Summary of the results of the dissertation
Connective ties in discourse:
Three ERP- studies on causal, temporal, and concessive connective ties and their influence on language processing.

I.   Introduction

The task the reader of a text has to accomplish is to connect the sentences in that discourse, to construct a global representation of what the text is about. This involves not only understanding the separate sentences but also the making of connections (inferences) between the sentences.

Previous research has found that the processing of single sentences as well as a multi-sentence discourse is incremental, with every element being integrated syntactically and semantically into the representation as it 'comes along', but that more complex operations that demand added resources can impede the understanding process (see for instance Mitchell, 1994 for an overview of sentence parsing theory and Carpenter, Miyake & Just, 1995, as well as Clifton & Duffy, 2001 for overviews of discourse processing).

It has been shown that readers automatically attempt to make connections between two adjacent sentences, also called bridging inferences (McKoon & Ratcliff, 1992; Graesser, Singer & Trabasso, 1994). A text can however make successive bridging inferences possible and still be globally incoherent –and consequentially difficult to process –if the central theme of the text cannot be identified (Dooling & Lachmann, 1971; Bransford & Johnson, 1972; St. George, Mannes, & Hoffman, 1994). In other words, it is not only necessary for a reader to make connections between two sentences, but also to integrate all sentences into a global representation of the meaning of the discourse. This representation is called the mental model (Johnson-Laird, 1983) or situation model (van Dijk & Kintsch, 1983). It has been proposed that readers routinely keep track of several dimension in a text such as space, time, causality, involved characters, and motivation, and that shared dimensions between sentences are used in the construction of an integrated situation model (Event-Updating Model, Zwaan, Langston & Graesser, 1995; Zwaan, Magliano & Graesser, 1995).

II.   Connective Ties

There are a large number of lexical elements that have the function of stating precisely which relation is present between two sentences: connective ties such as *deshalb* and *darum* (therefore), *danach* and *hinterher* (afterwards), and *trotzdem* and *dennoch* (nevertheless). These six adverbial connective ties have in common that they must be the sentence-initial element of their internal argument, the second sentence. Additionally, they obligatorily relate two sentences, both the internal and the external argument must be explicitly present and take the form of complete sentences. This distinguishes them from other adverbial lexical elements that can also stand in sentence-initial position such as deictical sentential adverbs (*gestern* (yesterday), *vorhin* (recently), *gern* (gladly), and *lieber* (rather)), which do not demand two arguments to be explicitly present in the discourse (Pasch, Brauße, Waßner & Herrmann, 2003). All six connective ties are

veridical in that they assert the truth of both their arguments (Blühdorn, Breindl & Waßner, 2004). Depending on their semantic content, however, they signal different relations in a discourse.

Deshalb and *darum* impose a causal relation between two sentences, the first being the cause and the second the consequence. The use of a causal connective tie is only possible if there is a causal relation already present between the two sentences, and / or that causal relation is known to a reader (example 1.a versus 1.b):

1.
    a.   The porcelain bowl was dropped. *Therefore*, it broke.
    b.   *The porcelain bowl was dropped. *Therefore*, the car broke down.

Trotzdem and *dennoch* are concessive, they denote a causal relation between the two sentences that however does not have the expected outcome (Stede, 2004). Due to this element of surprise, concessive connective ties can usually not be left out of a discourse (example 2.a), in contrast to causal and temporal connective ties. The two concessive connective ties are in certain respects found in complementary distribution with the two causal connective ties. Both can stand in causally related discourses, but causal connective ties are felicitous with the probable consequences of an event, and concessive connective ties are felicitous with the improbable outcomes of an event (examples 2.b and 2.c). It is possible to vary the probability of the outcome denoted in the internal argument by either inserting a negation or by varying the end of a pragmatic scale included in the internal argument (such as the scale between good and bad grades in examples 2.b and 2.c). This led to the hypothesis that there is a qualitative difference between incoherence (or a violation) in a discourse with a connective tie stemming from there being no causal relation present at all (2.d) and a violation due to the internal argument including the wrong end of the scale, denoting a probability of the outcome that is not selected by the connective tie used (2.e).

2.
    a.   ?July was very hot his year. John bought warm sweaters.
    b.   Mary studied hard for the exam. Therefore, she got an A.
    c.   Mary studied hard for the exam. Nevertheless, she got an F.
    d.   *Mary studied hard for the exam. Nevertheless, it rained.
    e.   *Mary studied hard for the exam. Nevertheless, she got an A.

Danach and *hinterher* signal a temporal relation; the first sentence describes the event that took place before the event denoted in the second sentence. A feature of these two temporal connective ties is that they can only be used felicitously if the first event is concluded before the second event commences (3.a), and if the two events are of a similar nature with regard to temporal duration (3.b). It is possible to use either a temporal or a causal connective tie in a causally related discourse, as long as the above conditions are met (3.c). This is proposed to be due to the fact that causal relations contain a temporal dimension, the cause having to take place before the effect.

3.
    a.   *We put all boxes into the car. *Afterwards*, we loaded the small boxes.
    b.   ?John moved to Australia. *Afterwards*, he had dinner.
    c.   It had snowed heavily. *Afterwards / Therefore*, John shoveled the driveway.

III. Previous Research on Connective Ties

Previous research has shown that connective discourses are processed differently from non-connective texts. A connective tie aids in the construction of a coherent text representation in coherent discourses (Caron, Micko & Thüring, 1988), and hinders the diagnosis of a coherence break in incoherent discourses (Ferstl & von Cramon, 2001).

It has also been reported that the relation a connective tie signals must match the underlying relation present in the discourse (Murray, 1997; Ferstl & von Cramon, 2001), and that the straightforward relations signaled by connective ties such as *therefore* and *afterwards* are easier to process than the more difficult discourse connections signaled by for instance concessive connective ties or temporal connective ties that state an event order not concurrent with the linear order of the linguistic input, such as *before x, y* (Townsend, 1983; Caron, Micko & Thüring, 1988; Münte, Schiltz & Kutas, 1998, but see also Baggio, 2004). These results suggest that the relation signaled by a connective tie is obligatorily attempted to be made by a reader.

Another question that has been investigated is when in processing the information provided by a connective tie is made use of. Millis & Just (1994) and Deaton & Gernsbacher (in press) presented evidence that a connective tie is not evaluated until the end of the discourse[1]. Haberlandt (1982) and Traxler, Bybee & Pickering (1998), as well as Münte, Schiltz & Kutas (1998) and Baggio (2004) showed that connective ties do influence the parse immediately.

In the context of the Event-Updating Model, a connective tie has the function of foregrounding the dimension that is the semantic content of the connective tie. In consequence, this could mean either that all other dimensions are temporarily backgrounded, but evaluated eventually at the end of the discourse, or that all other dimensions are excluded, that a connective tie states that the dimension denoted in the relation it signals is the only one present.

IV. Questions

The experiments presented in the present work had the purpose of investigating the following questions. The pilot study, experiment 1, used a self-paced sentence-reading time paradigm, and experiments 2, 3 and 4 employed the ERP-method (**e**vent-**r**elated **p**otentials).

- Do the processing contrasts between connective and non-connective elements found extend to deictical sentential adverbs; does the theoretical distinction between connective ties and deictical sentential adverbs proposed in Pasch et al. (2003) have 'cognitive reality', and hence express itself in sentence reading times (experiment 1) and / or the ERP curves (experiments 2 and 3)?
- 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)?
- When precisely is the information provided by connective ties used? There is some evidence that connective ties can 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).

V. Experiment 1: Pilot study

The first study manipulated two factors. The first was the presence or absence of a causal connective tie at the beginning of the second sentence presented, the second was the relation between the two sentences in each trial: there was either a causal relation present and the discourse coherent, or the two sentences were unrelated, resulting in an incoherent discourse. The study was a replication of Ferstl & von Cramon's (2001) behavioral pilot study, with three changes. The first was that only the causal connective ties *deshalb* and *darum* were used in the connective conditions, in contrast to the various connective ties as well as co-reference relations used by Ferstl & von Cramon. The second difference was that the deictical sentential adverbs *gestern* and *vorhin* were used as sentence-initial elements in the non-connective conditions. This made the third change possible, namely that all target sentences could have the same syntactic structure. Example 4 shows one of the 32 blocks of lexical material used, critical words are underlined:

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[1] In all studies examining connective ties the stimuli were mini-discourses comprised of two sentences. The end of the second sentence was therefore always the end of the discourse.

4.   Context: Der Herd war kaputt.   *The stove was broken.*

Coherent Targets:

a.	Connective:	<u>Deshalb / Darum</u>	machte	Berta	<u>Rohkost</u> für das Abendbrot.
		Therefore	*made*	*Berta*	*crudités for the dinner.*
b.	Non-Conn.:	<u>Gestern / Vorhin</u>	machte	Berta	<u>Rohkost</u> für das Abendbrot.
		Yesterday	*made*	*Berta*	*crudités for the dinner.*

Incoherent Targets:

c.	Connective:	<u>Deshalb / Darum</u>	kaufte	Klaus	<u>Dünger</u> in der Markthalle.
		Therefore	*bought*	*Klaus*	*fertilizer at the store.*
d.	Non-Conn.:	<u>Gestern / Vorhin</u>	kaufte	Klaus	<u>Dünger</u> in der Markthalle.
		Yesterday	*bought*	*Klaus*	*fertilizer at the store.*

Incoherent trials were obtained by switching the contexts of two coherent blocks of lexical material. There was an additional sentence constructed for each trial that was always coherent with the target sentence.

The 120 sentence pairs with additions were split into four lists and pseudo-randomized with 80 filler trials. The stimuli were presented to 48 subjects, self-paced sentence by sentence with a sentence match task (one word of either the target or the addition was slightly altered and presented as a match. Neither the connective tie nor the deictical sentential adverb was ever altered.).

Results showed no differences in reading times for the contexts or the additions. The experimental manipulation did not influence the error rates on the sentence match task. The reaction times showed that subjects had needed reliably longer to judge the match in connective trials. There was no influence of coherence here. The reading times for the targets showed reliably shorter reading times for coherent trials (4.a and b). Reading times were also reliably shorter for the connective coherent condition 4.a compared to the non-connective condition 4.b. The reverse contrast, that of the connective incoherent condition 4.c yielding longer reaction times than the non-connective incoherent condition 4.d was present descriptively, but not statistically.

These results were taken to show that connective ties do aid in the construction of a text representation in coherent discourses, in contrast to deictical sentential adverbs, which were therefore classified as non-connective, as suggested by Pasch et al..

Experiment 1 also shows that the information provided by connective ties is indeed used in the construction of a text representation, and that the drawing of bridging inferences is an obligatory process, as the contrast between coherent and incoherent trials was present despite the relatively shallow task of a sentence match, which was assumed not to trigger conscious inferencing processes. This result argues against the findings of Fletcher, Chrysler, van den Broek, Deaton & Bloom (1995), who showed that causal relations are not necessarily kept track of outside the domain of narrative text. The pilot study did not replicate Ferstl & von Cramon's finding that connective ties hinder in the diagnosis of an incoherence. Ferstl & von Cramon used a plausibility judgment, and therefore the proposal was made that diagnosis of an incoherence is not an automatic process. Since the diagnosis of incoherence was not task relevant in experiment 1, the presence or absence of a connective tie did not influence the processing of the incoherent trials. Subjects did not need to make sure that there was indeed no relation between the sentences in these conditions.

VI.   Experiment 2

In the second study, the materials from experiment 1 with an additional 48 blocks to make a total of 80 blocks of lexical material were used in an ERP study. The experimental manipulation was the same as in experiment 1, but instead of a sentence match task a plausibility judgment was used after each trial. To ensure that there was only one particular point in the target sentences at which an incoherence could be diagnosed, only 10 verbs were used equally often across the blocks, all chosen for their fairly globally applicable semantics, such as *kaufte* (bought), *suchte* (looked for), *verwendete* (used) etc..

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The stimuli were presented word-by-word or phrase-by-phrase (NPs and PPs were presented as a whole) with a presentation time of 450ms and an inter-stimulus interval of 100ms, resulting in a fixed presentation rate of one word or phrase every 550ms.

Unipolar EEG was recorded from 26 sites and digitalized at 250Hz while 28 right-handed subjects read and judged the stimuli. Each subject read half of the experimental materials in pseudo-randomized form. None had participated in experiment 1.

There were two grand-averages calculated. For the analysis of the first word of the target sentences, epochs were sorted by the four sentence-initial words (*deshalb*, *darum*, *gestern*, and *vorhin*), to examine possible immediate differences between connective and non-connective elements as well as lexical items. For the analysis of the object of the target sentence, EEG-epochs were averaged according to the conditions a through d in example 4, starting from the presentation of the object and encompassing the sentence-final prepositional phrase. Figure 1 shows the ERP curves for the lexical average at site FC5 (left anterior) and the ERP curves for the average by condition on the object at the central electrode CZ.
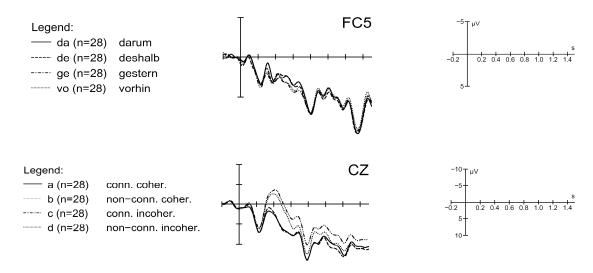

Figure 1: ERPs for the lexical average (FC5, top row) and the average by condition (CZ, bottom row), -200 to 1500ms, onset of critical word at 0ms, experiment 2, N=28.

The ERP results for experiment 2 were the following:

In the lexical average (Figure 1, top row), a negativity of both connective lexical items compared to the non-connective items proved to be statistically reliable for the left hemisphere. This effect had a left anterior maximum and was therefore classified as a working memory LAN. There was no difference found between either the two connective or the two non-connective conditions respectively.

In the average by condition (the object of the target sentences), an N400 was found for both incoherent conditions c and d, reliably larger for the connective incoherent condition c than the non-connective incoherent condition c. Additionally, a sentence-end negativity (SEN) was found at right anterior and central sites for the incoherent conditions, also larger for the connective incoherent condition c than the non-connective incoherent condition d.

The LAN found for both connective ties on the first word of the target sentences was interpreted to be a correlate of the processing of connective ties, reflecting either the integration of the first sentence as the external argument of the two-place relation denoted by the connective ties into the discourse representation, or the evaluation of the semantic content of the connective ties.

The N400 for the incoherent conditions was interpreted to show that incoming words are integrated not only into the current sentence, but into the semantic representation of the entire discourse constructed up to that point. This finding is similar to the results found in a number of previous studies (for instance Salmon & Pratt, 2002; Britz & Swaab, 2005; van Berkum, Brown,

Zwitzerlood, Kooijman & Hagoort, 2005; van Berkum, Hagoort & Brown, 1999c; van Berkum, Zwitzerlood, Brown & Hagoort, 2003b; Federmeier & Kutas, 1999a; Ditman, Holcomb & Kuperberg, 2005). The fact that the N400 found was larger for the connective incoherent condition than the non-connective incoherent condition was taken to support the conclusion that connective ties influence the parsing process incrementally and immediately.

The SEN for the incoherent conditions, also largest for the connective incoherent condition, was seen to suggest that while connective ties do have an immediate effect in the understanding of a text, the end of a discourse plays a prominent role in the construction of a complete situation model or 'message-level' semantic representation (Osterhout, 1997). An incoherence, and especially an incoherence in a connective discourse, would hinder the establishing of such a representation.

Experiment 2, however, suffered from a central confound: both connective ties used were causal, while both non-connective elements were temporal. It was therefore possible that all effects found pertained not to a contrast between connective and non-connective elements, but to processing differences between causal and temporal semantic relations in discourse. This possibility was investigated in experiment 3.

VII. Experiment 3

Experiment 3 had the purpose of determining whether the contrasts found in experiment 2 were indeed those between connective and non-connective elements and discourses. Additionally, the third experiment examined whether foregrounding of either the causal or the temporal dimension in suitable causally related discourses is possible, as suggested by the Event-Updating Model[2]. A third aspect investigated was whether the contrasts found on the first word in experiment 2 were due to the connective ties being task-relevant, by employing a probe detection task instead of a plausibility judgment in experiment 3. The stimulus materials in experiment 3 were manipulated along two dimensions. The first was the presence of a connective tie or a non-connective element in sentence-initial position in the target sentences. The second was the semantic content of the target-initial elements, being either temporal or non-temporal. All discourses were coherent, and the same 10 verbs used in experiment 2 were used here as well. Example 5 shows one of the 160 blocks of lexical material used in this study:

5. Context: Das Auto war auf dem Sandweg steckengeblieben.
        The car had gotten stuck on the sandy path.

    Connective Targets:
    a. <u>Darum</u> beschaffte Niklas <u>Kies</u> für die Auffahrt.   (CC) Connective Causal
        Therefore got Niklas gravel for the driveway.
    b. <u>Danach</u> beschaffte Niklas <u>Kies</u> für die Auffahrt.   (CT) Connective Temporal
        Afterwards got Niklas gravel for the driveway.

    Non-Connective Targets:
    c. <u>Gestern</u> beschaffte Niklas <u>Kies</u> für die Auffahrt.   (IT) Non-Conn. Temporal
        Yesterday got Niklas gravel for the driveway.
    d. <u>Gern</u> beschaffte Niklas <u>Kies</u> für die Auffahrt.   (F) Filler Condition[3]
        Gladly got Niklas gravel for the driveway.

If the LAN found on the first word of the target sentences in experiment 2 was due to a contrast between causal and temporal elements, then the two connective conditions should differ accordingly, the causal connective condition showing a LAN and the temporal connective and non-connective conditions not differing from each other. If the contrast on was due to a difference

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[2] The model in its present form however makes no predictions as to the interaction between dimensions. It only states that connective ties serve to foreground one dimension.
[3] The ideal completion of the paradigm would have been a non-connective causal condition. However, there appear to be no non-connective causal sentential adverbs.

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in processing between connective and non-connective elements, then the two connective conditions should both show a LAN, and both differ from the non-connective temporal condition.

If the contrasts found in experiment 2 were triggered by the task-relevance of the connective ties, then there should be no effects found on the first word.

The stimuli were split into four lists of 160 sentences each and pseudo-randomized.

The method of stimulus presentation and data recording was the same as in the previous ERP study, with the exception that instead of a plausibility judgment a probe detection task was used. A word from the context or target was presented at the end of each trial that had either been or been not present in the previous two sentences. Neither the connective ties nor the non-connective target-initial adverbs were used in the task. 20 right-handed subjects that had not taken part in either of the previous two studies participated.

Two grand averages were calculated from the EEG data, one for the first word of the target sentences, and the other for the object and sentence-final prepositional phrase of the targets. Both were averaged according to the four conditions in example 5.

Figure 2 shows the ERP curves for the first word at site FC5 (left anterior) and the ERP curves for the object average by condition at the central anterior electrode FZ.

Legend:
— CC (n=20) conn. caus.
----- CT (n=20) conn. temp.
-·-·- IT (n=20)   non−conn. temp.
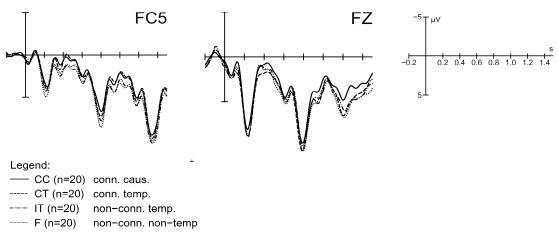········· F (n=20)   non−conn. non−temp

Figure 2: ERPs for the first word (FC5, left) and the object (FCZ, right) by condition, -200 to 1500ms, onset of critical words at 0ms, experiment 3, N=20.

The ERP results for experiment 3 were the following:

On the first word of the target sentences, there was a LAN found for both connective conditions for the left hemisphere, with a maximum at left anterior sites. There was no influence of lexical item found for this effect.

The object time window of the target sentence did not yield reliable ERP contrasts.

In the time window of the sentence-final prepositional phrase a contrast was found that visually appeared to exist between the causal connective condition CC and the other three conditions at central anterior and right anterior sites. Statistical analysis however showed that the contrast was reliable for both connective conditions compared to the non-connective conditions. There was no influence of lexical item found for this effect.

The replication of the LAN in experiment 3 was taken to show that the results of experiment 2 could indeed be interpreted as contrasts between connective and non-connective discourses. The lack of a difference between the two connective conditions in experiment 3 was taken to indicate that the LAN reflects the integration of the first sentence as the external argument of a two-place relation, and not the semantic evaluation of the semantic content of the connective ties. If that had been the case, then there should have been differences between the causal connective and the temporal connective condition. A third conclusion drawn from the occurrence of the LAN in experiment 3 was that the effect was indeed due to fundamental differences in processing between

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connective and non-connective elements, and not to task-relevance of the connective ties in experiment 2.

That there were no reliable contrasts between condition on the object of the target sentence was interpreted to show that foregrounding of either the temporal or the causal dimension in causally related coherent sentence pairs is possible, at least has no consequences on the integration of elements prior to the end of the discourse.

There were two possible interpretations regarding the contrast between connective and non-connective conditions at the end of the discourses.

The first alternative rested on the interpretation of the effect as a positivity for the non-connective conditions, following Kuperberg, Caplan, Eddy, Cotton & Holcomb, (2004), who interpreted a positivity found at the end of a two-sentence discourse for more obscure connections between the two sentences as a correlate of added inferencing cost, possibly a reflection of the update of the situation model. If seen as a positivity for the two non-connective conditions, the effect could be taken to reflect additional situation model updates for the non-connective conditions, an evaluation of all dimensions present in the discourse according to the Event-Updating Model. For the connective conditions, this evaluation would not be necessary under the assumption that foregrounding of one dimension via a connective tie results in all other dimensions being excluded.

The second alternative rested on the interpretation of the contrast as a negativity (SEN) for the two connective conditions, despite the fact that there were no violations present in the prior discourse. If seen as a negativity, the effect could be taken to occur not only in response to violation in previous material, but to reflect added integration cost of the message level representation or situation model in general. From that point of view, the foregrounding of a dimension in a text by way of a connective tie could result in the other dimensions present being backgrounded, but only until the end of the discourse, and evaluated at that point. Since there were no differences between connective and non-connective conditions indicative of added integration costs for the non-connective conditions at any point in the target sentences, and the latter interpretation would have to ignore the results reported by Kuperberg et al., the present work leans more towards the classification of the result as a positivity for the non-connective conditions, although further experimentation would have to confirm this hypothesis.

VIII. Experiment 4

In the last experiment, causal connective ties were compared to concessive connective ties. It was investigated whether the fact that concessive connective ties serve to announce unusual or surprising outcomes is made use of immediately upon encountering the connective tie, possibly eliciting a P3b indicative of the update of a situation model according to Donchin (1979, 1981) and Donchin & Coles (1988). The stimulus materials used in experiment 4 were manipulated along two dimensions. The first was the type of connective tie used, namely causal or concessive. The second was the probability of the outcome of the first sentence that was described in the second sentence, the internal argument. Causal connective ties were coherent with the probable outcomes while concessive connective ties were coherent with the improbable outcomes. Each type of connective tie occurred with probable as well as improbable outcomes, with the result that half of the stimulus materials contained a violation. This violation was however a violation of the semantic scale included in the internal argument: there was a causal relation present in all conditions, just not the 'right' one in half of the trials. Example 6 shows one of the 160 blocks of stimulus materials constructed:

6.   Context: In der Einladung wurde um formelle Kleidung gebeten.
                    The invitation requested formal dress.

       Coherent Targets:
       a.   Causal: Deshalb / Darum kaufte Sonja Lackschuhe in der Stadt.
                          Therefore bought Sonja patent leather shoes in the town.
       b.   Concessive: Trotzdem / Dennoch kaufte Sonja Turnschuhe in der Stadt.
                          Nevertheless bought Sonja jogging shoes in the town.

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Incoherent Targets:

c. Causal: <u>Deshalb / Darum</u> kaufte Sonja <u>Turnschuhe</u> in der Stadt.
   Therefore bought Sonja jogging shoes in the town.
d. Concessive: <u>Trotzdem / Dennoch</u> kaufte Sonja <u>Lackschuhe</u> in der Stadt.
   Nevertheless bought Sonja patent leather shoes in the town.

If the semantic content of the connective ties was integrated before the presentation of the object, then the concessive conditions should elicit an ERP effect (P3b) on the first word of the target sentences. Similarly, the concessive coherent condition should not elicit an N400 on the object, but both incoherent conditions should. If readers on the other hand blindly integrate elements according to a preferred straightforward cause-and-effect order, the concessive coherent and the causal incoherent conditions should elicit N400 effects. Since there were violations present in the stimuli, the respective incoherent conditions were expected to elicit sentence-end negativities (SENs).

The stimuli were split into four lists of 160 sentences each and pseudo-randomized. Presentation, the task used, and data recording were the same as in experiment 2. 22 right-handed subjects that had not taken part in any of the previous studies participated.

There were two grand-averages calculated. For the analysis of the first word of the target sentences, epochs were sorted by the four sentence-initial words (*deshalb*, *darum*, *trotzdem*, and *dennoch*), to examine possible immediate differences between causal and concessive elements as well as lexical items. For the analysis of the object of the target sentence, EEG-epochs were averaged according to the conditions a through d in example 6, starting from the presentation of the object and encompassing the sentence-final prepositional phrase. Figure 3 shows the ERP curves for the lexical average at sites FC5 (left anterior) and PZ (posterior central), and the ERP curves for the average by condition at the same electrodes.
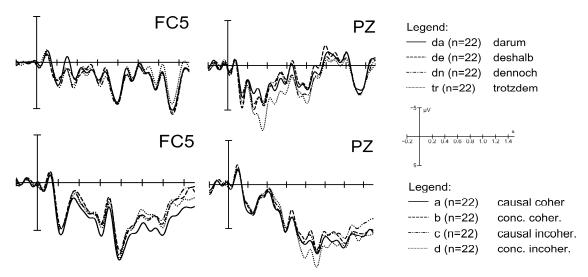

Figure 3: ERPs for the first word (FC5 and PZ, top row) and the object (FC5 and PZ, bottom row) by condition, -200 to 1500ms, onset of critical words at 0ms, experiment 4, N=22.

The ERP results for experiment 4 were the following:

There were no contrasts between conditions found for the first word at left anterior sites. There was a positivity for the condition *trotzdem* at posterior sites, followed by another, smaller positivity for both concessive conditions, visible at PZ in Figure 3, top row.

There were no contrasts between conditions in the N400-time window on the object of the target sentences. The concessive incoherent condition d elicited a late posterior positivity, visible at PZ in Figure 3, bottom row. On the sentence-final element, sentence-end negativities were found. At central anterior sites the contrast was between coherent and incoherent conditions, at

lateral anterior sites the contrast was between the causal coherent condition a and all other three conditions. The effect was reliable for both central and left-anterior sites.

The lack of contrast between causal and concessive elements for left anterior sites on the first word of the target sentences in experiment 4 was taken to support the notion that the LAN in experiments 2 and 3 reflected the integration of the first sentence, the context, as external argument of a two-place discourse relation, but not the semantic evaluation of the connective ties. This idea is supported not by the first positivity found for *trotzdem* (discussed below), but by the second, smaller positivity for both concessive conditions. This effect was interpreted as a P3b, indicative of a situation model update triggered by the concessive semantic content of *trotzdem* and *dennoch*. A similar update was not necessary for the causal or temporal connective ties in experiments 2, 3 and 4, since those elements were compatible with a straightforward, preferred intersententential relation, as suggested by Townsend (1983).

The first positivity was interpreted as an oddball effect (Duncan-Johnson & Donchin, 1977; Tueting, Sutton, & Zubin, 1970), triggered by the physical salience of the condition *trotzdem*, the only condition to have a sentence-initial word starting with a 'T', with 25% probability of occurrence, as opposed to a 'D' for the other three conditions, with 75% percent of occurrence. The alternative interpretation, that the earlier positivity reflects the situation model update predicted for only the condition *trotzdem* (with subject consequently not understanding the implications of *dennoch*) was examined, but rejected, since neither the behavioral data nor the post-session questionnaires nor the lexical frequency of the two connective ties suggested that subjects did not understand the meaning of *dennoch*. Additionally, the later positivity, very probably influenced in latency and amplitude by the earlier one, indicated that subjects did evaluate both concessive conditions.

There was no indication for added semantic integration costs for incoherent conditions on the object of the target sentences, i.e. no N400 effects. This finding could indicate that there is a qualitative difference between improbable and outright impossible outcomes in causal situations, since the obvious pragmatic violations in experiment 2 had elicited N400 effects. Since the causal incoherent condition did however not elicit an N400, it was postulated that cross-conditional interferences played a role. First, all incoherent continuations would have been coherent with the respective other connective tie, while all coherent continuations would have been incoherent. This added complexity of the materials might have resulted in the semantic integration of the objects being slowed down, according to the 3CAPS Model of discourse processing (Just & Carpenter, 1992; Carpenter, Miyake & Just, 1994; Just, Carpenter & Keller, 1996). Secondly, the close semantic relation between correct and incorrect continuations may have served to mask the violations, resulting in temporary semantic illusion (Hoeks, Stowe & Doedens, 2004; Kolk, Chwilla, van Herten & Oor, 2003; Nieuwland & van Berkum, 2005B). For the concessive incoherent condition, there was an indication that semantic illusion played a role, as this condition elicited a late positivity, similar to the effects found in the above studies. That the causal incoherent condition did not display this effect was accounted for by suggesting that the complexity of the material resulted in there being too few resources for a full calculation of the text representation, with a consequent fallback on local relations. In the concessive incoherent condition, the salience of the concessive connective ties might have raised the activation of the interclausal relationship, resulting in it being available not for an immediate diagnosis of the incoherence but a subsequent reanalysis as indicated by the late positivity.

On the sentence final element, the effects for central anterior electrodes indicate that subjects were aware of which conditions were coherent and which were not. The left-lateralized distribution of the sentence-end negativities was suggestive of the involvement of working-memory processes, possibly involving the explicit reactivation of the connective ties or the external argument. The occurrence of the SEN for all conditions but the causal coherent one suggested that the remaining three conditions demanded added integration work on the situation model or the 'message level' semantic representation. These results support the conclusion that readers do have a preference for canonical discourse relations, but not that readers blindly integrate elements according to such a preferred relation. If that had been the case, then the

concessive incoherent condition should not have elicited sentence-final effects, since without a concessive connective ties, this condition would have been as coherent as the causal coherent one.

IX. Conclusions

First of all, the theoretical distinction between connective and non-connective elements does have 'cognitive reality'. This was already shown in a number of previous studies (among them Caron, Micko & Thüring, 1988 and Ferstl & von Cramon, 2001). The present studies however show that there is also a difference between the one-place (deictical adverbs) and two-place (connective ties) discourse relations proposed by Pasch et al. (2003), since all three experiments in which this contrast was examined found clear indications of qualitatively different processing for connective ties (1, 2 and 3).

Secondly, the semantic content of different types of connective ties does play a role. This influence was found not with regard to the contrast found between connective and non-connective elements, the LAN, which is hence proposed to be a more abstract expression of the processing of connective ties. There was also no difference between causal and temporal connective ties prior to the end of the discourses in experiment 3. The incoherent discourses in experiment 2, and the comparison between causal and concessive connective ties in experiment 4 do however provide grounds for the conclusion that the semantic content of connective ties is made use of in processing, and that the relation signaled by the connective ties is the one readers attempt to make.

As to when the information connective ties provide used in processing, it seems that connectivity in general is taken at face value obligatorily. As long as the semantic content of the connective ties did not contradict a preferred simple cause-and-effect or linear first-and-second event order, there were no differences between the connective conditions (experiment 3), but the fact that concessive connective ties announce the need for a more complex situation model was evaluated immediately. Additionally, a violation of the intersentential relation resulted in an exacerbation of integration problems if a connective tie was present in experiment 2. It is therefore concluded here that connective ties influence the parsing process immediately.

This conclusion has to be qualified a bit, however, since the sentence-final elements suggested that connective ties triggered different end-of-discourse integration than non-connective elements. It seems that the answer to the question of when connective ties are processed is neither one of immediately nor at the end of the discourses, but that both positions (Millis & Just, 1994 and Deaton & Gernsbacher (in press) versus Haberlandt, 1982 and Traxler, Bybee & Pickering, 1998) have a point. It is suggested here that before the end of a discourse, economy plays an important role in that a straightforward causal or temporal relation is assumed unless there is evidence to the contrary (Townsend, 1983). A connective tie might serve to reduce dimensions calculated before the end of the discourse to that signified in its semantic content. At the end of the discourse, the text representation built is verified, and an integrated final situation model constructed, with all discourse dimensions present evaluated and taken into account, as suggested in the Event-Updating Model.

The studies reported in this dissertation show that connective ties are a useful way of investigating discourse processing, and that the ERP method is sensitive to a lot of the characteristica of connective ties.

X. References

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