the study by Münte, Schiltz & Kutas (1998), just that they assume that such a canonical relation is present unless there is evidence to the contrary. The fact that what Townsend would call out-of-canonical-order relations have to be explicitly marked via connective ties such as *before* or *nevertheless* underlines this apparent economical tactic in discourse processing: don't do any work that you don't definitely need to do.

X.2.2. The object: (in)coherence and foregrounding

The object of the target sentences was the crucial point at which it could be seen whether subjects took the connective ties into account before the end of the sentences. The following discussion is separated into incoherent and coherent discourses.

X.2.2.1. Connective ties in incoherent discourses

In the case of obviously incoherent discourses, a violation of the relation signaled by the connective tie (experiment 2), resulted in a larger N400 compared to the same violation without a previous connective tie. This finding provides further support not only for the idea that the N400 reflects semantic integration processes of an element into the representation of the entire discourse, not only the current sentence (St. George, Mannes & Hoffman, 1994; St. George, 1995; St. George, Mannes & Hoffman, 1997; Federmeier & Kutas, 1999a; van Berkum, Hagoort & Brown, 1999c; Salmon & Pratt, 2002; van Berkum, Zwitzerlood, Hagoort & Brown, 2003b; Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004; Britz & Swaab, 2005; van Berkum, Brown, Zwitzerlood, Kooijman & Hagoort, 2005; Ditman, Holcomb & Kuperberg, 2005; Yang & Perfetti, 2005). It also shows that the relation signaled by the connective tie is the one that readers assume to be present, as previously proposed by Murray (1997) and Ferstl & von Cramon (2001), and that the

influence of connective ties shows itself at least partly before the end of the sentence, as previously shown by Haberlandt (1982), Traxler, Bybee and Pickering (1998), and Münte, Schiltz & Kutas (1998).

In the case of more subtle violations (experiment 4), the impact of the connective ties on the integration of elements prior to the end of the sentence was more difficult to interpret, because the much higher complexity of the stimuli made processing generally more difficult for the subjects and thereby probably masked or delayed effects pertaining to the integration of the object. There was tentative evidence, however, that the close semantic relation between the violating element and a possible correct continuation resulted not in a reflection of that relation in the amplitude of the N400, but in the violation being temporarily ignored, as found in previous studies of semantic illusion (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B). The effect found would however have to be replicated in less complex concessive discourses before such a conclusion would be defendable.

X.2.3. Foregrounding: coherent discourses

In the coherent discourses (experiments 2, 3, and 4), there was no evidence for a difference between connective and non-connective conditions or different types of connective discourses on the object of the target sentences, suggesting that as long as the relation denoted by the connective tie is not violated, i.e. the inference signaled is possible, there is no alternate 'processing procedure' for connective versus non-connective discourses at that point in the parse. Similar results have been found by Millis & Just (1994), Deaton & Gernsbacher (in press), and Townsend (1983). These findings support the idea put forward in the Event-indexing Model that connective ties serve to foreground one of several possible dimensions present in discourse, dimensions that readers are assumed to keep track of (Zwaan, Langston & Graesser, 1995, Zwaan, Magliano & Graesser, 1995, see also Zwaan & Radvansky (1998); Gernsbacher (1990) and Givón (1992). If the foregrounded dimension does not 'clash' with incoming material, the operation is successful. In experiment 3, the foregrounding was felicitous in every case, as the stimuli allowed for causal as well as temporal relations. It would be interesting to see whether such foregrounding could be violated, for instance by placing causal connective ties in exclusively temporally related, but otherwise coherent, discourses and vice versa. According to the interpretation adopted in this work (chapter III), foregrounding the wrong dimension should result in incoherence, and elicit an N400 on the element where the discrepancy can be diagnosed.

X.2.4. Sentence-end effects: incrementality all the way?

The third stopping point in the three ERP-studies was the last element in the sentences presented. Previous studies have shown that the end of a sentence plays an important role in the construction of an integrated semantic representation, a 'message-level' representation (Osterhout 1997). Violations that occurred in prior material elicited negativities at this point in the parse (SEN), even though the last element itself did not add a further violation, in ERP investigations of stand-alone sentences (Hagoort, Brown & Groothusen, 1993, McKinnon & Osterhout, 1996, Osterhout & Mobley, 1995; Osterhout, Bersick, & McLaughlin, 1997; Osterhout & Holcomb, 1992 and 1993; Frisch, 2000). A similar effect has been reported for semantic violations of discourse (Ditman, Holcomb & Kuperberg (2005). In non-violating discourses, where there was however an indication that one condition required more integrative efforts than the other two, a late positivity was reported

(Kuperberg, Caplan, Eddy, Cotton & Holcomb, 2004). It was postulated here that an SEN is a reflection of problematic or impossible construction of a final situation model, while a late positivity at the end of the sentence is a correlate of a successful reanalysis or update of the situation model. As discussed in section IX.3.7.2, a distinction of the two effects, if they are indeed separate, is nearly impossible, and the interpretations of the relevant effects in the present studies will suffer accordingly from this ad hoc differentiation until independent evidence is obtained.

Keeping that problem in mind, the effects found at the end of the target sentences indicate that a substantial part of the evaluation of connective ties on the text representation and the situation model is evaluated at the end of the discourse, as already reported in several previous studies (Millis & Just, 1994; Deaton & Gernsbacher, in press).

The following discussion is again separated into one subsection each for incoherent and coherent discourses.

X.2.4.1. The end in incoherent discourses

In obviously incoherent discourses, i.e. experiment 2, there was a sustained negativity, an SEN, for the two incoherent conditions at the end of the sentence, larger for the connective condition. This supports the conclusions arrived at by Ferstl & von Cramon (2001), namely that a connective tie hinders in the diagnosis of an incoherence by signaling a relation that is not present, as well as the idea that a connective tie must match the underlying relation present in the discourse (chapter III, see also Murray, 1997).

For the more obscure violations in experiment 4, the last element of the target sentences also elicited sustained negativities, which, oddly enough, displayed a left-anterior maximum as opposed to the right-anterior maximum in experiment 2. The distribution of the effect is suggestive of the involvement of working-memory processes, maybe the reactivation of the external argument or the explicit recall of the connective tie. The most striking aspect of the effects found on the final element in experiment 4 was that the concessive coherent conditions also elicited a negativity. Since the materials were rather complex, it was suggested that the influence of the connective ties on the text representation could not be fully calculated until the end of the sentence. The occurrence of the effect in the first place demonstrates, however, that the connective ties did have an impact on the text representation.

Due to the complexity of the materials in experiment 4, there was no clear evidence for or against the postulated difference between outright violations and possible but dispreferred outcomes of a causal relation as implied by the connective tie (section III.4.2.6). The pattern of sentence-end negativities does however *not* support the conclusion that readers blindly order sentences in a text according to a preferred 'straightforward' temporal or causal pattern. In all conditions but the causal coherent one, the relation was not straightforward, but if the content of the connective ties had been completely ignored and the discourses mapped onto a simple causal relation, then the concessive incoherent condition should not have elicited an SEN, as without the connective ties, this condition would have been as coherent as the causal coherent one. The 3CAPS Model of discourse processing (Just & Carpenter, 1992; Carpenter, Miyake & Just, 1994; Just, Carpenter & Keller, 1996) provides a handy emergency exit here. It is assumed in that model that more complex operations demand more activation, and take longer than simpler processes. If the processing demands of a discourse exceed the activation available, then the evaluation of the input might be delayed until enough resources are available. This is what might have happened in experiment 4: due to the cross-conditional interference discussed above, there might not have been sufficient resources available to fully integrate the incoming material

until the end of the sentence, but the sentence-end effects as well as the behavioral data show that ultimately, it was done.

X.2.4.2. The end in coherent discourses

It was suggested here, following Kuperberg, Caplan, Eddy, Cotton & Holcomb, (2004), that more difficult but possible inference processes elicit late positivities on the last element in a coherent discourse, mayhap reflecting an update and evaluation of the situation model or a more demanding inference. The difference between the connective and non-connective conditions in experiment 3 was accordingly interpreted as a positivity for the non-connective conditions, reflecting the fact that there was no connective tie to prescribe the relation between the sentences and the connection had to be made without that 'help'. In the framework of the Event-updating Model (Zwaan, Langston & Graesser, 1995, Zwaan, Magliano & Graesser, 1995, see also Zwaan & Radvansky, 1998), these results could be taken to indicate that several dimensions such as time, motivation, and causality had to be evaluated and integrated into the final situation model. It was suggested that connective ties restrict the possible relations between two sentences to the dimension denoted by the connective tie. If this is the case, then the results found at the end of the sentences in experiment 3 could indeed be an indication of additional inferencing for the non-connective conditions, analogous to the results found by Kuperberg et al.. This interpretation does however involve the unproven assumption that connective ties do have the effect of reducing possible dimensions along which a discourse can be structured.

The alternative, that the effects found were negativities for the connective conditions in experiment 3, also allows for a plausible interpretation within the Event-updating Model and should therefore not be completely dropped from sight. The sentence-end negativities might occur not only for violations of discourse relations, but might also reflect added integration work in general. If several dimensions in discourse are routinely kept track of during processing, and connective ties foreground one of them, thereby backgrounding the others for the moment, then the remaining dimensions for which indices are shared between the sentences have to be evaluated at the end of the sentence, incurring added processing cost and eliciting negativities. This interpretation does not serve to explain Kuperberg et al.'s results. It also does not make room for any special function of connective ties, i.e. does not help to explain why connective ties are there in the first place, and applicable in discourse relations present without them as well, but it does seem as plausible as the 'positivity-option', and the four experiments here do not allow for a defninite distinction between the two possibilities.

In sum, all that can be said at this point is that the end of the sentence plays a role in the making of inferences and the construction of a final situation model, but it is possible that ERPs simply are not sensitive to the actual processes involved, or at least not sensitive enough to allow for a clear picture of the situation. The results found by Ferstl & von Cramon (2001) in their fMRI study, namely activation for the coherent conditions instead of the incoherent ones, additionally suggests that while ERPs allow for a good short-term picture of language processing, they do not cover enough time to capture all relevant processes.

X.3. A FINAL WORD

First and foremost, connective ties are a creature distinct from non-connective elements: there was evidence shown that ERPs reflect the 'discourse-operator' nature of connective ties; they are processed differently from non-connective elements right away. Deictical elements on the other hand are non-connective.

The above experiments also support the idea that the relation indicated by a connective tie is the one that readers attempt to make, even in the face of contradictory evidence, i.e. incoherent discourses.

Connective ties might indeed be explicit assembly instructions for discourse, but it should be noted that such manuals are not always needed. Use of a connective tie does constitute a special situation, since in most cases the same or similar inferences can be made between sentences in discourse without a connective tie as well.

As to *when* the information connective ties impart is used in parsing, there was evidence presented that connective ties influence the parsing process immediately, but that not all intersentential relations are evaluated at once or, if the material is very complex, not all relations can be taken into account for every new element processed.

The experiments reported here did confirm the results presented by previous research, namely that discourse as well as sentence processing is incremental to a high degree, with the possible exception of the final situation model or integrative semantic representation of a discourse, which is apparently not equivalent to the representation constructed during processing. Evidence was shown that the end of the discourse triggered additional integrative processes that were however also influenced by connective ties, if present. Speculatively, it could be said that before the end of a discourse, elements are integrated according to a relation assumed to be present, unless a connective tie forces a more complex representation. At the end of the discourse or sentence pair, this representation is evaluated, and connective ties have a noteable impact here, since they explicitly convey what type of interclausal relation is present. This kind of economy, of constructive laziness, seems to be present in all 'levels' of language processing (cf. the preference for interpreting an ambiguous sentence-initial noun phrase as the subject). It also makes intuitive sense, since understanding language as quickly and effortlessly as we do, there must be some truly powerful mechanisms involved, and nature is known for evolving impressively elegant procedures capable of economy and complexity simultaneously (such as, for instance, photosynthesis: the most efficient and cleanest way of producing energy).

It was also confirmed that different types of connective ties influence language processing in different ways. The precise underlying processes could not be identified on the basis of the three ERP studies presented here, but the present studies do show that ERPs are sensitive to the processing of connective ties, and that connective ties in turn can be used to examine discourse processing. Many more studies will be needed to clarify the picture, but the studies in this work do provide new information and demonstrate, analogously to the previous work they were based on, that understanding of discourse can be examined, at least up to a certain point. Ultimately, however, it is likely that discourse processing will also show up the limits of empirical methods, at least of ERPs, since, to pick up the initial quote, it is indeed not possible to extract the elephant in its entirety.

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APPENDICES

APPENDIX A

Stimulus Materials Experiment 1
Legend:
Context
#a Connective coherent
#b Non-connective coherent
#v Addition
#m 'false'-match for Target
#mv 'false'-match for Addition

Incoherent trials were constructed by switching the contexts of two coherent trials:
1 and 2, 3 and 4, 5 and 6 etc.

1 Der Herd war kaputt.
1a Deshalb machte Berta Rohkost zum Abendbrot.
1b Gestern machte Berta Rohkost zum Abendbrot.
1v Das Essen war lecker.
1m Deshalb machte Berta Salat zum Abendbrot.
1mv Das Essen war fade.

2 Der Gummibaum gedieh schlecht.
2a Deshalb kaufte Klaus Dünger im Baumarkt.
2b Gestern kaufte Klaus Dünger im Baumarkt.
2v Die Tüte war schwer.
2m Deshalb kaufte Klaus Dünger im Supermarkt.
2mv Die Tüte war riesig.

3 Es war sehr kalt geworden.
3a Deshalb kaufte Sara Kohlen beim Händler.
3b Gestern kaufte Sara Kohlen beim Händler.
3v Die Preise waren gestiegen.
3m Deshalb bestellte Sara Kohlen beim Händler.
3mv Die Kosten waren gestiegen.

4 Das Zimmer war zu dunkel.
4a Deshalb besorgte Thomas Lampen im Kaufhaus.
4b Gestern besorgte Thomas Lampen im Kaufhaus.
4v Die Auswahl war groß.
4m Deshalb besorgte Herbert Lampen im Kaufhaus.
4mv Die Auswahl ist groß.

5 Der Waldweg war sehr matschig.
5a Deshalb trug Olaf Stiefel beim Wandern.
5b Gestern trug Olaf Stiefel beim Wandern.
5v Die Landschaft war schön.
5m Deshalb trug Olaf Stiefel für s Wandern.
5mv Die Landschaft war vernebelt.

6 Das Stuhlbein war gebrochen.
6a Deshalb suchte Maja Holzleim im Keller.
6b Gestern suchte Maja Holzleim im Keller.
6v Die Suche war erfolgreich.
6m Deshalb fand Maja Holzleim im Keller.
6mv Die Arbeit war erfolgreich.

7 Fahrräder rosten sehr schnell.
7a Deshalb benutzte Heiner Fahrradöl zum Putzen.
7b Gestern benutzte Heiner Fahrradöl zum Putzen.
7v Der Putzlappen war löchrig.
7m Deshalb benutzte Heiner Schmieröl zum Putzen..
7mv Der Putzlappen war dreckig.

8 Zugfahrten können recht langweilig werden.
8a Deshalb besorgte Alexander Comics zum Lesen.
8b Gestern besorgte Alexander Comics zum Lesen.
8v Die Bilder waren lustig.
8m Deshalb kaufte Alexander Comics zum Lesen
8mv Die Figuren waren lustig.

9 Die Lieblingshose war zu eng geworden.
9a Deshalb machte Sophie Sport zum Abnehmen.
9b Vorhin machte Sophie Sport zum Abnehmen.
9v Das Schwimmen machte Spaß.
9a m Deshalb trieb Sophie Sport zum Abnehmen.
9m Das Joggen machte Spaß.

10 Fahrtwind kann empfindlich kalt sein.
10a Deshalb trug Alex Handschuhe beim Radfahren.
10b Vorhin trug Alex Handschuhe beim Radfahren.
10v Die Strecke war lang.
10m Deshalb trug Alex Knieschoner beim Radfahren.
10mv Die Strecke war bergig.

11 Ständig nur Sitzen macht zappelig.
11a Deshalb spielte Gunnar Tennis nach Büroschluß.
11b Vorhin spielte Gunnar Tennis nach Büroschluß.
11v Das Spiel war spannend.
11m Deshalb spielte Jürgen Tennis nach Büroschluß.
11mv Das Match war spannend.

12 Die Deckenlampe war kaputt.
12a Deshalb suchte Matthias Glühbirnen im Schrank.
12b Vorhin suchte Matthias Glühbirnen im Schrank.
12v Die Schranktür quietschte laut.
12m Deshalb suchte Matthias Kabel im Schrank.
12mv Die Kellertür quietschte laut.

13 Der Pappkarton hatte einen Riß.
13a Deshalb besorgte Sonja Klebeband im Supermarkt.
13b Vorhin besorgte Sonja Klebeband im Supermarkt.
13v Die Schlange war lang.
13m Deshalb besorgte Sonja Kleister im Supermarkt.
13mv Die Schlange war endlos.

14 Der Fliesenboden war recht fußkalt.
14a Deshalb verlegte Ralf Teppich im Zimmer.
14b Vorhin verlegte Ralf Teppich im Zimmer.

14v Die Arbeit war mühsam.
14m Deshalb verlegte Ralf Teppich im Flur.
14mv Die Arbeit ist mühsam.

15 Die Waschmaschine war ausgelaufen.
15a Deshalb suchte Christian Lappen zum Aufwischen.
15b Vorhin suchte Christian Lappen zum Aufwischen.
15v Das Putzen war anstrengend.
15m Deshalb benutzte Christian Lappen zum Aufwischen.
15mv Das Putzen war schweißtreibend.

16 Tintenskizzen lassen sich schlecht korrigieren.
16a Deshalb verwendete Kathrin Bleistifte beim Zeichnen.
16b Vorhin verwendete Kathrin Bleistifte beim Zeichnen.
16v Das Portrait war gelungen.
16m Deshalb verwendete Kathrin Kreide beim Zeichnen.
16mv Das Bild war gelungen.

17 Weihnachten rückte immer näher.
17a Darum bastelte Ingo Strohsterne im Wohnzimmer.
17b Gestern bastelte Ingo Strohsterne im Wohnzimmer
17v Das Ergebnis war annehmbar.
17m Gestern bastelte Ingo Engelchen im Wohnzimmer.
17mv Das Resultat war annehmbar.

18 In Flugzeugen kann es recht kühl werden.
18a Darum packte Julia Socken ins Handgepäck.
18b Gestern packte Julia Socken ins Handgepäck.
18v Die Wolle war weich.
18m Gestern packte Franziska Socken ins Handgepäck.
18mv Die Wolle war kratzig.

19 Winterjacken waren komplett ausverkauft.
19a Darum suchte Frank Mäntel im Laden.
19b Gestern suchte Frank Mäntel im Laden.
19v Die Verkäuferin war kompetent.
19m Gestern begutachtete Frank Mäntel im Laden.
19mv Die Bedienung war kompetent.

20 Sport ist gut für die Gesundheit.
20a Darum spielte Emma Fußball im Stadtpark.
20b Gestern spielte Emma Fußball im Stadtpark.
20v Das Wetter war herrlich.
20m Gestern spielte Emma Hockey im Stadtpark.
20mv Das Spiel war herrlich.

21 Das Rohr im Keller war geplatzt.
21a Darum bestellte Jörg Klempner ins Haus.
21b Gestern bestellte Jörg Klempner ins Haus.
21v Die Handwerker waren pünktlich.
21m Gestern bestellte Jörg Klempner ins Büro.
21mv Die Maler waren pünktlich.

22 Bei Computern gibt es große Preisunterschiede.
22a Darum verglich Stefan Angebote im Internet.
22b Gestern verglich Stefan Angebote im Internet.
22v Die Laptops waren teuer.
22m Gestern suchte Stefan Angebote im Internet.
22mv Die Modems waren teuer.

23 Bei Partys sollte man nicht nur Alkoholisches anbieten.
23a Darum kaufte Jens Säfte zum Trinken.
23b Gestern kaufte Jens Säfte zum Trinken.
23v Der Mangosaft war beliebt.
23m Gestern kaufte Jens Säfte zum Anbieten.
23mv Der Apfelsaft war beliebt.

24 Kontoauszüge sollte man aufheben.
24a Darum verwendete Torben Mappen zum Einheften.
24b Gestern verwendete Torben Mappen zum Einheften.
24v Die Blaue war voll.
24m Gestern verwendete Torben Mappen zum Ordnen.
24mv Die Grüne war voll.

25 Plastik ist nicht gut für die Umwelt.
25a Darum benutzte Katja Stofftüten beim Einkaufen.
25b Vorhin benutzte Katja Stofftüten beim Einkaufen.
25v Die Rote war kaputt.
25m Vorhin verwendete Katja Stofftüten beim Einkaufen.
25mv Die Gelbe war kaputt.

26 Man hat nicht immer Lust zum Kochen.
26a Darum bestellte Kathrin Pizza zum Essen.
26b Vorhin bestellte Kathrin Pizza zum Essen.
26v Die Peperoni waren lecker.
26m Vorhin bestellte Kathrin Pizza zum Abendbrot.
26mv Die Peperoni waren pappig.

27 Kahle Wände werden schnell langweilig.
27a Darum bestellte Jens Poster zum Aufhängen.
27b Vorhin bestellte Jens Poster zum Aufhängen.
27v Die Großen waren teuer.
27m Vorhin bestellte Jens Bilder zum Aufhängen.
27mv Die Bunten waren teuer.

28 Kristallzucker macht schnell dick.
28a Darum benutzte Susanne Honig zum Süßen.
28b Vorhin benutzte Susanne Honig zum Süßen.
28v Der Honig war klebrig.
28m Vorhin benutzte Hanna Honig zum Süßen.
28mv Der Honig war fest.

29 Viel Flüssigkeit hilft bei Erkältungen.
29a Darum kochte Peter Salbeitee zum Trinken.
29b Vorhin kochte Peter Salbeitee zum Trinken.
29v Die Teekanne war undicht.
29m Vorhin bereitete Peter Salbeitee zum Trinken.
29mv Die Teekanne ist undicht.

30 Orchideen brauchen sehr viel Pflege.
30a Darum kaufte Ines Kakteen fürs Büro.
30b Vorhin kaufte Ines Kakteen fürs Büro.
30v Die Stacheligen waren beliebter.
30m Vorhin bestellte Ines Kakteen fürs Büro.
30mv Die Stacheligen waren teurer.

31 In erleuchtete Fenster kann man leicht hineinsehen.
31a Darum besorgte Kirsten Gardinen zum Aufhängen.
31b Vorhin besorgte Kirsten Gardinen zum Aufhängen.
31v Der Stoff war hochwertig.
31m Vorhin nähte Kirsten Gardinen zum Aufhängen.
31mv Der Stoff ist hochwertig.

32 Ins Gesicht fallende Haare sind störend.
32a Darum trug Helga Zöpfe beim Kochen.
32b Vorhin trug Helga Zöpfe beim Kochen.
32v Die Haarbänder waren blau.
32m Vorhin trug Helga Mützen beim Kochen.
32mv Die Haargummis waren blau.

APPENDIX B

Stimulus Materials Experiment 2.
Context
#a Connective coherent
#b Non-connective coherent

Incoherent trials were constructed by switching the contexts of two coherent trials:
1 and 02, 03 and 04, 05 and 06 etc.

1 Der Herd war seit Tagen kaputt.
1a Deshalb machte Berta Rohkost für das Abendbrot.
1b Gestern machte Berta Rohkost für das Abendbrot.

2 Hohe Bäume nehmen viel Licht weg.
2a Deshalb beschaffte Martin Sträucher für den Vorgarten.
2b Gestern beschaffte Martin Sträucher für den Vorgarten.

3 Es war über Nacht sehr kalt geworden.
3a Deshalb kaufte Thea Strumpfhosen in der Kaufhalle.
3b Gestern kaufte Thea Strumpfhosen in der Kaufhalle.

4 Hunde sind keine Vegetarier.
4a Deshalb verwendete Silke Fleisch bei der Fütterung.
4b Gestern verwendete Silke Fleisch bei der Fütterung.

5 Das Zimmer war zu dunkel.
5a Deshalb besorgte Thomas Lampen in der Kaufhalle.
5b Gestern besorgte Thomas Lampen in der Kaufhalle.

6 Kristallzucker macht schnell dick.
6a Deshalb benutzte Susanne Honig für den Tee.
6b Gestern benutzte Susanne Honig für den Tee.

7 Die Deckenlampe war kaputt.
7a Deshalb suchte Matthias Glühbirnen auf dem Speicher.
7b Gestern suchte Matthias Glühbirnen auf dem Speicher.

8 Chemie hat im Gemüsegarten nichts zu suchen.
8a Deshalb verwendete Marius Pferdemist für das Salatbeet.
8b Gestern verwendete Marius Pferdemist für das Salatbeet.

9 Stoffmöbel sind schwer zu säubern.
9a Deshalb suchte Julia Ledersofas für das Wohnzimmer.
9b Gestern suchte Julia Ledersofas für das Wohnzimmer.

10 Der Waldweg war sehr matschig.
10a Deshalb wählte Kathrin Stiefel für die Wanderung.
10b Vorhin wählte Kathrin Stiefel für die Wanderung.

11 Zuviel Fernsehen macht dumm.
11a Deshalb bestellte Dörte Bücher für das Wochenende.
11b Gestern bestellte Dörte Bücher für das Wochenende.

12 Farbspritzer in den Kleidern sind selten auswaschbar.
12a Deshalb organisierte Luis Kittel für die Renovierung.
12b Vorhin organisierte Luis Kittel für die Renovierung.

13 Holzböden machen einen gemütlichen Eindruck.
13a Deshalb wählte Florian Dielen für die Küche.
13b Gestern wählte Florian Dielen für die Küche.

14 Blumenerde ist für Kakteen nicht geeignet.
14a Deshalb verwendete Stefan Sand für die Setzlinge.
14b Vorhin verwendete Stefan Sand für die Setzlinge.

15 Das Transparent sollte in satten Farben strahlen.
15a Deshalb benutzte Helmut Filzstifte für die Arbeit.
15b Gestern benutzte Helmut Filzstifte für die Arbeit.

16 Der Gummibaum gedieh schlecht.
16a Deshalb kaufte Klaus Dünger in der Markthalle.
16b Vorhin kaufte Klaus Dünger in der Markthalle.

17 Mit verstauchtem Knöchel kann man keinen Sport machen.
17a Deshalb organisierte Franz Brettspiele nach der Arbeit.
17b Gestern organisierte Franz Brettspiele nach der Arbeit.

18 Das Stuhlbein war gebrochen.
18a Darum suchte Gerda Holzleim auf dem Speicher.
18b Gestern suchte Gerda Holzleim auf dem Speicher.

19 Weihnachtsbäume geraten schnell in Brand.
19a Deshalb beschaffte Lydia Lichterketten für die Dekoration.
19b Gestern beschaffte Lydia Lichterketten für die Dekoration.

20 Es war nicht viel Geld für Getränke übrig.
20a Darum besorgte Sonja Limonade für die Party.
20b Gestern besorgte Sonja Limonade für die Party.

21 Ständig nur Sitzen macht zappelig.
21a Deshalb machte Gunnar Yoga nach der Arbeit.
21b Gestern machte Gunnar Yoga nach der Arbeit.

22 In Zettelsammlungen findet man selten etwas wie der.
22a Darum benutzte Cornelia Ordner für die Mitschriften.
22b Gestern benutzte Cornelia Ordner für die Mitschriften.

23 In Tunesien ist es im Sommer sehr heiß.
23a Deshalb wählte Andrea Blusen für die Reise.
23b Gestern wählte Andrea Blusen für die Reise.

24 Viele Kinder bewegen sich zu wenig.
24a Darum organisierte Ilse Ballspiele für den Nachmittag.
24b Gestern organisierte Ilse Ballspiele für den Nachmittag.

25 Viele Menschen essen kein rohes Fleisch.
25a Deshalb kaufte Jürgen Kochschinken für das Buffet.
25b Gestern kaufte Jürgen Kochschinken für das Buffet.

26 Weihnachten steht vor der Tür.
26a Darum machte Theo Strohsterne in der Schule.
26b Vorhin machte Theo Strohsterne in der Schule.

27 Es sollte ein feudales Mahl werden.

27a Deshalb besorgte Iris Hummer für den Hauptgang.
27b Gestern besorgte Iris Hummer für den Hauptgang.
28 Winterjacken waren komplett ausverkauft.
28a Darum suchte Frank Mäntel in der Herrenabteilung.
28b Vorhin suchte Frank Mäntel in der Herrenabteilung.

29 Die Sonne schien direkt auf den Monitor.
29a Deshalb bestellte Volker Gardinen für das Büro.
29b Gestern bestellte Volker Gardinen für das Büro.

30 Fliesenböden sind oft recht fußkalt.
30a Darum wählte Ralf Teppich für den Flur.
30b Vorhin wählte Ralf Teppich für den Flur.

31 Pudding ist ungesund.
31a Deshalb organisierte Irma Obst für den Nachtisch.
31b Gestern organisierte Irma Obst für den Nachtisch.

32 Der kaputte Stuhl sollte noch lange benutzt werden.
32a Darum verwendete Jörg Schrauben für die Reparatur.
32b Vorhin verwendete Jörg Schrauben für die Reparatur.

33 Man sollte im Urlaub nicht zuviel Bargeld dabeihaben.
33a Deshalb besorgte Helena Reiseschecks für den Urlaub.
33b Vorhin besorgte Helena Reiseschecks für den Urlaub.

34 Kühle Getränke sind angenehm an heißen Tagen.
34a Deshalb machte Annette Eistee in der Küche.
34b Vorhin machte Annette Eistee in der Küche.

35 Maschendraht bietet gar keinen Sichtschutz.
35a Deshalb beschaffte Ina Bretter für den Zaun.
35b Vorhin beschaffte Ina Bretter für den Zaun.

36 Es sollte eine schöne Bibliothek werden.
36a Deshalb kaufte Jutta Ledersessel für die Sitzecken.
36b Vorhin kaufte Jutta Ledersessel für die Sitzecken.

37 Im Januar ist es draußen recht kalt.
37a Deshalb benutzte Dieter Handschuhe auf dem Fahrrad.
37b Vorhin benutzte Dieter Handschuhe auf dem Fahrrad.

38 Heizungen sollten von Fachleuten repariert werden.
38a Deshalb bestellte Holger Handwerker für die Reparatur.
38b Vorhin bestellte Holger Handwerker für die Reparatur.

39 Wuchtige Möbel wirken bedrohlich in schmalen Räumen.
39a Deshalb beschaffte Jonas Wandregale für den Flur.
39b Vorhin beschaffte Jonas Wandregale für den Flur.

40 Auf nackte Ziegel kann man nicht tapezieren.
40a Deshalb suchte Elke Farbe für die Wände.
40b Vorhin suchte Elke Farbe für die Wände.

41 Das Girokonto war komplett leer.
41a Deshalb suchte Christian Sommerjobs in der Zeitung.
41b Vorhin suchte Christian Sommerjobs in der Zeitung.

42 Vitamine schützen vor Erkältungen.
42a Darum machte Alfred Obstsalat für den Nachtisch.
42b Gestern machte Alfred Obstsalat für den Nachtisch.

43 Betrunken Auto zu fahren ist sehr gefährlich.
43a Deshalb wählte Johann Sprudel in der Kneipe.
43b Vorhin wählte Johann Sprudel in der Kneipe.

44 Es lohnt sich selten, kaputte Sohlen zu reparieren.
44a Darum kaufte Oskar Schuhe in der Stadt.
44b Gestern kaufte Oskar Schuhe in der Stadt.

45 Das Gästezimmer sollte luxuriös werden.
45a Deshalb bestellte Christa Seidenstoff für die Bettwäsche.
45b Vorhin bestellte Christa Seidenstoff für die Bettwäsche.

46 Gerede im Hintergrund lenkt vom Lernen ab.
46a Darum benutzte Arthur Ohrstöpsel in der Bibliothek.
46b Gestern benutzte Arthur Ohrstöpsel in der Bibliothek.

47 Morgens ist gesundes Essen besonders wichtig.
47a Deshalb besorgte Sascha Müsli für das Frühstück.
47b Vorhin besorgte Sascha Müsli für das Frühstück.

48 Es war über Nacht sehr kalt geworden.
48a Darum bestellte Renate Kohlen für die Öfen.
48b Gestern bestellte Renate Kohlen für die Öfen.

49 Im März hat man meistens genug vom Winter.
49a Deshalb organisierte Mareike Strandurlaub für den April.
49b Vorhin organisierte Mareike Strandurlaub für den April.

50 Luftdichte Verpackung schützt vor Motten im Mehl.
50a Darum benutzte Sören Dosen für die Aufbewahrung.
50b Vorhin benutzte Sören Dosen für die Aufbewahrung.

51 Tropenhölzer eignen sich nicht für Fußböden.
51a Deshalb verwendete Johanna Kiefernholz für die Dielen.
51b Vorhin verwendete Johanna Kiefernholz für die Dielen.

52 Der Pappkarton hatte einen Riss.
52a Darum besorgte Günther Klebeband auf dem Heimweg.
52b Vorhin besorgte Günther Klebeband auf dem Heimweg.

53 Plastik ist nicht gut für die Umwelt.
53a Deshalb benutzte Hanna Stofftaschen für den Einkauf.
53b Vorhin benutzte Hanna Stofftaschen für den Einkauf.

54 Babys haben sehr empfindliche Haut.
54a Darum beschaffte Veronika Mandelöl für das Bad.
54b Vorhin beschaffte Veronika Mandelöl für das Bad.

55 An heißen Tagen ist schweres Essen belastend.
55a Deshalb machte Ben Salat für den Abend.
55b Vorhin machte Ben Salat für den Abend.

56 Im Tiefschnee kommt man schlecht vorwärts.
56a Darum organisierte Saskia Schlitten für die Winterreise.
56b Vorhin organisierte Saskia Schlitten für die Winterreise.

57 Wände im Bad sollten Feuchtigkeit aushalten.
57a Darum beschaffte Franziska Fliesen für die Sanierung.
57b Gestern beschaffte Franziska Fliesen für die Sanierung.

58 Im Gebirge sind vereiste Straßen besonders gefährlich.
58a Darum bestellte Helge Winterreifen für das Auto.
58b Gestern bestellte Helge Winterreifen für das Auto.

59 Büropflanzen müssen mit wenig Pflege auskommen.
59a Darum wählte Ines Kakteen für das Büro.
59b Gestern wählte Ines Kakteen für das Büro.

60 Die Lieblingshose war zu eng geworden.
60a Darum machte Claudia Sport nach der Uni.
60b Gestern machte Claudia Sport nach der Uni.

61 In Regalen stauben Gegenstände schnell ein.
61a Darum organisierte Jens Schränke für das Wohnzimmer.
61b Gestern organisierte Jens Schränke für das Wohnzimmer.

62 Immer mehr Menschen essen vegetarisch.
62a Darum besorgte Jochen Gemüse für die Grillparty.
62b Gestern besorgte Jochen Gemüse für die Grillparty.

63 Bei Ausgrabungen muss man sehr behutsam sein.
63a Darum beschaffte Karl Pinsel für die Arbeit.
63b Gestern beschaffte Karl Pinsel für die Arbeit.

64 Manchmal hat man keine Lust zum Kochen.
64a Darum wählte Olaf Pizza aus der Tiefkühltruhe.
64b Gestern wählte Olaf Pizza aus der Tiefkühltruhe.

65 Bei großen Partys geht schnell etwas zu Bruch.
65a Darum verwendete Harry Pappteller für das Essen.
65b Gestern verwendete Harry Pappteller für das Essen.

66 Zuviel Koffein kann zu Schlafstörungen führen.
66a Darum machte Beate Kräutertee nach dem Abendbrot.
66b Vorhin machte Beate Kräutertee nach dem Abendbrot.

67 Viele Schwangere wünschen sich eine Tochter.
67a Darum kaufte Maja Kleidchen in der Boutique.
67b Gestern kaufte Maja Kleidchen in der Boutique.

68 Das Parkett war extrem empfindlich.
68a Darum bestellte Amelie Filzschuhe für die Wohnung.
68b Vorhin bestellte Amelie Filzschuhe für die Wohnung.

69 Die Therapie gegen Flugangst war erfolglos.
69a Darum suchte Max Zugverbindungen für die Reise.
69b Gestern suchte Max Zugverbindungen für die Reise.

70 Die Großtante bestand auf Luxus.
70a Darum benutzte Ariane Silberlöffel für die Teeparty.
70b Vorhin benutzte Ariane Silberlöffel für die Teeparty.

71 Igel vertragen Milch überhaupt nicht.
71a Darum verwendete Brigitte Hackfleisch bei der Fütterung.
71b Gestern verwendete Brigitte Hackfleisch bei der Fütterung.

72 Eine Oper ist eine feierliche Sache.
72a Darum wählte Sabine Lackschuhe für die Premiere.
72b Vorhin wählte Sabine Lackschuhe für die Premiere.

73 Rauchen ist im Flugzeug verboten.
73a Darum kaufte Ellen Kaugummi für den Flug.
73b Vorhin kaufte Ellen Kaugummi für den Flug.

74 Der Sommer ist da.
74a Darum suchte Theresa Bikinis in der Stadt.
74b Vorhin suchte Theresa Bikinis in der Stadt.

75 Hochbetten müssen sicher befestigt sein.
75a Darum beschaffte Leon Dübel für die Aufhängung.
75b Vorhin beschaffte Leon Dübel für die Aufhängung.

76 Salz auf vereisten Straßen ist schlecht für die Umwelt.
76a Darum verwendete Sophia Sägespäne für den Fußweg.
76b Vorhin verwendete Sophia Sägespäne für den Fußweg.

77 In Dänemark kann es empfindlich kühl werden.
77a Darum besorgte Maria Wollpullover für den Urlaub.
77b Vorhin besorgte Maria Wollpullover für den Urlaub.

78 Kinder bekommen von Horrorfilmen schnell Alpträume.
78a Darum bestellte Roland Trickfilme für den Geburtstag.
78b Vorhin bestellte Roland Trickfilme für den Geburtstag.

79 Süßigkeiten sind schlecht für die Zähne.
79a Darum kaufte Dirk Kirschen für die Pause.
79b Vorhin kaufte Dirk Kirschen für die Pause.

80 Die Reiseroute führte über schmale Bergpfade.
80a Darum organisierte Daniel Esel für die Expedition.
80b Vorhin organisierte Daniel Esel für die Expedition.

APPENDIX C

Stimulus Materials Experiment 3

Legend:

Context
#a Causal connective
#b Temporal connective
#c Temporal non-connective
#d Filler

1 Die Kleinen waren auf dem glatten Parkett ausgerutscht.
1a Darum beschaffte Richard Teppich für den Kinder laden.
1b Danach beschaffte Richard Teppich für den Kinder laden.
1c Gestern beschaffte Richard Teppich für den Kinder laden.
1d Gern beschaffte Richard Teppich für den Kinderladen.

2 Die Treppe zum Baumhaus war weggebrochen.
2a Darum besorgte Ole Seile für die Strickleiter.
2b Danach besorgte Ole Seile für die Strickleiter..
2c Gestern besorgte Ole Seile für die Strickleiter.
2d Gern besorgte Ole Seile für die Strickleiter.

3 Die Kin der hatten die Comics abgelehnt.
3a Darum bestellte Ruben Krimis für die Ferien.
3b Danach bestellte Ruben Krimis für die Ferien.
3c Gestern bestellte Ruben Krimis für die Ferien.
3d Gern bestellte Ruben Krimis für die Ferien.

4 Die Seife hatte Ausschlag verursacht.
4a Darum kaufte Veronika Mandelöl für das Bad.
4b Danach kaufte Veronika Mandelöl für das Bad.
4c Gestern kaufte Veronika Mandelöl für das Bad.
4d Gern kaufte Veronika Mandelöl für das Bad.

5 Das ständige Sitzen hatte zu Schlaflosigkeit geführt.
5a Darum machte Gunnar Yoga vor dem Fernseher.
5b Danach machte Gunnar Yoga vor dem Fernseher.
5c Gestern machte Gunnar Yoga vor dem Fernseher.
5d Gern machte Gunnar Yoga vor dem Fernseher.

6 Der improvisierte Urlaub war zu anstrengend.
6a Darum organisierte Kelly Pauschalreisen für die Ferien.
6b Danach organisierte Kelly Pauschalreisen für die Ferien.
6c Gestern organisierte Kelly Pauschalreisen für die Ferien.
6d Gern organisierte Kelly Pauschalreisen für die Ferien.

7 Der März war kalt und völlig verregnet.
7a Darum organisierte Melanie Strandurlaub für den April.
7b Danach organisierte Melanie Strandurlaub für den April.
7c Gestern organisierte Melanie Strandurlaub für den April.
7d Gern organisierte Melanie Strandurlaub für den April.

8 Es war nicht genug Geld für Cluburlaub übriggeblieben.
8a Darum suchte Tanja Zeltplätze für den Sommer.
8b Danach suchte Tanja Zeltplätze für den Sommer.
8c Gestern suchte Tanja Zeltplätze für den Sommer.
8d Gern suchte Tanja Zeltplätze für den Sommer.

9 Der Monteur hatte vor hartem Wasser gewarnt.
9a Darum verwendete Rita Entkalker für die Waschmaschine.
9b Danach verwendete Rita Entkalker für die Waschmaschine.
9c Gestern verwendete Rita Entkalker für die Waschmaschine.
9d Gern verwendete Rita Entkalker für die Waschmaschine.

10 Der Fliesenboden war fußkalt und kaputt.
10a Darum wählte Ralf Teppich für den Flur.
10b Danach wählte Ralf Teppich für den Flur.
10c Gestern wählte Ralf Teppich für den Flur.
10d Gern wählte Ralf Teppich für den Flur.

11 Kristallzucker macht schnell dick.
11a Darum benutzte Susanne Honig für den Tee.
11b Hinterher benutzte Susanne Honig für den Tee.
11c Gestern benutzte Susanne Honig für den Tee.
11d Gern benutzte Susanne Honig für den Tee.

12 Die Verwaltung hatte den Angestellten das Spritgeld gestrichen.
12a Darum beschaffte Maria Fahrräder für die Kollegen.
12b Hinterher beschaffte Maria Fahrräder für die Kollegen.
12c Gestern beschaffte Maria Fahrräder für die Kollegen.
12d Gern beschaffte Maria Fahrräder für die Kollegen.

13 Die Kinder hatten nach gruseligen Filmen Albträume.
13a Darum bestellte Renate Trickfilme für den Geburtstag.
13b Hinterher bestellte Renate Trickfilme für den Geburtstag.
13c Gestern bestellte Renate Trickfilme für den Geburtstag.
13d Gern bestellte Renate Trickfilme für den Geburtstag.

14 Die Sonne schien seit dem Umbau direkt auf den Monitor.
14a Darum bestellte Volker Gardinen für das Büro.
14b Hinterher bestellte Volker Gardinen für das Büro.
14c Gestern bestellte Volker Gardinen für das Büro.
14d Gern bestellte Volker Gardinen für das Büro.

15 In der Hitze war das schwere Essen belastend.
15a Darum machte Ben Salat für den Abend.
15b Hinterher machte Ben Salat für den Abend.
15c Gestern machte Ben Salat für den Abend.
15d Gern machte Ben Salat für den Abend.

16 Der Arzt empfahl Ruhe für den verstauchten Knöchel.
16a Darum organisierte Franz Brettspiele nach der Arbeit.
16b Hinterher organisierte Franz Brettspiele nach der Arbeit.
16c Gestern organisierte Franz Brettspiele nach der Arbeit.
16d Gern organisierte Franz Brettspiele nach der Arbeit.

17 Der amerikanische Besuch hatte sich geweigert, viel zu laufen.
17a Darum organisierte Greta Mietwagen für das Wochenende.
17b Hinterher organisierte Greta Mietwagen für das Wochenende.
17c Gestern organisierte Greta Mietwagen für das Wochenende.
17d Gern organisierte Greta Mietwagen für das Wochenende.

18 Der Arzt hatte vor Bewegungsmangel gewarnt.
18a Darum organisierte Ilse Ballspiele für den Nachmittag.
18b Hinterher organisierte Ilse Ballspiele für den Nachmittag.
18c Gestern organisierte Ilse Ballspiele für den Nachmittag.
18d Gern organisierte Ilse Ballspiele für den Nachmittag.

19 Der Förderverein war bankrott gegangen.
19a Darum suchte Marta Sponsoren für das Projekt.
19b Hinterher suchte Marta Sponsoren für das Projekt.
19c Gestern suchte Marta Sponsoren für das Projekt.
19d Gern suchte Marta Sponsoren für das Projekt.

20 Das Gartenbuch hatte gegen Chemiedünger für Gemüse gewarnt.
20a Darum verwendete Marius Pferdemist für das Salatbeet.
20b Hinterher verwendete Marius Pferdemist für das Salatbeet.
20c Gestern verwendete Marius Pferdemist für das Salatbeet.
20d Gern verwendete Marius Pferdemist für das Salatbeet.

21 Der Umzug des Zoos war mit viel Stress verbunden.
21a Darum beschaffte Corinna Beruhigungsmittel für die Tiere.
21b Danach beschaffte Corinna Beruhigungsmittel für die Tiere.
21c Vorhin beschaffte Corinna Beruhigungsmittel für die Tiere.
21d Gern beschaffte Corinna Beruhigungsmittel für die Tiere.

22 Die Hunde waren über den Lattenzaun gesprungen.
22a Darum beschaffte Nathan Maschendraht für den Zwinger.
22b Danach beschaffte Nathan Maschendraht für den Zwinger.
22c Vorhin beschaffte Nathan Maschendraht für den Zwinger.
22d Gern beschaffte Nathan Maschendraht für den Zwinger.

23 Das Essensgeld war für so viele Leute recht knapp geworden.
23a Darum besorgte Irma Linsen für die Suppe.
23b Danach besorgte Irma Linsen für die Suppe.
23c Vorhin besorgte Irma Linsen für die Suppe.
23d Gern besorgte Irma Linsen für die Suppe.

24 Der neue Videorecorder war geliefert worden.
24a Darum bestellte Daniel Filme über das Internet.
24b Danach bestellte Daniel Filme über das Internet.
24c Vorhin bestellte Daniel Filme über das Internet.
24d Gern bestellte Daniel Filme über das Internet.

25 Das Rauchfleisch war kein großer Erfolg.
25a Darum kaufte Jürgen Kochschinken für das Buffet.
25b Danach kaufte Jürgen Kochschinken für das Buffet.
25c Vorhin kaufte Jürgen Kochschinken für das Buffet.
25d Gern kaufte Jürgen Kochschinken für das Buffet.

26 Der Herd funktionierte wieder.
26a Darum machte Dieter Nudeln für das Abendbrot.
26b Danach machte Dieter Nudeln für das Abendbrot.
26c Vorhin machte Dieter Nudeln für das Abendbrot.
26d Gern machte Dieter Nudeln für das Abendbrot.

27 Der Wecker klingelte vor Sonnenaufgang.
27a Darum machte Emily Kaffee für die Autofahrt.
27b Danach machte Emily Kaffee für die Autofahrt.
27c Vorhin machte Emily Kaffee für die Autofahrt.
27d Gern machte Emily Kaffee für die Autofahrt.

28 Die Grundierung war gut aufgetrocknet.
28a Darum suchte Herrmann Farbe für die Wände.
28b Danach suchte Herrmann Farbe für die Wände.
28c Vorhin suchte Herrmann Farbe für die Wände.
28d Gern suchte Herrmann Farbe für die Wände.

29 Das Stuhlbein war gebrochen.
29a Darum suchte Justus Holzleim auf dem Speicher.
29b Danach suchte Justus Holzleim auf dem Speicher.
29c Vorhin suchte Justus Holzleim auf dem Speicher.
29d Gern suchte Justus Holzleim auf dem Speicher.

30 Das Pizzarestaurant war übers Wochenende geschlossen.
30a Darum wählte Alina Curry für den Videoabend.
30b Danach wählte Alina Curry für den Videoabend.
30c Vorhin wählte Alina Curry für den Videoabend.
30d Gern wählte Alina Curry für den Videoabend.

31 Entkalker war ausverkauft gewesen.
31a Darum benutzte Annika Essig für die Reinigung.
31b Hinterher benutzte Annika Essig für die Reinigung.
31c Vorhin benutzte Annika Essig für die Reinigung.
31d Gern benutzte Annika Essig für die Reinigung.

32 Die Jeeps waren auf den steilen Pisten steckengeblieben.
32a Darum beschaffte Arndt Esel für die Expedition.
32b Hinterher beschaffte Arndt Esel für die Expedition.
32c Vorhin beschaffte Arndt Esel für die Expedition.
32d Gern beschaffte Arndt Esel für die Expedition.

33 Die teuren Schnitzel ließen nicht viel Geld für Getränke übrig.
33a Darum besorgte Günther Limonade für die Party.
33b Hinterher besorgte Günther Limonade für die Party.
33c Vorhin besorgte Günther Limonade für die Party.
33d Gern besorgte Günther Limonade für die Party.

34 Die Scherben hatten den Reifen zerschnitten.
34a Darum kaufte Anna Flicken für den Schlauch.
34b Hinterher kaufte Anna Flicken für den Schlauch.
34c Vorhin kaufte Anna Flicken für den Schlauch.
34d Gern kaufte Anna Flicken für den Schlauch.

35 Das Rauchen im Flugzeug ist verboten worden.
35a Darum kaufte Ellen Kaugummi für den Flug.
35b Hinterher kaufte Ellen Kaugummi für den Flug.
35c Vorhin kaufte Ellen Kaugummi für den Flug.
35d Gern kaufte Ellen Kaugummi für den Flug.

36 Umziehen im Hochsommer ist schweißtreibend.
36a Darum machte Annette Eistee in der Küche.
36b Hinterher machte Annette Eistee in der Küche.
36c Vorhin machte Annette Eistee in der Küche.
36d Gern machte Annette Eistee in der Küche.

37 Der Herd war kaputtgegangen.
37a Darum machte Berta Rohkost für das Abendbrot.
37b Hinterher machte Berta Rohkost für das Abendbrot.
37c Vorhin machte Berta Rohkost für das Abendbrot.
37d Gern machte Berta Rohkost für das Abendbrot.

38 Die Lieblingshose war zu eng geworden.
38a Darum machte Claudia Sport nach der Uni.
38b Hinterher machte Claudia Sport nach der Uni.
38c Vorhin machte Claudia Sport nach der Uni.
38d Gern machte Claudia Sport nach der Uni.

39 Markenkleidung hatte sich als überteuert erwiesen.
39a Darum suchte Diana Schnäppchen in der Damenabteilung.
39b Hinterher suchte Diana Schnäppchen in der Damenabteilung.
39c Vorhin suchte Diana Schnäppchen in der Damenabteilung.
39d Gern suchte Diana Schnäppchen in der Damenabteilung.

40 Die Prüfung war wunderbar gelaufen.
40a Darum wählte Jana Kaviar auf der Feier.
40b Hinterher wählte Jana Kaviar auf der Feier.
40c Vorhin wählte Jana Kaviar auf der Feier.
40d Gern wählte Jana Kaviar auf der Feier.

41 Majoran hatte zu Fisch nicht gut geschmeckt.
41a Darum benutzte Eva Petersilie für das Gratin.
41b Danach benutzte Eva Petersilie für das Gratin.
41c Gestern benutzte Eva Petersilie für das Gratin.
41d Lieber benutzte Eva Petersilie für das Gratin.

42 Die Wasserfarben waren auf dem Papier völlig verlaufen.
42a Darum benutzte Gregor Buntstifte für die Skizze.
42b Danach benutzte Gregor Buntstifte für die Skizze.
42c Gestern benutzte Gregor Buntstifte für die Skizze.
42d Lieber benutzte Gregor Buntstifte für die Skizze.

43 Der Süßstoff hatte merkwürdig geschmeckt.
43a Darum benutzte Jonas Zucker für den Kaffee.
43b Danach benutzte Jonas Zucker für den Kaffee.
43c Gestern benutzte Jonas Zucker für den Kaffee.
43d Lieber benutzte Jonas Zucker für den Kaffee.

44 Das Auto war auf dem Sandweg steckengeblieben.
44a Darum beschaffte Niklas Kies für die Auffahrt.
44b Danach beschaffte Niklas Kies für die Auffahrt.
44c Gestern beschaffte Niklas Kies für die Auffahrt.
44d Lieber beschaffte Niklas Kies für die Auffahrt.

45 Der Sturz vom Fahrrad war heftig.
45a Darum beschaffte Sonja Stützräder für die Kinder.
45b Danach beschaffte Sonja Stützräder für die Kinder.
45c Gestern beschaffte Sonja Stützräder für die Kinder.
45d Lieber beschaffte Sonja Stützräder für die Kinder.

46 In Dänemark wares empfindlich kühl gewesen.
46a Darum besorgte Maria Wollpullover für den Urlaub.
46b Danach besorgte Maria Wollpullover für den Urlaub.
46c Gestern besorgte Maria Wollpullover für den Urlaub.
46d Lieber besorgte Maria Wollpullover für den Urlaub.

47 Im Gebirge waren vereiste Straßen besonders gefährlich.
47a Darum bestellte Helge Winterreifen für das Auto.
47b Danach bestellte Helge Winterreifen für das Auto.
47c Gestern bestellte Helge Winterreifen für das Auto.
47d Lieber bestellte Helge Winterreifen für das Auto.

48 Der Winter kündigte sich an.
48a Darum bestellte Renate Kohlen für die Öfen.
48b Danach bestellte Renate Kohlen für die Öfen.
48c Gestern bestellte Renate Kohlen für die Öfen.
48d Lieber bestellte Renate Kohlen für die Öfen.

49 Für Schwarzfahren war eine Geldstrafe eingeführt worden.
49a Darum kaufte Ingolf Fahrkarten für den Bus.
49b Danach kaufte Ingolf Fahrkarten für den Bus.
49c Gestern kaufte Ingolf Fahrkarten für den Bus.
49d Lieber kaufte Ingolf Fahrkarten für den Bus.

50 Die neuen Nachbarn konnten über den Zaun sehen.
50a Darum kaufte Manfred Hecken für den Vorgarten.
50b Danach kaufte Manfred Hecken für den Vorgarten.
50c Gestern kaufte Manfred Hecken für den Vorgarten.
50d Lieber kaufte Manfred Hecken für den Vorgarten.

51 Die Strohsterne wollten nicht recht gelingen.
51a Darum machte Evelyn Lametta in der Schule.
51b Hinterher machte Evelyn Lametta in der Schule.
51c Gestern machte Evelyn Lametta in der Schule.
51d Lieber machte Evelyn Lametta in der Schule.

52 Der Brandschutz hatte Kerzen bei der Schulfeier verboten.
52a Darum organisierte Lydia Lichterketten für die Dekoration.
52b Hinterher organisierte Lydia Lichterketten für die Dekoration.
52c Gestern organisierte Lydia Lichterketten für die Dekoration.
52d Lieber organisierte Lydia Lichterketten für die Dekoration.

53 Die Farbspritzer in den Kleidern waren nicht auswaschbar.
53a Darum organisierte Saskia Kittel für die Renovierung.
53b Hinterher organisierte Saskia Kittel für die Renovierung.
53c Gestern organisierte Saskia Kittel für die Renovierung.
53d Lieber organisierte Saskia Kittel für die Renovierung.

54 Die Bahn hatte die Preise wie der erhöht.
54a Darum suchte Marta Flüge für die Reise.
54b Hinterher suchte Marta Flüge für die Reise.
54c Gestern suchte Marta Flüge für die Reise.
54d Lieber suchte Marta Flüge für die Reise.

055 Die Therapie gegen Flugangst war erfolglos.
55a Darum suchte Max Zugverbindungen für die Reise.
55b Hinterher suchte Max Zugverbindungen für die Reise.
55c Gestern suchte Max Zugverbindungen für die Reise.
55d Lieber suchte Max Zugverbindungen für die Reise.

56 Der Test hatte eine Allergie gegen Weizen festestellt.
56a Darum verwendete Ria Roggenmehl für die Brötchen.
56b Hinterher verwendete Ria Roggenmehl für die Brötchen.
56c Gestern verwendete Ria Roggenmehl für die Brötchen.
56d Lieber verwendete Ria Roggenmehl für die Brötchen.

57 Die Hunde vertrugen die vegetarische Kost nicht.
57a Darum verwendete Silke Fleisch bei der Fütterung.
57b Hinterher verwendete Silke Fleisch bei der Fütterung.
57c Gestern verwendete Silke Fleisch bei der Fütterung.
57d Lieber verwendete Silke Fleisch bei der Fütterung.

58 Die Chips waren alt und pappig.
58a Darum wählte Julian Erdnüsse an der Bar.
58b Hinterher wählte Julian Erdnüsse an der Bar.
58c Gestern wählte Julian Erdnüsse an der Bar.
58d Lieber wählte Julian Erdnüsse an der Bar.

59 Der Restaurantführer hatte das verkochte Risotto bemängelt.
59a Darum wählte Michael Pasta für den Hauptgang.
59b Hinterher wählte Michael Pasta für den Hauptgang.
59c Gestern wählte Michael Pasta für den Hauptgang.
59d Lieber wählte Michael Pasta für den Hauptgang.

60 Die Wanderstiefel wirkten unpassend in der Oper.
60a Darum wählte Sabine Lackschuhe für die Premiere.
60b Hinterher wählte Sabine Lackschuhe für die Premiere.
60c Gestern wählte Sabine Lackschuhe für die Premiere.
60d Lieber wählte Sabine Lackschuhe für die Premiere.

61 In Wasser gekocht schmeckte das Gemüse zu fade.
61a Darum benutzte Gerhard Brühwürfel für das Essen.
61b Danach benutzte Gerhard Brühwürfel für das Essen.
61c Vorhin benutzte Gerhard Brühwürfel für das Essen.
61d Lieber benutzte Gerhard Brühwürfel für das Essen.

62 Das teure Geschirr war zu Hause geblieben.
62a Darum benutzte Helena Blechtassen für die Getränke.
62b Danach benutzte Helena Blechtassen für die Getränke.
62c Vorhin benutzte Helena Blechtassen für die Getränke.
62d Lieber benutzte Helena Blechtassen für die Getränke.

63 Das Fundament war mit Wasser vollgelaufen.
63a Darum beschaffte Rachel Pumpen für die Baustelle.
63b Danach beschaffte Rachel Pumpen für die Baustelle.
63c Vorhin beschaffte Rachel Pumpen für die Baustelle.
63d Lieber beschaffte Rachel Pumpen für die Baustelle.

64 Es war Regen vorausgesagt worden.
64a Darum beschaffte Suse Partyzelte für das Gartenfest.
64b Danach beschaffte Suse Partyzelte für das Gartenfest.
64c Vorhin beschaffte Suse Partyzelte für das Gartenfest.
64d Lieber beschaffte Suse Partyzelte für das Gartenfest.

65 Der Pappkarton war unterwegs gerissen.
65a Darum besorgte Sonja Klebeband auf dem Heimweg.
65b Danach besorgte Sonja Klebeband auf dem Heimweg.
65c Vorhin besorgte Sonja Klebeband auf dem Heimweg.
65d Lieber besorgte Sonja Klebeband auf dem Heimweg.

066 Das Bargeld war schnell gestohlen worden.
66a Darum besorgte Tim Reiseschecks für den Urlaub.
66b Danach besorgte Tim Reiseschecks für den Urlaub.
66c Vorhin besorgte Tim Reiseschecks für den Urlaub.
66d Lieber besorgte Tim Reiseschecks für den Urlaub.

67 Die Kartoffeln waren nicht gar gewesen.
67a Darum bestellte Katharina Brot bei der Kellnerin.
67b Danach bestellte Katharina Brot bei der Kellnerin.
67c Vorhin bestellte Katharina Brot bei der Kellnerin.
67d Lieber bestellte Katharina Brot bei der Kellnerin.

68 Die Tapeten im Bad waren völlig aufgeweicht.
68a Darum bestellte Ulrich Fliesen für die Sanierung.
68b Danach bestellte Ulrich Fliesen für die Sanierung.
68c Vorhin bestellte Ulrich Fliesen für die Sanierung.
68d Lieber bestellte Ulrich Fliesen für die Sanierung.

69 Das genagelte Hochbett war zu wackelig.
69a Darum kaufte Leon Schrauben für die Konstruktion.
69b Danach kaufte Leon Schrauben für die Konstruktion.
69c Vorhin kaufte Leon Schrauben für die Konstruktion.
69d Lieber kaufte Leon Schrauben für die Konstruktion.

70 Die Hitze hatte Brandringe auf dem Tisch hinterlassen.
70a Darum kaufte Maren Untersetzer für die Töpfe.
70b Danach kaufte Maren Untersetzer für die Töpfe.
70c Vorhin kaufte Maren Untersetzer für die Töpfe.
70d Lieber kaufte Maren Untersetzer für die Töpfe.

71 Es war über Nacht sehr kalt geworden.
71a Darum kaufte Thea Strumpfhosen in der Kaufhalle.
71b Hinterher kaufte Thea Strumpfhosen in der Kaufhalle.
71c Vorhin kaufte Thea Strumpfhosen in der Kaufhalle.
71d Lieber kaufte Thea Strumpfhosen in der Kaufhalle.

72 Lametta selbst zu machen war sehr anstrengend.
72a Darum machte Theo Strohsterne in der Schule.
72b Hinterher machte Theo Strohsterne in der Schule.
72c Vorhin machte Theo Strohsterne in der Schule.
72d Lieber machte Theo Strohsterne in der Schule.

73 Die Autos waren völlig eingeschneit.
73a Darum organisierte Luis Schlitten für die Winterreise.
73b Hinterher organisierte Luis Schlitten für die Winterreise.
73c Vorhin organisierte Luis Schlitten für die Winterreise.
73d Lieber organisierte Luis Schlitten für die Winterreise.

74 Die erste Nacht im Zelt war fürchterlich.
74a Darum suchte Gereon Hotelzimmer auf der Insel.
74b Hinterher suchte Gereon Hotelzimmer auf der Insel.
74c Vorhin suchte Gereon Hotelzimmer auf der Insel.
74d Lieber suchte Gereon Hotelzimmer auf der Insel.

75 Das Jobangebot war nicht akzeptabel.
75a Darum suchte Tori Anzeigen in der Zeitung.
75b Hinterher suchte Tori Anzeigen in der Zeitung.
75c Vorhin suchte Tori Anzeigen in der Zeitung.
75d Lieber suchte Tori Anzeigen in der Zeitung.

76 Das teure Bild war zu schwer für den Nagel.
76a Darum verwendete Lina Dübel für die Aufhängung.
76b Hinterher verwendete Lina Dübel für die Aufhängung.
76c Vorhin verwendete Lina Dübel für die Aufhängung.
76d Lieber verwendete Lina Dübel für die Aufhängung.

077 Das genagelte Stuhlbein zerbrach wieder.
77a Darum verwendete Sophia Schrauben für die Reparatur.
77b Hinterher verwendete Sophia Schrauben für die Reparatur.
77c Vorhin verwendete Sophia Schrauben für die Reparatur.
77d Lieber verwendete Sophia Schrauben für die Reparatur.

78 Die Kakteen waren in der Blumenerde eingegangen.
78a Darum verwendete Stefan Sand für die Setzlinge.
78b Hinterher verwendete Stefan Sand für die Setzlinge.
78c Vorhin verwendete Stefan Sand für die Setzlinge.
78d Lieber verwendete Stefan Sand für die Setzlinge.

79 Der Cocktail war viel zu süß gewesen.
79a Darum wählte Jakob Bier an der Bar.
79b Hinterher wählte Jakob Bier an der Bar.
79c Vorhin wählte Jakob Bier an der Bar.
79d Lieber wählte Jakob Bier an der Bar.

80 Der Wolkenbruch hatte den Pfad völlig aufgeweicht.
80a Darum wählte Olaf Stiefel für die Wanderung.
80b Hinterher wählte Olaf Stiefel für die Wanderung.
80c Vorhin wählte Olaf Stiefel für die Wanderung.
80d Lieber wählte Olaf Stiefel für die Wanderung.

81 Es wird empfohlen, keine Plastiktüten zu verwenden.
81a Deshalb benutzte Hanna Stofftaschen für den Einkauf.
81b Danach benutzte Hanna Stofftaschen für den Einkauf.
81c Gestern benutzte Hanna Stofftaschen für den Einkauf.

81d Gern benutzte Hanna Stofftaschen für den Einkauf.

82 Die Affen hatten die Zoobesucher mit Dreck beworfen.
82a Deshalb beschaffte Carlo Glasscheiben für die Käfige.
82b Danach beschaffte Carlo Glasscheiben für die Käfige.
82c Gestern beschaffte Carlo Glasscheiben für die Käfige.
82d Gern beschaffte Carlo Glasscheiben für die Käfige.

83 Das fertige Baugerüst machte das Zimmer recht dunkel.
83a Deshalb besorgte Thomas Lampen in der Kaufhalle.
83b Danach besorgte Thomas Lampen in der Kaufhalle.
83c Gestern besorgte Thomas Lampen in der Kaufhalle.
83d Gern besorgte Thomas Lampen in der Kaufhalle.

84 Die Kellnerin hatte die Pasta empfohlen.
84a Deshalb bestellte Armin Spaghetti für den Hauptgang.
84b Danach bestellte Armin Spaghetti für den Hauptgang.
84c Gestern bestellte Armin Spaghetti für den Hauptgang.
84d Gern bestellte Armin Spaghetti für den Hauptgang.

85 Der Gummibaum hatte viele Blätter verloren.
85a Deshalb kaufte Klaus Dünger in der Markthalle.
85b Danach kaufte Klaus Dünger in der Markthalle.
85c Gestern kaufte Klaus Dünger in der Markthalle.
85d Gern kaufte Klaus Dünger in der Markthalle.

86 An Wintertagen war das kalte Essen nicht beliebt.
86a Deshalb machte Elke Braten für den Sonntag.
86b Danach machte Elke Braten für den Sonntag.
86c Gestern machte Elke Braten für den Sonntag.
86d Gern machte Elke Braten für den Sonntag.

087 Der Zeltplatz war überschwemmt worden.
87a Deshalb organisierte Dina Hotelzimmer für die Urlauber.
87b Danach organisierte Dina Hotelzimmer für die Urlauber.
87c Gestern organisierte Dina Hotelzimmer für die Urlauber.
87d Gern organisierte Dina Hotelzimmer für die Urlauber.

88 Bei Computern hatte es große Preisveränderungen gegeben.
88a Deshalb suchte Doreen Angebote in den Läden.
88b Danach suchte Doreen Angebote in den Läden.
88c Gestern suchte Doreen Angebote in den Läden.
88d Gern suchte Doreen Angebote in den Läden.

89 Es war verboten worden , mit Salz zu streuen.
89a Deshalb verwendete Jörg Sand für den Fußweg.
89b Danach verwendete Jörg Sand für den Fußweg.
89c Gestern verwendete Jörg Sand für den Fußweg.
89d Gern verwendete Jörg Sand für den Fußweg.

90 Das bestellte Linoleum war häßlich und eingerissen.
90a Deshalb wählte Hakan Dielen für die Küche.
90b Danach wählte Hakan Dielen für die Küche.
90c Gestern wählte Hakan Dielen für die Küche.
90d Gern wählte Hakan Dielen für die Küche.

91 Die Parkverwaltung hatte die unbefestigten Pfade kritisiert.
91a Deshalb beschaffte Andi Steinplatten für die Wege.
91b Hinterher beschaffte Andi Steinplatten für die Wege.
91c Gestern beschaffte Andi Steinplatten für die Wege.
91d Gern beschaffte Andi Steinplatten für die Wege.

92 Der Vermieter hatte den kahlen Balkon kritisiert.
92a Deshalb besorgte Mareike Lavendel auf dem Markt.
92b Hinterher besorgte Mareike Lavendel auf dem Markt.
92c Gestern besorgte Mareike Lavendel auf dem Markt.
92d Gern besorgte Mareike Lavendel auf dem Markt.

93 Die Katzen hatten den Sessel ruiniert.
93a Deshalb besorgte Miriam Kratzbäume in der Tierhandlung.
93b Hinterher besorgte Miriam Kratzbäume in der Tierhandlung.
93c Gestern besorgte Miriam Kratzbäume in der Tierhandlung.
93d Gern besorgte Miriam Kratzbäume in der Tierhandlung.

94 Japanisches Essen war nicht jedermanns Sache.
94a Deshalb bestellte Anne Antipasti für das Buffett.
94b Hinterher bestellte Anne Antipasti für das Buffett.
94c Gestern bestellte Anne Antipasti für das Buffett.
94d Gern bestellte Anne Antipasti für das Buffett.

95 Die Nachbarn hatten sich über das Getrampel beschwert.
95a Deshalb kaufte Jule Teppiche für den Flur.
95b Hinterher kaufte Jule Teppiche für den Flur.
95c Gestern kaufte Jule Teppiche für den Flur.
95d Gern kaufte Jule Teppiche für den Flur.

096 Das gemeinsame Picknick war ein voller Erfolg geworden.
96a Deshalb organisierte Bettina Ausflüge für die Kollegen.
96b Hinterher organisierte Bettina Ausflüge für die Kollegen.
96c Gestern organisierte Bettina Ausflüge für die Kollegen.
96d Gern organisierte Bettina Ausflüge für die Kollegen.

97 Das uralte Auto war nicht angesprungen.
97a Deshalb organisierte Bob Ersatzteile für den Motor.
97b Hinterher organisierte Bob Ersatzteile für den Motor.
97c Gestern organisierte Bob Ersatzteile für den Motor.
97d Gern organisierte Bob Ersatzteile für den Motor.

98 Die alte Nachbarin hatte sich das Bein gebrochen.
98a Deshalb organisierte Bryan Pfleger für die Genesung.
98b Hinterher organisierte Bryan Pfleger für die Genesung.
98c Gestern organisierte Bryan Pfleger für die Genesung.
98d Gern organisierte Bryan Pfleger für die Genesung.

99 Die Eichenbretter waren zu dunkel.
99a Deshalb verwendete Harry Kiefernholz für die Dielen.
99b Hinterher verwendete Harry Kiefernholz für die Dielen.
99c Gestern verwendete Harry Kiefernholz für die Dielen.
99d Gern verwendete Harry Kiefernholz für die Dielen.

100 Die vielen Bonbons hatten Karies verursacht.
100a Deshalb wählte Dirk Kirschen für die Pause.
100b Hinterher wählte Dirk Kirschen für die Pause.
100c Gestern wählte Dirk Kirschen für die Pause.
100d Gern wählte Dirk Kirschen für die Pause.

101 Die Großtante hatte das billige Besteck abgelehnt.
101a Deshalb benutzte Helmut Silberlöffel für die Teeparty.
101b Danach benutzte Helmut Silberlöffel für die Teeparty.
101c Vorhin benutzte Helmut Silberlöffel für die Teeparty.
101d Gern benutzte Helmut Silberlöffel für die Teeparty.

102 Auf dem Rockkonzert waren die Biergläser ausgegangen.
102a Deshalb beschaffte Tom Plastikbecher für die Getränke.
102b Danach beschaffte Tom Plastikbecher für die Getränke.
102c Vorhin beschaffte Tom Plastikbecher für die Getränke.
102d Gern beschaffte Tom Plastikbecher für die Getränke.

103 Man hatte sich auf ein feudales Mahl geeinigt.

103a Deshalb besorgte Wolfgang Hummer für den Hauptgang.
103b Danach besorgte Wolfgang Hummer für den Hauptgang.
103c Vorhin besorgte Wolfgang Hummer für den Hauptgang.
103d Gern besorgte Wolfgang Hummer für den Hauptgang.

104 Die Kneipe war zur Eröffnung rappelvoll gewesen.
104a Deshalb bestellte Werner Nachschub über den Großhandel.
104b Danach bestellte Werner Nachschub über den Großhandel.
104c Vorhin bestellte Werner Nachschub über den Großhandel.
104d Gern bestellte Werner Nachschub über den Großhandel.

105 Mit leerem Bauch war die Prüfung schlecht gelaufen.
105a Deshalb kaufte Sascha Müsli für das Frühstück.
105b Danach kaufte Sascha Müsli für das Frühstück.
105c Vorhin kaufte Sascha Müsli für das Frühstück.
105d Gern kaufte Sascha Müsli für das Frühstück.

106 Der Spaziergang im Winter war zwar schön, aber kalt.
106a Deshalb machte Peer Grog in der Küche.
106b Danach machte Peer Grog in der Küche.
106c Vorhin machte Peer Grog in der Küche.
106d Gern machte Peer Grog in der Küche.

107 Die Esel waren nicht wüstentauglich.
107a Deshalb organisierte Lara Kamele für die Expedition.
107b Danach organisierte Lara Kamele für die Expedition.
107c Vorhin organisierte Lara Kamele für die Expedition.
107d Gern organisierte Lara Kamele für die Expedition.

108 Das Freibad hatte Eröffnung gefeiert.
108a Deshalb suchte Theresa Bikinis in der Stadt.
108b Danach suchte Theresa Bikinis in der Stadt.
108c Vorhin suchte Theresa Bikinis in der Stadt.
108d Gern suchte Theresa Bikinis in der Stadt.

109 Die Servietten waren ausgegangen.
109a Deshalb verwendete Jacques Taschentücher für die Hände.
109b Danach verwendete Jacques Taschentücher für die Hände.
109c Vorhin verwendete Jacques Taschentücher für die Hände.
109d Gern verwendete Jacques Taschentücher für die Hände.

110 Der Architekt war gegen hohe Bäumen vorm Haus.
110a Deshalb wählte Martin Sträucher für den Vorgarten.
110b Danach wählte Martin Sträucher für den Vorgarten.
110c Vorhin wählte Martin Sträucher für den Vorgarten.
110d Gern wählte Martin Sträucher für den Vorgarten.

111 Die Kaninchen hatten das frische Gras aufgefressen.
111a Deshalb beschaffte Susanne Heu für die Tiere.
111b Hinterher beschaffte Susanne Heu für die Tiere.
111c Vorhin beschaffte Susanne Heu für die Tiere.
111d Gern beschaffte Susanne Heu für die Tiere.

112 Viele Freunde waren Vegetarier geworden.
112a Deshalb besorgte Jochen Gemüse für die Grillparty.
112b Hinterher besorgte Jochen Gemüse für die Grillparty.
112c Vorhin besorgte Jochen Gemüse für die Grillparty.
112d Gern besorgte Jochen Gemüse für die Grillparty.

113 Die Partykasse war voller als erwartet.
113a Deshalb besorgte Sören Champagner für die Feier.
113b Hinterher besorgte Sören Champagner für die Feier.
113c Vorhin besorgte Sören Champagner für die Feier.
113d Gern besorgte Sören Champagner für die Feier.

114 Es war ein langer Arbeitstag gewesen.
114a Deshalb bestellte Kathrin Pizza für den Fernsehabend.
114b Hinterher bestellte Kathrin Pizza für den Fernsehabend.
114c Vorhin bestellte Kathrin Pizza für den Fernsehabend.
114d Gern bestellte Kathrin Pizza für den Fernsehabend.

115 Die Untersuchung ergab, daß es eine Tochter werden würde.
115a Deshalb kaufte Maja Kleidchen in der Boutique.
115b Hinterher kaufte Maja Kleidchen in der Boutique.
115c Vorhin kaufte Maja Kleidchen in der Boutique.
115d Gern kaufte Maja Kleidchen in der Boutique.

116 Die alten Treter waren häßlich und unbequem.
116a Deshalb kaufte Oskar Schuhe in der Stadt.
116b Hinterher kaufte Oskar Schuhe in der Stadt.
116c Vorhin kaufte Oskar Schuhe in der Stadt.
116d Gern kaufte Oskar Schuhe in der Stadt.
117 Es waren mehr Gäste gekommen als erwartet.
117a Deshalb machte Florian Kaffee in der Küche.
117b Hinterher machte Florian Kaffee in der Küche.
117c Vorhin machte Florian Kaffee in der Küche.
117d Gern machte Florian Kaffee in der Küche.

118 Das Gulasch hatte für so viele nicht ausgereicht.
118a Deshalb machte Ivan Käsebrote für die Gäste.
118b Hinterher machte Ivan Käsebrote für die Gäste.
118c Vorhin machte Ivan Käsebrote für die Gäste.
118d Gern machte Ivan Käsebrote für die Gäste.

119 Ein Telegramm hatte die Gäste angekündigt.
119a Deshalb machte James Tee für die Gesellschaft.
119b Hinterher machte James Tee für die Gesellschaft.
119c Vorhin machte James Tee für die Gesellschaft.
119d Gern machte James Tee für die Gesellschaft.

120 Die Lampe war mit einem Knall durchgebrannt.
120a Deshalb suchte Matthias Glühbirnen auf dem Speicher.
120b Hinterher suchte Matthias Glühbirnen auf dem Speicher.
120c Vorhin suchte Matthias Glühbirnen auf dem Speicher.
120d Gern suchte Matthias Glühbirnen auf dem Speicher.

121 Die Aktenordner paßten nicht in den Rucksack.
121a Deshalb benutzte Cristoph Mappen für die Mitschriften.
121b Danach benutzte Cristoph Mappen für die Mitschriften.
121c Gestern benutzte Cristoph Mappen für die Mitschriften.
121d Lieber benutzte Cristoph Mappen für die Mitschriften.

122 Der Gips hatte an der Wand nicht gehalten.
122a Deshalb beschaffte Ernst Mörtel für die Ausbesserung.
122b Danach beschaffte Ernst Mörtel für die Ausbesserung.
122c Gestern beschaffte Ernst Mörtel für die Ausbesserung.
122d Lieber beschaffte Ernst Mörtel für die Ausbesserung.

123 Die wuchtigen Möbel paßten nicht in den schmalen Raum.
123a Deshalb besorgte Jonas Wandregale für das Bad.
123b Danach besorgte Jonas Wandregale für das Bad.
123c Gestern besorgte Jonas Wandregale für das Bad.
123d Lieber besorgte Jonas Wandregale für das Bad.

124 Das Fernsehprogramm versprach nichts Interessantes.
124a Deshalb bestellte Dörte Bücher über das Internet.

124b Danach bestellte Dörte Bücher über das Internet.
124c Gestern bestellte Dörte Bücher über das Internet.
124d Lieber bestellte Dörte Bücher über das Internet.

125 Die Amseln hatten die gesamte Saat aufgefressen.
125a Deshalb kaufte Christa Abdeckungen für die Beete.
125b Danach kaufte Christa Abdeckungen für die Beete.
125c Gestern kaufte Christa Abdeckungen für die Beete.
125d Lieber kaufte Christa Abdeckungen für die Beete.

126 Zuviel Koffein hatte zu Schlafstörungen geführt.
126a Deshalb machte Beate Kräutertee für den Abend.
126b Danach machte Beate Kräutertee für den Abend.
126c Gestern machte Beate Kräutertee für den Abend.
126d Lieber machte Beate Kräutertee für den Abend.

127 Die Sammeltassen waren in den Regalen völlig eingestaubt.
127a Deshalb organisierte Alex Vitrinen für das Wohnzimmer.
127b Danach organisierte Alex Vitrinen für das Wohnzimmer.
127c Gestern organisierte Alex Vitrinen für das Wohnzimmer.
127d Lieber organisierte Alex Vitrinen für das Wohnzimmer.

128 Die Flecken waren nicht aus dem Bezug zu entfernen.
128a Deshalb suchte Julia Ledersofas für das Wohnzimmer.
128b Danach suchte Julia Ledersofas für das Wohnzimmer.
128c Gestern suchte Julia Ledersofas für das Wohnzimmer.
128d Lieber suchte Julia Ledersofas für das Wohnzimmer.

129 Der Test fand Schadstoffe in Babyflaschen aus Plastik.
129a Deshalb verwendete Rene Glasflaschen für die Milch.
129b Danach verwendete Rene Glasflaschen für die Milch.
129c Gestern verwendete Rene Glasflaschen für die Milch.
129d Lieber verwendete Rene Glasflaschen für die Milch.

130 Die Strafe für betrunkenes Fahren war erhöht worden.
130a Deshalb wählte Immo Sprudel in der Kneipe.
130b Danach wählte Immo Sprudel in der Kneipe.
130c Gestern wählte Immo Sprudel in der Kneipe.
130d Lieber wählte Immo Sprudel in der Kneipe.

131 Die Motten hatten die Mehltüten angefressen.
131a Deshalb benutzte Anke Dosen für die Aufbewahrung.
131b Hinterher benutzte Anke Dosen für die Aufbewahrung.
131c Gestern benutzte Anke Dosen für die Aufbewahrung.
131d Lieber benutzte Anke Dosen für die Aufbewahrung.

132 Das Gerede im Hintergrund hatte sehr abgelenkt.
132a Deshalb benutzte Arthur Ohrstöpsel in der Bibliothek.
132b Hinterher benutzte Arthur Ohrstöpsel in der Bibliothek.
132c Gestern benutzte Arthur Ohrstöpsel in der Bibliothek.
132d Lieber benutzte Arthur Ohrstöpsel in der Bibliothek.

133 Die Vögel hatten fast alle Kirschen angefressen.
133a Deshalb beschaffte Adriana Netze für die Obstbäume.
133b Hinterher beschaffte Adriana Netze für die Obstbäume.
133c Gestern beschaffte Adriana Netze für die Obstbäume.
133d Lieber beschaffte Adriana Netze für die Obstbäume.

134 Die spitzen Absätze hatten das Parkett zerkratzt.
134a Deshalb bestellte Amelie Filzschuhe für die Wohnung.
134b Hinterher bestellte Amelie Filzschuhe für die Wohnung.
134c Gestern bestellte Amelie Filzschuhe für die Wohnung.
134d Lieber bestellte Amelie Filzschuhe für die Wohnung.

135 Das Leinen war kratziger als erwartet.
135a Deshalb bestellte Christa Seidenstoff für die Bettwäsche.
135b Hinterher bestellte Christa Seidenstoff für die Bettwäsche.
135c Gestern bestellte Christa Seidenstoff für die Bettwäsche.
135d Lieber bestellte Christa Seidenstoff für die Bettwäsche.

136 Die Beziehung war dem Ende nahe.
136a Deshalb suchte Barbara Wohnungen in der Stadt.
136b Hinterher suchte Barbara Wohnungen in der Stadt.
136c Gestern suchte Barbara Wohnungen in der Stadt.
136d Lieber suchte Barbara Wohnungen in der Stadt.

137 Winterjacken waren komplett ausverkauft.
137a Deshalb suchte Frank Mäntel in der Herrenabteilung.
137b Hinterher suchte Frank Mäntel in der Herrenabteilung.
137c Gestern suchte Frank Mäntel in der Herrenabteilung.
137d Lieber suchte Frank Mäntel in der Herrenabteilung.

138 Der Mörtel hatte sich als zu grobkörnig erwiesen.
138a Deshalb verwendete Ben Gips für das Projekt.
138b Hinterher verwendete Ben Gips für das Projekt.
138c Gestern verwendete Ben Gips für das Projekt.
138d Lieber verwendete Ben Gips für das Projekt.

139 Die Lichterketten waren zwar sicher, aber häßlich.
139a Deshalb verwendete Ludwig Wachskerzen für die Dekoration.
139b Hinterher verwendete Ludwig Wachskerzen für die Dekoration.
139c Gestern verwendete Ludwig Wachskerzen für die Dekoration.
139d Lieber verwendete Ludwig Wachskerzen für die Dekoration.

140 Die alten Stoffmöbel waren sehr fleckig.
140a Deshalb wählte Georg Ledersessel für die Sitzecken.
140b Hinterher wählte Georg Ledersessel für die Sitzecken.
140c Gestern wählte Georg Ledersessel für die Sitzecken.
140d Lieber wählte Georg Ledersessel für die Sitzecken.

141 Der Pinsel hinterließ Streifen im Lack.
141a Deshalb benutzte Charlotte Sprühfarben für den Anstrich.
141b Danach benutzte Charlotte Sprühfarben für den Anstrich.
141c Vorhin benutzte Charlotte Sprühfarben für den Anstrich.
141d Lieber benutzte Charlotte Sprühfarben für den Anstrich.

142 Im Zettelchaos war das Zeugnis verschwunden.
142a Deshalb benutzte Cornelia Ordner für die Mitschriften.
142b Danach benutzte Cornelia Ordner für die Mitschriften.
142c Vorhin benutzte Cornelia Ordner für die Mitschriften.
142d Lieber benutzte Cornelia Ordner für die Mitschriften.

143 Die Bretter hatten den Tunnel nicht stabilisiert.
143a Deshalb beschaffte Jens Balken für die Baustelle.
143b Danach beschaffte Jens Balken für die Baustelle.
143c Vorhin beschaffte Jens Balken für die Baustelle.
143d Lieber beschaffte Jens Balken für die Baustelle.

144 Der Teig hatten etwas fad geschmeckt.
144a Deshalb besorgte Jutta Zimt für das Gebäck.
144b Danach besorgte Jutta Zimt für das Gebäck.
144c Vorhin besorgte Jutta Zimt für das Gebäck.
144d Lieber besorgte Jutta Zimt für das Gebäck.

145 Es zeigte sich, daß der Schaden kompliziert war.

145a Deshalb bestellte Holger Handwerker für die Reparatur.
145b Danach bestellte Holger Handwerker für die Reparatur.
145c Vorhin bestellte Holger Handwerker für die Reparatur.
145d Lieber bestellte Holger Handwerker für die Reparatur.

146 Die Kartoffeln hatten schlecht ausgesehen.
146a Deshalb kaufte Ina Reis für das Essen.
146b Danach kaufte Ina Reis für das Essen.
146c Vorhin kaufte Ina Reis für das Essen.
146d Lieber kaufte Ina Reis für das Essen.

147 Der Pudding war angebrannt.
147a Deshalb organisierte Ingo Obst für den Nachtisch.
147b Danach organisierte Ingo Obst für den Nachtisch.
147c Vorhin organisierte Ingo Obst für den Nachtisch.
147d Lieber organisierte Ingo Obst für den Nachtisch.

148 Der Kontoauszug war nicht sehr erfreulich.
148a Deshalb suchte Christian Sommerjobs in der Zeitung.
148b Danach suchte Christian Sommerjobs in der Zeitung.
148c Vorhin suchte Christian Sommerjobs in der Zeitung.
148d Lieber suchte Christian Sommerjobs in der Zeitung.

149 Bei unvorsichtigen Ausgrabungen war viel zerstört worden.
149a Deshalb verwendete Karl Pinsel für die Arbeit.
149b Danach verwendete Karl Pinsel für die Arbeit.
149c Vorhin verwendete Karl Pinsel für die Arbeit.
149d Lieber verwendete Karl Pinsel für die Arbeit.

150 Der Farn war über den Urlaub ausgetrocknet.
150a Deshalb wählte Ines Kakteen für das Büro.
150b Danach wählte Ines Kakteen für das Büro.
150c Vorhin wählte Ines Kakteen für das Büro.
150d Lieber wählte Ines Kakteen für das Büro.

151 Beim Radfahren waren die Hände fast angefroren.
151a Deshalb benutzte Anja Handschuhe auf dem Fahrrad.
151b Hinterher benutzte Anja Handschuhe auf dem Fahrrad.
151c Vorhin benutzte Anja Handschuhe auf dem Fahrrad.
151d Lieber benutzte Anja Handschuhe auf dem Fahrrad.

152 Die Kreidefarben waren auf dem Entwurf viel zu blaß.
152a Deshalb benutzte Ariane Filzstifte für das Poster.
152b Hinterher benutzte Ariane Filzstifte für das Poster.
152c Vorhin benutzte Ariane Filzstifte für das Poster.
152d Lieber benutzte Ariane Filzstifte für das Poster.

153 Die starke Sonne hatte zu Verbrennungen geführt.
153a Deshalb besorgte Alexander Sonnencreme für die Kinder.
153b Hinterher besorgte Alexander Sonnencreme für die Kinder.
153c Vorhin besorgte Alexander Sonnencreme für die Kinder.
153d Lieber besorgte Alexander Sonnencreme für die Kinder.

154 Der Vermieter warnte vor Stromausfällen.
154a Deshalb besorgte Alfred Kerzen für den Notfall.
154b Hinterher besorgte Alfred Kerzen für den Notfall.
154c Vorhin besorgte Alfred Kerzen für den Notfall.
154d Lieber besorgte Alfred Kerzen für den Notfall.

155 Das Obst hatte sich als faulig herausgestellt.
155a Deshalb machte Franzi Pudding für den Nachtisch.
155b Hinterher machte Franzi Pudding für den Nachtisch.
155c Vorhin machte Franzi Pudding für den Nachtisch.
155d Lieber machte Franzi Pudding für den Nachtisch.

156 In Schweden war vor Mückenplagen gewarnt worden.
156a Deshalb organisierte Anton Insektenspray für die Reise.
156b Hinterher organisierte Anton Insektenspray für die Reise.
156c Vorhin organisierte Anton Insektenspray für die Reise.
156d Lieber organisierte Anton Insektenspray für die Reise.

157 Die Igel bekamen von Milchprodukten schlimmen Durchfall.
157a Deshalb verwendete Brigitte Hackfleisch bei der Fütterung.
157b Hinterher verwendete Brigitte Hackfleisch bei der Fütterung.
157c Vorhin verwendete Brigitte Hackfleisch bei der Fütterung.
157d Lieber verwendete Brigitte Hackfleisch bei der Fütterung.

158 Bei der großen Party war viel Geschirr zerbrochen.
158a Deshalb verwendete Johanna Pappteller für das Essen.
158b Hinterher verwendete Johanna Pappteller für das Essen.
158c Vorhin verwendete Johanna Pappteller für das Essen.
158d Lieber verwendete Johanna Pappteller für das Essen.

159 Die Pullover waren viel zu warm gewesen.
159a Deshalb wählte Andrea Blusen für die Reise.
159b Hinterher wählte Andrea Blusen für die Reise.
159c Vorhin wählte Andrea Blusen für die Reise.
159d Lieber wählte Andrea Blusen für die Reise.

160 Der Kochschinken hatte nicht sehr lecker ausgesehen.
160a Deshalb wählte Dorothee Salami auf dem Markt.
160b Hinterher wählte Dorothee Salami auf dem Markt.
160c Vorhin wählte Dorothee Salami auf dem Markt.
160d Lieber wählte Dorothee Salami auf dem Markt.

APPENDIX D

Stimulus Materials Experiment 4

Context
#a Causal coherent
#b Concessive coherent
#c Causal incoherent
#d Concessive incoherent

1 Luftdichte Verpackung schützt vor Motten im Mehl.
1a Deshalb benutzte Anke Blechdosen für die Aufbewahrung.
1b Trotzdem benutzte Anke Stoffbeutel für die Aufbewahrung.
1c Deshalb benutzte Anke Stoffbeutel für die Aufbewahrung.
1d Trotzdem benutzte Anke Blechdosen für die Aufbewahrung.

2 Brot schimmelt schnell in geschlossenen Behältern.
2a Darum benutzte Annika Papiertüten für die Aufbewahrung.
2b Trotzdem benutzte Annika Plastikdosen für die Aufbewahrung.
2c Darum benutzte Annika Plastikdosen für die Aufbewahrung.
2d Trotzdem benutzte Annika Papiertüten für die Aufbewahrung.

3 Die Bauzeichnung musste leicht zu verändern sein.
3a Deshalb benutzte Ariane Bleistifte für die Arbeit.
3b Dennoch benutzte Ariane Filzstifte für die Arbeit.
3c Deshalb benutzte Ariane Filzstifte für die Arbeit.
3d Dennoch benutzte Ariane Bleistifte für die Arbeit.

4 Igel bekommen von Milchprodukten schlimmen Durchfall.
4a Darum benutzte Brigitte Fleisch bei der Fütterung.
4b Dennoch benutzte Brigitte Käse bei der Fütterung.
4c Darum benutzte Brigitte Käse bei der Fütterung.
4d Dennoch benutzte Brigitte Fleisch bei der Fütterung.

5 Das Gästezimmer sollte luxuriös wer den.
5a Deshalb benutzte Christa Seidenstoff für die Bettwäsche.
5b Trotzdem benutzte Christa Nylonstoff für die Bettwäsche.
5c Deshalb benutzte Christa Nylonstoff für die Bettwäsche.
5d Trotzdem benutzte Christa Seidenstoff für die Bettwäsche.

6 Im Zettelchaos findet man selten den Richtigen.
6a Darum benutzte Cornelia Ordner für die Mitschriften.
6b Trotzdem benutzte Cornelia Kisten für die Mitschriften.
6c Darum benutzte Cornelia Kisten für die Mitschriften.
6d Trotzdem benutzte Cornelia Ordner für die Mitschriften.

7 Pappe weicht im Regen schnell auf.
7a Deshalb benutzte Eileen Plastiksäcke für den Transport.
7b Dennoch benutzte Eileen Pappkartons für den Transport.
7c Deshalb benutzte Eileen Pappkartons für den Transport.
7d Dennoch benutzte Eileen Plastiksäcke für den Transport.

8 Plastik ist nicht gut für die Umwelt.
8a Darum benutzte Hanna Stofftüten für den Einkauf.
8b Dennoch benutzte Hanna Plastiktüten für den Einkauf.
8c Darum benutzte Hanna Plastiktüten für den Einkauf.
8d Dennoch benutzte Hanna Stofftüten für den Einkauf.

9 Rucksäcke sind nicht gerade stoßsicher.
9a Deshalb benutzte Andreas Plastikflaschen für die Getränke.
9b Trotzdem benutzte Andreas Glasflaschen für die Getränke.
9c Deshalb benutzte Andreas Glasflaschen für die Getränke.
9d Trotzdem benutzte Andreas Plastikflaschen für die Getränke.

10 Auf nackte Ziegel kann man nicht tapezieren.
10a Darum benutzte Herrmann Leimfarbe für die Wände.
10b Trotzdem benutzte Herrmann Rauhfaser für die Wände.
10c Darum benutzte Herrmann Rauhfaser für die Wände.
10d Trotzdem benutzte Herrmann Leimfarbe für die Wände.

11 Teures Geschirr eignet sich nicht für Picknicks.
11a Deshalb benutzte Ingo Blechtassen für die Getränke.
11b Dennoch benutzte Ingo Porzellantassen für die Getränke.
11c Deshalb benutzte Ingo Porzellantassen für die Getränke.
11d Dennoch benutzte Ingo Blechtassen für die Getränke.

12 Das Transparent sollte in satten Farben strahlen.
12a Darum benutzte Jakob Filzstifte für die Arbeit.
12b Dennoch benutzte Jakob Bleistifte für die Arbeit.
12c Darum benutzte Jakob Bleistifte für die Arbeit.
12d Dennoch benutzte Jakob Filzstifte für die Arbeit.

13 Freitags gibt es besonders viele Staus.
13a Deshalb benutzte Markus Landstraßen auf der Heimreise.
13b Trotzdem benutzte Markus Autobahnen auf der Heimreise.
13c Deshalb benutzte Markus Autobahnen auf der Heimreise.
13d Trotzdem benutzte Markus Landstraßen auf der Heimreise.

14 Der Waldweg war sehrmatschig.
14a Darum benutzte Olaf Stiefel bei der Wanderung.
14b Trotzdem benutzte Olaf Sandalen bei der Wanderung.
14c Darum benutzte Olaf Sandalen bei der Wanderung.
14d Trotzdem benutzte Olaf Stiefel bei der Wanderung.

15 Kristallzucker ist ungesund.
15a Deshalb benutzte Oskar Honig für den Tee.
15b Dennoch benutzte Oskar Zucker für den Tee.
15c Deshalb benutzte Oskar Zucker für den Tee.
15d Dennoch benutzte Oskar Honig für den Tee.

16 Es sollte weihnachtlich schmecken.
16a Darum benutzte Volker Kardamom für den Kuchen.
16b Dennoch benutzte Volker Erdbeeren für den Kuchen.
16c Darum benutzte Volker Erdbeeren für den Kuchen.
16d Dennoch benutzte Volker Kardamom für den Kuchen.

17 Das Parkett war extrem empfindlich.
17a Deshalb beschaffte Amelie Filzschuhe für die Wohnung.
17b Trotzdem beschaffte Amelie Holzschuhe für die Wohnung.
17c Deshalb beschaffte Amelie Holzschuhe für die Wohnung.
17d Trotzdem beschaffte Amelie Filzschuhe für die Wohnung.

18 Stoffbezüge sind schwer zusäubern.
18a Darum beschaffte Julia Ledersofas für das Wohnzimmer.

18b Trotzdem beschaffte Julia Cordsofas für das Wohnzimmer.
18c Darum beschaffte Julia Cordsofas für das Wohnzimmer.
18d Trotzdem beschaffte Julia Ledersofas für das Wohnzimmer.

19 Nicht jede Pflanze kann draußen überwintern.
19a Deshalb beschaffte Kathleen Rosen für den Vorgarten.
19b Dennoch beschaffte Kathleen Kakteen für den Vorgarten.
19c Deshalb beschaffte Kathleen Kakteen für den Vorgarten.
19d Dennoch beschaffte Kathleen Rosen für den Vorgarten.

20 Die Verwaltung hatte den Angestellten das Spritgeld gestrichen.
20a Darum beschaffte Maria Fahrräder für die Kollegen.
20b Dennoch beschaffte Maria Mietwagen für die Kollegen.
20c Darum beschaffte Maria Mietwagen für die Kollegen.
20d Dennoch beschaffte Maria Fahrräder für die Kollegen.

21 Wandfarbe weicht Papier schnell auf.
21a Deshalb beschaffte Saskia Plastik für die Abdeckung.
21b Trotzdem beschaffte Saskia Zeitung für die Abdeckung.
21c Deshalb beschaffte Saskia Zeitung für die Abdeckung.
21d Trotzdem beschaffte Saskia Plastik für die Abdeckung.

22 Meerschweinchen müssen viel Frisches fressen.
22a Darum beschaffte Sina Löwenzahn für die Tiere.
22b Trotzdem beschaffte Sina Trockenfutter für die Tiere.
22c Darum beschaffte Sina Trockenfutter für die Tiere.
22d Trotzdem beschaffte Sina Löwenzahn für die Tiere.

23 Die Parkverwaltung hatte die unbefestigten Pfade kritisiert.
23a Deshalb beschaffte Sophia Steinplatten für die Wege.
23b Dennoch beschaffte Sophia Kies für die Wege.
23c Deshalb beschaffte Sophia Kies für die Wege.
23d Dennoch beschaffte Sophia Steinplatten für die Wege.

24 Kaninchen sollten nicht zuviel Grünfutter fressen.
24a Darum beschaffte Susanne Heu für die Tiere.
24b Dennoch beschaffte Susanne Gras für die Tiere.
24c Darum beschaffte Susanne Gras für die Tiere.
24d Dennoch beschaffte Susanne Heu für die Tiere.

25 Affen bewerfen die Zoobesucher gerne mit Dreck.
25a Deshalb beschaffte Carlo Glasscheiben für die Käfige.
25b Trotzdem beschaffte Carlo Gitter für die Käfige.
25c Deshalb beschaffte Carlo Gitter für die Käfige.
25d Trotzdem beschaffte Carlo Glasscheiben für die Käfige.

26 Es war nicht viel Geld für Getränke übrig.
26a Darum beschaffte Günther Limonade für die Party.
26b Trotzdem beschaffte Günther Champagner für die Party.
26c Darum beschaffte Günther Champagner für die Party.
26d Trotzdem beschaffte Günther Limonade für die Party.

27 Bei Kleinkindern landet das meiste Essen auf dem Boden.
27a Deshalb beschaffte Jan Zeitung für den Eßplatz.
27b Dennoch beschaffte Jan Teppich für den Eßplatz.
27c Deshalb beschaffte Jan Teppich für den Eßplatz.
27d Dennoch beschaffte Jan Zeitung für den Eßplatz.

28 Hochbetten müssen sicher befestigt sein.
28a Darum beschaffte Leon Dübel für die Aufhängung.
28b Dennoch beschaffte Leon Nägel für die Aufhängung.
28c Darum beschaffte Leon Nägel für die Aufhängung.
28d Dennoch beschaffte Leon Dübel für die Aufhängung.

29 Die Kleinen waren auf dem glatten Boden ausgerutscht.
29a Deshalb beschaffte Richard Teppich für den Kinderladen.
29b Trotzdem beschaffte Richard Parkett für den Kinderladen.
29c Deshalb beschaffte Richard Parkett für den Kinderladen.
29d Trotzdem beschaffte Richard Teppich für den Kinderladen.

30 Das Zimmer war zu dunkel.
30a Darum beschaffte Thomas Lampen in der Kaufhalle.
30b Trotzdem beschaffte Thomas Jalousien in der Kaufhalle.
30c Darum beschaffte Thomas Jalousien in der Kaufhalle.
30d Trotzdem beschaffte Thomas Lampen in der Kaufhalle.

31 Pfand wird auf Jahrmärkten selten zurückgebracht.
31a Deshalb beschaffte Tom Plastikbecher für die Getränke.
31b Dennoch beschaffte Tom Gläser für die Getränke.
31c Deshalb beschaffte Tom Gläser für die Getränke.
31d Dennoch beschaffte Tom Plastikbecher für die Getränke.

32 Es sollte ein feudales Mahl werden.
32a Darum beschaffte Wolfgang Hummer für den Hauptgang.
32b Dennoch beschaffte Wolfgang Bratwurst für den Hauptgang.
32c Darum beschaffte Wolfgang Bratwurst für den Hauptgang.
32d Dennoch beschaffte Wolfgang Hummer für den Hauptgang.

33 Das Essensgeld war für so viele Leute recht knapp geworden.
33a Deshalb besorgte Irma Linsen für die Suppe.
33b Trotzdem besorgte Irma Garnelen für die Suppe.
33c Deshalb besorgte Irma Garnelen für die Suppe.
33d Trotzdem besorgte Irma Linsen für die Suppe.

34 Bei großen Partys geht schnell etwas zu Bruch.
34a Darum besorgte Johanna Pappteller für das Essen.
34b Trotzdem besorgte Johanna Porzellan für das Essen.
34c Darum besorgte Johanna Porzellan für das Essen.
34d Trotzdem besorgte Johanna Pappteller für das Essen.

35 Der Vermieter forderte Blühpflanzen für den Balkon.
35a Deshalb besorgte Mareike Geranien auf dem Markt.
35b Dennoch besorgte Mareike Efeu auf dem Markt.
35c Deshalb besorgte Mareike Efeu auf dem Markt.
35d Dennoch besorgte Mareike Geranien auf dem Markt.

36 Katzen kratzen mit Vorliebe an Polstermöbeln.
36a Darum besorgte Miriam Rattansessel für das Wohnzimmer.
36b Dennoch besorgte Miriam Cordsessel für das Wohnzimmer.
36c Darum besorgte Miriam Cordsessel für das Wohnzimmer.
36d Dennoch besorgte Miriam Rattansessel für das Wohnzimmer.

37 Offenes Feuer in Zelten ist gefährlich.
37a Deshalb besorgte Renate Taschenlampen für die Pfadfinder.
37b Trotzdem besorgte Renate Öllampen für die Pfadfinder.
37c Deshalb besorgte Renate Öllampen für die Pfadfinder.
37d Trotzdem besorgte Renate Taschenlampen für die Pfadfinder.

38 Nachtaktive Haustiere sind für Kinder ungeeignet.
38a Darum besorgte Sandra Papageien für die Familie.
38b Trotzdem besorgte Sandra Eulen für die Familie.

38c Darum besorgte Sandra Eulen für die Familie.
38d Trotzdem besorgte Sandra Papageien für die Familie.

39 Tierhaarallergien können sehr belastend sein.
39a Deshalb besorgte Tanja Goldfische für die Wohnung.
39b Dennoch besorgte Tanja Katzen für die Wohnung.
39c Deshalb besorgte Tanja Katzen für die Wohnung.
39d Dennoch besorgte Tanja Goldfische für die Wohnung.

40 Babys haben sehr empfindliche Haut.
40a Darum besorgte Veronika Mandelöl für das Bad.
40b Dennoch besorgte Veronika Kernseife für das Bad.
40c Darum besorgte Veronika Kernseife für das Bad.
40d Dennoch besorgte Veronika Mandelöl für das Bad.

41 Kleine Hundewelpen sind noch nicht stubenrein.
41a Deshalb besorgte Christoph Zeitungen für die Schlafecke.
41b Trotzdem besorgte Christoph Decken für die Schlafecke.
41c Deshalb besorgte Christoph Decken für die Schlafecke.
41d Trotzdem besorgte Christoph Zeitungen für die Schlafecke.

42 Die Sonne schien direkt auf den Monitor.
42a Darum besorgte Gerhard Gardinen für das Büro.
42b Trotzdem besorgte Gerhard Lampen für das Büro.
42c Darum besorgte Gerhard Lampen für das Büro.
42d Trotzdem besorgte Gerhard Gardinen für das Büro.

43 Im Gebirge sind vereiste Straßen besonders gefährlich.
43a Deshalb besorgte Helge Winterreifen für das Auto.
43b Dennoch besorgte Helge Sommerreifen für das Auto.
43c Deshalb besorgte Helge Sommerreifen für das Auto.
43d Dennoch besorgte Helge Winterreifen für das Auto.

44 Die Nachbarn beschwerten sich über jeden Lärm.
44a Darum besorgte Henry Teppich für das Spielzimmer.
44b Dennoch besorgte Henry Trommeln für das Spielzimmer.
44c Darum besorgte Henry Trommeln für das Spielzimmer.
44d Dennoch besorgte Henry Teppich für das Spielzimmer.

45 Immer mehr Menschen essen vegetarisch.
45a Deshalb besorgte Jochen Gemüse für die Grillparty.
45b Trotzdem besorgte Jochen Schnitzel für die Grillparty.
45c Deshalb besorgte Jochen Schnitzel für die Grillparty.
45d Trotzdem besorgte Jochen Gemüse für die Grillparty.

46 Wenige Pflanzen gedeihen in dunklen Räumen.
46a Darum besorgte Justus Efeu für den Flur.
46b Trotzdem besorgte Justus Lavendel für den Flur.
46c Darum besorgte Justus Lavendel für den Flur.
46d Trotzdem besorgte Justus Efeu für den Flur.

47 Die Partykasse war voller als erwartet.
47a Deshalb besorgte Sören Champagner für die Feier.
47b Dennoch besorgte Sören Dosenbier für die Feier.
47c Deshalb besorgte Sören Dosenbier für die Feier.
47d Dennoch besorgte Sören Champagner für die Feier.

48 Geklaute Geldscheine sind endgültig weg.
48a Darum besorgte Tim Reiseschecks für den Urlaub.
48b Dennoch besorgte Tim Bargeld für den Urlaub.
48c Darum besorgte Tim Bargeld für den Urlaub.
48d Dennoch besorgte Tim Reiseschecks für den Urlaub.

49 Zuviel Fernsehen macht dumm.
49a Deshalb bestellte Dörte Bücher für das Wochenende.
49b Trotzdem bestellte Dörte Videos für das Wochenende.
49c Deshalb bestellte Dörte Videos für das Wochenende.
49d Trotzdem bestellte Dörte Bücher für das Wochenende.

50 Kohle ist zum Heizen am Besten geeignet.
50a Darum bestellte Greta Briketts für den Ofen.
50b Trotzdem bestellte Greta Holz für den Ofen.
50c Darum bestellte Greta Holz für den Ofen.
50d Trotzdem bestellte Bernd Briketts für den Ofen.

51 Die Allergie gegen Getreide war schlimmer geworden.
51a Deshalb bestellte Katharina Kartoffeln bei der Kellnerin.
51b Dennoch bestellte Katharina Brot bei der Kellnerin.
51c Deshalb bestellte Katharina Brot bei der Kellnerin.
51d Dennoch bestellte Katharina Kartoffeln bei der Kellnerin.

52 Kohle eignet sich nicht für offene Feuerstellen.
52a Darum bestellte Kerstin Holz für den Kamin.
52b Dennoch bestellte Kerstin Briketts für den Kamin.
52c Darum bestellte Kerstin Briketts für den Kamin.
52d Dennoch bestellte Kerstin Holz für den Kamin.

53 Offenstehende Gegenstände stauben schnell ein.
53a Deshalb bestellte Lina Vitrinen für das Wohnzimmer.
53b Trotzdem bestellte Lina Regale für das Wohnzimmer.
53c Deshalb bestellte Lina Regale für das Wohnzimmer.
53d Trotzdem bestellte Lina Vitrinen für das Wohnzimmer.

54 Die Kellnerin hatte die Pasta empfohlen.
54a Darum bestellte Maren Spaghetti für den Hauptgang.
54b Trotzdem bestellte Maren Pizza für den Hauptgang.
54c Darum bestellte Maren Pizza für den Hauptgang.
54d Trotzdem bestellte Maren Spaghetti für den Hauptgang.

55 Starke Medikamente darf man nicht eigenmächtig nehmen.
55a Deshalb bestellte Thea Vitamine gegen den Schnupfen.
55b Dennoch bestellte Thea Codein gegen den Schnupfen.
55c Deshalb bestellte Thea Codein gegen den Schnupfen.
55d Dennoch bestellte Thea Vitamine gegen den Schnupfen.

56 Kinder bekommen von gruseligen Filmen schnell Albträume.
56a Darum bestellte Verena Trickfilme für den Geburtstag.
56b Dennoch bestellte Verena Horrorfilme für den Geburtstag.
56c Darum bestellte Verena Horrorfilme für den Geburtstag.
56d Dennoch bestellte Verena Trickfilme für den Geburtstag.

57 Handwerker sind meist zu teuer für Studenten.
57a Deshalb bestellte Franz Freunde für die Renovierung.
57b Trotzdem bestellte Franz Maler für die Renovierung.
57c Deshalb bestellte Franz Maler für die Renovierung.
57d Trotzdem bestellte Franz Freunde für die Renovierung.

58 Viele Menschen mögen kein rohes Fleisch.
58a Darum bestellte Georg Buletten für das Buffet.
58b Trotzdem bestellte Georg Tatar für das Buffet.
58c Darum bestellte Georg Tatar für das Buffet.
58d Trotzdem bestellte Georg Buletten für das Buffet.

59 Mit einem Gipsbein kommt man schlecht aus dem Haus.
59a Deshalb bestellte Hans Brettspiele für das Wochenende.
59b Dennoch bestellte Hans Kinokarten für das Wochenende.
59c Deshalb bestellte Hans Kinokarten für das Wochenende.
59d Dennoch bestellte Hans Brettspiele für das Wochenende.

60 Es musste ein riesiges Loch für das Fundament gegraben wer den.
60a Darum bestellte Karl Bagger für die Arbeit.
60b Dennoch bestellte Karl Schaufeln für die Arbeit.
60c Darum bestellte Karl Schaufeln für die Arbeit.
60d Dennoch bestellte Karl Bagger für die Arbeit.

61 Heizungen sollten von Fachleuten repariert wer den.
61a Deshalb bestellte Paul Klempner für die Reparatur.
61b Trotzdem bestellte Paul Freunde für die Reparatur.
61c Deshalb bestellte Paul Freunde für die Reparatur.
61d Trotzdem bestellte Paul Klempner für die Reparatur.

62 Die Kinder lasen ungern Comics.
62a Darum bestellte Ruben Krimis für die Ferien.
62b Trotzdem bestellte Ruben Mangas für die Ferien.
62c Darum bestellte Ruben Mangas für die Ferien.
62d Trotzdem bestellte Ruben Krimis für die Ferien.

63 Bei Ausgrabungen muss man sehrbehutsam sein.
63a Deshalb bestellte Sascha Bürsten für die Arbeit.
63b Dennoch bestellte Sascha Schaufeln für die Arbeit.
63c Deshalb bestellte Sascha Schaufeln für die Arbeit.
63d Dennoch bestellte Sascha Bürsten für die Arbeit.
64 Wände im Bad sollten Feuchtigkeit aushalten.
64a Darum bestellte Ulrich Fliesen für die Sanierung.
64b Dennoch bestellte Ulrich Tapeten für die Sanierung.
64c Darum bestellte Ulrich Tapeten für die Sanierung.
64d Dennoch bestellte Ulrich Fliesen für die Sanierung.

65 Viele Schwangere wünschen sich einen Sohn.
65a Deshalb kaufte Maja Höschen in der Boutique.
65b Trotzdem kaufte Maja Kleidchen in der Boutique.
65c Deshalb kaufte Maja Kleidchen in der Boutique.
65d Trotzdem kaufte Maja Höschen in der Boutique.

66 In der Einladung wurde um formelle Kleidung gebeten.
66a Darum kaufte Sonja Lackschuhe in der Stadt.
66b Trotzdem kaufte Sonja Turnschuhe in der Stadt.
66c Darum kaufte Sonja Turnschuhe in der Stadt.
66d Trotzdem kaufte Sonja Lackschuhe in der Stadt.

67 Der kleine Neffe konnte noch nicht lesen.
67a Deshalb kaufte Dina Videos für das Wochenende.
67b Dennoch kaufte Dina Bücher für das Wochenende.
67c Deshalb kaufte Dina Bücher für das Wochenende.
67d Dennoch kaufte Dina Videos für das Wochenende.

68 Rauchen ist im Flugzeug verboten.
68a Darum kaufte Ellen Kaugummi für den Flug.
68b Dennoch kaufte Ellen Zigaretten für den Flug.
68c Darum kaufte Ellen Zigaretten für den Flug.
68d Dennoch kaufte Ellen Kaugummi für den Flug.

69 Dänische Sommer können empfindlich kühl sein.
69a Deshalb kaufte Esther Radiatoren für das Ferienhaus.
69b Trotzdem kaufte Esther Ventilatoren für das Ferienhaus.
69c Deshalb kaufte Esther Ventilatoren für das Ferienhaus.
69d Trotzdem kaufte Esther Radiatoren für das Ferienhaus.

70 Es war über Nacht sehr kalt geworden.
70a Darum kaufte Eva Handschuhe in der Kaufhalle.
70b Trotzdem kaufte Eva Sonnenmilch in der Kaufhalle.
70c Darum kaufte Eva Sonnenmilch in der Kaufhalle.
70d Trotzdem kaufte Eva Handschuhe in der Kaufhalle.

71 Zitrusfrüchte sind im Winter am Besten.
71a Deshalb kaufte Franzi Orangen für den Nachtisch.
71b Dennoch kaufte Franzi Erdbeeren für den Nachtisch.
71c Deshalb kaufte Franzi Erdbeeren für den Nachtisch.
71d Dennoch kaufte Franzi Orangen für den Nachtisch.

72 Büropflanzen müssen mit wenig Pflege auskommen.
72a Darum kaufte Ines Kakteen für das Büro.
72b Dennoch kaufte Ines Orchideen für das Büro.
72c Darum kaufte Ines Orchideen für das Büro.
72d Dennoch kaufte Ines Kakteen für das Büro.

73 In der Stadt sind nur Kleintiere erlaubt.
73a Deshalb kaufte Niklas Kaninchen für den Hinterhof.
73b Trotzdem kaufte Niklas Schafe für den Hinterhof.
73c Deshalb kaufte Niklas Schafe für den Hinterhof.
73d Trotzdem kaufte Niklas Kaninchen für den Hinterhof.

74 Vitamin C schützt vor Erkältungen.
74a Darum kaufte Werner Orangen für den Nachtisch.
74b Trotzdem kaufte Werner Pudding für den Nachtisch.
74c Darum kaufte Werner Pudding für den Nachtisch.
74d Trotzdem kaufte Werner Orangen für den Nachtisch.

75 Zum Lernen sollte man sich einen ruhigen Ort schaffen.
75a Deshalb kaufte Arthur Ohrstöpsel für die Bibliothek.
75b Dennoch kaufte Arthur Hörspiele für die Bibliothek.
75c Deshalb kaufte Arthur Hörspiele für die Bibliothek.
75d Dennoch kaufte Arthur Ohrstöpsel für die Bibliothek.

76 Süßigkeiten sind schlecht für die Zähne.
76a Darum kaufte Dirk Kirschen für die Pause.
76b Dennoch kaufte Dirk Schokolade für die Pause.
76c Darum kaufte Dirk Schokolade für die Pause.
76d Dennoch kaufte Dirk Kirschen für die Pause.

77 Die Tiefkühltruhe funktioniert nicht.
77a Deshalb kaufte Hannes Obst für den Nachtisch.
77b Trotzdem kaufte Hannes Eiskrem für den Nachtisch.
77c Deshalb kaufte Hannes Eiskrem für den Nachtisch.
77d Trotzdem kaufte Hannes Obst für den Nachtisch.

78 Wuchtige Möbel wirken bedrohlich in schmalen Räumen.
78a Darum kaufte Jonas Regale für den Flur.
78b Trotzdem kaufte Jonas Schränke für den Flur.
78c Darum kaufte Jonas Schränke für den Flur.
78d Trotzdem kaufte Jonas Regale für den Flur.

79 Rohes Fleisch ist nicht jedermanns Sache.
79a Deshalb kaufte Jürgen Kochschinken für das Buffet.
79b Dennoch kaufte Jürgen Hackepeter für das Buffet.
79c Deshalb kaufte Jürgen Hackepeter für das Buffet.
79d Dennoch kaufte Jürgen Kochschinken für das Buffet.

80 Es sollte eine schöne Bibliothek wer den.
80a Darum kaufte Kilian Regale für die Bücher.
80b Dennoch kaufte Kilian Kisten für die Bücher.
80c Darum kaufte Kilian Kisten für die Bücher.
80d Dennoch kaufte Kilian Regale für die Bücher.

81 Japanisches Essen wird immer beliebter.
81a Deshalb machte Anne Sushi für das Buffet.
81b Trotzdem machte Anne Antipasti für das Buffet.
81c Deshalb machte Anne Antipasti für das Buffet.

81d Trotzdem machte Anne Sushi für das Buffet.

82 Kühle Getränke sind angenehm an heißen Tagen.
82a Darum machte Annette Limonade in der Küche.
82b Trotzdem machte Annette Kaffee in der Küche.
82c Darum machte Annette Kaffee in der Küche.
82d Trotzdem machte Annette Limonade in der Küche.

83 Schwangere sollten Stress vermeiden.
83a Deshalb machte Antje Yoga im achten Monat.
83b Dennoch machte Antje Examen im achten Monat.
83c Deshalb machte Antje Examen im achten Monat.
83d Dennoch machte Antje Yoga im achten Monat.

84 Der Herd war seit Tagen kaputt.
84a Darum machte Berta Salat für das Abendbrot.
84b Dennoch machte Berta Nudeln für das Abendbrot.
84c Darum machte Berta Nudeln für das Abendbrot.
84d Dennoch machte Berta Salat für das Abendbrot.

85 An Wintertagen war kaltes Essen nicht beliebt.
85a Deshalb machte Elke Braten für den Sonntag.
85b Trotzdem machte Elke Salat für den Sonntag.
85c Deshalb machte Elke Salat für den Sonntag.
85d Trotzdem machte Elke Braten für den Sonntag.

86 Roher Fisch kann eine riskante Sache sein.
86a Darum machte Jana Fischstäbchen für das Mittagessen.
86b Trotzdem machte Jana Sushi für das Mittagessen.
86c Darum machte Jana Sushi für das Mittagessen.
86d Trotzdem machte Jana Fischstäbchen für das Mittagessen.

87 An heißen Tagen ist schweres Essen belastend.
87a Deshalb machte Judith Salat für den Abend.
87b Dennoch machte Judith Gulasch für den Abend.
87c Deshalb machte Judith Gulasch für den Abend.
87d Dennoch machte Judith Salat für den Abend.

88 Der Diätplan sah Rohkost vor.
88a Darum machte Jule Salat für das Abendbrot.
88b Dennoch machte Jule Eintopf für das Abendbrot.
88c Darum machte Jule Eintopf für das Abendbrot.
88d Dennoch machte Jule Salat für das Abendbrot.

89 Feuchte Wärme ist gut gegen Entzündungen.
89a Deshalb machte Sven Senfwickel für den Hals.
89b Trotzdem machte Sven Eiswickel für den Hals.
89c Deshalb machte Sven Eiswickel für den Hals.
89d Trotzdem machte Sven Senfwickel für den Hals.

90 In Osteuropa gibt es bald viele Karrierechancen.
90a Darum machte Heiner Polnischkurse an der Hochschule.
90b Trotzdem machte Heiner Spanischkurse an der Hochschule.
90c Darum machte Heiner Spanischkurse an der Hochschule.
90d Trotzdem machte Heiner Polnischkurse an der Hochschule.

91 Die Briten sind keine großen Kaffeetrinker.
91a Deshalb machte James Tee für die Gesellschaft.
91b Dennoch machte James Espresso für die Gesellschaft.
91c Deshalb machte James Espresso für die Gesellschaft.
91d Dennoch machte James Tee für die Gesellschaft.

92 Das Höhentraining war sehrerfolgreich.
92a Darum machte Luis Rekorde bei dem Turnier.
92b Dennoch machte Luis Trostpreise bei dem Turnier.
92c Darum machte Luis Trostpreise bei dem Turnier.
92d Dennoch machte Luis Rekorde bei dem Turnier.

93 Die Knieverletzung hatte intensives Training verhindert.
93a Deshalb machte Lukas Trostpreise nach dem Rennen.
93b Trotzdem machte Lukas Medaillen nach dem Rennen.
93c Deshalb machte Lukas Medaillen nach dem Rennen.
93d Trotzdem machte Lukas Trostpreise nach dem Rennen.

94 Nach dem Winterspaziergang war allen richtig kalt.
94a Darum machte Peer Grog in der Küche.
94b Trotzdem machte Peer Eistee in der Küche.
94c Darum machte Peer Eistee in der Küche.
94d Trotzdem machte Peer Grog in der Küche.

95 Weihnachten steht vor der Tür.
95a Deshalb machte Theo Sterne in der Schule.
95b Dennoch machte Theo Hasen in der Schule.
95c Deshalb machte Theo Hasen in der Schule.
95d Dennoch machte Theo Sterne in der Schule.

96 Ostern steht vor der Tür.
96a Darum machte Till Stoffhasen in der Schule.
96b Dennoch machte Till Strohsterne in der Schule.
96c Darum machte Till Strohsterne in der Schule.
96d Dennoch machte Till Stoffhasen in der Schule.

97 Autos bleiben im Wüstensand schnell stecken.
97a Deshalb organisierte Lara Kamele für die Expedition.
97b Trotzdem organisierte Lara Jeeps für die Expedition.
97c Deshalb organisierte Lara Jeeps für die Expedition.
97d Trotzdem organisierte Lara Kamele für die Expedition.

98 Im März hat man meistens genug vom Winter.
98a Darum organisierte Sara Strandurlaub für den April.
98b Trotzdem organisierte Sara Skiurlaub für den April.
98c Darum organisierte Sara Skiurlaub für den April.
98d Trotzdem organisierte Sara Strandurlaub für den April.

99 Viele Kinder bewegen sich zuwenig.
99a Deshalb organisierte Ilse Ballspiele für den Nachmittag.
99b Dennoch organisierte Ilse Videospiele für den Nachmittag.
99c Deshalb organisierte Ilse Videospiele für den Nachmittag.
99d Dennoch organisierte Ilse Ballspiele für den Nachmittag.

100 Manche Pflanzen eignen sich nicht für Zimmerkulturen.
100a Darum organisierte Ina Bonsaibäume für die Wohnung.
100b Dennoch organisierte Ina Apfelbäume für die Wohnung.
100c Darum organisierte Ina Apfelbäume für die Wohnung.
100d Dennoch organisierte Ina Bonsaibäume für die Wohnung.

101 Man hat nicht immer Lust, zulernen.
101a Deshalb organisierte Silke Comics vor dem Seminar.
101b Trotzdem organisierte Silke Fachtexte vor dem Seminar.
101c Deshalb organisierte Silke Fachtexte vor dem Seminar.
101d Trotzdem organisierte Silke Comics vor dem Seminar.

102 Es ist klug, sich für die Uni vorzubereiten.
102a Darum organisierte Sylvia Fachtexte vor dem Seminar.
102b Trotzdem organisierte Sylvia Comics vor dem Seminar.
102c Darum organisierte Sylvia Comics vor dem Seminar.
102d Trotzdem organisierte Sylvia Fachtexte vor dem Seminar.

103 Der Bergpfad war zu schmal für Autos.
103a Deshalb organisierte Diana Esel für die Expedition.

103b Dennoch organisierte Diana Laster für die Expedition.
103c Deshalb organisierte Diana Laster für die Expedition.
103d Dennoch organisierte Diana Esel für die Expedition.

104 Wenige Mitarbeiter waren an Ausflügen interessiert.
104a Darum organisierte Bettina Sektabende für die Kollegen.
104b Dennoch organisierte Bettina Picknicks für die Kollegen.
104c Darum organisierte Bettina Picknicks für die Kollegen.
104d Dennoch organisierte Bettina Sektabende für die Kollegen.

105 Der letzte Aktivurlaub war viel zu anstrengend gewesen.
105a Deshalb organisierte Armin Kreuzfahrten für die Ferien.
105b Trotzdem organisierte Armin Klettertouren für die Ferien.
105c Deshalb organisierte Armin Klettertouren für die Ferien.
105d Trotzdem organisierte Armin Kreuzfahrten für die Ferien.

106 Der amerikanische Besuch hatte sich geweigert, viel zu laufen.
106a Darum organisierte Steffen Bustouren für das Wochenende.
106b Trotzdem organisierte Steffen Wanderungen für das Wochenende.
106c Darum organisierte Steffen Wanderungen für das Wochenende.
106d Trotzdem organisierte Steffen Bustouren für das Wochenende.

107 In Berlin ist man mit der S-Bahn meist am schnellsten.
107a Deshalb organisierte Rene Tageskarten für die Besucher.
107b Dennoch organisierte Rene Mietwagen für die Besucher.
107c Deshalb organisierte Rene Mietwagen für die Besucher.
107d Dennoch organisierte Rene Tageskarten für die Besucher.

108 Die Allergie gegen Insektenstiche war lebensgefährlich.
108a Darum organisierte Anton Skiurlaub für die Osterferien.
108b Dennoch organisierte Anton Wanderurlaub für die Osterferien.
108c Darum organisierte Anton Wanderurlaub für die Osterferien.
108d Dennoch organisierte Anton Skiurlaub für die Osterferien.

109 Die uralten Autos waren die Reparatur nicht mehrwert.
109a Deshalb organisierte Robert Mietwagen nach dem Unfall.
109b Trotzdem organisierte Robert Ersatzteile nach dem Unfall.
109c Deshalb organisierte Robert Ersatzteile nach dem Unfall.
109d Trotzdem organisierte Robert Mietwagen nach dem Unfall.

110 Im Tiefschnee kommt man auf Beinen schlecht vorwärts.
110a Darum organisierte Burkhard Schlitten für die Winterreise.
110b Trotzdem organisierte Burkhard Pferde für die Winterreise.
110c Darum organisierte Burkhard Pferde für die Winterreise.
110d Trotzdem organisierte Burkhard Schlitten für die Winterreise.

111 Der Arzt hatte Sport verordnet.
111a Deshalb organisierte Nils Dauerläufe für den Nachmittag.
111b Dennoch organisierte Nils Videospiele für den Nachmittag.
111c Deshalb organisierte Nils Videospiele für den Nachmittag.
111d Dennoch organisierte Nils Dauerläufe für den Nachmittag.

112 Der Strand war weit weg von der Haltestelle.
112a Darum organisierte Kevin Fahrräder für die Gruppe. R
112b Dennoch organisierte Kevin Fahrkarten für die Gruppe.
112c Darum organisierte Kevin Fahrkarten für die Gruppe.
112d Dennoch organisierte Kevin Fahrräder für die Gruppe.

113 Der Sommer ist da.
113a Deshalb suchte Theresa Bikinis in der Stadt.
113b Trotzdem suchte Theresa Mäntel in der Stadt.
113c Deshalb suchte Theresa Mäntel in der Stadt.
113d Trotzdem suchte Theresa Bikinis in der Stadt.

114 Die Eltern konnten ein Studium nicht zahlen.
114a Darum suchte Tori Jobangebote nach dem Abitur.
114b Trotzdem suchte Tori Universitäten nach dem Abitur.
114c Darum suchte Tori Universitäten nach dem Abitur.
114d Trotzdem suchte Tori Jobangebote nach dem Abitur.

115 Die neuen Bezüge mussten billig sein.
115a Deshalb suchte Doreen Nylonstoff für die Bettwäsche.
115b Dennoch suchte Doreen Seidenstoff für die Bettwäsche.
115c Deshalb suchte Doreen Seidenstoff für die Bettwäsche.
115d Dennoch suchte Doreen Nylonstoff für die Bettwäsche.

116 Es war nicht viel Geld für Urlaub übriggeblieben.
116a Darum suchte Kelly Zeltplätze für den Sommer.
116b Dennoch suchte Kelly Luxushotels für den Sommer.
116c Darum suchte Kelly Luxushotels für den Sommer.
116d Dennoch suchte Kelly Zeltplätze für den Sommer.

117 Die Bahn hatte die Preise wieder erhöht.
117a Deshalb suchte Marta Flüge für die Reise.
117b Trotzdem suchte Marta Züge für die Reise.
117c Deshalb suchte Marta Züge für die Reise.
117d Trotzdem suchte Marta Flüge für die Reise.

118 Markenkleidung ist völlig überteuert.
118a Darum suchte Nadine Billigware in der Damenabteilung.
118b Trotzdem suchte Nadine Designerhosen in der Damenabteilung.
118c Darum suchte Nadine Designerhosen in der Damenabteilung.
118d Trotzdem suchte Nadine Billigware in der Damenabteilung.

119 Die Stiftung hatte das Stipendium bewilligt.
119a Deshalb suchte Ria Studienplätze nach dem Abitur.
119b Dennoch suchte Ria Jobangebote nach dem Abitur.
119c Deshalb suchte Ria Jobangebote nach dem Abitur.
119d Dennoch suchte Ria Studienplätze nach dem Abitur.

120 Es lohnt sich selten, kaputte Sohlen zureparieren.
120a Darum suchte Sabrina Schuhe in der Stadt.
120b Dennoch suchte Sabrina Schuster in der Stadt.
120c Darum suchte Sabrina Schuster in der Stadt.
120d Dennoch suchte Sabrina Schuhe in der Stadt.

121 Das Girokonto war komplett ausgeräumt.
121a Deshalb suchte Christian Sommerjobs in der Zeitung.
121b Trotzdem suchte Christian Reisetipps in der Zeitung.
121c Deshalb suchte Christian Reisetipps in der Zeitung.
121d Trotzdem suchte Christian Sommerjobs in der Zeitung.

122 Winterkleidung sollte lang und warm sein.
122a Darum suchte Frank Mäntel in der Herrenabteilung.

122b Trotzdem suchte Frank Jacken in der Herrenabteilung.
122c Darum suchte Frank Jacken in der Herrenabteilung.
122d Trotzdem suchte Frank Mäntel in der Herrenabteilung.

123 Es war seit Tagen windig und regnerisch.
123a Deshalb suchte Gereon Hotelzimmer auf der Insel.
123b Dennoch suchte Gereon Zeltplätze auf der Insel.
123c Deshalb suchte Gereon Zeltplätze auf der Insel.
123d Dennoch suchte Gereon Hotelzimmer auf der Insel.

124 Ständig nur Sitzen macht zappelig.
124a Darum suchte Gunnar Tennispartner nach der Arbeit.
124b Dennoch suchte Gunnar Schachpartner nach der Arbeit.
124c Darum suchte Gunnar Schachpartner nach der Arbeit.
124d Dennoch suchte Gunnar Tennispartner nach der Arbeit.

125 Große Parkplätze sind in der Innenstadt selten.
125a Deshalb suchte Julian Kleinwagen auf der Messe.
125b Trotzdem suchte Julian Limousinen auf der Messe.
125c Deshalb suchte Julian Limousinen auf der Messe.
125d Trotzdem suchte Julian Kleinwagen auf der Messe.

126 Im Garten möchte man nicht beobachtet wer den.
126a Darum suchte Manfred Tannen für den Zaun.
126b Trotzdem suchte Manfred Primeln für den Zaun.
126c Darum suchte Manfred Primeln für den Zaun.
126d Trotzdem suchte Manfred Tannen für den Zaun.

127 Das Abendprogramm sollte klassische Musik beinhalten.
127a Deshalb suchte Manuel Konzerte in der Zeitung.
127b Dennoch suchte Manuel Fußballspiele in der Zeitung.
127c Deshalb suchte Manuel Fußballspiele in der Zeitung.
127d Dennoch suchte Manuel Konzerte in der Zeitung.

128 Die Therapie gegen Flugangst war erfolglos.
128a Darum suchte Siggi Züge für die Reise.
128b Dennoch suchte Siggi Flüge für die Reise.
128c Darum suchte Siggi Flüge für die Reise.
128d Dennoch suchte Siggi Züge für die Reise.

129 Hunde sind keine Vegetarier.
129a Deshalb verwendete Alexandra Fleisch bei der Fütterung.
129b Trotzdem verwendete Alexandra Gemüse bei der Fütterung.
129c Deshalb verwendete Alexandra Gemüse bei der Fütterung.
129d Trotzdem verwendete Alexandra Fleisch bei der Fütterung.

130 Weihnachtsbäume geraten schnell in Brand.
130a Darum verwendete Lydia Lichterketten für die Dekoration.
130b Trotzdem verwendete Lydia Wachskerzen für die Dekoration.
130c Darum verwendete Lydia Wachskerzen für die Dekoration.
130d Trotzdem verwendete Lydia Lichterketten für die Dekoration.

131 Im Januar ist es draußen rechtkalt.
131a Deshalb verwendete Anja Handschuhe auf dem Fahrrad.
131b Dennoch verwendete Anja Shorts auf dem Fahrrad.
131c Deshalb verwendete Anja Shorts auf dem Fahrrad.
131d Dennoch verwendete Anja Handschuhe auf dem Fahrrad.

132 Man2 braucht selten scharfe Mittel zum Putzen.
132a Darum verwendete Doris Essig für die Reinigung.
132b Dennoch verwendete Doris Chlor für die Reinigung.
132c Darum verwendete Doris Chlor für die Reinigung.
132d Dennoch verwendete Doris Essig für die Reinigung.

133 Das teure Bild war sehr schwer.
133a Deshalb verwendete Helena Dübel für die Aufhängung.
133b Trotzdem verwendete Helena Reißzwecken für die Aufhängung.
133c Deshalb verwendete Helena Reißzwecken für die Aufhängung.
133d Trotzdem verwendete Helena Dübel für die Aufhängung.

134 Der Test hatte eine Allergie gegen Nüsse festgestellt.
134a Darum verwendete Ramona Erdbeeren für den Kuchen.
134b Trotzdem verwendete Ramona Mandeln für den Kuchen.
134c Darum verwendete Ramona Mandeln für den Kuchen.
134d Trotzdem verwendete Ramona Erdbeeren für den Kuchen.

135 Der kaputte Stuhl sollte nochlange benutzt werden.
135a Deshalb verwendete Ilka Holzleim für die Reparatur.
135b Dennoch verwendete Ilka Klebeband für die Reparatur.
135c Deshalb verwendete Ilka Klebeband für die Reparatur.
135d Dennoch verwendete Ilka Holzleim für die Reparatur.

136 Der Test fand Schadstoffe in Babyflaschen aus Kunststoff.
136a Darum verwendete Katja Glasflaschen für die Milch.
136b Dennoch verwendete Katja Plastikflaschen für die Milch.
136c Darum verwendete Katja Plastikflaschen für die Milch.
136d Dennoch verwendete Katja Glasflaschen für die Milch.

137 Tropenhölzer eignen sich nicht für Fußböden.
137a Deshalb verwendete Harry Kiefer für die Dielen.
137b Trotzdem verwendete Harry Mahagoni für die Dielen.
137c Deshalb verwendete Harry Mahagoni für die Dielen.
137d Trotzdem verwendete Harry Kiefer für die Dielen.

138 Die Großtante bestand auf Luxus.
138a Darum verwendete Helmut Silberlöffel für die Teeparty.
138b Trotzdem verwendete Helmut Plastiklöffel für die Teeparty.
138c Darum verwendete Helmut Plastiklöffel für die Teeparty.
138d Trotzdem verwendete Helmut Silberlöffel für die Teeparty.

139 Der Chef war beim Essen sehr auf Kultur bedacht.
139a Deshalb verwendete Jacques Servietten für das Gedeck.
139b Dennoch verwendete Jacques Klopapier für das Gedeck.
139c Deshalb verwendete Jacques Klopapier für das Gedeck.
139d Dennoch verwendete Jacques Servietten für das Gedeck.

140 Gesalzte Straßen sind schmerzhaft für Hundepfoten.
140a Darum verwendete Jörg Sand für den Fußweg.
140b Dennoch verwendete Jörg Salz für den Fußweg.
140c Darum verwendete Jörg Salz für den Fußweg.
140d Dennoch verwendete Jörg Sand für den Fußweg.

141 Lichterketten am Baum wirken immer etwas steril.
141a Deshalb verwendete Ludwig Wachskerzen für die Dekoration.
141b Trotzdem verwendete Ludwig Elektrokerzen für die Dekoration.
141c Deshalb verwendete Ludwig Elektrokerzen für die Dekoration.

141d Trotzdem verwendete Ludwig Wachskerzen für die Dekoration.

142 Chemie hat im Gemüsegarten nicht s zusuchen.
142a Darum verwendete Marius Pferdemist für das Salatbeet.
142b Trotzdem verwendete Marius Kunstdünger für das Salatbeet.
142c Darum verwendete Marius Kunstdünger für das Salatbeet.
142d Trotzdem verwendete Marius Pferdemist für das Salatbeet.

143 Kakteen vertragen keine saure Erde.
143a Deshalb verwendete Stefan Sand für die Setzlinge.
143b Dennoch verwendete Stefan Torf für die Setzlinge.
143c Deshalb verwendete Stefan Torf für die Setzlinge.
143d Dennoch verwendete Stefan Sand für die Setzlinge.

144 Feuchte Wärme im Schuh fördert Fußpilz.
144a Darum verwendete Martin Sandalen in der Hitze.
144b Dennoch verwendete Martin Stiefel in der Hitze.
144c Darum verwendete Martin Stiefel in der Hitze.
144d Dennoch verwendete Martin Sandalen in der Hitze.

145 Die Lieblingshose ist zu eng geworden.
145a Deshalb wählte Claudia Möhren auf der Party.
145b Trotzdem wählte Claudia Torte auf der Party.
145c Deshalb wählte Claudia Torte auf der Party.
145d Trotzdem wählte Claudia Möhren auf der Party.

146 Der Acker hinter dem Haus sollte zur Spielwiese werden.
146a Darum wählte Suse Rasen für die Bepflanzung.
146b Trotzdem wählte Suse Karotten für die Bepflanzung.
146c Darum wählte Suse Karotten für die Bepflanzung.
146d Trotzdem wählte Suse Rasen für die Bepflanzung.

147 In Tunesien ist es im Sommer sehrheiß.
147a wählte Andrea T-Shirts für die Reise.
147b Dennoch wählte Andrea Pullover für die Reise.
147c Deshalb wählte Andrea Pullover für die Reise.
147d wählte Andrea T-Shirts für die Reise.

148 Zuviel Koffein kann zu Schlafstörungen führen.
148a Darum wählte Beate Kräutertee nach dem Abendbrot.
148b Dennoch wählte Beate Espresso nach dem Abendbrot.
148c Darum wählte Beate Espresso nach dem Abendbrot.
148d Dennoch wählte Beate Kräutertee nach dem Abendbrot.

149 Wärme wirkt bei Erkältungen lindernd.
149a Deshalb wählte Sabine Saunagänge für den Nachmittag.
149b Trotzdem wählte Sabine Eisbäder für den Nachmittag.
149c Deshalb wählte Sabine Eisbäder für den Nachmittag.
149d Trotzdem wählte Sabine Saunagänge für den Nachmittag.

150 Fingerschmuck ist hinderlich beim Tippen.
150a Darum wählte Kathrin Halskettchen bei der Arbeit.
150b Trotzdem wählte Kathrin Silberringe bei der Arbeit.
150c Darum wählte Kathrin Silberringe bei der Arbeit.
150d Trotzdem wählte Kathrin Halskettchen bei der Arbeit.

151 Morgens ist gesundes Essen besonders wichtig.
151a Deshalb wählte Sigrid Müsli nach dem Aufstehen.
151b Dennoch wählte Sigrid Pralinen nach dem Aufstehen.
151c Deshalb wählte Sigrid Pralinen nach dem Aufstehen.
151d Dennoch wählte Sigrid Müsli nach dem Aufstehen.

152 Eine Oper ist eine feierliche Sache.
152a Darum wählte Stefanie Kleider für die Premiere.
152b Dennoch wählte Stefanie Jeans für die Premiere.
152c Darum wählte Stefanie Jeans für die Premiere.
152d Dennoch wählte Stefanie Kleider für die Premiere.

153 Mixgetränke sind oft viel zu süß.
153a Deshalb wählte Ernst Bier an der Bar.
153b Trotzdem wählte Ernst Cocktails an der Bar.
153c Deshalb wählte Ernst Cocktails an der Bar.
153d Trotzdem wählte Ernst Bier an der Bar.

154 Der Restaurantführer hatte die schlechten Reisgerichte bemängelt.
154a Darum wählte Michael Pasta für den Hauptgang.
154b Trotzdem wählte Michael Risotto für den Hauptgang.
154c Darum wählte Michael Risotto für den Hauptgang.
154d Trotzdem wählte Michael Pasta für den Hauptgang.

155 Holzböden machen einen gemütlichen Eindruck.
155a Deshalb wählte Florian Dielen für die Küche.
155b Dennoch wählte Florian Linoleum für die Küche.
155c Deshalb wählte Florian Linoleum für die Küche.
155d Dennoch wählte Florian Dielen für die Küche.

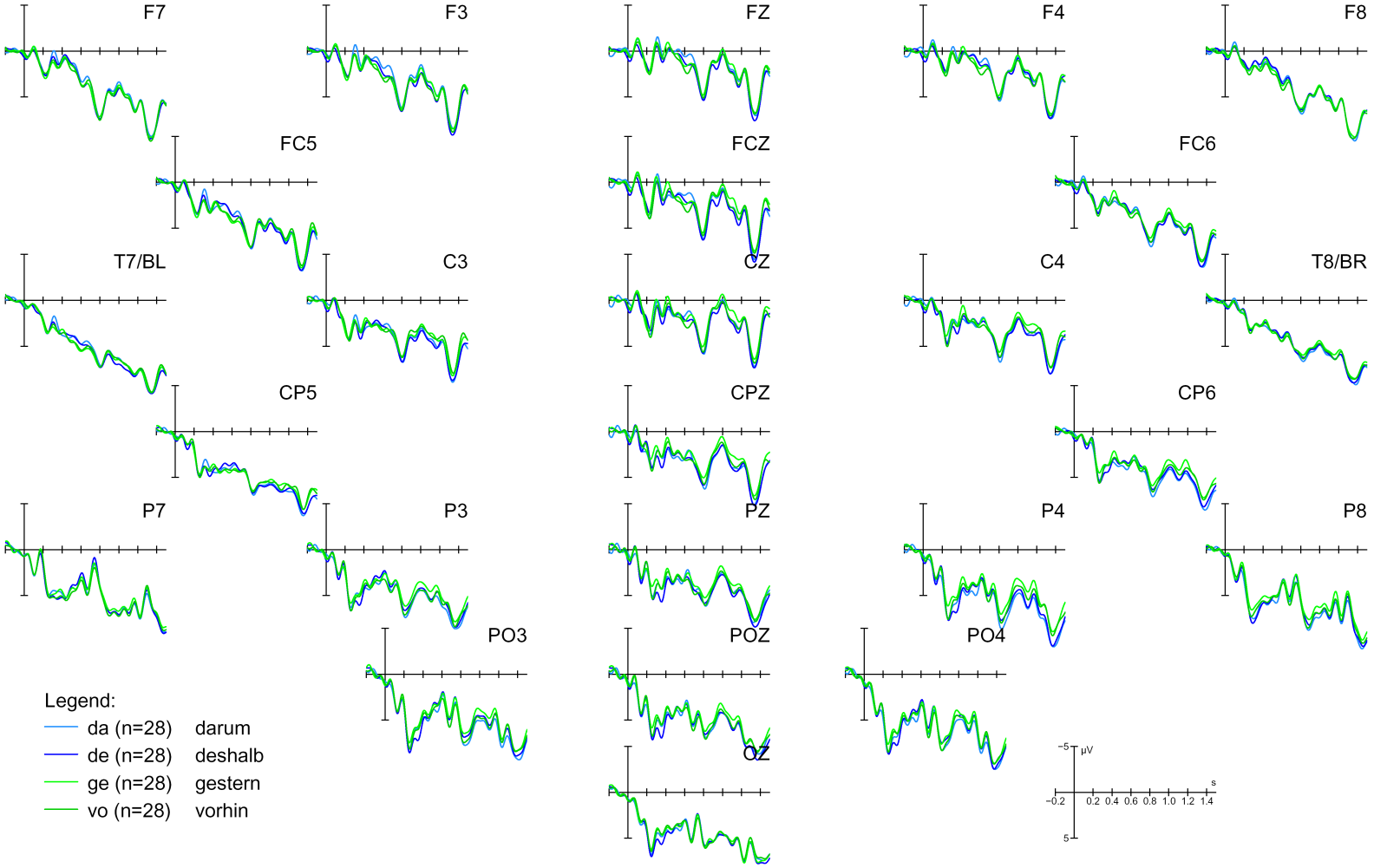
156 Betrunken Autofahren ist sehr gefährlich.
156a Darum wählte Johann Sprudel in der Kneipe.
156b Dennoch wählte Johann Schnaps in der Kneipe.
156c Darum wählte Johann Schnaps in der Kneipe.
156d Dennoch wählte Johann Sprudel in der Kneipe.

157 Die Kneipe war für schlechtes Bier bekannt.
157a Deshalb wählte Alexander Cocktails an der Bar.
157b Trotzdem wählte Alexander Pils an der Bar.
157c Deshalb wählte Alexander Pils an der Bar.
157d Trotzdem wählte Alexander Cocktails an der Bar.

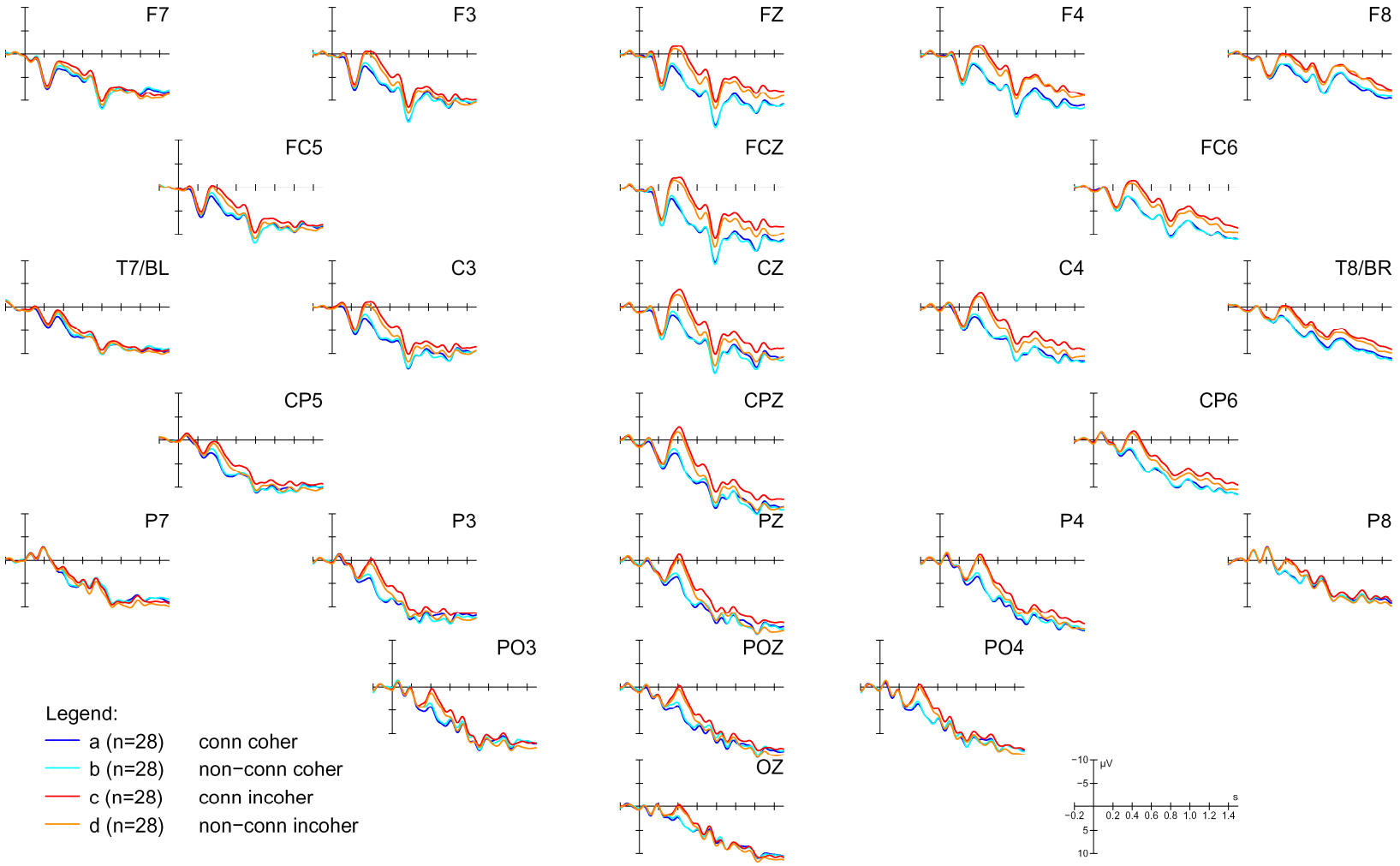
158 Hohe Bäume nehmen viel Licht weg.
158a Darum wählte Bastian Rosen für die Terrasse.
158b Trotzdem wählte Bastian Eichen für die Terrasse.
158c Darum wählte Bastian Eichen für die Terrasse.
158d Trotzdem wählte Bastian Rosen für die Terrasse.

159 Vor Operationen darf man nichts essen.
159a Deshalb wählte Bernd Fencheltee auf der Station.
159b Dennoch wählte Bernd Käsebrote auf der Station.
159c Deshalb wählte Bernd Käsebrote auf der Station.
159d Dennoch wählte Bernd Fencheltee auf der Station.

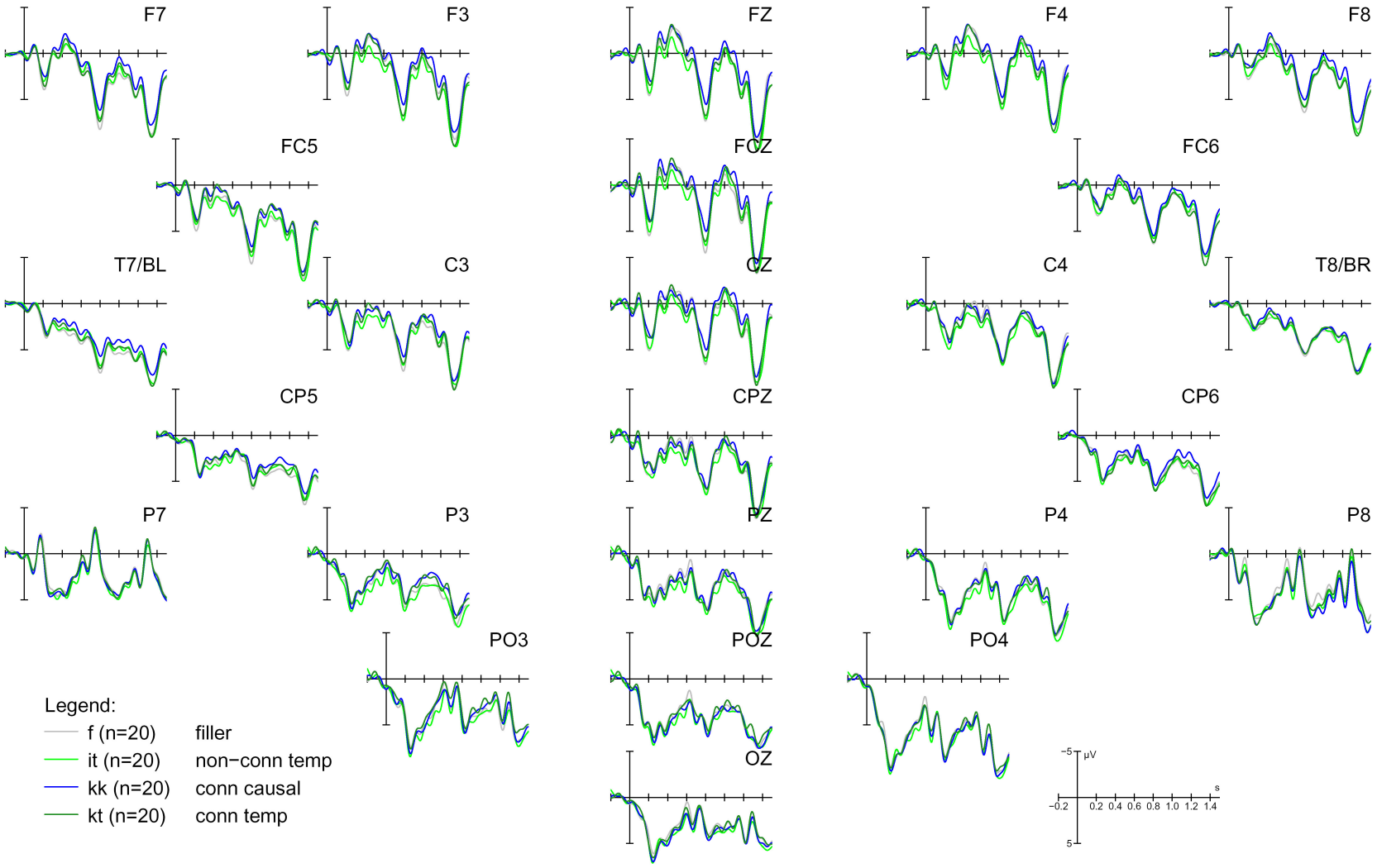
160 Koffein wirkt entwässernd auf den Körper.
160a Darum wählte Benedikt Sprudel während der Hitzewelle.
160b Dennoch wählte Benedikt Kaffee während der Hitzewelle.
160c Darum wählte Benedikt Kaffee während der Hitzewelle.
160d Dennoch wählte Benedikt Sprudel während der Hitzewelle.



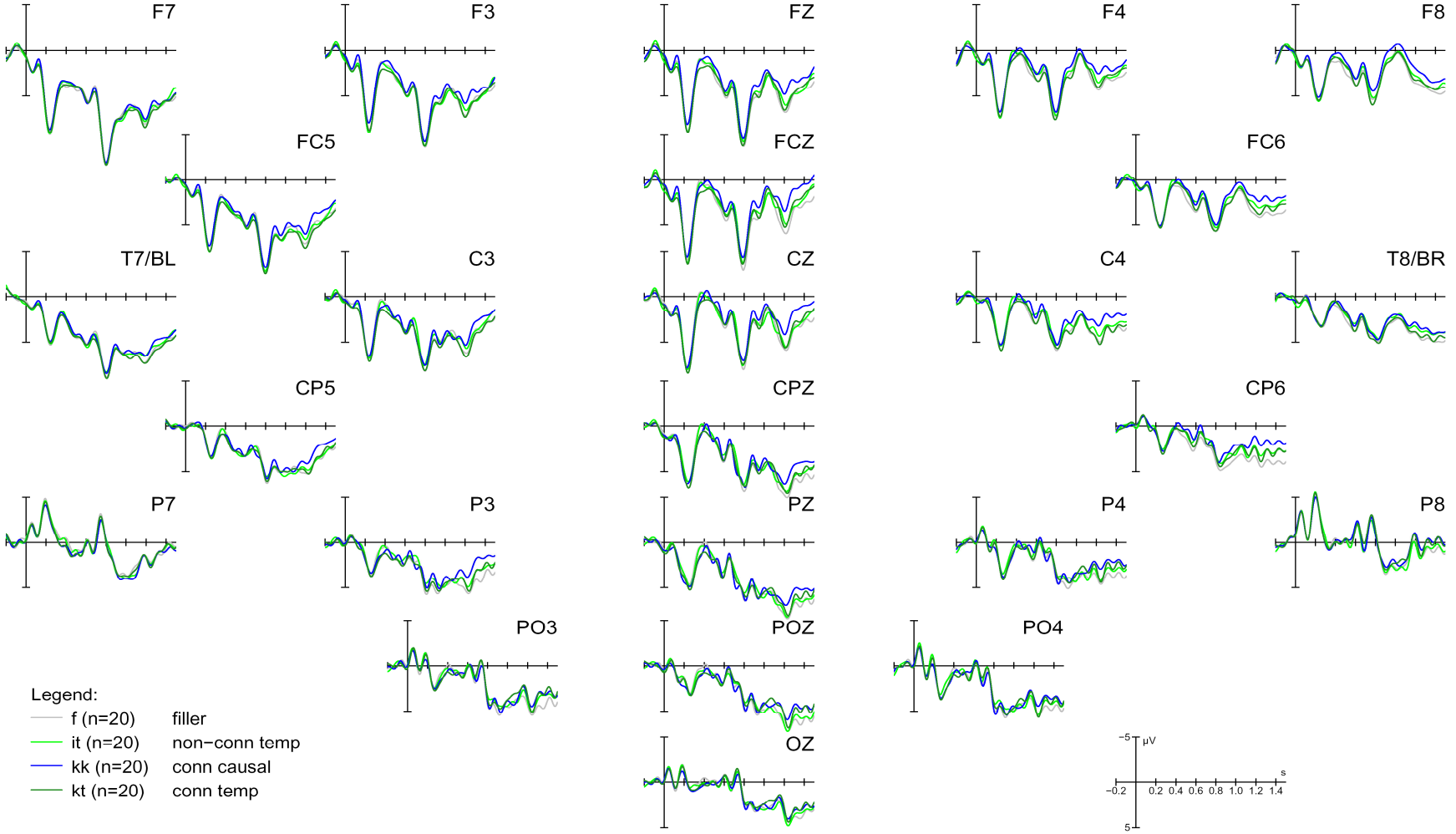
APPENDIX E: Grand-Average Experiment 2. First word of target sentence. –200 to 1500ms. N=28.



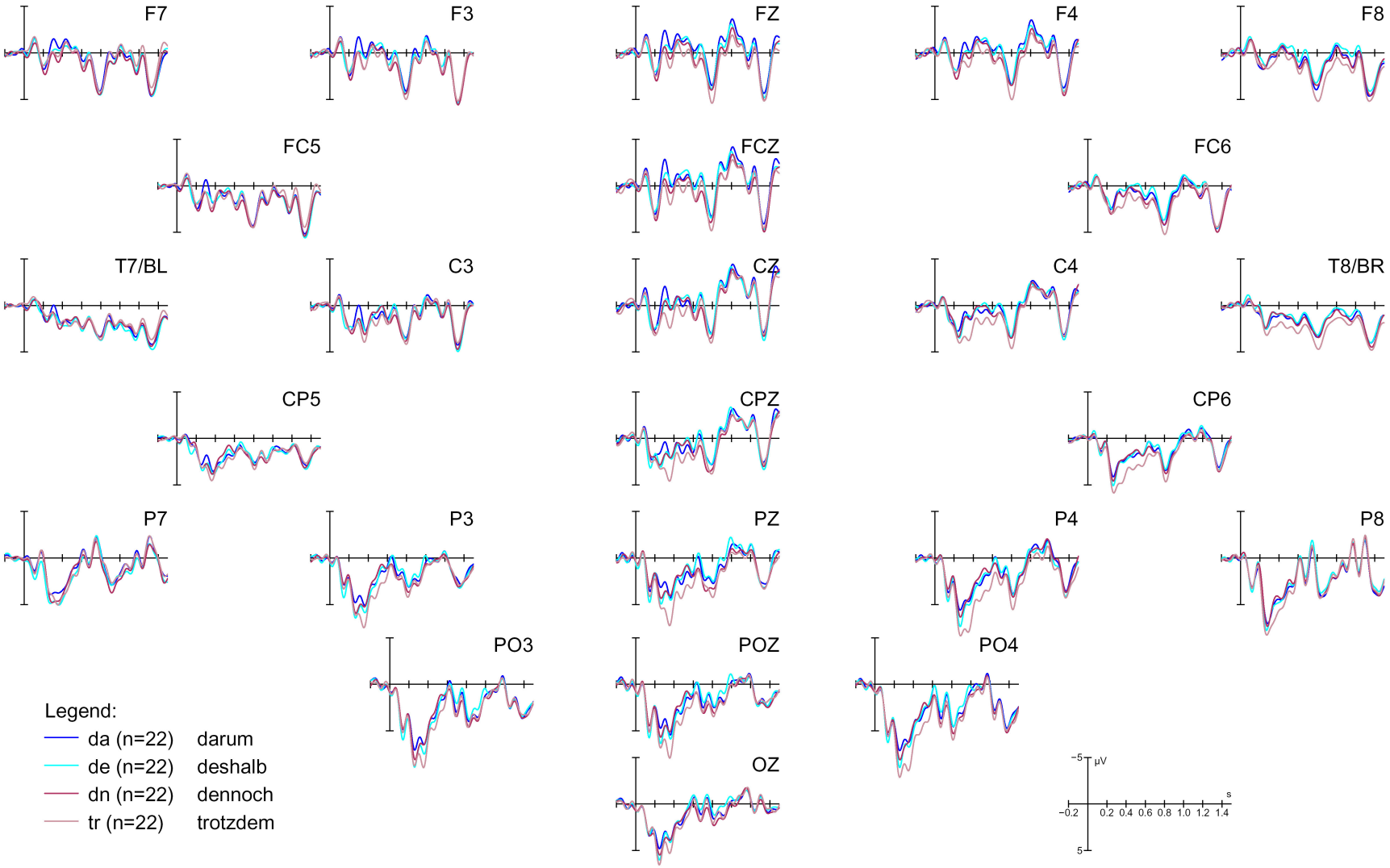
APPENDIX E: Grand-Average Experiment 2. Object of target sentence. –200 to 1500ms. N=28. W



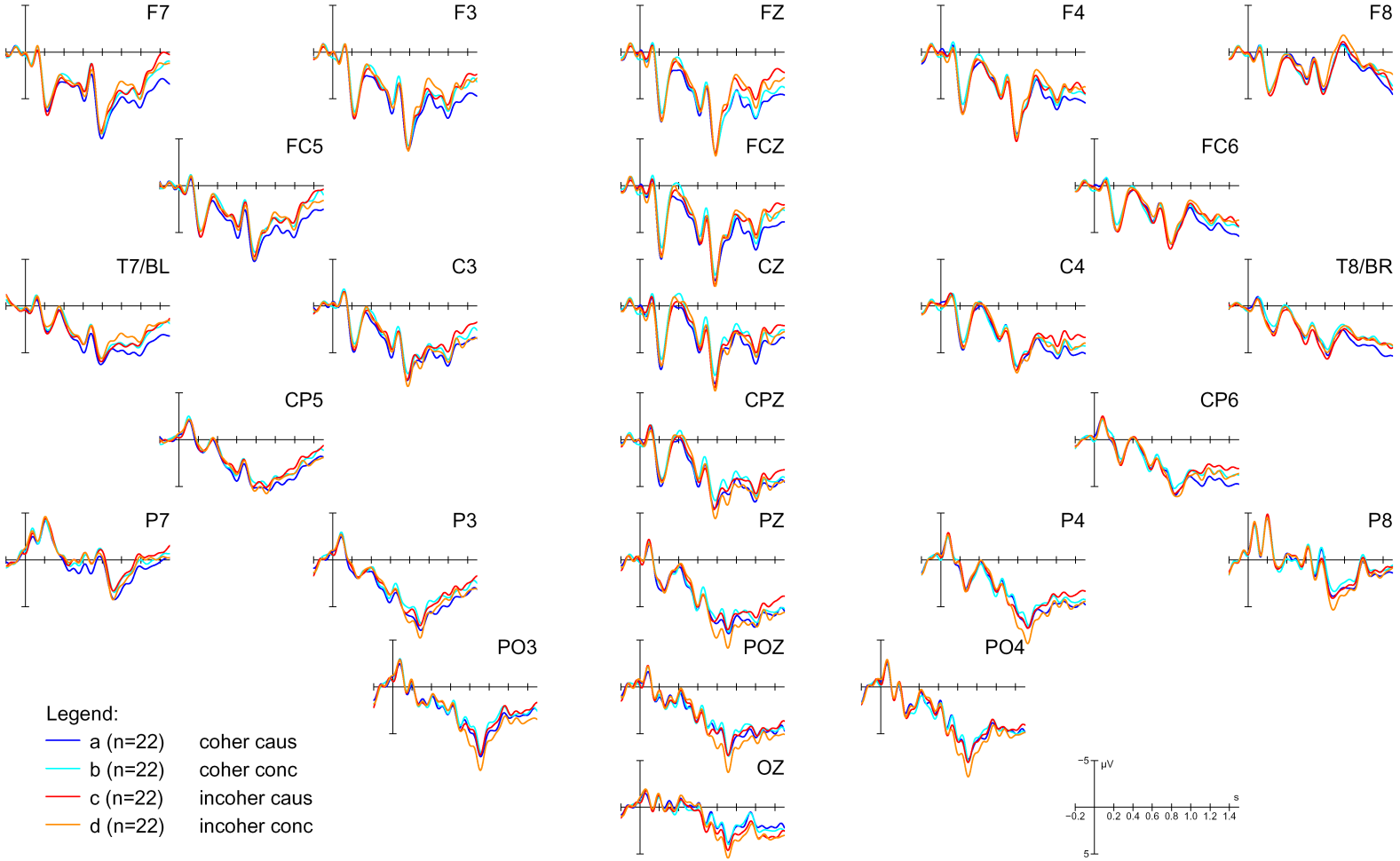
APPENDIX F: Grand-Average Experiment 3. First word of target sentence. –200 to 1500ms. N=20.



APPENDIX F: Grand-Average Experiment 3. Object of target sentence. –200 to 1500ms. N=20.



APPENDIX G: Grand-Average Experiment 4. First word of target sentence. –200 to 1500ms. N=22. Z



APPENDIX G: Grand-Average Experiment 4. Object of target sentence. –200 to 1500ms. N=22. AA

CURRICULUM VITAE

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1980 –1984	Grade school, Grundschule Fuhsestraße, Hannover, Germany
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1986 –1994	Ricarda - Huch – Gymnasium, Hannover, Germany
1988 –1989	9th grade at the Baseline Junior High School Boulder, Colorado; USA
1991 – 1992	12th grade at the Instituto Francisco Possenti, Mexiko-City, Mexico
1994	Abitur
1994 – 1996	**Undergraduate studies in General and Theoretical Linguistics** Potsdam University, Germany
1995 – 1996	Student assistant, Institut for Psychology, Potsdam University
Feb. / March 1996	Guest hearer at Northwestern University; Evanston, Illinois, USA
1996 – 2000	**Graduate studies in General and Theoretical Linguistics** Potsdam University, Germany
July 1996 – Feb. 1997	Student assistant**,** Institute for General and Theoretical Linguistics, Potsdam University
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2001	**Diplom**
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