# The Comprehension of the Passive Voice by Different Populations and the Effects of Structural Priming on this Process

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# CHAPTER I – GENERAL INTRODUCTION

# General Introduction

This thesis investigates the comprehension of the passive voice in three distinct populations. First, the comprehension of passives by adult German speakers was studied, followed by an examination of how German-speaking children comprehend the structure. Finally, bilingual Mandarin-English speakers were tested on their comprehension of the passive voice in English, which is their L2. An integral part of testing the comprehension in all three populations is the use of structural priming. In each of the three distinct parts of the research, structural priming was used for a specific reason. In the study involving adult German speakers, productive and receptive structural priming was directly compared. The goal was to see the effect the two priming modalities have on language comprehension. In the study on German-acquiring children, structural priming was an important tool in answering the question regarding the delayed acquisition of the passive voice. Finally, in the study on the bilingual population, cross-linguistic priming was used to investigate the importance of word order in the priming effect, since Mandarin and English have different word orders in passive voice sentences.

This introductory chapter will give an overview of all the relevant sections of the thesis, starting from the description of the passive voice in the three languages examined – German, English and Mandarin. Furthermore, certain key features of the passive voice will be compared across the languages in order to obtain a clearer picture of the relationships between them. In addition, previous research on the comprehension and production of the passive voice in all three populations will be described, followed by an overview of structural priming and the most important theoretical aspects of the method. The key method used in the current thesis was eye tracking. Some general background on the method with a focus on the visual-world paradigm will be given. Finally, the main questions of the thesis will be posed, followed by the expected outcomes and the relevance of the topic for future research and our understanding of language processing in humans.

## About the Passive Voice

Some types of sentences are produced and understood with more difficulty than others. While reading this, you probably did not even realize that the previous sentence was written in the passive voice. It does not state who produces and comprehends different types of sentences with difficulty. Nevertheless, it is perfectly clear that the doer of the action, the unnamed agent in the sentence, is *people*. In order to express certain ideas, we often use tools outside the lexicon – namely, the choice of syntactic structure can be used to convey a certain message in a specific way. If a sentence used is not the most frequent, canonical type of sentence suitable for expressing a certain idea, then it is usually marked in some way (Sturt, Keller & Dubey, 2010). Markedness here entails the preference for a specific structure in a given context. The choice of a less preferred structure carries this additional marked information that is outside of the lexical meaning of the words used in the sentence. This information provided through markedness is additionally outside of the semantic scope, since active and passive voices relate the same meaning and comprise identical roles – an agent and a patient.

The passive voice, the cross-linguistically marked structure when it comes to describing who did what to whom, exists in many languages and its processing and usage have been the focus of much research over the past several decades. It has been so popular because it can provide us with answers to a variety of questions. Research on this structure can tell us how syntax is processed in different populations, how thematic roles in a sentence affect its understanding, the importance of word order and animacy, whether there are similarities between syntax in different languages, and what similarities exist between language comprehension and language production. Studying passives can also help explain how language is acquired and processed by children and second-language learners. There are many more questions which the study of passives can help to answer, but the current thesis will focus on

the last three – the relationship between language production and language comprehension by using the effect of structural priming, the acquisition of language by children, and structural similarities between typologically distinct languages.

What exactly is the passive voice? In many of the world´s languages, there are two distinct grammatical voices – the active voice and the passive voice.[1] In English, active is the canonical structure (Slobin & Bever, 1982). It is the more common and unmarked form of a sentence which contains a transitive verb. The passive, on the other hand, is less common and is marked in the sense that it is used only under certain conditions. In English, for example, the passive appears 1026 times for every 100,000 words (as suggested by the corpus analysis in Huang, Zheng, Meng & Snedeker, 2013). There is often additional information provided when it is used (for the structure of a passive sentence, see Figure 1). The passive is derived from an active sentence, according to standard linguistic theories (Burchert & De Bleser, 2004). The passive is formed when the object NP of an active sentence is raised to the Spec IP position (Guasti, 2004). This forms the Argument chain, also known as the A-chain. The noun which would normally serve as the object of an active sentence comes into a more prominent position and becomes the subject in a passive sentence. This movement topicalizes the theme and makes the verb (and the actual doer – the *agent* of the action) of lesser importance. In this way, the topic of the sentence shifts, and what was prominent in an active sentence becomes of much less importance in a passive one, and vice versa (Turner & Rommetveit, 1967). This is why passives are the marked structure in languages in which actives are the canonical form. They are used in circumstances where the agent is either unknown or represents a more general entity – such as *people* or *everyone* (Armon-Lotem et al., 2016). The passive is marked in languages

[1] Numerous syntacticians also state the existence of the so-called `middle voice´ which exists in many languages, including English and German, and it denotes a structure on the crossroads between the active and the passive voice (Kemmer, 1993; Steinbach, 2002). An example of such a ´middle voice´ structure in English would be the sentence ´The book sells well,´ since it cannot clearly be placed in either of the two other voice categories. In German, a good example is the sentence ´Das Buch liest sich leicht,´ which translates as ´The book reads itself easily; The book is easy to read.´

that prefer the focus on the agent. In some languages, however, the preferred structure or at least the structure used equally as often as agent-first is patient-first. Such languages include Sesotho (Demuth, 1990), Standard Indonesian (Gil, 2008) and others.[2]

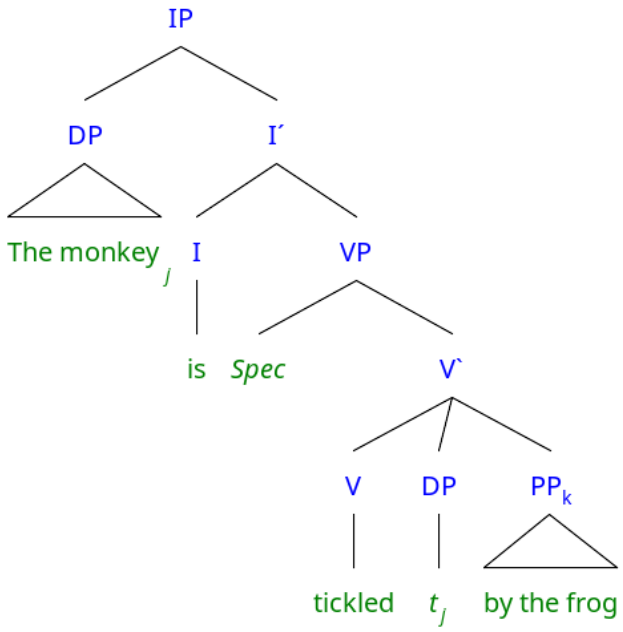


*Figure 1.1. The structure of a sentence in passive voice – $t_j$ in the DP of the verb marks the trace of the DP which is now raised to the IP Spec position (The monkey$_j$)*

Since the doer of the action is either unknown or signifies a more general and wide-ranging agent, it is often omitted from the passive voice sentences.

Short passives – also known as truncated passives – are a more common form than the full passive in many languages (Guasti, 2004). The short passive consists of the theme / experiencer and the verb (see Figure 2). The short passive in English can be read and comprehended in two distinct ways – it can be a full passive sentence, but also as an adjectival phrase. Instead of interpreting the sentence in [1] as a shortened version of a full passive, it can be read in the same way as [2]. This possibility of reading the shortened passive adjectivally

[2] Languages with a freer word order may not have such a strong preference for either. For instance, Turkish and Serbo-Croatian have a word order freer than English, but the sentence structure with the agent at the beginning and the theme after the lexical verb still constitutes the most common sentence type (Slobin, 1970).

exists in English and some other languages where the verbal morphology does not distinguish between the two forms. In German, for instance, this is not the case, and the two forms of the passive are distinguishable. The so-called stative passive, which uses the verb *sein* as the auxiliary verb, can be read adjectivally. The so-called eventive passive, with the auxiliary verb *werden*, cannot be read in this way.

[1] The door is closed.

[2] The door is blue.

This possibility of interpreting the passive adjectivally has consequences in terms of how it is processed. The passive interpretation requires the parser to understand the A-chain movement and the non-canonical structure. In the case of adjectival interpretation, there is no argument movement involved.

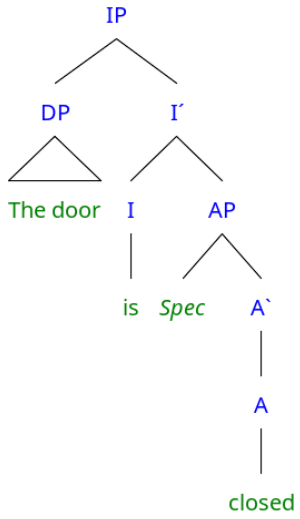


*Figure 1.2. The structure of a truncated passive sentence interpreted adjectivally.*

Passives in the German language share many of the characteristics of English passives, but they also have several important distinctive features. German passives, like the English ones, are formed by the movement of the theme to the more prominent position (e.g. Slobin & Bever, 1982; Armon-Lotem et al., 2016) (see Figure 3 for the structure of a German passive voice sentence). It can have a long and a short form. In the long form, the agent can be expressed through the *by-phrase* (*von-phrase*). It contains an auxiliary verb (*werden*) and a past participle of the lexical verb.

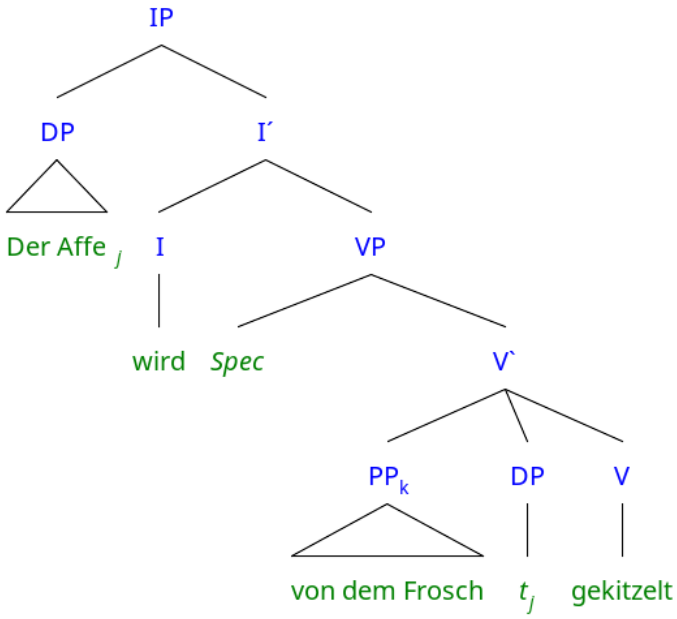


*Figure 1.3. The structure of a German passive sentence*

On the other hand, the German passive has a different word order than the one in English. In German passive sentences, the lexical verb occupies the final position, after the *by-phrase*. Also, the distinction between the stative [3] and eventive [4] passives is much more prominent than in English, since in German it is overtly marked (Kratzer, 2000). The German stative passive is formed with the auxiliary verb *sein* and the eventive passive with the auxiliary verb *werden*.

[3] Der Reis **war** von einem Experten gekocht.

The.NOM rice be.3P.SG.PAST by an.DAT expert cook.PART

*The rice was in a cooked state (having been cooked by an expert).*

[4] Der Reis **wurde** von einem Experten gekocht.

The.NOM rice become.3P.SG.PAST by an.DAT expert cook.PART

*The rice went through the process of being cooked (by an expert)*[3].

The passive voice in Mandarin Chinese is also formed by A-chain movement. It is even less frequent than the English passive, as it occurs 110 times for every 100,000 words (as suggested by the corpus analysis in Huang et al., 2013). It is marked by the auxiliary particle BEI, which is used solely for the purpose of marking the passive (Huang et al., 2013). This distinguishes the Mandarin passive from the English and German ones, since in those two languages the elements used in the formation of a passive sentence – the auxiliary verb, the *by-phrase* and the lexical verb in the past participle form – are also used to form other structures in the respective languages [5] and [6].

[5] Der Mann **wird** morgen reisen.

The.NOM man AUX tomorrow travel.

*The man is going to travel tomorrow. (future intent)*

[6] The baby is washed **by the bed.**

*(the locative usage of the by-phrase in English)*

[3] Examples adapted from Abbot-Smith & Behrens, 2006.

The passive voice in Mandarin has a different word order than that of English [7]. Whereas the English passive has the structure Theme-Verb-Agent, in Mandarin it is Theme-Agent-Verb (Li & Thompson, 1989). The word orders of the Mandarin passive and the German passive have the same word and constituent order.

| | | | | |
|---|---|---|---|---|
| [7] | NP1 | **BEI** | NP2 | Verb |
| | The monkey | BEI | frog | tickle |
| | *The monkey is tickled by the frog.* | | | |

The main context for use of the passive in Mandarin is adversity or danger (Li & Thompson, 1989). This type of construction depicts an action where something unwanted or "unfortunate" has happened. This makes passives in Mandarin highly marked, since the verbs receive a negative connotation, even when they have a neutral meaning in active sentences.

In summary, the passive voice in many languages is an infrequent and thus marked structure, though there are some exceptions to this. Typically, it is syntactically derived from an active sentence via A-chain movement. It shifts the focus from the agent and the action of the sentence to the patient. The agent can be completely omitted. Short passives without the agent can sometimes be interpreted as adjectival phrases, and in this case, the syntactic structure is simpler than that of a full passive sentence.

## Processing of the Passive Voice by Adults

Whenever adult speakers of any given language are tested on their processing of passives – be it comprehension or production – they typically do not exhibit difficulties with this structure. Some smaller variances between different groups of adults have been found. Since passives are generally an infrequent construction in everyday speech and tend to occur

more often in formal texts, individuals with higher academic attainment are faster at processing passives than individuals with lower academic attainment (Street & Dąbrowska, 2014). The lower academic attainment group performed just above chance level, more in line with the children acquiring the language than with the higher-performing adults. Also, both of the groups of adults found passive sentences with verbs that are infrequently passivized to be more difficult than sentences with verbs commonly used in passive constructions.

Adults tend to produce passives far less frequently than actives in free speech as measured by corpus data analyses. Depending on the language and the type of analysis, passives can represent anywhere between less than one and up to five percent of utterances (e.g. Slobin & Bever, 1982 for English, Turkish, Italian and Serbo-Croatian; Huang et al., 2013 for English and Mandarin; Perovic, Vuksanović, Petrović, & Avramović-Ilić, 2014 for Serbian; Arai & Mazuka, 2014, for Japanese). In a grammaticality judgment and reaction time study, Ambridge and colleagues (2016) investigated English-speaking adults' comprehension of passives. Their conclusion was that the semantics of the verb play a significant role in the reaction time and acceptability of a sentence when it is in the passive voice. The researchers presented the participants with three types of verbs from the perspective of their thematic role assignments. One group featured verbs that had Agent-Patient roles (e.g. *push*, *kick*, *wash*), another group had Theme-Experiencer roles (e.g. *scare*, *irritate*, *worry*), and the third group had Experiencer-Theme roles (e.g. *love*, *watch*, *ignore*). In one of the experiments, the participants were asked to rate the plausibility of the passive sentence with these verbs. In earlier grammaticality judgment experiments, participants were typically asked to rate sentences as either grammatical or ungrammatical. By enabling them to place the sentence somewhere along a scale of acceptability, a more fine-grained picture for the adequacy of passives was obtainable. Passive sentences containing verbs with the Agent-Theme thematic roles were the most likely to be marked as grammatical, whereas the verbs with the Theme-Experimenter roles were less likely

to be marked as grammatical. A similar outcome was seen in the reaction time measurement in the same experiment, where the participants were the fastest in determining whether the Agent-Theme verbs could be passivized.

In summary, in those languages that were tested, adult speakers did not exhibit major problems understanding the passive voice. Differences were noticed between adults with higher and lower levels of academic performance. Those with higher levels of academic performance were faster at processing the structure than the other group. Adults use passives relatively infrequently in many of the languages tested, and the verbs that require the Agent-Theme thematic roles are more likely to be marked as acceptable for passivization than those that require the Theme-Experiencer or Experiencer-Theme thematic roles.

## Acquisition and Processing of the Passive Voice by Children

Over the last half-century, numerous studies investigating the acquisition of diverse languages have shown that children exhibit difficulties with the acquisition and comprehension of passives until rather late in their language development. Depending on the particular study and the language in question, the age range for when the children start to understand passives near or at the adult level is between four and seven years of age (e.g. Turner & Rommetveit, 1967; Slobin, 1970; Slobin & Bever, 1982; Borer & Wexler, 1987; Ellis, 2002; Hirsch & Wexler, 2004; Armon-Lotem et al., 2016). This might come as a surprise, considering that children produce and comprehend the active voice at a very young age, already at about the age of two (Slobin, 1970; Slobin & Bever, 1982; Bencini & Valian, 2008). With a few exceptions (e.g. Demuth, 1990; Gil, 2008), it would seem that whenever the acquisition of passives is tested, children struggle with it and underperform with the structure.

When it comes to their acquisition, not all passives are the same. Some studies have shown that short passives might be easier for children to understand than full ones (Fox & Grodzinsky, 1998). Also, the type of verb appears to affect the comprehension of passives in children as well. Previous research has shown that action verbs (those with the Agent-Theme thematic role assignment) tend to be easier for children to comprehend in a passive sentence than non-action verbs (Fox & Grodzinsky, 1998; Hirsch & Wexler, 2004; Ambridge et al., 2016). The sentence ´*The boy is loved by the girl*´ would in this case be more difficult for children than the sentence ´*The boy is pushed by the girl.* ´ As seen in the studies on adults' understanding of passives, the thematic role assignment plays a significant role there as well. Adults are faster and more likely to accept a passive with verbs that have the Agent-Theme structure. In their understanding of passives, children start out with semantically-constrained knowledge (Ambridge et al., 2016). According to some theories, their understanding of passives is related to particular verbs and they do not generalize across new verbs that they acquire. Young children copy the utterances of their caregivers, so they use passives only in the way the caregivers do, basically by repeating the exact same sentence. Children do not spread their knowledge of the passive to new verbs. This generalization occurs at a later point. For this reason, their understanding of passives is poor (but, see Bancini & Valian, 2008).

There are different explanations as to why this delay in the acquisition of passives occurs in children. One group of theories focuses on the relative infrequency of passives in language overall, particularly in child-directed speech (e.g. Demuth, 1990, Ellis, 2002). Another set of theories blames the *by-phrase* of the passive sentence, claiming that young children misinterpret it, which then leads to the faulty understanding of the entire sentence (Fox & Grodzinsky, 1998; Guasti, 2004). Yet another group of theories states that the A-chain itself and the movement needed for the formation of a passive sentence are too difficult and out of reach for children

before the necessary neural and cognitive maturation takes place (Borer & Wexler, 1987; Hirsch & Wexler, 2004).

The first theory supposes that passives are acquired more slowly due to their relative infrequency. Children acquire language from their environment. The more common a structure is, the faster children acquire it and start using it. At first, this usage is lexically bound (Savage, Lieven, Theakston & Tomasello, 2003, Bencini & Valian, 2008). This means that, in very early stages, children first learn a specific structure – in this case the passive voice – bound to a specific lexical structure. Their knowledge of the passive is connected only to certain words (most commonly verbs). Children at this stage are not able to separate the verbs from the syntactic structures in which they heard them. In other words, if a child hears a certain verb used in the passive, that child will probably be able to use the verb in the passive later on, basically copying the structure they heard from a caretaker or another adult. They cannot abstract their knowledge and understanding of the passive voice to new sentences. Because of this lack of exposure, children acquire passives rather late. Studies that showed early abstraction of passives looked at languages where the passive construction is either as common as or even preferred over the active voice, for Sesotho (Demuth, 1990) and for Standard Indonesian (Gil, 2008).

Another reason proposed for the delay in the acquisition of passives lies in the interpretation of the *by-phrase*. Young children can process passive voice sentences more-easily in their shortened / truncated form (Fox & Grodzinsky, 1998; Guasti, 2004). In their short form, passive sentences can be parsed adjectivally, and this is an easier task for them than the A-chain movement and the theme rising to the prominent position in a sentence (Marshall, Marinis, & van der Lely, 2007). When a child encounters a full passive sentence with the agent expressed via the *by-phrase,* she finds it difficult to assign a proper theta role to this noun phrase which occurs at an "unexpected" position within a sentence (Fox & Grodzinsky, 1998). Children start

off by thinking that they are encountering a regular active sentence, and after the *by-phrase* they have difficulties re-assigning the proper theta-roles, so they tend to perform at chance level. Alternatively, children tend to stay with the active interpretation or look for other cues within the sentence which could help them properly interpret it – e.g. morphological cues, real-world knowledge, prosody, context (Savage et al., 2003).

The third group of theories focuses on children's inability to appropriately comprehend the movement of the theta roles once the A-chain is formed (Borer & Wexler, 1987; Hirsch & Wexler, 2004; Marshall et al., 2007; Amridge et al., 2016). According to this approach, children are unable to properly parse the movement that characterizes the formation of any (full) passive voice sentence (see Figure 1). According to Guasti, passives would be considered one of the UG universals, and thus should be readily available for children from an early stage (Guasti, 2004). However, not all elements of language are available from the start, and psychological and neurological maturation is needed before the full command of passives is accessible for children (Borer & Wexler, 1987; Hirsch & Wexler, 2004).

In summary, previous research has shown that children acquiring multiple languages struggle with the passive voice until rather late in their development. Different theories have been developed over time to account for this delay. One theory blames the infrequency of the passive voice in the language input, so that children are not exposed to the structure often enough to learn it properly. Another approach focuses on the *by-phrase* of full passive sentences. Young children have problems assigning a proper theta role to an agent of the action who is located in an untypical place within the *by-phrase*. Children have fewer problems comprehending short passives without the agent, because there is only one theta role to assign. Furthermore, children start producing short passives earlier in their development. The third theory focuses on the A-chain and its raising, which are too difficult for children to comprehend

before a certain age. Young children lack certain neurological and psychological maturation before this complex syntactic process becomes available.

### Acquisition and Processing of the Passive Voice by Bilinguals

To my knowledge, there are no studies that specifically look at the processing of passives in bilinguals per se as an isolated process. The studies that do investigate the processing of passives usually involve structural priming, which will be discussed in the next segment. In these studies, bilingual participants are exposed to passives in one language, usually their L1 (but this could also be their L2), and then they are asked to describe an image in their other language (Loebell & Bock, 2003 for German-English bilinguals; Hartsuiker, Pickering & Veltkamp, 2004 for Spanish-English bilinguals; Chen, Jia, Wang, Dunlap & Shin, 2013 for Chinese-English bilinguals). The latter two studies show that bilinguals are more likely to produce passive sentences in a picture-description task after priming than before. Loebell and Bock (2003), however, did not find a priming effect between English and German for passives, but with the double-object dative structures (e.g. `*The boy sent his pen-pal a letter´*) the priming effect was visible cross-linguistically. Loebell and Bock, (2003) also compared the performance of the bilinguals to that of monolinguals and found that monolingual German speakers did exhibit the priming effect. Their conclusion was that the difference in the word order between English and German passive structures was the reason why cross-linguistic priming was not successful for passives, but was present in another structure where the two languages have the same word order – thematic role order.

## Methodological Background

## What is Structural Priming and What can it tell us About the Processing of the Passive Voice?

Structural priming is a well-known phenomenon in psycholinguistics, where exposure to a certain structure affects the subsequent processing of upcoming sentences (Bock, 1986; Branigan, Pickering, Liversedge, Stewart & Urbach, 1995). These sentences can be similar to one another – using the same verb for example – or they can be lexically unrelated: there may be no overlap in the nouns or verbs used, but the structure of the sentence itself will be identical or related. By *structure*, most psycholinguists mean the syntactic form of the sentence. If the sentence presented is passive, the participants will be more likely to produce another passive sentence (e.g. Bock, 1986; Hartsuiker & Kolk, 1998; Bock & Griffin, 2000). Priming does not only affect the production of new sentences. After exposure to a passive sentence, the comprehension of the structure is affected because the parsing becomes faster or easier (e.g. Arai & Mazuka, 2014).

Several explanations exist as to why structural priming happens and what its function is. It may serve as a useful tool for speaker alignment in dialogue (Branigan et. al., 2007), where one speaker repeats a structure previously used by the interlocutor. This helps the interlocutors agree on a subconscious level. Another likely reason is the implicit learning account (Chang, Dell, Bock, & Griffin, 2000; Savage, Lieven, Theakston & Tomasello, 2006; Fine & Jaeger, 2013). It says that priming is the way in which new syntactic structures are acquired. Learning happens because the parser becomes familiarized with the primed structure due to repeated exposure. The structure was previously not expected and, because of this, an error occurred each time during its interpretation. This repeated exposure would lead to increased expectations of encountering the structure. Yet another approach is the Temporary Activation Hypothesis (Pickering, Branigan, Cleland & Stewart, 2000). According to this theory, structural priming temporarily facilitates access to a given structure. This essentially means that previous exposure

makes it easier to process the same structure immediately afterwards, due to the activation of the necessary neural connections.

## Structural Priming in Production

Priming in language production means that participants are more likely to use a certain structure in describing an image or answering a question if they have just heard that same structure used previously. This can be a passive sentence, a double-object construction, a subject cleft, relative clauses or another structure, depending on the study and language in question (e.g. Branigan, Pickering & Cleland, 2000; Branigan, Pickering, McLean & Cleland, 2007). The speaker may not necessarily be aware that she is using the primed structure. This suggests that priming occurs as an unconscious mechanism which affects language processing. Priming in production has been proven to be effective in children (e.g. Savage et al., 2003; Bencini & Valian, 2008) adults (e.g. Bock, 1986; Bock & Griffin, 2000) and bilinguals (e.g. Hartsuiker et al., 2004; Schoonbaert, Hartsuiker & Pickering, 2007; Kidd, Tennant & Nitschke, 2015).

## Structural Priming in Comprehension

The priming effect manifests itself in different ways in language comprehension – for instance, through faster reaction times in a self-paced reading task (Jaeger & Snider, 2013; Myslín, & Levy, 2016; Hsieh, 2017), through more overall looks towards a target image, or anticipatory looks towards an image that corresponds to the prime sentence in an eye-tracking experiment (e.g. Thothathiri & Snedeker, 2008; Arai & Mazuka, 2014). Anticipatory looks represent the gaze shift towards the image which the participant expects to be mentioned next in the sentence. (Arai, van Gompel, & Scheepers, 2007; Arai & Mazuka, 2014; Traxler, Tooley

& Pickering, 2014). Anticipatory looks reveal the predictive nature of language processing, since the focus of attention is on a part of a sentence which is not yet heard (Kuperberg & Jaeger, 2016). Eye-tracking studies using the visual-world paradigm have shown that comprehenders direct their gaze faster towards the target image presented on a screen when they were exposed to a structurally similar prime sentence before the presentation of the target sentence (Arai, et al., 2007; Thothathiri & Snedeker, 2008; Arai & Mazuka, 2014; Traxler et al., 2014). There are also ERP studies looking at the brain's responses during sentence comprehension with structural priming. The results of these studies show a reduced positivity in the time window analogue to the P600 signal after exposure to a prime. The P600 component marks a registered positivity occurring at about or after 500 ms post-stimulus onset, and is typically interpreted as a processing of ambiguous sentences, or reanalysis of incorrect syntactic structures (Ledoux, Traxler & Swaab, 2007; Tooley, Traxler & Swaab, 2009; Chen, Xu, Tan, Zhang & Zhong, 2013). The primed structure is in all cases a reduced relative clause, and the reduction occurs after the disambiguating phrase.[4] Before priming, the P600 is found at this region due to a garden-path effect and the initial misinterpretation of the sentence by the participants. After priming, the surprisal effect is lower, as the expectation of the relative clause increases. The reduced positivity result was interpreted as a lowered cognitive load needed for processing the targeted structures after already being exposed to the same type of structures immediately before.

[4] For instance, the P600 component for the target sentence `*The manager proposed by the directors was a bitter old man´* was smaller after priming with a sentence that has an identical structure, such as `*The speaker proposed by the group would work perfectly for the program´* than after a sentence *´The speaker proposed the solution to the group at the space pogram´* (Ledoux et al., 2007).

## Structural Priming of the Passive Voice

The passive voice has been a widely-used construction in structural priming studies for decades. Already Bock (1986) investigated whether increased exposure to passive voice sentences leads to an increased production of the passive voice by participants. Passives are a good structure to combine with priming because they are relatively rare in most of the languages investigated so far and are distinctively different from actives in those same languages. In order for priming to occur, the structure needs to be relatively infrequent (Loebell & Bock, 2003; Chang, Dell & Bock, 2006; Reitter, Keller & Moore, 2011). Over the years, different studies have used priming of passives with all of the populations on which priming studies have been conducted. Adults have been primed for their comprehension of passives (e.g. Bock, 1986; Segaert, Menenti, Weber & Hagoort, 2011), as have children (e.g. Bencini & Valian, 2008; Arai & Mazuka, 2014; Gámez & Vasilyeva, 2015), and bilinguals (e.g. Bernolet, Hartsuiker & Pickering, 2009; Chen et al., 2013; Hartsuiker et al., 2014; Hsieh, 2017).

These studies used priming of passive voice structures for various reasons. Some wanted to compare the comprehension of passives in children and adults, others looked at syntactic comprehension in bilinguals and how lexically driven it is, and yet others were interested in the lexical overlap between the prime and the target, and the effect it has on the strength of the priming effect. What the results of all the different studies show is that after exposure to a passive structure in priming, participants are more likely to use passives to describe an image or a situation in studies focusing on language production; or, they look more often towards the correct image, reacting faster or having reduced P600 components after priming in studies focusing on language comprehension. The lexical (and semantic) similarity between the prime and the target increases the priming effect, but it is not crucial for the priming effect to take place. These studies show that even though passives are infrequent in spoken language, increased exposure to them can increase their production under experimental circumstances.

The effect is strongest with adults and bilinguals since priming can occur with a minimal overlap (lexical, semantic or word order) between primes and targets. The children's data tend to show that larger overlap between the prime and the target is needed for priming to have an effect. The children's data leads to the conclusion that they have more difficulties with the structure and tend to interpret it in a more restricted way, not being able to separate their lexical knowledge of verbs from the abstract knowledge of the passive voice. When it comes to cross-linguistic priming in bilinguals, successful priming between languages is indicative of how the knowledge of the structure extends across languages regardless of other linguistic domains such as phonology, morphology and even word order.

There are claims that structural priming of passives (or many other structures, for that matter) is not a purely syntactic phenomenon. It is more related to the shift of prominence from the agent to the theme, where this shift in prominence is what is actually being primed (Hare & Goldberg, 1999; Popov & Hristova, 2014; Köhne, Pickering & Branigan, 2014). In other words, what causes the priming effect is on the level of semantics and the switching between the thematic roles (and possibly word order), not the syntactic structure itself. For this reason, the authors make a distinction between **structural priming** on the one hand and **(pure) syntactic priming** on the other. Structural priming entails priming the entire structure of the sentence, which includes its syntactic form, thematic roles and possibly word order, although the latter is not always necessary for successful priming to occur. Pure syntactic priming, then, means that only the syntactic structure of the prime sentence causes the participant to produce a sentence with the identical syntactic structure, even without matching theta roles. Although it is clear that, when passives are concerned, their syntactic structure and thematic role assignment are closely connected, it is difficult to disentangle the effects of syntax from the thematic role / semantic effect. The three studies that did try to do this (Hare & Goldberg, 1999; Popov & Hristova, 2014; Köhne et al., 2014) only managed to show that thematic role assignment in

combination with the word order can be primed. In the two experiments, the position of the θ-roles in the prime caused the participants to use the same order of θ-roles in their utterances. They did not, however, manage to find the pure syntactic priming effect. For this to happen, the prime and target structures would need to have the same syntactic form, yet different thematic roles. As already mentioned, these two elements are usually closely connected and mutually dependent. In this work, I will primarily use the term **structural priming**, as the separation of syntactic and semantic forms in the passive is difficult to track and not the focus of this thesis.

## Eye Tracking and the Visual-World Paradigm as a Window into Syntactic Processing

Eye tracking has been used by psycholinguists for decades. It is a non-invasive tool that can show real-time processing of language in virtually all populations. The basic idea of eye tracking is to make use of a specific means of information processing and attention focusing in human adults, namely that we look at things that are talked about. It designates the connection between the human mind and body and our body's ability to react to cognitive stimuli in various ways. In this specific context, it is our eyes´ tendency to focus on the most important piece of information or the one that is being processed at the moment.

Some eye-tracking studies have used the so-called 'poor-man´s eye tracker' (Thothathiri & Snedeker, 2008; Hung et al., 2013). This is essentially a regular camera placed in the center of an elevated surface where several different objects are placed in the four corners. The participants listen to the target sentence and the camera measures their gaze. After the experiment, the looks need to be coded, usually manually, for each frame of the video individually. Most of the eye-tracking research has been performed with professional high-resolution eye trackers that automatically follow and mark the gaze throughout the experiment.

Linguistic studies using eye tracking can be divided into two main categories –reading studies and visual-world paradigm studies.[5] The former involve participants reading words or sentences on a screen while their eye movements, first pass, saccades, fixations, speed-ups and other information are measured (e.g. Traxler et al., 2014; Fine & Jaeger, 2013). The visual-world paradigm combines spoken language which is presented auditorily – either via loudspeakers or via headphones – with an image on a screen. In other words, it combines language and visual stimuli, which is similar to how language is processed in the real world. In the visual materials, there can be one figure on the screen, two or more of them depicted (see Figure 4 for examples), or it can be a video presentation. The choice of the visual materials depends greatly on the question the study wants to address. The main premise of the visual-world paradigm is that the participants tend to look towards the part of the screen that matches the element of the audio-presented sentence they are currently processing, or that they believe will be mentioned next. Since human language tends to be predictive in nature (e.g. Chang et al., 2006; Huang et al., 2013; Kuperberg & Jaeger, 2016), the parsers´ looks would reflect this tendency by focusing on the segment they expect to hear next. Their looks would be fixated on the element on the screen that would match the most probable interpretation of the sentence. That tendency can be used to investigate language parsing in real time. This is done by exposing individuals to multiple plausible elements on the screen and then measuring at what point in time they focus on the target one (the one that matches the target sentence they heard). Furthermore, it can also be determined which of the other plausible elements not included in the sentence were focused on, for how long and to what degree. The paradigm has proven a valuable tool for investigating syntactic processing in very young children (e.g. Trueswell, Sekerina, Hill & Logrip, 1999; Thothathiri & Snedeker, 2008; Arai & Mazuka, 2014). It is also

[5] There are also other types of studies conducted with the help of the eye-tracking technology that will not be discussed in much detail, such as pupillometry (for an overview of the method, see for example Laeng, Sirois & Gredebäck, 2012; and for its use in language studies, see for instance Engelhardt, Ferreira & Patsenko, 2010).

widely used with adult participants, however, as it can provide useful information on language parsing in real time.

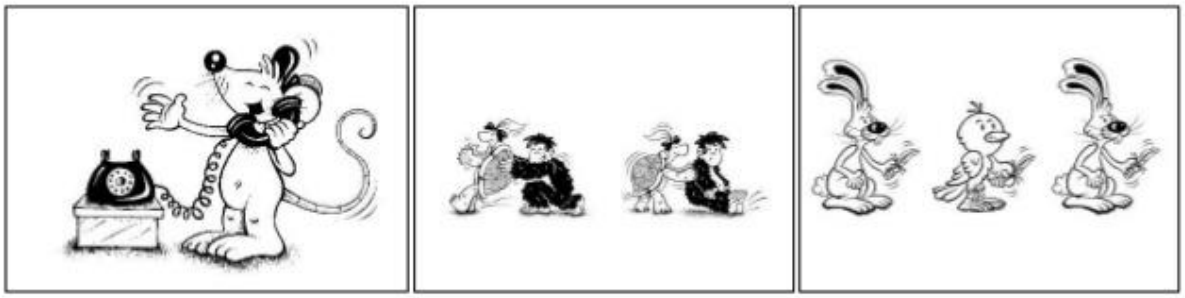

*Figure 1.4. Examples of visual-world scenes with one, two and three objects / figures*

The visual-world paradigm has been used in research on passives throughout the years. The main contribution of this paradigm to the study of passives is the possibility to measure the exact timing at which participants commit to the passive interpretation of the sentence. As previously mentioned, passives as an infrequent structure with a non-canonical thematic role assignment are usually not expected by the parser, so participants in the visual-world paradigm experiments tend to first look towards an image that would match the active interpretation of the sentence being played auditorily. At some point during the sentence presentation, the participant realizes that the sentence is actually in the passive voice, and switch her gaze towards an image that matches such an interpretation of the sentence. The processing of the passive voice has been investigated using the visual-world paradigm in Japanese adults and children (Arai & Mazuka, 2014), German adults and children (Haendler & Adani, 2013), Chinese adults and children (Huang et al., 2013), English healthy adults and adults with aphasia (Meyer, Mack & Thompson, 2012), and English-speaking children and adults (Stromswold, Eisenband, Norland, & Ratzan, 2002). These studies focused on different languages and the main questions they addressed differed somewhat, but the results of all of them can be summed up as follows: healthy adult monolingual speakers tend to look towards the correct image on the screen relatively quickly during the presentation of the passive target sentence. The

conclusion from this is that they correctly parse the passive target sentence relatively quickly, and they usually do not need to hear the entire structure. Depending on the language, this typically occurs immediately after the first disambiguating element that they come across – the first element from the onset of the sentence that unambiguously makes that sentence passive. On the other hand, children and individuals with aphasia exhibit difficulties processing the passive voice. Their looks towards the image on the screen that matches the passive interpretation of the sentence is closer to chance level and it takes more time for them to commit to the passive interpretation. They need to hear more disambiguating elements or, alternatively, they need more time to process the elements they hear.

## The Current Thesis

This thesis will investigate the processing of the passive voice from three different perspectives. It will look at the comprehension of passives by German-speaking adults and how different priming modalities influence this processing. It will also investigate the processing of passives by German-acquiring children and investigate how priming affects their parsing of the structure. Finally, the processing of passives by bilingual Mandarin-English speakers will be tested in order to see whether and in what way the comprehension of passives in L2 can be affected by priming in L1.

The first study will consider how German-speaking adults process the passive voice. The passive in German has several characteristics which make it an interesting candidate for such an experiment. On top of that, two distinct priming modalities will be directly compared. Structural priming denotes previous exposure to a certain structure, but what does this previous exposure mean exactly? Is it enough for the participant to just hear the prime sentence in order for them to be primed and faster at processing it afterwards, or does the participant need to repeat the prime sentence first? Different studies have used both of these methods, which are

referred to here as ‘receptive’ and ‘productive’ priming. Receptive priming is the silent exposure in which the prime is merely heard (and presumably understood). Productive priming entails repetition of the prime sentence by the participant. This seemingly simple dichotomy between silent listening and repetition of the prime structure has important implications for our understanding of the distinction between language production and language comprehension. Previous research has directed little attention to direct comparison of the two in an experimental setting, yet theoretical work on the relationship between language comprehension and language production has been an important topic for decades.

The second study will investigate the comprehension of passive sentences and the effect priming has on German-acquiring children. Previous research on the acquisition of passives has established the approximate timing of the acquisition in German-acquiring children. They start to comprehend passives close to the adult level between the ages of four and five. The current study will use eye tracking with the visual-world paradigm and structural priming to answer two main questions. The first question regards the timing of the processing. How much of the passive sentence do German-acquiring children need to hear before committing to the passive voice interpretation? Unlike English, German is morphologically more marked and thus has a freer word order. Both should affect children’s processing of German passives. The second question has to do with the cause for delay in the acquisition of passives. Three main theories explaining late acquisition and difficulties comprehending the passive voice have different predictions for the outcome of the experiment. These three theories about delayed acquisition all have different predictions for the effect structural priming might have on children´s comprehension of passives. The outcome of the second study will show which one is the most likely cause of the delay, at least with regard to German-speaking children.

Finally, the third study will look at the processing of the passive voice in English by bilinguals. Recent work has shown that syntactic processing can be shared between different

languages. It would seem that fluent bilinguals store the information about grammar from their L1 and L2 together, and thus access the necessary information in a similar manner. Cross-linguistic priming has proven to be a practical tool for testing this claim. The current experiment investigates priming from L1 Mandarin into L2 English for the passive voice. Apart from the syntactic structure, other elements of the passive voice in the two languages differ – word order and thematic role order.[6] The languages are also typologically different, and by using different lexical materials in the primes and targets, all other overlaps are avoided apart from syntactic form and the fronting of the theme.

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[6] In both Mandarin and English, the theme of a passive sentence is the first NP, but the agent and the VP have different positions within the sentence in the two languages.

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# Chapter II: The Effects of Productive and Receptive Structural priming on the Comprehension of German Passives: an Eye Tracking Study

**The Effects of Productive and Receptive Structural priming on the Comprehension of German Passives: an Eye Tracking Study**

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**Abstract**: The relationship between language production and language comprehension is one of the most important questions in psycholinguistic research. Some theories claim both are closely related and connected. Others, however, state that a connection exists but is rather weak; the two modalities of language function mostly unrelatedly or are at least not tightly intertwined. To investigate this dichotomy, an eye tracking experiment with a modified single image paradigm was designed, and the comprehension of passive sentences in adult German native speakers was tested. Based on Bock and colleagues' 2007 study, a priming paradigm was developed. The results show that both priming from comprehension and priming from production have a facilitative effect on the comprehension of passives, but the effect of productive priming is significantly stronger. These results support the weak connection hypothesis between language production and language comprehension.

# Introduction

## The relationship between language production and comprehension

One of the most important questions in language processing studies is whether there is a direct connection between the production and the comprehension of language, and how such a connection manifests itself. This connection is important for better understanding of language processing in general. Pickering and Garrod (2013) were the first to propose a comprehensive theory of production and comprehension which incorporates both modalities. They proposed

that language production and language comprehension is closely intertwined and mutually support each other. Since the publication of their paper, some further experimental work has been done to show how the production-comprehension relation manifests itself, but no clear conclusion has been reached.

## Priming as a method of testing this relationship

Structural priming has been proven to be an adequate psycholinguistic method for testing this relationship. Syntactic or structural priming is a well-documented phenomenon in which exposure to one type of structure affects the subsequent processing of lexically unrelated sentences (Bock, 1986; Branigan, Pickering, Liversedge, Stewart & Urbach, 1995).

There are different interpretations as to why priming happens and what its function is. One theory claims it may be a useful tool for speaker alignment in dialogue (Branigan et. al., 2007) where one speaker repeats a structure previously heard from an interlocutor. Another theory, the implicit learning account (Chang, Dell, Bock, & Griffin, 2000; Bock & Griffin, 2000) states that priming is how new structures are acquired. Learning happens because the individual becomes familiarized with the primed syntactic structure due to repeated exposure to it. Another approach is the Temporary Activation Hypothesis (Savage, Lieven, Theakston & Tomasello, 2006). According to this theory, structural priming temporarily facilitates the access to a given structure. This essentially means that previous exposure makes it easier to process the same structure immediately afterwards, due to the activation of the necessary connections.

When it comes to the relationship between production and comprehension in language, structural priming can be useful in two ways. For the first, it can show how previous exposure to a structure affects language production and how it affects language comprehension. The second is to look at how **productive priming**, where the participants produce the prime

sentences themselves and **receptive priming**, where participants only need to passively listen to and understand the priming sentence – affect language processing, and whether a difference between the two exists. The current study will investigate the effects of both receptive and productive priming on language comprehension. The aim is to see whether both priming modalities have an effect on syntactic processing, and if there is any difference in the priming pattern between them. A successful cross-modal priming – productive priming which affects the processing of a receptively encountered sentence – would support a close relationship between the two language modalities. On the other hand, an absence of such priming or a significant difference between the patterns of the two priming modalities would possibly indicate a separation between the systems involved in the production and comprehension of language.

## Previous priming in production studies

In studies on language production, structural priming means that after exposure to a certain type of a sentence, e.g., a direct object relative clause, a speaker is far more likely to produce the same structure (e.g. Branigan, Pickering & Cleland, 2000; Branigan, Pickering, McLean & Cleland, 2007). The speaker would not necessarily be aware that she had used the primed structure, which suggests that priming results from an unconscious mechanism affecting language processing. Priming effects consistently show that the production of sentences is facilitated by previous exposure to a structurally similar sentence. Bock and colleagues (2007) provided the first language production study which directly compared the effects from receptive and productive priming. In their experiment, participants either only passively listened to a prime sentence or repeated a prime sentence out loud before they needed to describe a target image. The structures that were investigated were English passives and dative double-object or prepositional object sentences. The results showed that both receptive and productive priming

had an effect on the choice of the structure used in the picture description task. Participants produced more passive and certain types of transitive sentences[7] after priming with corresponding structures. Priming was evident even after several intervening trials, and there was no significant difference in the effect between the two priming modalities. The exposure to a prime without a response and its overt repetition led to the same outcome. Bock and colleagues (2007) interpreted their findings as evidence for an integrated system for language production and comprehension. The shared systems between the two language modalities – production and comprehension – enable cross-modal priming, i.e. receptive priming to a language production task.

## Previous priming in comprehension studies

In language comprehension studies, the priming effect can be revealed in different ways – for example, through faster reaction times in a self-paced reading task (Jaeger & Snider, 2013; Myslín, & Levy, 2016), through more overall looks towards a target image, or anticipatory looks towards an image which corresponds to the prime sentence in an eye tracking experiment. Anticipatory looks represent the gaze shift towards the image which the participant expects to be mentioned next in the sentence (Arai, van Gompel, & Scheepers, 2007; Arai & Mazuka, 2014; Traxler, Tooley & Pickering, 2014). Anticipatory looks reveal the predictive nature of language processing, since the focus of attention is on a part of sentence which is not yet heard (Kuperberg & Jaeger, 2016).

7 In their study, participants were primed either by a dative double object sentence *(The team owner told the columnist an offensive joke.*) or by a dative prepositional sentence *(The team owner told an offensive joke to the columnist.*). In both instances, the participants were more likely to use the structure they were primed with when describing an image which depicted an unrelated transitive action (Bock et al., 2007).

Eye tracking studies using the visual-world paradigm have shown that listeners direct their gaze towards the target image presented on a screen more quickly when being exposed to a structurally similar prime sentence before the presentation of the target sentence (Arai et al., 2007; Thothathiri & Snedeker, 2008; Arai & Mazuka, 2014; Traxler et al., 2014). A study by Arai and colleagues (2007) showed facilitative priming effects only when there was a lexical overlap, i.e., when the verbs in the prime sentence and target sentence were identical, but no such effect when the verbs were different, in spite of the syntactic structure of the sentence being the same. The work by Thothathiri and Snedeker (2008) looked at the priming effects from comprehension to comprehension with transitive double-object sentences. The results of their three experiments show that priming has an effect on the comprehension of such structures in adults, and it is noticeable after the end of the first NP which follows the verb. In their eye tracking study with the visual-world paradigm, this was exhibited in more looks towards the image which corresponded to the primed structure interpretation. Differently to Arai and colleagues study (2007), the outcome here was that the verb does not need to be identical between the target and the prime for priming to have an effect. A similar outcome was also found in an eye tracking study by Traxler and colleagues (2014) which involved a reading paradigm, where participants first silently read the primes and then the targets, written on the screen. The structures in question were reduced relative clauses, and the dependent measure was the first pass time and the total time of fixations. In this instance, as well as in Arai and colleagues' study (2007), the repetition of the verb led to stronger priming effects. This means that participants moved their gaze more quickly from the disambiguating region after a prime with a similar structure.

Arai and Mazuka (2014) investigated the comprehension of Japanese passive sentences after exposure to an active or a passive prime in a visual-world paradigm. They found a strong priming effect, as indicated by more looks to the target image after priming. The effect had

already occurred before the disambiguating second NP appeared in the target sentence, showing that the participants were more likely to interpret an ambiguous sentence as passive rather than active after a passive prime sentence. The participants had already diverted their gaze towards the image, which would correspond to a passive interpretation. The effect was strongest in adults, followed by 6-year-old children, with 5-year-olds exhibiting the weakest effect.

There are also ERP studies looking at the brain's responses during sentence comprehension with structural priming. The results of these studies show a reduced positivity in the time window analogue to the P600 signal – after exposure to a prime. The primed structure was in all cases a reduced relative clause, and the reduction occurred after the disambiguating phrase. Before priming, the P600 is found at this region due to a garden-path effect i.e. the initial misinterpretation of the sentence by the participants. After priming, the surprisal effect is lower, as the expectation of the relative clause increases. The P600 component marks a registered positivity occurring at around or after 500 ms post stimulus onset and is typically interpreted as the processing of ambiguous sentences, or the reanalysis of incorrect syntactic structures (Ledoux, Traxler & Swaab, 2007; Tooley, Traxler & Swaab, 2009; Chen, Xu, Tan, Zhang & Zhong, 2013). The reduced positivity result was interpreted as indicating a lowered cognitive load being required for processing the targeted structures, after already having been exposed to the same type of structures immediately before.

## Research question

To the best of my knowledge, no previous study on language comprehension has directly compared the effects which the receptive and productive priming have on language comprehension. The only other study that has compared the effects of the two priming modalities was the language production study by Bock and colleagues (2007) mentioned above.

Furthermore, previous studies which have looked at the effect of either the receptive or productive priming on language comprehension did not include a control group in their research. Having a control group which is not exposed to any type of priming can serve as a better baseline for the research on priming effects on language comprehension. Using a between-subject design, in which one group is exposed to priming and another group is not, creates optimal testing conditions. With this in mind, the current focuses on the two following questions:

- Is there a difference in the effect of receptive and productive priming on language comprehension?
- Is there a difference in language comprehension between the receptive and productive priming groups, and a control group which has been exposed to no priming at all?

If the effect of receptive and productive priming is the same, that would further support the theories which suggest a close connection between language production and language comprehension (Bock et al., 2007; Pickering & Garrod, 2013). However, if there is a significant difference in the effect size or pattern, that could undermine the premise that the relationship between the two language modalities is tight. In that case, it would be possible to assume that differences in the two language modalities – production and comprehension - are greater than the similarities. Alternatively, it could be claimed, in this case, that priming and / or eye tracking may not be the most suitable methods for testing the relationship between language comprehension and production.

## Motivation: Why eye-tracking is useful

Eye tracking is a method well-suited to researching language comprehension. The participants in a typical visual-world paradigm experiment need to listen to sentences and look at a set of images or videos. This is as close as possible to the natural language processing which occurs in the real world. A typical eye tracker used in visual-world experiments has a high temporal resolution. It enables tracking for where on the screen the participants looked, and the different points of the sentence they were listening to. This makes it possible to pinpoint the exact time at which the focus of the participant shifts from one image to the other, and when participants decode the target sentence. Even more importantly, it is possible to align the gaze shifts and patterns to specific regions in the sentence.

## Short preview for experiment and hypotheses

The current study aimed to broaden the scope of previous experiments by looking at the effects of different priming modalities on language comprehension. It compared receptive and productive priming, and their effects on the comprehension of sentences. Performance after priming in both of these modalities was compared to the performance of a control group for which the target sentences were not primed

Comparing the results of the primed group to a non-primed control group is important, because the non-primed data presents the most suitable baseline for analysis. This approach has only previously been used in production studies. In some production studies, indeed in most comprehension ones, the participants were typically exposed to an unrelated structure which served as a replacement for a prime. These were, for instance: an active voice in a passive voice priming experiment (Thothathiri & Snedeker, 2008; Messenger, Branigan, McLean, 2012; Arai & Mazuka, 2014); cleft sentences in passive voice priming experiments (Bernolet, Collina & Hartsuiker, 2016); intransitive sentences in a passive voice and double-object priming

experiment (Bock et al., 2007); transitive sentences in a double-object / sentential complement priming experiment (Myslín & Levy, 2016). The current study used both approaches as controls for the passive voice priming – one group was exposed to active voice primes before the passive voice targets, and another group was not exposed to any prime sentence before the passive voice target.

The current study used eye tracking with the visual-world paradigm, which has proven to be successful in structural priming experiments with adults as well as with children. Based on previous research on structural priming in language production and comprehension, both receptive and productive priming should lead to more looks towards the target image at an earlier point during the target sentence presentation, i.e. anticipatory looks towards the target.

## Methods

**Participants**: 78 adult native German speakers took part in the study (15 male; mean age: 23 years, age range: 18-44). The participants were students and employees of the University of Potsdam, and they participated for class credits or a cash reward. All reported having normal or corrected-to-normal vision, normal hearing and no neurological or psychological problems. They were all native speakers of German, with no simultaneous bilingual background. The ethics approval was received from the ethics committee of the University of Potsdam, and all the participants signed an informed consent form prior to the start of the experiment. The participants were randomly assigned to one of three experimental groups. The first group (N=26) was the receptive priming group which would only passively listen to the prime. The second group (N=26), the productive priming group was asked to repeat the prime sentence out loud after hearing it. The third group of participants (N=24) was not exposed to any priming.

**Materials and Design**: The language materials comprised German sentences, either in the active or passive voice. For use in the prime sentences, 6 high-frequency transitive verbs were selected (*tragen* "carry", *jagen* "hunt", *füttern* "feed", *treten* "kick", *küssen* "kiss" and *ziehen* "pull"). Each verb was used in four prime sentences throughout the experiment, twice in active and twice in passive voice. Six other high-frequency transitive verbs were selected for the target sentences (*kämmen* "comb", *zeichnen* "draw", *fangen* "grab", *schieben* "push", *waschen* "wash", *kitzeln* "tickle"). Each verb was used in four different target sentences. Each verb was a regular German verb, meaning it formed the past participle – used in the passive verb form in German – with the prefix *ge-*. Because the prime and the target sentences did not share the same verbs, the lexical boost effect from the priming verb was avoided, and the focus was solely on the syntactic structure (Rowland, Chang, Ambridge, Pine & Lieven, 2012).

Four animal names were chosen as arguments for both the prime and target sentences – *der Hase* (the rabbit), *der Vogel* (the bird), *der Affe* (the monkey) and *der Frosch* (the frog). These nouns are marked for masculine gender on the determiner. In German, unambiguous case marking is only present for masculine nouns. Thus, the function of the noun phrases was clearly marked by the form of the determiner preceding the nouns (see examples 1. and 2.) and the sentence was unambiguous. Furthermore, two of the nouns were additionally marked with a suffix -n when in the Accusative or Dative (*den*/*dem Affe<u>n</u>* – the monkey, *den*/*dem Hase<u>n</u>* – the rabbit). German nouns marked for feminine and neuter gender have determiners which sometimes overlap in their paradigms. In other words, the determiners sometimes have the same form in different grammatical cases, or the form is shared with another gender.

The animals were selected and paired so that they did not represent each other's prey or natural enemy (such as cat and mouse, or shark and seal), thus real-life knowledge could not interfere with sentence interpretation.

1. Der Hase kitzelt den Vogel.

The,MASC.NOM rabbit tickles the.MASC.ACC bird.

*The rabbit is tickling the bird.*

2. Der Hase wird von dem Vogel gekitzelt.
   The.MASC.NOM rabbit AUX by the.MASC.DAT bird tickled.
   *The rabbit is tickled by the bird.*

In the experimental sentences, the nouns *der Affe* and *der Frosch* always occurred together as a pair, as did the nouns *der Vogel* and *der Hase*. For the creation of the prime sentences, each of these two pairs of nouns was combined with all of the 6 prime verbs. Each sentence was presented once in an active and once in a passive voice. This resulted in 24 prime sentences (6 verbs x 2 animal pairs x 2 sentence types = 24 items). The same pairs of nouns were used (i.e. *der Affe* with *der Frosch* and *der Vogel* with *der Hase*), but with 6 other verbs to create the targets, yielding 24 target sentences. Every participant was presented 4 times with each of the 6 verbs. However, they only heard the same verb twice in the same voice (two times in active and two times in passive). Even then, this repetition of the same verb in the same voice was done in combination with a different pair of animals. In other words, each experimental item was a unique sentence and was presented only once (see Figure 2.1 for the experiment layout of the receptive and productive priming groups).

| **Experiment conditions and number of items per condition** | | **Priming sentence type** | |
|---|---|---|---|
| | | *Active* | *Passive* |
| **Target sentence type** | *Active* | 6 | 6 |
| | *Passive* | 6 | 6 |

*Figure 2.5. Experiment layout for the priming groups - conditions and the number of items per condition*

Two pseudo-randomized experiment lists were compiled from the primes and the targets. In the lists, the same verb was never repeated twice in a row, nor the same voice (active or passive) repeated more than twice in a row. On top of this, the primes and the targets were put together in such a way that the same combination of prime-target sentences did not appear as an item in the experiment more than twice in a row. For instance, if a passive prime sentence was followed by a passive target sentence, this combination appeared at most twice in a row. This held for all other possible combinations of primes and targets (passive prime – active target; active prime – active target and active prime – passive target). One list started with an active sentence as the target, and the other started with a passive sentence as the target. Participants were randomly assigned to one of the two lists before the beginning of the experiment.

The experiment had a 2 x 2 x 2 factorial design with priming condition (receptive, productive) as a between-subjects factor and prime sentence type (passive voice, active voice) and target sentence type (passive voice, active voice) as within-subjects factors. In addition to this, a control group not exposed to the primes but only to the target sentences was tested.

The sentences were recorded by a female native German speaker in a sound-proof recording room. The pitch of each sentence was normalized using Praat software (Boersma, & Weenink, 2015).

The visual materials comprised two types of images – one image for each prime sentence and another image for each target sentence. All images were black-and-white drawings of the

Figure 2.6: Example of an image that accompanied the prime sentence

animals which were referred to in the sentences performing an action. In the images for the prime sentences, two animals performed an action that matched the meaning of the corresponding sentence (see Figure 2.2). The images for the target sentences featured one animal in the center, and two other animals, which were identical to each other, on either side of the central animal (see Figure 3). The animals all faced the same direction and performed the same action. Set up in this way, one image can correspond to an active voice and to a passive voice sentence interpretation (e.g. *The rabbit is tickling the bird. / The rabbit is tickled by the bird.*). As previously mentioned, such an adjusted single-image paradigm has proven especially suitable for eye tracking experiments since it simplifies the image (e.g. Scheepers & Crocker, 2004; Arai, van Gompel & Scheepers, 2007; Adani, 2011; Arai & Mazuka, 2014).

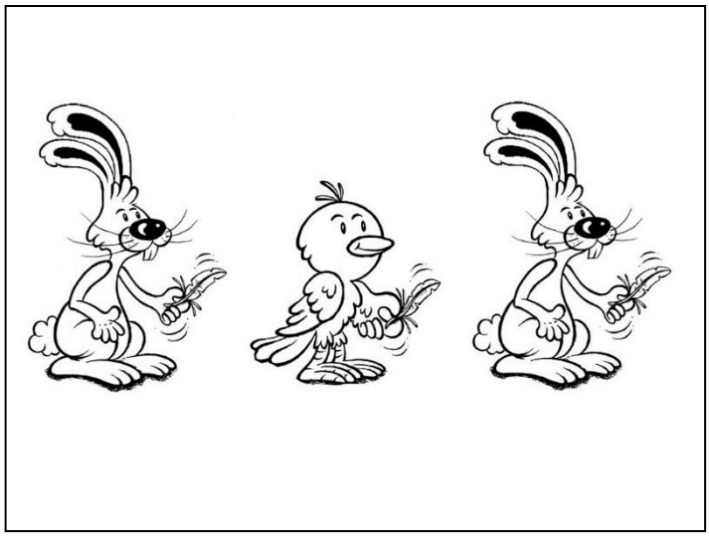

Figure 2.7: Example of an image that accompanied the target sentence

In each trial, the first noun phrase of the target sentence referred to the two identical animals on each side of the image (*rabbit* for the example in Fig. 2.3) and was always the sentence subject with nominative case marking. This way, a temporary ambiguity was created at the end of the first noun phrase which still allowed for an active or a passive interpretation of the sentence, i.e., interpreting the rabbit as the agent or the patient of the action. This ambiguity could only be resolved when the verb (active or passive form) was presented. A distinction could therefore be made between the looks to the image that match the target sentence interpretation and those that do not match the target sentence interpretation. If, for instance, the target sentence is a passive one (*The rabbit is tickled by the bird*), the participants would fixate their gaze towards the rabbit that is the patient of the tickling action first, then also towards the bird, who is the agent. They should therefore ignore the rabbit who is doing the tickling. By comparing the proportion of looks towards the animal matching the target sentence interpretation – the target animal – with the looks towards the animal that represents the incorrect interpretation of the sentence – the distractor animal – a conclusion can be made about how the participants interpreted the target sentence. Since the participants were primed before they were exposed to the target, their looking patterns could be expected to differ depending on the type of prime. As previous literature on priming passive voice in comprehension has shown, it can be expected

that participants parse the passive target faster after passive priming. Active voice should not affect the comprehension of a passive sentence, since it is already the more common and highly-expected structure. The structures which are less frequent, and therefore less expected, are more suitable candidates for structural priming (Thothathiri & Snedeker, 2008; Myslín & Levy, 2016). Apart from the effect of structural priming, a possible difference may occur in the pattern of looks regarding the type of priming – receptive or productive.

Four practice items were also created, following the same principle as the prime and target items, but the practice items included intransitive / unergative verbs (dream of, run, swim, talk on the phone – *träumen von*, *laufen*, *schwimmen*, *telefonieren*) to avoid exposing the participants to too many transitive verbs in either the active or passive form before the experiment. Two additional animals were used (the turtle and the mouse – *die Schildkröte*, *die Maus*).

**Procedure:** The experiment took place in a specially prepared room at the University of Potsdam with no natural light. The Tobii 1750 binocular eye tracker was used with 50 Hz temporal resolution. The stimuli were presented using ClearView software, version 2.5.1, on a 17-inch TFT display with 1280 x 1024 resolution.

After signing the consent form and reading the instructions for participation in experiments with human subjects, both of which were approved by the ethics committee of the University of Potsdam, the participants were seated in front of the eye tracker at a distance of about 60 cm from the screen. The experimenter briefly explained the form of the experiment to the participants, focusing on what they should do when they hear a prime sentence. For the productive priming group, the participants were instructed to repeat the prime sentence that they had heard. The participants in the receptive priming group were instructed to stay silent but to pay attention to the sentences.

A brief introduction video explained the procedure in detail. This video consisted of an image of a female face and the audio recording of the full instructions which were recorded by the same female speaker who recorded the items in the experiment. The instructions for the productive priming group stated that they should repeat the sentence they heard after seeing the signal on-screen (the signal was the face of the female character). The receptive group´s instructions said that they would see images and hear sentences, and that they should focus on them the whole time. No overt task, as a response to the test sentences, was given to either of the groups. After these introductions, any questions about the procedure were answered, and then the recording of the experiment began. First, the four practice items were presented. The participants were instructed to look at the images and listen to the sentences. They were told that they should focus on all the items, because they would be asked questions about the sentences in a second, offline part of the experiment. After the eye tracking part of the experiment, the participants were debriefed and it was explained to them what the actual purpose of the study was, so no additional offline questioning was performed.

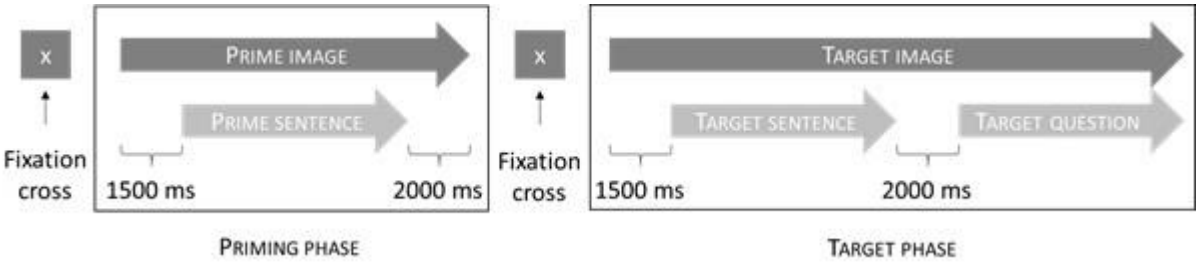


*Figure 2.4: Experimental procedure for the receptive priming group*

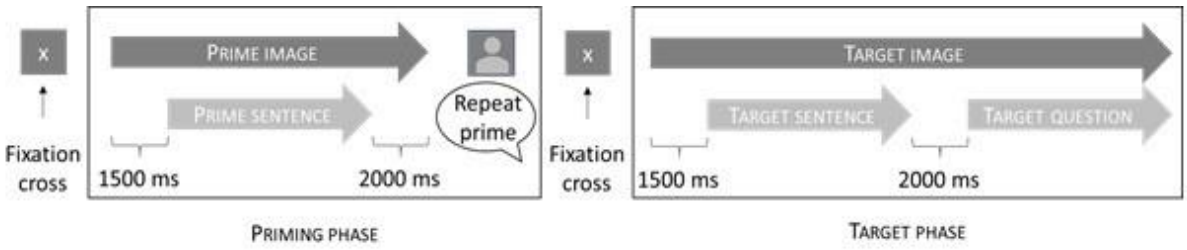


Figure 2.5: Experimental procedure for the productive priming group

In both the receptive and the productive priming conditions, each trial started with the presentation of the prime image. 1500 ms after the priming image had appeared on the screen, the acoustic presentation of the prime sentence started. The prime image remained on the screen for further 2000 ms after the end of the sentence. Then a fixation cross appeared on the screen for the receptive priming group (see Figure 2.4). For the productive priming group, the prime image also stayed on the screen for 2000 ms after the end of the sentence, but then a face appeared on the screen, signaling that the participant should now repeat the prime sentence out loud. After the participant's repetition of the sentence, the experimenter finished the priming phase for this group by pressing a control button (see Figure 2.5) and the fixation cross occurred at the screen. The fixation cross was presented for 500 ms to both groups. The procedure for the control group did not contain any priming.

After the priming, the target image was displayed on the screen. 1500 ms after the image had appeared on the screen, the presentation of the target sentence started. The target image stayed on the screen for 2000 ms after the sentence ended. Following this, a comprehension question was asked - "Can you see this monkey / frog / rabbit / bird?" ("*Kannst du den Affen / Frosch / Hasen / Vogel sehen?*"). This question was used to maintain the attention of the participants, and they did not need to provide an answer. After that, the next trial started immediately. This part of the experiment was identical for the receptive priming, the productive priming and for the control group of participants.

## Preparation of data for analysis

The target animal is the one of the two identical animals on the target image that matches the thematic role (agent or patient) of the first NP of the target sentence. The distractor animal is the second identical animal on either the right or the left side of the image. The eye gaze data was analyzed, starting from the onset of the sentence. The first 2000 ms of this data was taken

for the analysis, since this length of time roughly corresponded to the average duration of the target sentences in the experiment. Mean values of looking scores were calculated for every 200 ms of the time window taken into the analysis. The proportion of looks to the target animal was calculated as the amount of looks to the target vs the amount of looks to the distractor animal in each of the time windows. This way, 11 time windows were created, starting from the sentence onset at 0 ms and ending at 2000 ms. These time windows were chosen as it takes approximately 200 ms for an eye to program and execute a saccade (Thothathiri & Snedeker, 2008). The onset of each sentence was determined using PRAAT (Boersma, & Weenink, 2015) and the eye tracking data of all participants, and was baselined to this onset for each item (see Figure 2.7 in the data analysis section). This baselining is performed by labeling the onset of each target sentence auditorily as the time segment zero. Any possible misalignment is therefore avoided and the measurements for all of the items are comparable.

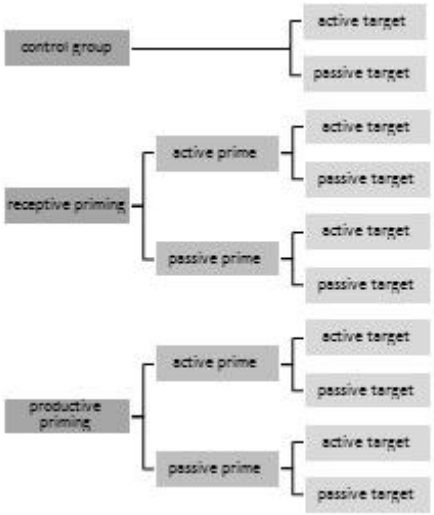


*Figure 2.6. Experiment design*

Due to the nature of the items, prime sentence type (active or passive voice) and target sentence type (active or passive voice) were combined together with priming condition (control group, receptive priming, productive priming) into a single variable for analysis. This means that there were no separate levels in the data analysis for prime type and target type. This was done in order to enable meaningful data processing. The control group had no prime, so it would not have these levels in the linear model and this would lead to an inadequate model fit (see

Figure 6 for the breakdown of the experiment variables). In the end, the experiment data was sorted into a 5 x 2 design – five priming groups x two target sentence groups. The priming groups were:

1. Control group;
2. Receptive priming – active prime;
3. Receptive priming – passive prime;
4. Productive priming – active prime;
5. Productive priming – passive prime.

Passive voice target data was compared between the receptive priming and the productive priming groups. Similarly, the active voice target data was compared to the control group´s active voice sentences. No comparison was performed between the active and the passive targets in any of the groups.

## Data Analysis

The analysis was done using log ratios of the proportion of looks towards the target versus looks to the distractor animal during the presentation of the target sentence. For the analysis, mixed effect models were fitted, using the R program (R Development Core Team (2008) and the lme4 package (Bates, Maechler, Bolker & Walker, 2015). The model included the combined factors of priming condition + prime sentence type and target sentence type as fixed effects. As for random effects, participants and items were included in the analysis. A Likelihood Ratios Test was used to compute the *p*-values. The analysis was done for each of the 11 time windows separately. The proportions of looks towards the target animal of the control group (no priming) for the passive target sentence condition was used for the intercept. This enabled direct

comparison of the looking proportions between the control group and both of the primed groups. Since the baseline for the analysis was the control group and their passive target sentences, all of the comparisons were made with this group´s looks during passive target sentences. A separate model was constructed for the active target sentences analysis. The residuals of the final model appeared to be normally distributed upon visual inspection (see Table 1. for an overview of the results).

## Results

In the time windows 0 and 200 ms there were no significant differences between the looks to the target of the control group and both the receptive and productive priming groups. At time window 400 ms, both the receptive priming group (β=0.0879; SE=0.0435; z=2.0212; p=0.044) and the productive priming group (β=0.1075; SE=0.0480; z=2.2409; p=0.025) had significantly more looks towards the target animal than the control group. In the time window 600 ms, the receptive priming group was not significantly different to the control group in the proportion of looks to the target (β=0.0691; SE=0.0416; z=1.6595; p=0.097), whereas the productive priming group had significantly more looks directed towards the target animal (β=0.1559; SE=0.0507; z=3.0766; p=0.002). In the time windows 800 ms, 1000 ms and 1200 ms, both receptive and productive priming groups showed significantly more looks to the target than the control group (see table 1). In the time window 1400 ms, again, only the productive priming group had significantly more target looks than the control group (β=0.1262; SE=0.0546; z=2.3110; p=0.022), whereas the receptive priming group did not (β=0.0671; SE=0.0459; z=1.4603; p=0.145). In the later time windows (1600 ms, 1800 ms and 2000 ms) there were no significant differences between the groups.

**Table 1.**

Analysis output for log ratios of proportions of looks towards the target versus the distractor image, and the results for all of the time windows with the passive priming sentence, passive target sentence and the priming modality (control group, receptive and productive)

| | β | SE | z-value | p-value |
|---|---|---|---|---|
| Time window 0 ms | | | | |
| (Intercept) | 0.1305 | 0.0226 | 5.7782 | <0.001 |
| receptive priming | 0.0250 | 0.0383 | 0.6536 | 0.514 |
| productive priming | 0.0039 | 0.0435 | 0.0889 | 0.929 |
| Time window 200 ms | | | | |
| (Intercept) | 0.1533 | 0.0238 | 5.7782 | <0.001 |
| receptive priming | 0.0530 | 0.0411 | 0.6536 | 0.198 |
| productive priming | 0.0641 | 0.0482 | 0.0889 | 0.184 |
| Time window 400 ms | | | | |
| (Intercept) | 0.1817 | 0.0240 | 7.5837 | <0.001 |
| receptive priming | 0.0879 | 0.0435 | 2.0212 | 0.044* |
| productive priming | 0.1075 | 0.0480 | 2.2409 | 0.025* |
| Time window 600 ms | | | | |
| (Intercept) | 0.1971 | 0.0244 | 8.0664 | <0.001 |
| receptive priming | 0.0691 | 0.0416 | 1.6595 | 0.097 |
| productive priming | 0.1559 | 0.0507 | 3.0766 | 0.002* |
| Time window 800 ms | | | | |
| (Intercept) | 0.1950 | 0.0256 | 7.6029 | <0.001 |
| receptive priming | 0.1095 | 0.0406 | 2.6949 | 0.007* |
| productive priming | 0.1760 | 0.0507 | 3.4719 | <0.001* |
| Time window 1000 ms | | | | |
| (Intercept) | 0.2213 | 0.0268 | 8.2444 | <0.001 |
| receptive priming | 0.0851 | 0.0418 | 2.0371 | 0.042* |
| productive priming | 0.1969 | 0.0510 | 3.8603 | <0.001* |
| Time window 1200 ms | | | | |
| (Intercept) | 0.2580 | 0.0264 | 9.7755 | <0.001 |
| receptive priming | 0.0859 | 0.0424 | 2.0259 | 0.043* |
| productive priming | 0.2008 | 0.0512 | 3.9231 | <0.001* |
| Time window 1400 ms | | | | |
| (Intercept) | 0.3561 | 0.0303 | 11.7487 | <0.001 |
| receptive priming | 0.0671 | 0.0459 | 1.4603 | 0.145 |
| productive priming | 0.1262 | 0.0546 | 2.3110 | 0.022* |

| | | | | |
|---|---|---|---|---|
| Time window 1600 ms | | | | |
| (Intercept) | 0.4221 | 0.0299 | 14.1375 | <0.001 |
| receptive priming | 0.0772 | 0.0450 | 1.7150 | 0.088 |
| productive priming | 0.0458 | 0.0561 | 0.8161 | 0.415 |
| Time window 1800 ms | | | | |
| (Intercept) | 0.4758 | 0.0284 | 16.7731 | <0.001 |
| receptive priming | -0.0176 | 0.0437 | -0.4031 | 0.687 |
| productive priming | 0.0042 | 0.0539 | 0.0786 | 0.937 |
| Time window 2000 ms | | | | |
| (Intercept) | 0.5039 | 0.0285 | 17.6662 | <0.001 |
| receptive priming | -0.0297 | 0.0432 | -0.6884 | 0.492 |
| productive priming | -0.0526 | 0.0526 | -1.0005 | 0.318 |

*Table 2.1: Data Analysis output*

In order to compare the effects of receptive priming and productive priming with one another, the same model was fitted again, but with the baseline set to the target looks for passive sentences of the receptive priming group instead of the control group. This enabled a direct comparison with the productive priming group. The difference between the receptive priming and the productive priming was significant in two consecutive time windows: in the time window at 1000 ms (β=-0.1118; SE=0.0548; z=-2.0401; p=0.042) and at 1200 ms (β=-0.1149; SE=0.0554; z=-2.0757; p=0.038). In both time windows, the productive priming group had significantly more looks towards the target image than the receptive priming group. In all other time windows, the difference between the two priming conditions was not significant (see figure 2.7).

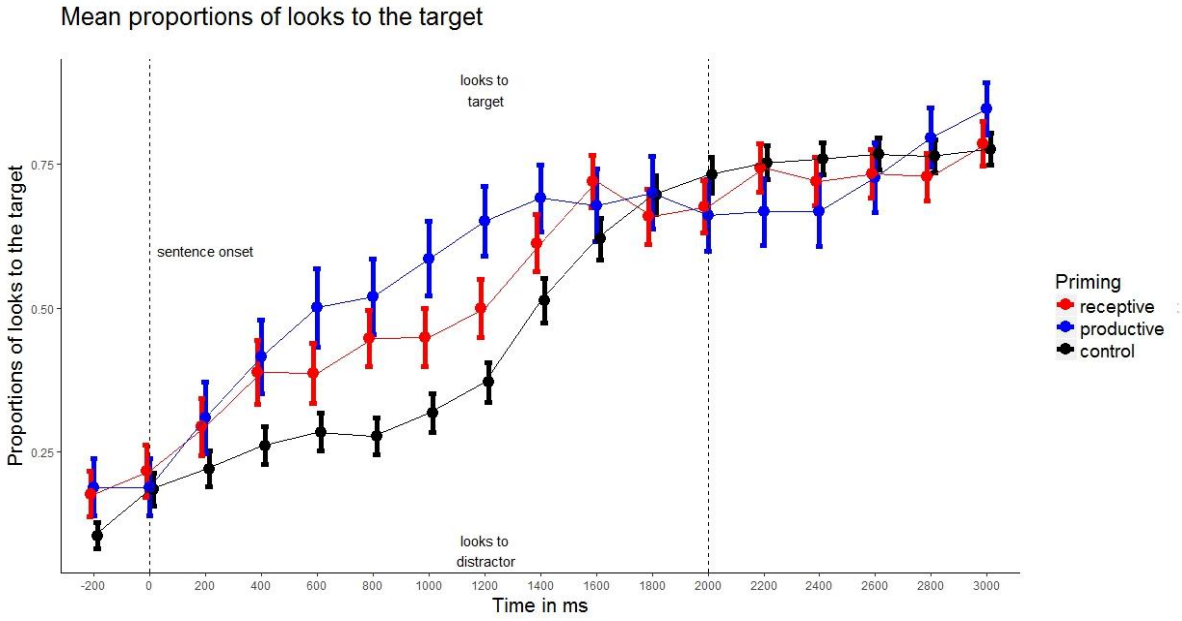


*Figure 2.7. Average proportions of looks towards the target during the presentation of a passive target sentence after hearing a passive prime sentence. The vertical lines correspond to the averaged onset of the sentence – 0 ms, and the average onset of the lexical verb – 2000 ms. The plot does not take into account the data adjusted for random effects, thus certain differences to the data analysis output occurred.*

The active voice priming condition did not lead to any significant differences between the priming groups.

A separate model was fit for the proportion of looks for the active target sentences. The active sentences of the control group were entered as the baseline (see Figure 2.8). The model was constructed in the same way as that for the analysis of passive target sentence looks. In this new analysis, receptive priming led to significantly fewer looks to the target image, which means it had an inhibitory effect in time windows from 600 ms up to 1200 ms post sentence onset – for time window 600 (β=-0.1778; SE=0.0430; z=-4.137; p<0.001); for time window 800 (β=-0.1681; SE=0.0421; z=-3.989; p<0.001); for time window 1000 (β-0.1149; SE=0.0421; z=-2.729; p=0.006); and for time window 1200 (β=-0.0969; SE=0.0412; z=-2.350; p=0.019). Productive priming showed an inhibitory effect in time windows at 400 ms, 600 ms and 800 ms post sentence onset – for time window 400 (β=-0.0997; SE=0.0488; z=-2.041; p=0.042); for time window 600 (β=-0.1736; SE=0.04814; z=-3.606; p<0.001); and for time window 800 (β=-0.1510; SE=0.0513; z=-2.946; p=0.003). There was no significant difference

between the two different priming modalities here in any of the time windows. Furthermore, there was no effect of exposure to passive prime sentences when the target sentences were active.

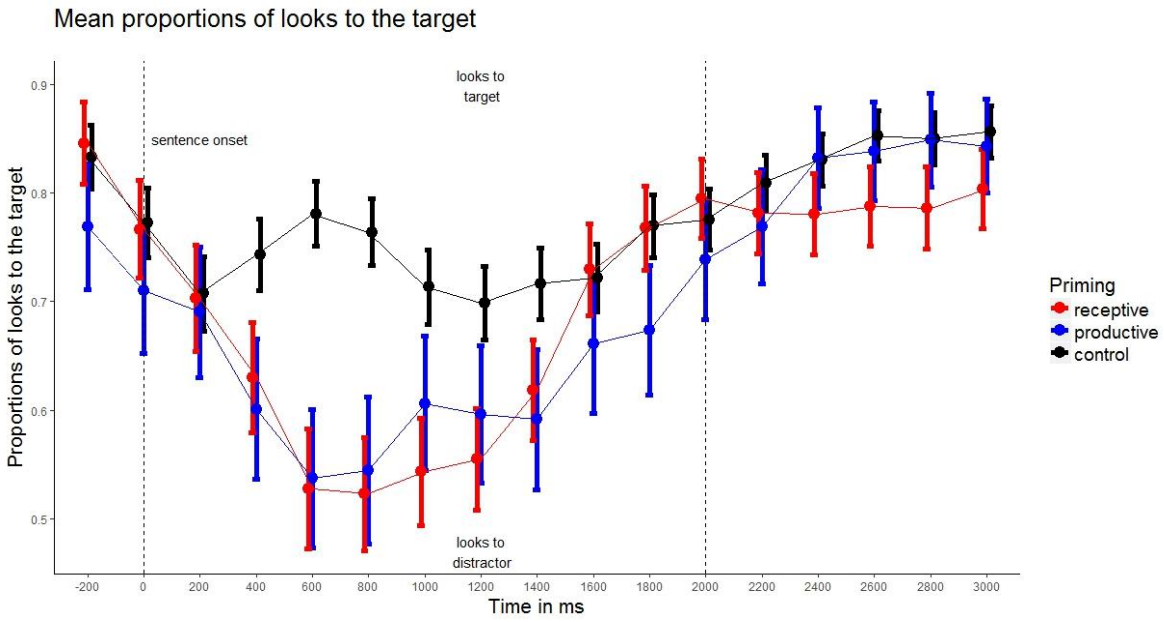


*Figure 2.8. The average proportion of looks towards the target (up) vs the distractor (down) during the presentation of an active target sentence after hearing an active prime sentence. The vertical lines correspond to the averaged onset of the sentence – 0 ms, and the average end of the active sentence – 2000 ms. The plot does not take into account the data adjusted for random effects, thus certain differences to the data analysis output occurred.*

## Discussion

By comparing receptive priming – passive exposure to the prime sentence – with productive priming – the overt repetition of the prime structure, we were able to show that both have a significant facilitatory effect on the anticipatory looks towards the target during the presentation of a passive sentence at different points in time. The key findings from the current study are that receptive priming with passive sentences affected the passive target sentence comprehension significantly in the time windows between 400 and 1200 ms post sentence

onset, with the exception of the time window at 600 ms post sentence onset. Priming led to increased looks towards the target image when compared to the control group. The onset of the prime effect roughly corresponds to the end of the first noun phrase in the passive target sentence. By the same token, productive priming significantly affected looks to the target in the time window between 400 and 1400 ms post sentence onset.

Furthermore, there was a significant difference between the two priming modalities in the time windows 1000 and 1200 ms. Here, productive priming had a significantly stronger effect, and led to more looks towards the target image on the screen than the receptive priming.

This outcome shows that both priming modalities exhibit a significant facilitatory effect on the comprehension of passive sentence, as seen by a larger number of anticipatory looks towards the target image in the current experiment. The anticipatory looks here mean that the participants did not need to hear the entire sentence before deciding that it was in a passive voice, therefore deciding on the thematic role of the animal which was mentioned first. This result supports the findings of previous studies by Bock and colleagues (2007). Structural priming from both comprehension and production has a facilitatory effect on language processing – in their case this was language production, and in the current study it is comprehension. The timing of the priming effect in the current experiment is similar to the one found in Thothathiri and Snedeker's 2008 study, and is present at about 600 ms, right after the first NP. On the other hand, certain differences between the two priming modalities did become obvious in the current study, and we will here give our interpretation of the results.

In the 2007 Bock and colleagues study, receptive and productive priming had an identical effect on the production outcome. It is interesting that the modality of the prime, i.e. whether the prime was passively heard or overtly repeated, was marginally significant in their study, meaning that there was a certain difference in the effect's strength between the two modalities on the production of primed structures, in favor of productive priming. In the Bock and

colleagues experiment, the participants were successfully primed through both language modalities. They used the passive voice when describing the images presented equally, often after both priming modalities. However, the participants in the group with overt repetition of the prime had more target responses altogether[8]. The authors state that this unbalance in the number of target (i.e. passive voice) responses might have affected the final outcome as well. The effect of modality did not interact significantly with other variables in their experiment. The results of the current study show that the participants who were in the productive priming group (i.e. who *produced* a passive sentence) exhibited stronger priming effects than those in the receptive priming group, who only listened to the prime sentence without repeating it. The difference was present in two consecutive time windows (at 1000 ms and 1200 ms post sentence onset). This particular result demonstrates clear differences in the predictive power of the two language modalities – production and comprehension. Overt repetition of the prime requires correct reception and production at the same time. The participants first need to carefully listen to the entire sentence, focusing on the meaning, but also the entire structure from beginning to end. After this, they need to repeat the same sentence correctly, they then hear themselves produce the sentence, which leads to additional language input as well (Bock et al., 2007). The receptive priming group may have not paid as much attention to the prime sentence, since they were not required to complete any task.

Another relevant aspect that the current study brought about is showing that productive priming has a strong priming effect cross-modally. When priming is combined with language comprehension, as in the current study, it is clear that priming from production – i.e. the

8

In their study, the priming modality (receptive / productive) was a between-subject factor, and the prime types (active / passive and double-object dative / prepositional phrase) were within-subject factors, just as in the current study.

productive priming – had a significantly stronger effect on the comprehension of the passive voice.

Bock and colleagues (2007) looked at the effects of the two modalities of priming but measured only the production outcomes. Once both studies are analyzed together, the overall story of the effects of structural priming on language becomes more complete. Looking only at the priming effects on either language production (as the Bock and colleagues study did) or on language comprehension (as the current study did) would seem to be presenting only half of the picture. For a more general conclusion about the relationship between language production and language comprehension, examining the interaction of all of the modalities would require a 2 x 2 comparison (2 priming modalities – comprehension and production x 2 outcome modalities – comprehension and production).

No previous study, to the best of our knowledge, has looked at the priming effects with actives. Interestingly, an inhibitory effect was found with active target sentences when primed with actives. In the time windows of 400 ms to 800 ms for the priming from production, that is 600 ms to 1200 ms for the priming from comprehension. This effect might have occurred for several reasons. Firstly, the priming conditions were compared to the control group which was not subjected to any kind of priming. In previous studies there were no control groups present, nor was looking at the priming / inhibition effects with active sentence a commonly performed task. It is possible that the priming groups looked less towards the target after the first NP either because they were expecting a passive sentence or they were analyzing the image in more detail than the control group, because they were exposed to double the number of images and sentences overall – i.e. primes plus targets. In sum, the control group was at or near the ceiling throughout the presentation of the active sentence, with their looks fixated on the target animal almost throughout the entire presentation of the target active voice sentence, with very few diverted towards the distractor animal.

Having in mind the proposed model of language production and comprehension by Pickering and Garrard (2013), it is clear that the current study shows larger differences between the two language modalities than previously thought. This is due to the difference in effect size between the two language modalities when priming from both is compared. It was possible to see this difference due to the eye tracking methodology used in the current experiment, and the clear focus of the study on the distinction between the priming from comprehension and priming from production.

Future studies would need to answer the question of whether comparable results can be found with other demographics. Children´s results, in particular, would be interesting, since children acquire language through listening to others and gain the statistical knowledge of use and structure. Only later, after acquiring the knowledge, do children start producing the structure. This would mean that the production potentially is of a reduced significance to future language comprehension. It would be useful to see if, and at what point during language development, this trend reverses.

## Conclusion

Our study compared the effects of structural priming from language comprehension and from language production. This was done in order to investigate whether the effects of the two priming modalities on comprehension differ, since their effect on language production seems to be identical (Bock et al., 2007). The structure used in this study was the passive in German language, which can undoubtedly be interpreted as such only at the onset of the “by phrase”, as before that other contender structures exist. The visual-world paradigm was used in an eye

tracking experiment to measure the anticipatory gaze towards the target animal in the image during sentence comprehension. The results show that both modalities lead to more anticipatory looks towards the correct image when compared to the control group, but with differences in the looking pattern. Whereas both priming modalities already lead to anticipatory looks after the first NP, productive priming (with overt repetition) lead to even more prominent looks than receptive priming (passive exposure to the prime) towards the target image at about 1000 to 1200 ms post sentence onset. The results are interpreted as the consequence of increased cognitive load and an additional task imposed on the participants in the productive priming group, who needed to understand the prime and then accurately reproduce it. The outcomes of the current study complement those of the experiments by Bock and colleagues (2007) and add new insight to the different modalities of language – production and comprehension. The current study data does not completely match the Pickering and Garrard model of language, since the differences observed between comprehension and production are relatively large and would point towards different processing for the two. Future studies with children, bilinguals and other demographics would be required to give an additional facet to the current work, and help to answer questions about the relationship between language production and language comprehension in more detail.

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# CHAPTER III – PRIMING EFFECTS ON THE COMPREHENSION OF PASSIVE SENTENCES BY GERMAN-ACQUIRING CHILDREN – AN EYE TRACKING STUDY

**Priming Effects on the Comprehension of Passive Sentences by German-Acquiring Children – an Eye Tracking Study**

Nenad Jovanovic, James Law, Kai Alter, Barbara Höhle

**Abstract**: Understanding of passives is generally difficult for children. There are three main theories which explain the cause of the problem. The current study used syntactic priming to elicit better comprehension in German-acquiring children. In combination with eye tracking, the results of the experiments will show which of the three main theories best explains the likely cause of the delay. The children did not benefit from structural priming in the current experiment and continued to have problems with the structure. This outcome aligns with the predictions of the A-chain deficit hypothesis. It states that children under a certain age do not possess the required cognitive capacities to properly understand the syntactic movement involved in the creation of a passive structure. It is concluded from these results, that he children were not able to use abstract syntactic knowledge to properly understand passives. The adult participants did not exhibit such difficulties, and structural priming led to more looks towards the target for them.

## Introduction

Children understand active sentences such as "*The girl is pushing the boy*" very early in their language development, from around the age of two years (Slobin, 1970; Slobin & Bever, 1982). On the other hand, the corresponding sentence in the passive voice "*The boy is being pushed by the girl*" is difficult for children up to the age of six years to understand, depending on the particular language and method of testing (e.g. Slobin, 1970; Slobin & Bever, 1982; Borer & Wexler, 1987; Ellis, 2002; Hirsch & Wexler, 2004). There are a few exceptions to this pattern (Demuth, 1990; Gil, 2008), but most of the children who have so far been tested while

acquiring a variety of languages have exhibited difficulties in producing and correctly interpreting sentences in the passive voice.

## Theories on the delay in the comprehension of passives

Researchers have long tried to understand what causes this delay in the acquisition of passives, and why the structure poses such a problem for children. There are three main groups of theories about what causes this delay. One group of theories suggests that the lack of exposure to passives and its relative infrequency in child-directed speech is the main reason for the delay (e.g. Demuth, 1990, Ellis, 2002). Passives are infrequent in many languages. Children do not receive enough input early on to be able to abstract the knowledge of the structure. They usually continue to interpret them as much more common and canonical active sentences (Ellis, 2002).

The second group points to the '*by-phrase*' of the passive sentence, and proposes that children are unable to assign the proper theta role to it (Fox & Grodzinsky, 1998; Guasti, 2004). According to this theory, children´s main difficulty lies in misunderstanding the "*by-phrase*" of the full passive sentences. Short (or truncated) passives such as "*The boy is pushed*" are often easier for children to comprehend (Armon-Lotem et al., 2016). In short passives, children only have one thematic role to assign – the patient or experiencer, and that does not pose a major problem for them. Once the thematic role of the agent is included via the "*by-phrase*", in a position where it does not usually occur, a child´s role assignment system breaks down and they tend to use other available cues to interpret the sentence (Fox & Grodzinsky, 1998; Guasti, 2004). Children then perform at chance level in experiments with passive voice sentences.

The third set of theories about the cause of the delay in passive acquisition focuses on the syntactic structure itself, and the inability of young children to process the A-chain that is

created in a passive sentence. Each passive voice sentence is produced when the object of an active sentence rises above the verb to the SPEC IP position. In this process, the object leaves its trace and forms an A-chain. The raising of the object is difficult for children to properly comprehend before a certain cognitive maturation takes place. This forms the basis of the A-Chain Deficit Hypothesis (ACDH) (Borer & Wexler, 1987; Hirsch & Wexler, 2004).

## Acquisition of passives by German-speaking children

Several studies over the past few decades have investigated when German-speaking children acquire the passive. Some general conclusions can be drawn from this work. Firstly, the children acquiring German exhibit difficulties with the structure early on in their language development (Haendler & Adani, 2013). Secondly, they start to produce and comprehend passives at an adult-like or near adult-like level around the age of four (Haendler & Adani, 2013; Dittmar, Abbot-Smith, Lieven & Tomasello, 2014) or five (Aschermann, Gülzow & Wendt, 2004). Finally, short passives are easier for German-speaking children than full passives (Armon-Lotem et al., 2016). As can be seen, the findings for German-speaking children do not deviate much from children acquiring other languages when it comes to when they acquire the structure and how the acquisition proceeds. They suffer from similar comprehension difficulties to other children at an early stage of language development. There are, however, several distinctive features which separate German-speaking children from others, and these occur due to some general characteristics of the German language and of the passive voice in particular.

Firstly, German is a language with case markings. There are four cases in German, and they are usually marked on the determiners which precede nouns. This feature makes the word order more flexible, and as a consequence, children acquiring German rely less on word order and focus more on the morphological case markers (Aschermann et al., 2004). This case markedness, in combination with other cues, such as the onset of the "*by-phrase"*, could help

the German-acquiring children understand passives earlier than, for instance, English-acquiring children, since it provides several cues in a row. Even though the subject of a passive sentence in German is marked for the nominative case (just like the subject of an active sentence), the second noun phrase of a passive sentence (i.e. the by-phrase), which denotes the agent, is marked for dative. However, only the nouns marked for the masculine gender in German have a distinctive case marking in all four German cases. The nouns marked for feminine and neuter genders have paradigms which sometimes overlap. Some of their case markings have an identical form to that of a different gender, or the same case form marking within the same grammatical gender.

Secondly, German has two distinctively marked types of passive constructions. One is the **stative passive**, which describes the state of the experiencer after the action (see example 1). The other is the **eventive passive**, which describes the process the experiencer is going through (see example 2) (examples taken from Abbot-Smith & Behrens, 2006).

3. Der Reis **war** von einem Experten gekocht.

   TheNOM rice be.3P.SG.PAST by an.DAT expert cook.PART

   *The rice was in a cooked state (having been cooked by an expert).*

4. Der Reis **wurde** (von einem Experten) gekocht.

   The.NOM rice become.3P.SG.PAST (by an.DAT expert) cook.PART

   *The rice went through the process of being cooked (by an expert)*[9].

9 Examples adapted from Abbot-Smith & Behrens, 2006.

The stative passive appears in the spontaneous speech of German-acquiring children earlier than the eventive passive[10] (Abbot-Smith & Behrens, 2006). Furthermore, children have more difficulties with the comprehension of the eventive passive until the age of five (Haendler & Adani, 2013). Finally, the auxiliary verb *werden*, which is used in the construction of the eventive passive, also has a function in expressing the future desire or intent in German. There are indices that the acquisition of the eventive passive with the auxiliary *werden* slows down the acquisition of the future construction with the same auxiliary verb (Abbot-Smith & Behrens, 2006).

In summary, German-acquiring children share some similarities with children acquiring other languages regarding the processing of passive constructions. They acquire them rather late – at around the age of five – and find short passives easier than long ones. Also, the German stative passive is easier for German-acquiring children to comprehend, and they start producing it earlier than the eventive passive.

## The Effect of structural priming on children´s comprehension of passives

Even though the passive voice poses a problem for children, in several studies across different languages, structural priming has been shown to have a beneficial effect on their processing of this type of sentence. Structural (or syntactic) priming occurs when the comprehension or production of a certain sentence type is affected by previous exposure to a similar sentence type (Bock, 1986). It has been uncovered in experiments with adults (e.g. Bock, 1986), as well as with children (e.g. Hartsuiker, Bernolet, Schoonbaet, Speybroeck &

10 The same has been assumed for English-speaking children, but is more difficult to empirically prove, due to the overlap in the form between the stative and eventive passive (Guasti, 2004).

Vanderlst, 2008; Arai & Mazuka, 2014). The effects of structural priming do not need to be short-lived and restricted to two sentences, one after the other. They can extend over several hours or even days after the priming occurs (Hartsuiker, et al., 2008). This has led to the formation of a theory that priming has a function in language learning – more specifically, in the implicit learning of language (Chang, Dell, Bock & Griffin, 2000, Pickering & Ferreira, 2008; Savage, Lieven, Theakston & Tomasello, 2006; Fine & Jaeger, 2013). According to the implicit learning account, structural priming is considered to be one of the ways in which children acquire new syntactic structures and language in general. The primed structures are remembered over a longer period of time, and they become internalized in the child's syntactic knowledge (Chang, et al., 2000; Savage, et al., 2006; Fine & Jaeger, 2013).

When it comes to the priming of the passive voice, only a handful of studies so far have addressed the topic. Several studies have shown that it can lead to increased production or to faster processing in children´s comprehension. Arai and Mazuka (2014) used eye tracking with a visual-world paradigm to investigate the effect structural priming has on the comprehension of passives in Japanese-speaking children. In their experiment, five- and six-year-olds were first exposed to receptive priming with a passive sentence, accompanied with an appropriate image of two animals performing the action described in the sentence. During the second stage, they saw an image with three animals standing in a row and performing two different actions (see Figure 3.1).

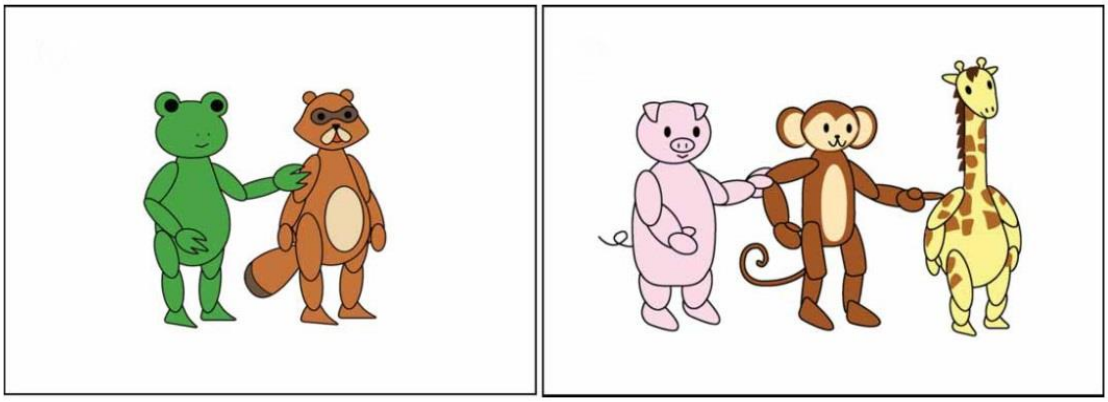

*Figure 3.8: Items used in the Arai & Mazuka study (2014). On the left is an example of the image used alongside the prime sentence, and on the right is an example of the image used alongside the target sentence*

The target image was accompanied by a target passive sentence in which two of the three animals in the picture were named as the theme / experiencer and the agent of the action. The looks towards the target animal (i.e. the one that was involved in the action together with the animal in the middle and was described by the target sentence; e.g. "*The monkey is suddenly grabbed by the pig.*") were measured, and the results showed that after structural priming Japanese-acquiring children tend to look more towards the target animal. Interestingly, the six-year-old children were primed to a greater extent than the younger age group. This was interpreted as a greater ability by the older children to understand the structure, and their overall better command of the passive voice.

Messenger, Branigan and McLean (2012) used structural priming with a picture description task. The children, aged six and nine, were asked to describe an image displaying an action which included a transitive verb. Before the picture description, the children were exposed to either an active or a passive sentence. Both age groups were more likely to use the passive to describe the action after being primed by a passive sentence directly beforehand.

Savage and colleagues (2003) looked at structural priming with three different age groups of English-speaking children: three-, four- and six- year-olds. The participants needed to describe an image after being primed either with an active or a passive sentence. Additionally,

the primes had either a large lexical overlap with the target (same verb used in prime and target) or they had low lexical overlap (different verb used in prime and target). The oldest age group exhibited both structural and lexical priming – they produced more passive sentences, regardless of the verb overlaps in prime and target. On the other hand, the younger children only showed lexically-driven priming – they only produced more passives when the verb which they needed to use in the target sentence was identical to the verb they had heard in the prime sentence. The researchers concluded that younger children do not possess abstract knowledge of syntax, and their representations are more lexically driven. By the age of six, children start applying syntactic rules across verbs and their syntactic knowledge and processing skills are more abstract than before. Because their syntactic processing is more abstract, structural priming leads to increased production of passives with older children, even when the verbs in the prime and the target are different.

In an attempt to test this claim further, Bencini and Valian (2008) looked at how younger children, aged three, comprehend and produce passive sentences. Earlier theories proposed that, at an early stage of language acquisition, children do not possess abstract knowledge of complex syntax and rather use specific constructions as fixed expressions (Savage, Lieven, Theakston & Tomasello, 2003; Goldwater, Tomlinson, Echols & Love, 2011). The researchers used syntactic priming in which the child needed to repeat the prime sentence first before being asked to describe an image of a transitive action. The experiment showed that even at this early age, children who were primed with sentences in passive voice produced more passive sentences when describing images. In the comprehension part of the experiment, the children needed to point to a picture that matched a passive sentence. This time the children did not seem to benefit from priming, as there was no difference between the priming and the no priming conditions. All children, however, were above chance on the passives comprehension task. Bencini and Valian (2008) considered the successful priming in production as evidence in support of the

early abstraction theories. These theories state that even young children possess abstract grammatical knowledge which can be tapped into under experimental conditions.

Gámez and Vasilyeva's (2015) study looked at structural and semantic[11] priming of passives with five- and six-year-old English-speaking children. They tested whether animacy plays a significant role in structural priming and syntactic processing at this age. The results showed that when the target sentence had an animate experiencer, the children were more likely to produce a passive sentence when primed by a passive sentence than when the prime had an inanimate experiencer. This correlation between the animacy of the experiencer and the production of passives shows that children do not rely solely on syntax when it comes to processing complex structures.

Previous studies on priming of children in sentence comprehension are scarce, and the outcomes vary from study to study. Only one study has, so far, tested children at an age at which they should be able to comprehend passives, at least to a certain extent (Arai & Mazuka, 2014). In their experiment, Japanese-speaking children were successfully primed and looked more towards the part of the target image that corresponds to the passive voice interpretation of the target sentence. They expected to hear a passive sentence already before the disambiguating second NP. Importantly, the six-year-old children were primed to a greater extent than the five-year-olds. This leaves several unanswered questions and room for further investigation. German has a similar thematic role assignment in the passive voice to Japanese (Patient-Agent-Verb), and the NPs are also morphologically marked. Running a similar study to that of Arai and Mazuka with German-acquiring children should provide additional insight into the matter of passives comprehension and the effect of priming.

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11 Semantic priming here entails priming on the level of thematic roles and / or animacy

## The Current Study

The current study will ask two key questions:

- What is the underlying reason for the late acquisition of passives by German-speaking children? The three main theories that explain the delay in acquisition of the passive have different predictions for the outcome of the current experiment. The theories which blame the lack of exposure to the structure and its infrequency predicts improved comprehension of passives after priming. The A-chain Deficit Hypothesis (ACDH) (Borer & Wexler, 1987; Hirsch & Wexler, 2004) does not predict successful priming of passives. The approach states that children are unable to comprehend passives due to the still-undeveloped cognitive mechanisms necessary to comprehend the A-chains in passives and their movement. The third theory states that children cannot assign a proper theta-role to the "*by-phrase"* (Fox & Grodzinsky, 1998; Guasti, 2004). The expectation for the current study is that after the *by-phrase,* the children would be unsure of how to interpret the sentence, and no clear looking pattern will emerge, since they will not be able to use their syntactic knowledge in parsing the sentence. Before the "*by-phrase"* – just after the first noun phrase and the auxiliary verb *werden* - the children may look more towards the image that corresponds to the passive sentence, particularly after being primed with a passive sentence. The theory states that short passives are easier to comprehend for children, so the first part of the passive sentence – before the "*by-phrase*" – would potentially be easier for children to understand. The current study would be a good way of testing this claim.

- What effect does structural priming have on the comprehension of passives in German-acquiring children? Previous research has shown that structural priming can lead to the production of more passive sentences and to more looks towards the correct image (i.e.

the image that correspond to the passive interpretation) in comprehension studies which used eye tracking (Arai & Mazuka, 2014). Testing the comprehension of the structure in children who are acquiring German would be of interest due to the specific nature of the passive structure in this language.

Based on existing research, it can be expected to successfully prime the comprehension of passive sentences in German-acquiring children. This priming would be exhibited through more looks towards the target part of the image during the auditory presentation of the target sentence. In the current study, children between the ages of five and six were tested. This age range matches that which Arai and Mazuka tested in their study on priming in comprehension of Japanese passives. It is also the time period when, according to the ACDH, children should become able to process A-chains and movement properly.

The experimental image presented three animals standing in a row and performing the same action. Two animals on each side were identical to one another, but different in color. The animal in the center was different to the two animals on either side (see image 3.3). In the current experiment, the target sentence always started with the noun phrase that matched both identical animal figures on each side of the image. In this way, a temporary ambiguity is created until the verb phrase – i.e. the entire sentence – ends. Before that, the target sentence can further develop to be either in active or passive voice. This would mean that it is not clear if the first noun phrase is the agent (in an active voice sentence) or the theme of the action (in a passive voice sentence). That is why both interpretations are possible after the first noun phrase presentation, and both the left and the right animal images would be the correct ones to look at. After the final verb, it becomes clear which one of the two interpretations of the target image corresponds to the target sentence, and one of the animals on each side becomes the target figure – the agent of the action described in the target sentence. The other animal is then the distractor figure. It is not involved in the action of the target sentence, and therefore does not correspond

to the correct interpretation of the target sentence. The animal figure in the center of the target image is always included in the target sentence as the second noun phrase (as the agent in the passive sentence).

The expected outcome of the current study would be more looks towards the target figure during and after the auditory presentation of a passive target sentence, after exposure to the passive voice primes. This would indicate faster or easier processing of passives. Alternatively, it would indicate increased expectation of the structure. The same outcome would be expected from the adult control group, since priming of passives in comprehension has been shown with adult participants in numerous previous studies (e.g. Bock, 1986; Arai, van Gompel, & Scheepers, 2007; Thothathiri & Snedeker, 2008; Arai & Mazuka, 2014; Traxler, Tooley & Pickering, 2014). On the other hand, no study has investigated the priming effect magnitude in German-speaking adults in relation to passives. The precise time course of the comprehension is also a new finding the current study is expected to yield. Previous research on German-speaking children has only confirmed the presence of priming, but with eye tracking the effect that priming has on the time course of processing the target sentence will become apparent. It is expected that the priming effect will be seen early on during sentence comprehension, after the first noun phrase, or at the onset of the *by-phrase*. Previous work on Japanese (Arai & Mazuka, 2014) showed priming already during early stages of passive sentence interpretation. The expectation is to see similar results with German-speaking adults, despite the difference in the word order. In other words, after priming, the adult participants should already expect to hear a passive sentence after the first noun phrase, despite the fact that at that stage it is still not clear whether the sentence is in the passive voice. The advantage of testing German speakers is that although the passive construction is relatively similar in the two languages, the German active voice differs in several different features from the passive voice. In Japanese, the structures are basically indistinguishable up to the VP, which is marked for the passive voice in its morphology (Arai & Mazuka, 2014).

# Experiment I – Children

## Methods

**Participants** – 43 monolingual German-acquiring children took part in the study (23 male). The age range of the participants at the time of testing was between 5;6 and 6;0 years (mean age 5;8). The children were recruited through the BabyLab of the University of Potsdam, from the Potsdam region. The parents of the participating children signed an informed consent form for the study, which was approved by the Ethics Committee of the University of Potsdam. Before the start of the experiment, all of the children completed a subtest[12] of a standardized test for the comprehension of German sentences – *Test zum Satzverstehen von Kindern* (Siegmüller, Kauschke, van Minnen & Bittner, 2011). The children also completed the Raven´s Colored Matrices Test (Raven, Raven & Court, 2001). The two tests were used to ensure that the participating children had typical language ability and non-verbal IQ. The parents also filled out a questionnaire on the language input and development of their children. All of the children had normal hearing and normal to corrected-to-normal vision and no color blindness.

**Materials** – The experimental materials comprised of auditorily presented sentences and visually presented drawings. The audio materials were sentences either in the active or passive voice and comprehension questions. These were recorded by two female native German speakers at a normal speed and tone of voice. One speaker recorded the sentences used for the

12 The children completed the following parts of the full TSVK: Subtest 3: *Wortstellung*; Subtest 4: *Passiv-Strukturen*; Subtest 5: *Bildungssätze*; Subtest 6: *Objektrelativsätze*.

experiment while the other recorded the comprehension questions. The pitch of each recording was normalized using Praat software (Boersma, & Weenink, 2015). 6 high-frequency transitive verbs were used for the prime sentences (*tragen* "carry", *jagen* "hunt", *füttern* "feed", *treten* "kick", *küssen* "kiss" and *ziehen* "pull"). 6 additional high-frequency verbs were used for the target sentences (*kämmen* "comb", *zeichnen* "draw", *fangen* "grab", *schieben* "push", *waschen* "wash", *kitzeln* "tickle"). All of the verbs used in the experiment were regular German verbs. Their past participle uses the prefix *ge-*. This is important because the past participle is used in the construction of passive sentences in German. Each verb was repeated 4 times throughout the experiment for each participant, twice in the active and twice in the passive voice. This applies to the verbs used in the prime sentences and for those used in the target sentences. In the experiment, the sentences in the passive voice are considered the targets, whereas the sentences in the active voice are considered to be controls. Similarly, only the priming sentences which are in passive voice are considered to be true primes. Active sentences used in the priming segment are considered to be the control condition primes. Previous studies which used active voice prime sentences did not find that they had any effect on the comprehension of passive target sentences (e.g. Savage et al., 2006; Messenger et al., 2012; Gámez & Vasilyeva, 2015).

There were four different animal names used in the sentences for both the primes and the targets. These were *der Affe* (the monkey), *der Hase* (the rabbit), *der Vogel* (the bird) and *der Frosch* (the frog). These were chosen because they are marked for masculine gender on the definite article in the German language. This was crucial for the current study because only the masculine gender nouns are distinctively marked in all four of German grammatical cases (Nominative – *der*; Dative – *dem*; Accusative – *den*; Genitive – *des*). Using only masculine nouns made the syntactic function of the noun clear in both active and passive sentences (see examples 1 and 2).

- Der Affe kitzelt den Frosch.

The,MASC.NOM monkey tickles the.MASC.ACC frog.

*The monkey is tickling the frog.*

- Der Affe wird von dem Frosch gekitzelt.

  The.MASC.NOM monkey AUX by the.MASC.DAT frog tickled.

  *The monkey is tickled by the frog.*

The animals were used in the experimental sentences – both in primes and in targets – always in the same pairs. One pair was *der Frosch* (the frog) and *der Affe* (the monkey). The other pair was *der Hase* (the rabbit) and *der Vogel* (the bird). The animals were paired in this way because they do not represent each other´s natural prey and enemy, such as, for instance, a cat and a mouse, or a shark and a seal. This was done to avoid the effect of real-world knowledge on the interpretation of the sentences. Additionally, two other animals – *die Maus* (the mouse) and *die Schildkröte* (the turtle) were used for the practice items in combination with four unrelated intransitive verbs. In total, there were 24 items used in the study (6 verbs x 2 prime sentence types x 2 target sentence types). See Table 1 for the outline of the items and conditions.

Two pseudo-randomized lists of target sentences were created. In each list, the same verb never appeared twice in a row and sentences in the same voice (active or passive) never appeared more than twice in a row. The same randomization rule was also applied for priming sentences. Furthermore, the same combination of the prime and target sentence voice also never appeared more than twice in a row. For example, if a prime sentence was in the passive voice and the target sentence in the active voice, this prime-target combination could be repeated only once more in the following prime-target item. In one of the two lists, the first target sentence was in the active voice, and in the other list, it was a passive sentence.

| Experiment conditions and number of items per condition | | Prime sentence type | |
|---|---|---|---|
| | | *Active / control* | *passive* |
| **Target sentence type** | *Active / control* | 6 | 6 |
| | *passive* | 6 | 6 |

*Table 3.1: Experiment layout - conditions and number of items per condition*

There were two types of images which were used as visual materials in the experiment. One group of images were black and white drawings which were presented with the prime sentences. In each of these, the two animals were centrally located in the image and performed an action that matched the prime sentence (see Figure 3.2).

Figure 3.9: An example of the drawing which accompanied the prime sentence

The other types of images were drawings used with the target sentences. In these images, three animals stood in a horizontal line behind each other and each one performed the same action to the animal in front of them (see Figure 3.3). Two of the animals on the sides were identical, but differently colored. The animal in the center was different to the other two, and it was black and white. The animals on the sides were either red, blue or yellow. The combination of the two colors in the target images was never repeated twice in a row. Each of the three colors

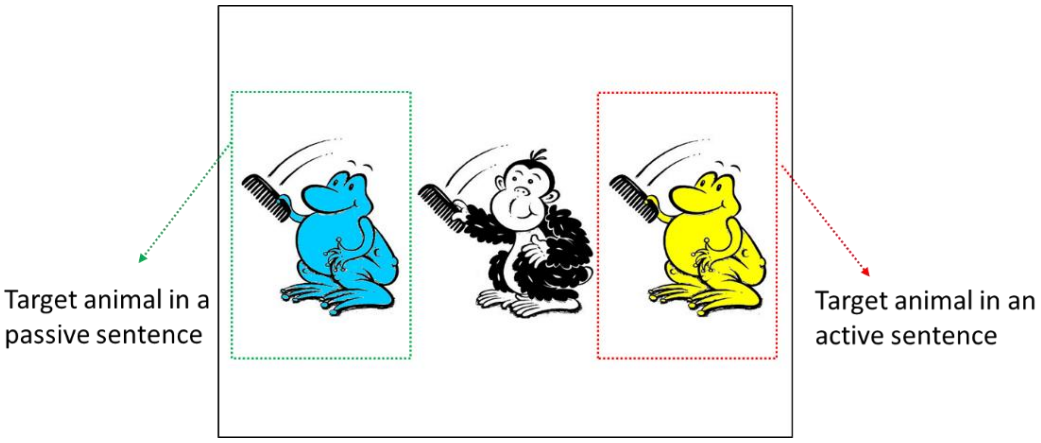


Figure 3.10: An example of the target image

was shown the same number of times. Also, the direction that the animals in the drawings were facing (to the left or to the right) was counter-balanced across the items. The same image can correspond to an active and to a passive sentence simultaneously (e.g. *The frog is combed by the monkey* and *The frog is combing the monkey*.).

**Procedure** – The experiment took place in a specially prepared room at the BabyLab of the University of Potsdam, into which no natural light entered. The Tobii 1750 binocular eye tracker was used with 50 Hz temporal resolution. The stimuli were presented using the ClearView software version 2.5.1 on a 17-inch TFT display with 1280 x 1024 resolution.

The children first completed the two standardized tests described above. After that, they were seated in front of the eye tracker at a distance of 60 cm. The parents were given the choice of either sitting behind the child or in an adjacent room where the experimenter was also present.

Firstly, the eye tracker was calibrated for each participant using a 9-point calibration. At the beginning of the experiment, a short video with two female character drawings in the center of the screen appeared that explained the procedure. The characters said that the child would participate in a simple game where they need to either repeat a sentence after hearing it or say which color an animal in the picture is. The repetition of a sentence was part of the priming segment and naming the color of the target animals was the response to the comprehension question following the target image. After the explanation, the child was asked if the instructions were clear and any misunderstandings were sorted out. Then the four practice items were presented. This helped the child to become familiar with the procedure of repeating the prime sentences and giving answers to comprehension questions. During the practice segment, the child was encouraged to repeat the sentence or give an answer if she was feeling insecure or confused. After the practice items, and when the procedure was clear to the participants, the actual experiment began.

At the beginning of each trial, a fixation cross appeared in the center of the screen for 500 ms. After this, the prime image was presented. The image stayed on-screen for 1500 ms, after which it was accompanied by a corresponding prime sentence, presented auditorily via

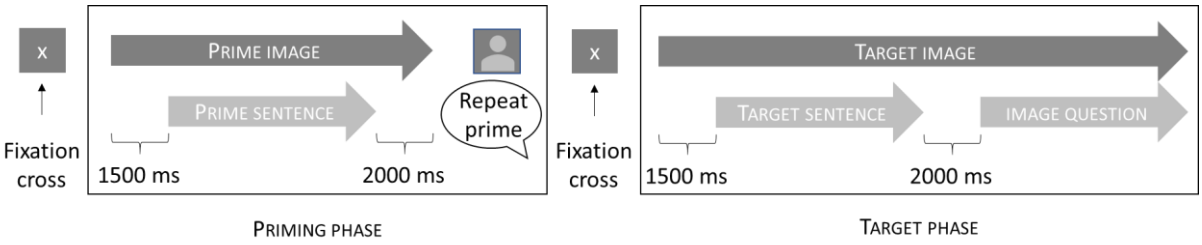


Figure 3.11: Procedure for the experiment

loudspeakers. The image stayed on-screen for an additional 2000 ms after the end of the sentence. After this, an image of one of the two female characters from the instruction video appeared, which signaled that the child should repeat the sentence they had just heard. The target image disappeared from the screen. In its place, another image appeared of the same

female character as at the beginning of the experiment. This ensured that all prime images were presented for an equal amount of time to each child. Some children needed more time than others to repeat the prime sentence, and by showing another image instead of the image that corresponded to the prime sentence, it was ensured that the length of exposure to the prime picture was equal for all participants. When the child repeated the sentence, the examiner would note on a score form whether the repetition was correct or not. The experimenter then ended the prime segment by pressing a button on the control computer and the target segment would begin (see Figure 3.4).

Another fixation cross appeared in the center of the screen for 500 ms, and then the target image with three figures was presented. After 2000 ms the target sentence was played, while the target image was still on-screen. After the end of the sentence, the image remained on the screen silently for additional 2000 ms, when the female character asked the comprehension question: "*Welche Farbe hat denn dieser Affe / Hase / Vogel / Frosch?*" (Which color is this monkey / rabbit / bird / frog?). The child named one color, and the experimenter marked down the answer on the response form. Afterwards, the experimenter pressed the control button and the next item started.

## Data Analysis

One child´s data was excluded due to an eye tracker malfunction. Another four children either did not cooperate during the experiment (they did not repeat the prime sentences and / or did not give any answers to the comprehension questions) or their scores on the two standardized tests were not in the range of typical development. Thus, in total, the results of five children were excluded from data analysis. The results of the remaining 38 children were used for further data analysis and will be reported here. The accuracy scores were calculated as the number of correct answers on the comprehension question after each target sentence.

For the eye tracking data analysis, only the items where the child gave the correct answer to the comprehension question were taken into account. The reasoning was that if the child gave an incorrect response, they had clearly misinterpreted the sentence, or had other problems understanding the task. The proportions of looks were aligned to the onset of the auditorily presented target sentence for each item. The analysis was performed on the proportion of looks towards the target versus the looks to the distractor animal, and in the time period between the onset of the auditorily presented target sentence and 5000 ms post sentence onset. This time window was divided into 10 time windows of 500 ms length for analysis. The duration of the whole window was fixed to 5000 ms, as this was the average duration between the onset of the sentence and the onset of the comprehension question. In other words, not just the duration of the target sentence was taken into the analysis, but also the time after the sentence offset until the comprehension question started. For the analysis, Mixed Effects Models were used with the R program (R Development Core Team, 2015) and the lme4 package (Bates, Maechler, Bolker & Walker, 2015). A separate analysis was done on each of the 10 time windows, which means that 10 separate models were fit. For fixed effects, the target sentence type (passive and active) and prime sentence type (passive and active) were entered into the model. A two-way interaction between the variables was also included. Individual participants and items were added as random effects. Sum Contrast was used for the prime sentence type and target sentence type. Active prime sentences paired with passive target sentences (i.e., the control condition) were used as the intercept for the final model. The Linear mixed model fit was calculated by maximum likelihood t-tests. The plotted residuals of the final model were normally distributed upon visual inspection.

## Results

Behavioral data – Accuracy was measured as the percentage of correct answers to the comprehension question which was asked after each target sentence. The question entailed naming the color of the animal in the image corresponding to the one involved in the action described by the target sentence.

**Table 3.2**
Accuracy (in percentages) for the comprehension questions

| Target sentence type | Accuracy (%) | *sd* |
|---|---|---|
| Active voice (overall) | 81,24% | 22.15 |
| after active voice prime | 82.54% | 22.54 |
| after passive voice prime | 79.95% | 21.97 |
| | | |
| Passive voice (overall) | 58.67% | 29.14 |
| after active voice prime | 61.21% | 28.14 |
| after passive voice prime | 56.14% | 30.27 |

Table 3.2: Percentage of accurate answers to the comprehension questions with standard deviation

For the target sentences in the active voice, the children gave, on average, 81,24% correct answers (*sd*=22.15). For active target sentences primed with active primes, the children gave 82.54% correct answers (*sd*=22.54). For active target sentences primed with passive primes, the children gave 79.95% correct answers (*sd*=21.97). For all target sentences in passive voice, the children answered on average 58.67% correctly (*sd*=29.14). For passive target sentences primed with a passive prime, the children gave 56.14% correct answers (*sd*=30.27). For passive target sentences primed with actives, the children gave 61.21% correct answers (*sd*=28.14) (See Table 3.2 for the summary of the results). One-sided t-tests showed that responses to target sentence comprehension questions were significantly above chance for both active and passive voice target sentences ($t$ = 2.5962, $df$ = 75, $p < 0.01$ for passives and $t$ = 12.297, $df$ = 75, $p < 0.01$ for actives). Welch Two Sample t-test showed that there is a significant difference between the number of correct answers to the comprehension questions between target sentences in the

active and passive ($t$ = 5.375; $df$ = 139.98; $p$<0.001). No significant difference was found between the two priming conditions with the passive voice target sentences ($t$ = 0.757, $df$ =73.61, $p$= 0.4515). There was also no significant difference between active target sentences, regardless of the prime type ($t$ = 0.5079, $df$ = 73.951, $p$= 0.613).

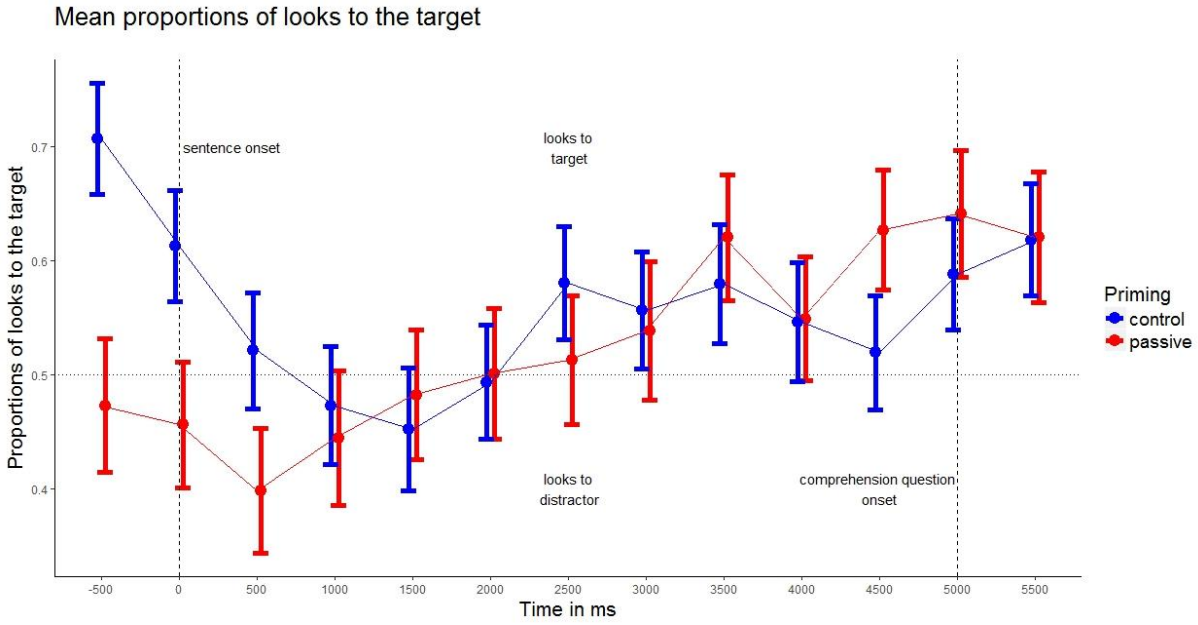


Figure 3.12: Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 500 ms windows for the children group, with the target sentence in passive voice

Eye tracking data – The analysis was done on the proportion of looks to the target animal versus the looks to the distractor animal during target sentence presentation. The analysis was doneon the data starting from the target sentence onset. There was no main effect of prime sentence type in any of the time windows included. Also, no interaction between the target sentence type and the prime sentence type was found in any of the time windows. The only significant main effect was the difference between the target passive and the control prime sentence, with the participants looking towards the target image significantly more in the time window that started at 3500 ms post sentence onset (β=0.1293; SE=0.0633; z=2.044; p=0.0466).

The first analysis looked at the interaction of primes and targets on the overall performance of children, but it was not possible to tell at which time window children commit to the passive voice interpretation of the target sentence. This is manifested in looks towards the target image above chance level. To see at which point in time the children look towards the target animal above chance, a one sample t-test was run with the proportion of looks to the target compared against chance with a 95% confidence interval. For passive target sentences which were primed with the passive, the first time window where the proportion of looks was significantly above chance level was the time window starting at 3500 ms ($t$ = 2.0319, $df$ = 72, $p$ = 0.0459). The children´s proportions of looks to the target were higher than chance level also at 4500 ms ($t$ = 2.1112, $df$ = 75, $p$ = 0.0381); and again at 5000 ms ($t$ = 2.4766, $df$ = 69, $p$ = 0.0079).

The same one sample t-test was performed on the passive target sentences that were primed with active prime sentences. There were four time windows in which children showed a proportion of  above chance to the target animal. At the time window at 0 ms the children were already looking towards the target at an above chance level ($t$ = 2.7106, $df$ = 90, $p$ = 0.0040). The next time window in which they looked above chance towards the target was at 2500 ms ($t$ = 1.7634, $df$ = 94, $p$ = 0.0405). Also, at 3500 ms children looked at an above chance level towards the target ($t$ = 1.6639, $df$ = 82, $p$ = 0.0499). Finally, at 5000 ms the children also looked significantly more towards the target image than towards the distractor ($t$ = 2.0254, $df$ = 90, $p$ = 0.0229).

Centered eye tracking data – At the sentence onset at time window 0, the children did not look equally at the target and distractor with regards to the priming condition they had been exposed to. In other words, they looked at the target image more when they were exposed to an active prime sentence, even before the onset of the target sentence. 63.7 % of looks were directed towards the target image. In contrast, when primed with passive sentences, in the time

window 0 children were more likely to be looking at the distractor image. They were looking 46.5 % towards the target image. This difference at the sentence onset may have affected the proportions of looks throughout the whole analysis window. In order to properly evaluate the change that occurred from the sentence onset for both of the conditions – active and passive sentence primes – the proportions of looks were centered in time window 0 by adding the difference from the chance level to the mean for the passive priming condition and subtracting the difference from the mean for the control priming condition (see figure 3.5).

One sample t-tests were then run again for the passive voice target sentences primed with passive voice priming sentences at each 500 ms time window to compare the difference of the mean from time window 0. The change in the proportion of looks was significantly above baseline level in time window 3500 ms post sentence onset ($t = 2.6463$, $df = 72$, $p = 0.005$). The same change was significant at time window 4500 ms ($t = 2.7389$, $df = 75$, $p = 0.004$) and again at 5000 ms ($t = 3.087$, $df = 69$, $p = 0.001$). For the active prime condition, the change in the proportion of looks was already significantly below baseline at the time window 1000 ms ($t = -3.0623$, $df = 84$, $p = 0.003$). The change was also below baseline at time windows 1500 ms ($t = -3.3283$, $df = 77$, $p = 0.001$); then at 2000 ms ($t = -2.7752$, $df = 87$, $p = 0.007$) and once again at 4500 ms post sentence onset ($t = -2.3269$, $df = 92$, $p = 0.02$).

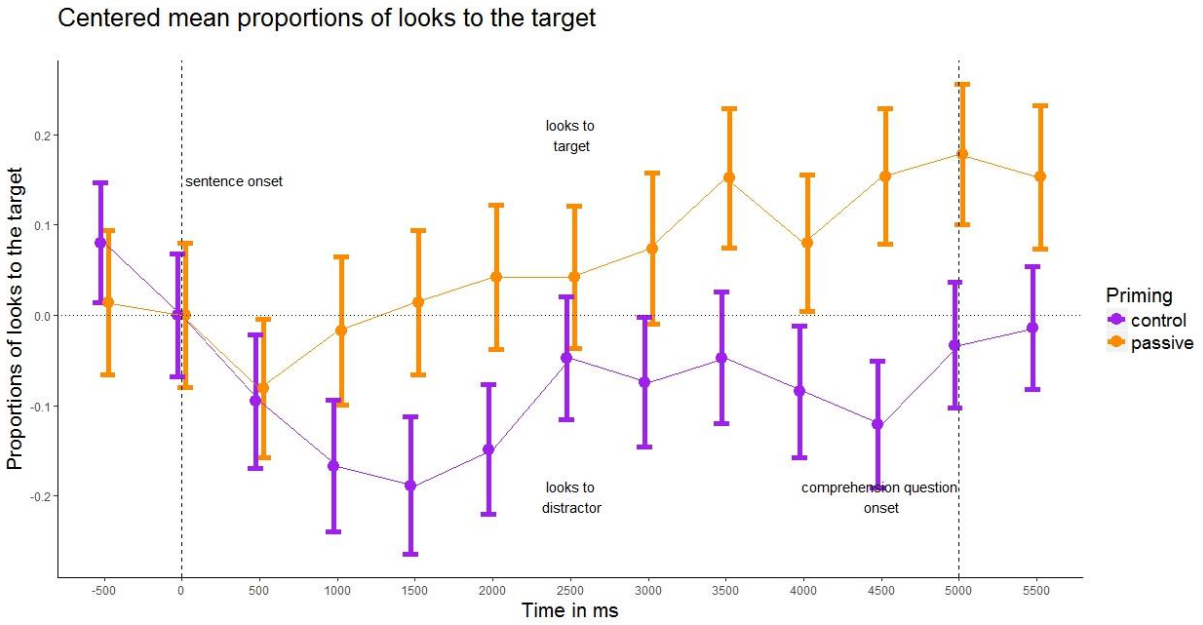


Figure 3.13: Centered proportion of looks towards the target versus the looks towards the distractor image.

# Experiment II – Adults

## Methods

**Participants** – 50 adult native speakers of German were tested (27 female, mean age 23). They were all students at the University of Potsdam and participated for class credits. They all had normal or corrected-to-normal vision with no color blindness and normal hearing. The adult participants also signed a consent form previously approved by the university´s ethics committee.

**Procedure** – The adult participants were randomly assigned to one of two groups. The first group constituted the priming group. With this group, the same general procedure was used as with the children. The items were identical to those used in the experiment with children. The other, control group was the no-priming group. They had the same procedure, except that

instead of active and passive prime sentences, they heard and repeated structurally different sentences with unrelated protagonists. Four different intransitive verbs were used for this "pseudo-priming" – *schwimmen* (swim), *träumen von* (dream of), *rännen* (run), *telefonieren* (talk on the telephone). Two animals from the practice trials were the protagonists – *die Maus* (the mouse) and *die Schildkröte* (the turtle). The participants from both the priming group and the control group were told that they were participating in a control study for an experiment with children. The adults filled out a questionnaire with questions on their language background and usage, as well as questions on their ability to recognize colors. The accuracy scores for the adult participants were not taken into account.

## Data analysis

The data analysis of the eye tracking experiment for the adult participants was conducted in the same way as for the children's data. All adult participants were included in the analysis. First, only the data of the priming group was analyzed. This procedure mirrored the analysis done with the children´s eye tracking data. Secondly, the priming group data was collapsed together with the control non-priming group data and a new analysis was performed.

## Results – the priming group

In the time window at 4000 ms post sentence onset, the adult participants were significantly more likely to look at the target image when previously primed by a passive prime sentence than with a control active sentence ($\beta$= 0.1168; SE= 0.0395; z= 2.956; p= 0.0048). The same effect was found in the last time window at 5000 ms post sentence onset ($\beta$= 0.0767; SE= 0.0332; z= 2.310; p= 0.0212). See Figure 3.7 for results.

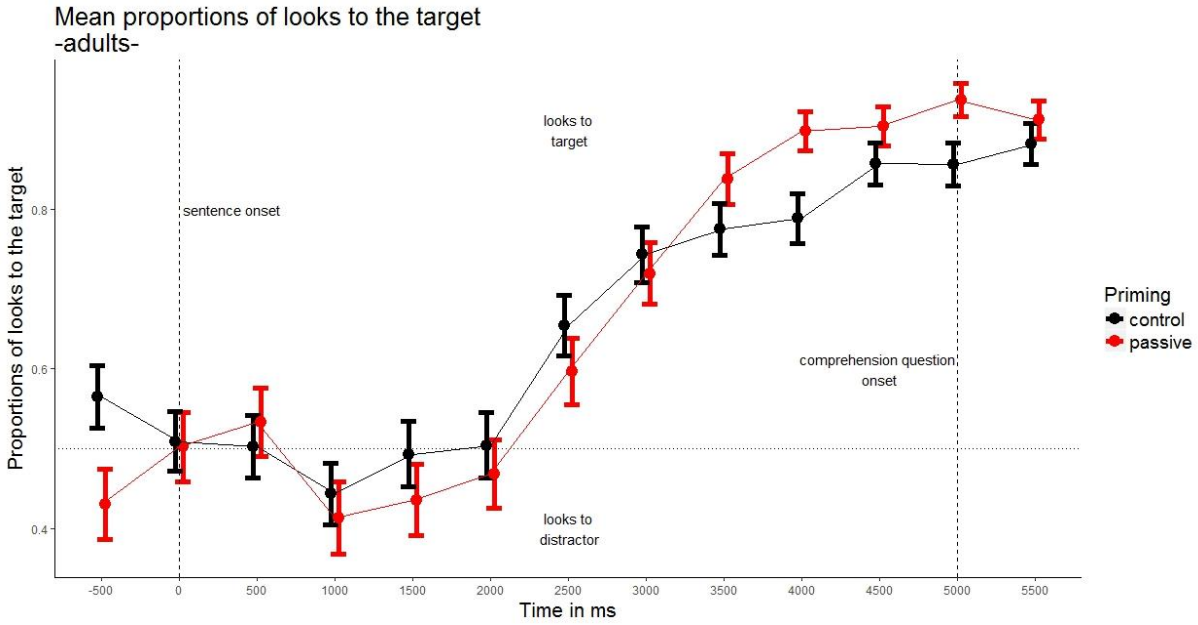


Figure 3.14: Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 500 ms windows for the adult group, with the target sentence in passive voice

The adult gaze data was compared against the chance level, just as the children's data was. A one-sample t-test was performed for each time window. The looks towards the target animal were constantly higher than chance in all time windows starting from 2500 ms for both priming conditions ($t$ = 1.9831, $df$ = 114, $p$ = 0.0249).

## Results – the control no-priming group

The data of the control group was combined with that of the priming group. The data analysis was run the same way as with the child participants. In the time window at 3500 ms there was a significant difference between the pseudo-priming condition and priming with a passive sentence ($\beta$=0.15864; $SE$=0.05231; $z$=3.033; $p$=0.00276). The same effect was seen in the following time window at 4000 ms ($\beta$=0.18037; $SE$=0.04881; $z$=3.695 $p$=0.000293). In the time window at 4500 ms, both types of priming (passive voice and active voice) led to significantly more looks towards the target than the pseudo-priming (the passive priming sentences – $\beta$=0.128613; $SE$=0.043932; $z$=2.928; $p$=0.0038 – and the active priming sentences

– $\beta$=0.088939; *SE*=0.042121; *z*=2.111; *p*=0.0361). In the last time window tested, at 5000 ms post sentence onset, again only the passive prime let to significantly more looks towards the target than the control condition (i.e. the pseudo-prime) ($\beta$=0.12661; *SE*=0.04544; *z*=2.786; *p*=0.00594). See Figure 3.8 for results.

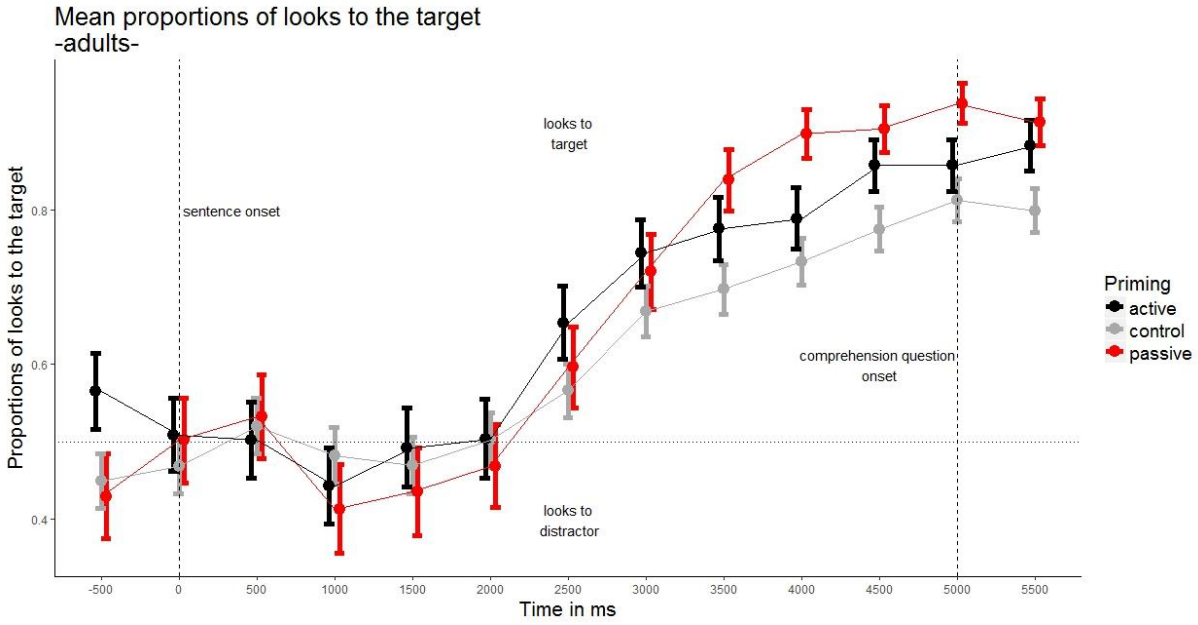


Figure 3.15: Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 500 ms windows for the adults group, with the target sentence in passive voice

The one-sample t-test showed that from 2500 ms the control group participants looked at the target image significantly above chance level ($t$ = 2.4656, $df$ = 312, $p$ = 0.0071).

## Discussion

The current study set out to provide answers to two questions about the comprehension of passives by German-acquiring children. The initial aim of the study was to test the three different theories on the delay in the acquisition of passives by children. The second question concerned whether structural priming affects the comprehension of passives in German-acquiring children. As described in the introduction, each of the three theoretical approaches to the difficulty with the passive voice had different predictions for the outcome of the experiment.

The ACDH claims that the core deficit lies in the inability of children to properly comprehend the A-chain movement which occurs in sentences in the passive voice (Borer & Wexler, 1987; Hirsch & Wexler, 2006). It predicts the absence of comprehension or poor comprehension with possible preference for the active interpretation and no significant effect of priming. The frequentist theory, which points out the relative infrequency of passive voice structures in child-directed speech, predicts overall improved comprehension when priming is present (Demuth, 1990, Ellis, 2002). Finally, the theory in which the main cause for the delay is the misunderstanding of the "*by-phrase*" predicts successful priming in the first part of the sentence. In the second part, after the "*by-phrase*", the comprehension should go back to chance level or possibly in the opposite direction, towards active interpretation (Fox & Grodzinsky, 1998, Guasti, 2004).

It is clear already from the accuracy scores that children at this age exhibited some level of difficulty in understanding the passive. The responses they provided to the comprehension question after the passive voice target sentences were 58.67% correct. Since both the agent and the theme in the experimental sentences were animate, and real-world knowledge also did not provide additional help in correct interpretation, the only cue the children had to interpreting the passive sentences was the syntactic structure – the combination of the auxiliary verb *werden*, the "*by-phrase*" and the verb form together, provide a structural cue for interpreting the sentences as passives. In the absence of other potential cues, the children´s comprehension of the passive voice was significantly lower than that of the active voice sentences (81.24%). These findings match, to a large extent, previous studies on the comprehension and production of passives by German-speaking children (Dittmar et al., 2014; Haendler & Adani, 2013; Aschermann et al., 2004; Armon-Lotem et al., 2016). In the current study, the children were above 80% of accuracy on actives, and around 60% on passives. It is important to notice the large variability in the data, which clearly illustrates the difference in the language acquisition process in children of this age. The variability can be seen in both behavioral and the eye

tracking results. Despite the relatively narrow and compact age range of the children (less than 6 months between the youngest and the oldest) and the language development and non-verbal IQ scores also being within the range for typically developing children, the results show how language acquisition is not a uniform process, done in the same way and at the same pace by all individuals. Other factors play an important role in this process as well. The scope of the current study did not include these additional factors, thus future research would need to include them in their setup.

The results from the children's study are clear. German-acquiring children at the age of 5;8 in the experiment had difficulties understanding the passive voice sentence. In the eye tracking part of the experiment, the looks towards the target and distractor animals were at chance level, until rather late in the sentence presentation, after the offset of the sentence. What is more important is that in the current study, structural priming with a passive sentence did not lead to more looks towards the target animal when the target was a passive sentence. In other words, structural priming with passive voice primes did not directly affect the children´s processing and comprehension of passive target sentences. As mentioned in the introduction, the frequentist theory predicts faster comprehension after more exposure to the structure. The main premise is that the infrequency of the structure and lack of exposure cause difficulties and overall slower comprehension of passives. Similarly, the theory by Fox and Grodzinsky (1998) would also, in our interpretation of their work, lead to more looks towards the target animal in the image – with or without priming – the problem in correct interpretation should occur after the by-phrase. Their theory states that the main difficulty in children´s comprehension of passives is how to properly assign the theta role to the by-phrase. This also has not been the case with the data of the current study. The children´s looks were at or below chance level until the end of the auditorily presented sentence. The A-chain Deficit Hypothesis predicts that due to lack of maturation, children below a certain age cannot comprehend the syntactic movements associated with the formation of passive sentences. This hypothesis seems to best explain the

results of the current study. The children´s immature grammar is not at a level at which passive voice can correctly be processed, and their interpretation breaks down, so they need to rely on other mechanisms to understand the sentence. In the current setup, this was not easy for them, because the actions depicted were deliberately reversible. Their real-world knowledge could not have provided support. Hence, the children struggled and were at chance level, not committing to either of the interpretations until the very end of the sentence.

What is more, it would seem that the children did not fully commit to the passive interpretation of the sentence, despite the fact that they gave a correct answer to the comprehension question. This may have come as a surprise, since the eye tracking data analysis included only the items from each child where they had given a correct answer to the comprehension question. The data from children´s incorrect items was not taken into account, with the view that children who made errors did not interpret the sentence correctly in the first place, thus their looking scores would be at or possibly below chance level.

The eye tracking data is further supported by the behavioral results. There was no difference in the accuracy between the passive and active prime conditions when it came to the number of correct answers. Overall, children gave more correct responses to questions with the active / control target sentences. With passive target sentences, children performed at around 58%.

The adult control participants looked at the target character earlier, which suggests that they committed much faster to the passive interpretation of the target sentence than the children did. Furthermore, the pseudo-priming group´s gaze data would suggest they also committed to the passive interpretation before the end of the sentence presentation. Since the data was analyzed in 500 ms time windows, it is difficult to say at exactly which point during the sentence the adult participants committed to the passive voice interpretation. It would seem that this occurred towards the end of the sentence, possibly after the "*by-phrase*" was presented. However, since the eye tracking data was aligned to the sentence onset, and not the onset of the

"*by-phrase*", it is difficult to pinpoint the exact moment. On top of this, structural priming with passives led to more looks towards the target image at the end of the target sentence for the adults. The fact that the pseudo-priming group did not differ significantly from the group which was exposed to active prime sentences, except in the time window at 4000 ms is in line with findings which state that active prime sentences do not have a priming, nor an inhibitory effect on the comprehension of passives, which may be due to their overall high frequency and canonicity. The significant difference in the looks to the target between the pseudo-priming group and the active prime condition in one time window after the end of the target sentence might be a sign of lexical priming. The same pairs of animals were used in the prime and target sentences. In the pseudo-priming group, the animals in the prime sentences were different from those in the target sentences.

A slightly different picture is presented where the eye tracking data of the children is centered. With the change in looks for the control and passive prime conditions aligned, the data showed how the looks progressed over time. The looks towards the target increased for the condition with the passive prime. After 3500 ms, the change in looks towards the target were significantly different than at the sentence onset – they were diverted significantly more towards the target animal. In the control condition, this was not the case. The looks were either at the same level as the onset or below it throughout the sentence presentation. These results from the centered data would suggest that the overall trend was towards increased looks at the target image when the passive prime sentence was previously heard. This finding, however, should be taken with some caution, since it merely shows the tendency of the change of data. The overall looking scores were still fairly poor for the passive sentence, and thus the children´s interpretation of the structure, as well.

Our findings partially match previous work on the acquisition of German passives, at least in the behavioral data. German-speaking children in earlier studies showed above chance performance on passives at the same age as in other languages – 5, or even earlier, between 4

and 5 years – depending on the study (Dittmar et al., 2014; Haendler & Adani, 2013; Aschermann et al., 2004; Armon-Lotem et al., 2016). There are two possible reasons why the older children in the current study did not perform better than those in previous research. In the current study, an attempt was made to ensure the absence of most non-linguistic cues for interpreting the sentences correctly. When children cannot use syntactic cues, they need to reach out for other possible ways for interpreting sentences correctly (e.g. Slobin, 1980; Thothathiri & Snedeker, 2008). Another possible cause for the outcome of the current study is that the procedure was too complex for the children to follow. The children first saw and heard the priming image, after which they needed to repeat it. The target image and auditorily presented sentence were then played, and the children needed to name the color of the animal which matched the correct interpretation of the sentence. This might have been difficult for children to do and to focus on.

The methodology used in the current experiment should not have been the main cause of the weak performance of children and the absence of the priming effect. Other studies have used a similar approach and identical or similar verbs to the one in the current work, and still shown a significant increase in looks to the target after structural priming (e.g. Arai & Mazuka, 2014). That is why it cannot be said that the children had problems understanding the task or focusing. Further support for this claim can be seen in the scores from the non-verbal IQ and sentence comprehension tasks that the children completed. The children had no problems with either of the tasks, and they performed within the average scores.

The eye tracking data aligns with the behavioral data of the current study, but also of previous experiments as well. The children performed well on the actives, and just above chance level on the comprehension of passives.

## Conclusion

The current experiment tried to enhance processing of passives in German-acquiring children and to investigate the time course of their processing of the structure. An eye tracking experiment with a visual-world paradigm was developed. A single-image paradigm was used with three protagonists performing the same transitive action. The eye tracking results show that children did not benefit from structural priming. It did not improve their comprehension of passives, either in the number of correct answers nor in the proportion of looks towards the target ROI on-screen. The children were overall above chance level in the comprehension task, with passive sentences being more difficult than active ones. This finding would be best explained by the A-chain deficit hypothesis, and the inability of the children´s cognitive systems to process complex syntactic structures. There are some limitations to the procedure which might have further contributed to the outcome. The adults, on the other hand, were relatively quick in determining whether the sentence was in the active or passive voice. They did benefit from previous exposure to passive prime sentences, since the structural priming effect led to more looks to the target. The approximate timing of their looks would suggest that German-speaking adults commit to the passive sentence interpretation during or after the "*by-phrase*", but a more detailed analysis would be needed to precisely pinpoint the moment of disambiguation.

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# Chapter IV - Priming the Comprehension of Passives in Mandarin-English Bilinguals – Different Outcomes for Bilinguals and Monolinguals

**Priming the Comprehension of Passives in Mandarin-English Bilinguals – Different Outcomes for Bilinguals and Monolinguals**

Nenad Jovanovic, Kai Alter, James Law, Barbara Höhle

**Abstract:** Previous literature has shown that after structural priming in one language bilinguals tend to use the same structure in speech in the other language. Much less is known about how and if this cross-linguistic structural priming effect manifests itself in comprehension. The current study used eye tracking measurements to investigate the effects of cross-linguistic structural priming in comprehension of the passive voice. Mandarin Chinese – English bilinguals and English monolinguals were tested. The data showed that after hearing a passive sentence in Mandarin, participants were significantly more likely to anticipate a passive sentence in English right after the first word. Cross-linguistic structural priming had an effect in comprehension between two typologically different languages. The data best fits the models in favor of shared syntactic processing. The monolinguals were not primed, lending support for the claim that larger lexical overlap is needed for successful priming of monolinguals.

## Introduction

Many humans can use more than one language (Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016). Bilinguals can seemingly use either one of their languages with great ease, adapting to their environment, or code switch and use both languages in an accurate manner if the context allows. Understanding how bilinguals process language has been of interest to linguists for decades. An intense debate has been going on over recent years regarding the most suitable model to explain how bilinguals successfully exploit two languages with varying morpho-syntax and lexicon, and other distinctive features. Possibly the most intense discussion

surrounds bilinguals´ usage of morpho-syntax and the seemingly effortless transition from one system to the other. Several studies have investigated the processing of syntax in bilinguals using different methods, as well as different language pairs and different syntactic structures. There are still many unanswered questions, from the effect of L2 proficiency and the effect of translation from L1, to the best model of language which can explain all of the particularities of bilingualism. Cross-linguistic structural priming has proven a very suitable way of investigating one language´s influence over another, and has shed a new light on some of these questions.

## Structural Priming

Structural priming has been observed and used in studies on monolingual language processing for many years. It represents an increased likelihood of using a certain syntactic structure after being exposed to it immediately beforehand (Bock, 1986). A variety of topics have been investigated using syntactic priming as a tool in many different languages: English (Bock, 1986); German (Brandt, Nitschke, & Kidd, 2017); Japanese (Arai & Mazuka, 2014); Chinese (Chen, Xu, Tan, Zhang & Zhong, 2013), Dutch (Hartsuiker & Kolk, 1998) to name but a few of the languages. Different versions of structural priming have been implemented over the years. A common method is a picture description task with a confederate who first describes an image using the key syntactic structure, and in the process primes the participant in the experiment to use the same structure to describe their image (e.g. Branigan, Pickering & Cleland, 2000; Branigan, Pickering, McLean, & Cleland, 2007; Cleland & Pickering, 2003; Hartsuiker, Bernolet, Schoonbaert, Speybroeck, & Vanderelst, 2008). Acting out activities have been used as primes in studies with children (Thothathiri, & Snedeker, 2008). In this study, the children first listened to and acted out the prime sentences, and after that they heard the target sentence. Their eye fixations were then measured, as an indicator of how they interpreted the

sentence. Written sentence completion after reading a prime sentence was used with adults (Scheepers, 2003; Loncke, Van Laere & Desmet, 2011). Regardless of the methodology, language and syntactic structure in question, the outcome was always the same – higher production of the primed structure than without priming or when the prime is an unrelated structure.

Structural priming has not only been investigated in language production, but in language comprehension too. Structural priming in comprehension means that previous exposure to a certain syntactic structure affects the way in which upcoming sentences with the identical syntactic form are understood. This happens either because the comprehension of the primed structure becomes faster, the expectation for the structure increases, or the surprisal effect from an unexpected low-frequency structure decreases.

Outcomes vary depending on the method used to measure structural priming in comprehension. In ERP studies, previous exposure to the target structure decreases the P600 effect in the target sentence, suggesting that the garden path effect is reduced (Ledoux, Traxler, & Swaab, 2007; Chen et al., 2013), faster RT in a sentence reading task (Myslín, & Levy, 2016; Hsieh, 2017), or anticipatory looks towards the target image in an experiment employing eye tracking (Arai, van Gompel, & Scheepers, 2007; Arai & Mazuka, 2014). These results clearly show that priming affects the way sentences are comprehended, and not only their production. Comprehension priming studies have the advantage of being able to show the more nuanced and detailed effects of structural priming. In production experiments, the participant either repeats the primed structure or the alternative one. In comprehension studies, on the other hand, the strength of the priming effect can usually be traced from the target sentence onset until its end, and even after that, with more refined measures and noticeably subtle differences between structures.

Various other effects are visible during comprehension priming studies, such as the garden-path effect. Here, the participants are initially misled to opt for a wrong interpretation, before realizing that the meaning of the sentence is completely different. For instance, in the sentence "*Put the frog on the napkin in the box*", the participants can easily get confused after the first part of the sentence "*Put the frog on the napkin*-", which is in itself a complete sentence (Trueswell, Sekerina, Hill & Logrip, 1999). Only after hearing the rest of the phrase can they accurately interpret the sentence structure and the relationship between the constituents. This and similar effects can be measured appropriately only in comprehension – in the current study with the eye tracking method – since by the end of the sentence, most individuals realize the actual meaning, and the garden-path effect is no longer detectable by the production or act out methods. Such findings are important because they show that sentences are being parsed from the very onset and all possible interpretations are being tested, based on the previous knowledge and experience of the parser (Chang, Dell, & Bock, 2006).

What is more important, perhaps, is that by showing priming effects in comprehension, similar to the effect in production, the question arises regarding the similarity between these two language modalities. Most researchers agree that language production and language comprehension share certain features, despite obvious differences. For instance, in Pickering and Garrod's language model (2013), they state that the two modalities support each other and are intertwined, meaning that language production contains language comprehension, and that during comprehension, the production nodes are also activated. There are still, however, other language approaches which state that the two modalities have almost nothing in common and function virtually separately from one another. For instance, Newmeyer (2003) states that humans are capable of understanding very complex sentence structures which they had never encountered before, and producing sentences they have never heard before, and that therefore the syntactic system of a language must be separate from the actual usage. Successful structural

priming in comprehension goes against these views on the separation of production and comprehension.

But how does structural priming work effectively in the first place, and what does it tell us about language processing in general? On the one hand, the so-called lexicalist approach states that word lemmas, and especially those which represent verbs, comprise separate nodes which are activated during priming and then remain activated for a certain time, so that they are more easily accessible later on. That, in effect, leads to structural priming (Pickering & Branigan, 1998). This means that if, for instance, the prime sentence was a dative structure with the direct and indirect object – "*The man gave the woman the book.*" – the verb "*give*" will become more activated, and more easily accessed for production. In addition, the preference for the direct object + indirect object structure afterwards would become more activated and expected, instead of the alternative structure – indirect object + prepositional phrase. If the person who was exposed to this sentence needs to utilize the same or a similar verb, they will (also) be more likely to use the same sentence structure. This approach is effective in explaining the so called lexical boost effect (Rowland, Chang & Ambridge, 2012; Traxler, Tooley & Pickering, 2014), which implies that structural priming is stronger when the prime and target verbs are the same.

Another relevant theory in explaining the effect of structural priming is the error-based implicit learning approach (Chang et al., 2006). It states that each previous exposure to a certain structure causes a permanent learning effect. This, consequently, makes the structure more accessible in the future. Priming is not just a temporary activation of a structure, but rather leaves it permanently more accessible, as the usage of the structure increases. The less frequent the structure, the higher the chance of learning, due to an erroneous initial interpretation. According to Chang and colleagues (2006), this is one of the main ways in which children acquire a language. Through constant exposure to new structures or increased exposure to old

ones, the inherent statistical knowledge on the usage and frequency of a structure solidifies. Priming over several items, or priming effects present after a longer period of time, can both be adequately explained by this approach. According to this theory, the structure remains constantly activated because it is learnt, so there is no reason why it should not be accessible after many unrelated items or later in time.

## Cross-linguistic Structural Priming

Priming has also served as an invaluable tool in cross-linguistic studies. Exposing participants to a structure in one language, and then looking at how this affects their processing of another language, is a straightforward way of directly tapping into the interaction between the two languages. It is relevant that a considerable number of studies on cross-linguistic structural priming show that there is a shared syntactic representation in bilinguals, because it undoubtedly shows a relationship between two grammar systems in the bilinguals´ mind and how easily they affect each other. This is contrary to some previous theories on bilingual language processing which claimed that the grammars, as well as lexicons, of two languages are completely separate in bilinguals. Previous studies have looked at both priming from L1 to L2 – e.g. Loebell & Bock (2003) for German-English cross-linguistic priming; Hartsuiker, Pickering & Veltkamp (2004) for Spanish-English cross-linguistic priming; Chen and colleagues (2013) for Chinese-English cross-linguistic priming; Salamoura and Williams (2007) for Greek-English cross-linguistic priming; Cai, Pickering, Yan, & Branigan, (2011) for Cantonese-Mandarin cross-linguistic priming. Others have also looked at priming from L2 onto L1 (Schoonbaert, Hartsuiker, & Pickering, 2007). The study by Schoonbaert and colleagues (2007) looked at each direction of priming in bilinguals, and concluded that the effect exists regardless of the language used as a prime. Interestingly, they found that when the target verb is the direct translation of the prime verb, priming from L1 to L2 is enhanced. This corresponds

to the so-called lexical boost effect found in monolingual priming studies (Hartsuiker et al., 2008). However, when the prime was in L2 and the target sentence in L1, no enhancement effect of the verb translation was found to have occurred. Schoonbaert and colleagues (2007) claim that this unbalance was not predicted by the model of syntactic priming by Hartsuiker and colleagues (2004).

## The Current Study

The current study will look at cross-linguistic priming in comprehension from L1 Mandarin to L2 English. By focusing on these two typologically different languages, any effect of phonetic, morphological or lexical overlap can be avoided, and more focus can be placed on the structure of the sentence – its syntactic form and the thematic role assignment, i.e. the constituent order. Previous studies on these languages in bilinguals looked at the effects cross-linguistic priming has on production. Chen and colleagues (2013) exposed Mandarin-speaking participants to primes in Mandarin and asked them to describe images in English in an attempt to prime more frequent production of passive sentences. The priming did lead to significantly more passives being produced in English. In the study, the same was attempted with English as a prime, and Mandarin the target. The results were similar here as well, with more passives in Mandarin being produced after the English primes. The authors used this to support the thesis that word order similarity is not necessary for cross-linguistic priming. Their findings are in line with several other studies, which successfully primed structures between languages with different word orders.

In a more recent study, Hsieh (2017) used a self-paced reading task to look at the priming effects of relative clauses in Mandarin-English bilinguals. The passive relative clauses in Mandarin, such as "*The student praised by the principle received good grades"* reduced the reading time during the disambiguating segment, the "*by-phrase*", in the English target

sentence. Furthermore, the lexical boost effect did not significantly affect the priming, showing that different verbs can be used to prime cross-linguistically.

The current study will build on the previous work by Chen and colleagues (2013) and Hsieh (2017) and use eye tracking as a method of measuring the effect that cross-linguistic priming has on language comprehension. Eye tracking has an advantage over reaction time measures, since it can pinpoint a garden path effect which occurs/may occur during the comprehension of a passive sentence in English. In a sentence "*The man is pushed by the artist"*, a short-lived ambiguity arises before the -ed morpheme on the verb is presented. Up to this point, the sentence reads as an unmarked canonical SVO type sentence, where it is expected for the first NP to be the agent, for instance: "*The man is push-ing the box*." If an ambiguity is present amongst bilinguals at this point, the expectation is that after structural priming with a similar structure – in this case a passive sentence – the ambiguity would decrease or no longer be present, since the expectation for the passive structure would rise.

The current study will test the comprehension of highly-proficient bilinguals living in the L2-speaking environment. This is a novel approach (but see Hartsuiker et al., 2004). By testing highly-proficient bilinguals, the claim that proficiency plays a key role in cross-linguistic priming can be tested (Hartsuiker & Brnolet, 2017). Previous studies have stated that proficient L2 speakers have more similarities in language processing to native speakers of a language. L2 syntax processing starts of lexically driven. This means that the syntactic structures are learnt exclusively in relation to certain lexemes, usually verbs. Processing of these syntactic structures is then limited to only those verbs. Abstraction of the syntactic structure and its separation from the particular verb happen later, with more language input. As L2 proficiency improves, the syntax becomes less lexicalized, and the second language starts to have shared syntactic nodes with the first language (Hartsuiker et al., 2004; Hartsuiker & Bernolet, 2017; Hartsuiker et al., 2016). This means that the syntactic processing of the second

language is done in a way similar to the processing in the first language, and certain syntactic categories are stored together for both languages. Therefore, it is claimed, more proficient L2 speakers can more easily be primed.

Finally, for the current study, in experiment 2, a group of monolingual English speakers will be tested to investigate whether there are similarities between native speakers and highly-proficient L2 speakers when it comes to the comprehension of passives with and without priming. Several other studies have also used a monolingual group to compare the results of cross-linguistic priming (e.g. Loebell and Bock, 2003; Bernolet, Hartsuiker, & Pickering, 2013; Hartsuiker et al., 2016), but those have always been monolingual speakers who use the same L1 as bilinguals. By comparing Mandarin-English bilinguals to their English monolingual counterparts, a better understanding of L2 processing can be achieved, and a direct comparison to the comprehension of L1 can be made. This finding could contribute to the discussion on how similar processing of syntax by bilinguals is to that of monolinguals, with most theories supporting the claim that this processing is different, even in highly proficient bilinguals (e.g. Clahsen & Felser, 2006; Clahsen & Felser, 2017).

In summary, the current study will focus on the three main questions: Can comprehension in proficient, late bilinguals be primed from their L1 to L2? Is there a garden-path effect in L2 processing in bilinguals and does priming affect it? Do proficient bilinguals perform at the same level as monolinguals?

Based on previous findings and literature that has already been discussed here, the expectation is that the bilinguals will be successfully primed. The current study will do this in an eye tracking experiment with a visual-world paradigm, which would entail more preferential viewings of the target image and faster viewings of the target image after priming in L1. Similar studies have been done with different language pairs, including Mandarin and English. A significant garden path effect might be detected, similar to the one seen in monolinguals.

Finally, monolinguals should be successfully primed, and the pattern of their comprehension should either be like that of bilinguals or their looks should show a faster parsing of the passive voice. The same pattern of priming should be present in both groups, as the theoretical framework of previous studies would support this claim.

The structure used in the current study is the passive voice. This construction has been successfully primed in monolingual studies (e.g. Segaert, Menenti, Weber & Hagoort, 2011; Arai & Mazuka, 2014), as well as in several cross-linguistic studies (e.g. Hartsuiker et al, 2004). On the other hand, Loebell and Bock (2003) ran a study on German-English bilinguals where they successfully primed the production of datives, but not of passives. English and German passives have different word orders, whereas the German one is similar to the Mandarin one, with the main verb occurring at the last position, after the agent.

## The Passive in English and Mandarin

Passives in Mandarin share several features with those in English. The canonical and the most frequent structure in both languages is the active agent-verb-theme (Li & Thompson, 1989). Therefore passives, which in the two languages have a different constituent order, are a derived and marked sentence structure in both languages. In English, the passive has the theme-verb-agent structure, whereas in Mandarin it is theme-agent-verb. Passive constructions are infrequent in spoken Mandarin, as they are in English (Huang, Zheng, Meng, & Snedeker, 2013). The authors in the same study looked at the frequency of passives in spoken language corpora of English and of Mandarin Chinese. They established that whereas in English passives occurred 1026 times per 100.000 words, in Mandarin Chinese they appeared only 110 times per 100.000 words. This means that passives are more than 9 times less frequent in spoken Mandarin than in spoken English.

There are also several differences between the two languages regarding this structure. First, the passive in Mandarin has a different word order to the one in English, which can be seen in (1) (Li & Thompson, 1989). The standard word order in Chinese passives can be seen in (2), and the passive without the second NP (i.e. the Agent) can be seen in (3).

1. *NP1 verb NP2 (by phrase).*
2. *NP1 bèi NP2 verb.*
3. *NP1 bèi verb*

Secondly, the particle *bèi,* which is used to mark the passive structure, serves no other purpose in Chinese (Huang et al., 2013), whereas each part of the English passive sentence morpho-syntax also has other uses (see example 4). For instance, the past participle is used in constructing the present perfect tense (5), and the preposition *by* has other uses (e.g. temporal, as in (6)).

4. *The man is pushed by the artist.*
5. *The man has pushed the artist.*
6. *The man will arrive by tomorrow morning.*

Thirdly, according to Li and Thompson (1989), the main usage of the passive construction in Chinese is the adversity. This type of construction depicts an action where something unwanted or "unfortunate" has happened. This way, passive sentences are additionally marked, since the verbs used here have negative connotations, even though they would have a neutral meaning in an active sentence.

In summary, the English and the Mandarin passive are both infrequently used structures, with the theme NP occupying the first NP position in the sentence. On the other hand, the word

order between the two passives differs, when they are in full form (the truncated passives only have a single noun phrase and the verb phrase), the Chinese *bèi* marker is used solely for the purpose of creating passive sentences, and a common usage of passives in Chinese is for adversary situations.

To understand the Mandarin syntax even better, it is important to mention that apart from the *bèi* passives, Mandarin also has the *bǎ* constructions (Li & Thomspon, 1989). These are essentially active sentences, with a NNV word order and agent-theme-verb θ-roles (see (7)). These marked active sentences will not be tested in the current experiment.

7. NP1 bǎ NP2 verb.

## Summary

The current study will use eye tracking with the visual-world paradigm to investigate the effect of cross-linguistic priming from Mandarin to English passives (Experiment 1). Highly-proficient Mandarin-English bilinguals will be tested. They will first be primed with passive sentences in Mandarin Chinese. After that, they will hear target passive sentences in English. Furthermore, a monolingual English-speaking group will be used to check for the same effects within a single language (Experiment 2). With the use of eye tracking and the single picture visual-world paradigm being employed, understanding of the passive structure can be observed during sentence comprehension. If priming occurs, the disambiguating word can easily be traced. This can be done by measuring at what point in time during sentence comprehension the participants commit to the passive interpretation of the sentence. The point at which this occurs – first NP, auxiliary verb, second NP – will mark that this part of the target sentence is crucial in the correct parsing of passive sentences.

# Study I

## Methods

**Participants** – 33 bilingual Mandarin-English speakers were recruited at Newcastle University (3 male; mean age: 25). They participated for class credits or a cash reward. Before the start of the experiment, the participants signed a written consent form which had been approved by the Newcastle University´s Ethics Committee. They also filled out a questionnaire which focused on their linguistic background, language usage and proficiency, as well as levels of exposure to both Mandarin Chinese and English. All of the participants had previously taken the official IELTS exam, with the lowest grade being 5.5, and the highest 8.5 on a 9-point scale (median grade: 7). The minimum time spent in the UK prior to testing was 2 months. The participants were primarily studying either the university´s masters´ program on Mandarin-English translation or the masters´ program for teaching English as a second language. The high individual and average IELTS scores, together with their study program focusing on the in-depth understanding of the English language, ensured that participants were proficient in their second language. All had normal hearing and normal to corrected-to-normal vision, and they could all name the colors used in the study. All of them used Mandarin Chinese as their main language and English as a second language, with one participant additionally using Hokkien[13] at home. At the end of the experiment, each participant took a debriefing questionnaire, which asked if they understood the items in English and if the task was too difficult, too fast or if the sentences used were too complex. The results show that they all knew each of the nouns and verbs used prior to testing, and the task and items were not too complex to understand.

13 Hokkien is a one from a group of languages used in southern China.

**Materials**- Items used in the experiment comprised auditorily presented sentences of mutually-reversible transitive actions performed by animals. The sentences were accompanied by matching images. The sentences were either in the active or passive voice. The sentences used for priming were recorded by a female speaker of standard Mandarin, at a normal speed and tone of voice. The target sentences were recorded by a female native English speaker, also at a normal speed and tone of voice. Both female speakers also recorded instructions for the experiment in their respective languages. The English native speaker additionally recorded the comprehension questions which were played after each target sentence. The volume of the sentences was normalized using Praat software (Boersma, & Weenink, 2015). For the primes, 6 high-frequency transitive verbs were used (*carry*, *hunt*, *feed*, *kick*, *kiss* and *pull*). Each priming verb was repeated 4 times during the experiment, twice in an active and twice in a passive voice.

For target sentences, 6 other high-frequency transitive verbs were used (*comb*, *draw*, *grab*, *push*, *wash* and *tickle*). Each target verb was also repeated 4 times throughout the experiment. The protagonists in all the sentences were two pairs of animals – a monkey and a frog, and a bird and a rabbit. The animals were paired so that they did not represent each other´s predator or prey. This could potentially influence the interpretation of sentences by including real-world knowledge of the relationship between the agent and the theme (e.g. cat and mouse, or shark and seal). 24 priming sentences were used (6 verbs, 2 pairs of animals, 2 voices), and also 24 target sentences. In total, there were 6 items in each condition (6 x active prime sentence and active target sentence; 6 x active prime sentence and passive target sentence; 6 x passive prime sentence and active target sentence; 6 x passive prime sentence and passive target sentence). Two pseudo-randomized lists of items were created. For both prime and target sentences, the same verb never appeared twice in a row. Furthermore, the sentence in the same voice – active or passive – was never repeated more than twice in a row. On top of this, the same combination of prime-target sentence voice never occurred more than twice in a row. For instance, if the prime sentence was in the passive voice, and the target sentence in the passive,

the same combination could occur only once again immediately following this pair. After that, another combination of prime-target sentences had to be used. As mentioned in the introduction, previous literature did not find priming effects of active voice sentences on the comprehension of passive voice sentences. The active voice is more common in both English and Mandarin. Structural priming is typically present only with less frequent and thus less expected structures. The expectation for a canonical structure – such as active voice – is already high, and the nodes necessary for its correct interpretation are constantly active (Chang et al., 2006; Hartsuiker & Bernolet, 2017).

Additionally, 4 non-related verbs (*sleep*/*dream*, *swim*, *imagine* and *talk*) were used to create 16 "prime-target" filler pairs. These verbs were chosen since they are either unergative or describe psychological states, thus cannot be passivized, and therefore would not affect the experiment or prime the comprehension of target sentences in any way. The protagonists used in the filler items were a turtle and a mouse, which further prevented any possible lexical priming. Each filler was then repeated twice throughout the experiment. There was always at least one filler "prime-target" pair between two real experimental items.

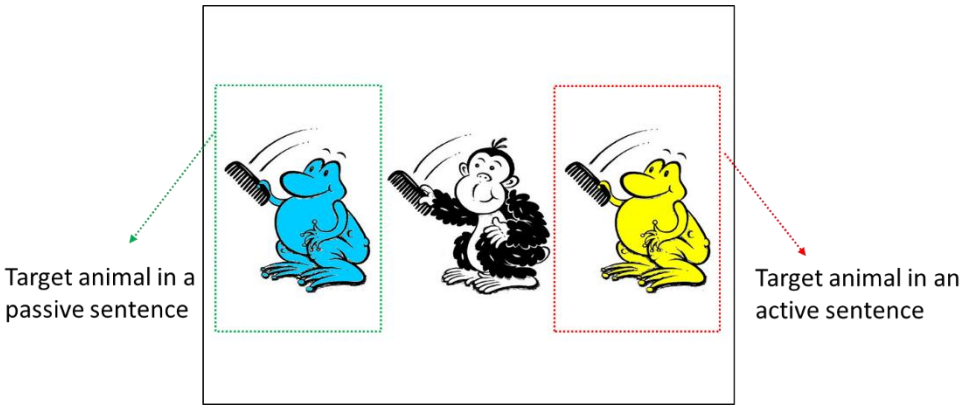


Figure 4.16: An example of the target image layout

The images presented alongside the prime sentences comprised black-and-white drawings of two animals in the center of the screen performing an action together. The images used along with the target sentences had three animals in a row horizontally, performing an identical action onto the animal in front. This adjusted single-image paradigm has proven

suitable for eye tracking experiments, where it reduces the number of items in the picture (e.g. Scheepers & Crocker, 2004; Arai et al., 2007; Adani, 2011; Arai & Mazuka, 2014). The image consisted of two identical animals left and right of the center in two distinct colors, and another animal in the center (see Figure 4.1). Both of the identical animals on each side were colored either red, yellow or blue. The combination of the two colors was never repeated twice in a row, and each color was repeated the same number of time in the images. Additionally, the direction the animals in the target images were facing was counterbalanced across the experiment. The drawings for the filler items followed the same pattern. Additionally, a drawing of two female characters was used at the beginning of the experiment while two female voices explained the procedure in Mandarin and English.

**Procedure**- The study was conducted at the Newcastle University eye tracking lab. The Tobii X1 Light Eye Tracker was used with 30 Hz temporal resolution. Tobii Studio software version 3.2.3 was used to present the items on an HD, 1920 x 1080 resolution TFT monitor. The sound was played via headphones.

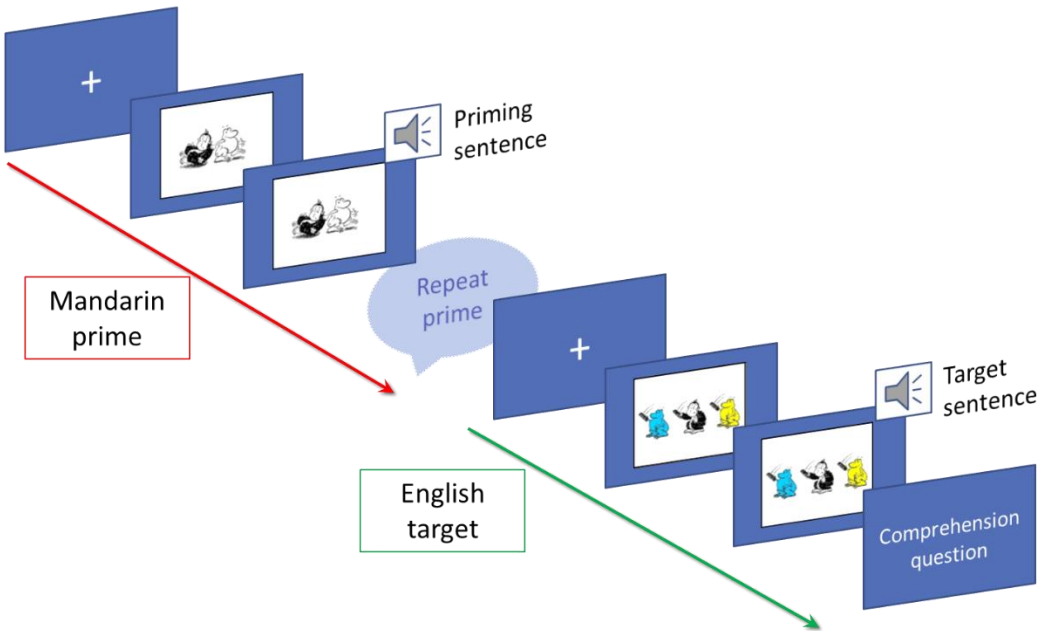


Figure 4.17: The procedure of experiment I, with the priming segment in Mandarin and the target segment in English

After filling in the consent form and the language questionnaire, the participants were seated in front of the eye tracker at a distance of 60 cm. The eye tracker was calibrated for each participant using a nine-point calibration. The experiment started once the calibration was successful. First, there was a black-and-white drawing presented on the screen of two female characters. They explained the procedure in Mandarin and in English. Three practice "prime-target" items were presented to help participants get used to the setup of the experiment and make sure they understand the procedure. The task for the participants was to repeat out loud the sentence they heard in Mandarin (the prime) and then to name the correct color of the animal in the picture after hearing the English sentence (the target). The naming of the color of the animal had two goals. It ensured that the participants were focused throughout the experiment, and it provided accuracy data, since only one of the colored animals was the one involved in the action described by the target sentence (as shown in Figure 4.1).

Each segment of the experiment started with the priming part. First, the prime image was presented. After 1500 ms, the prime sentence which described the action in the image was played via headphones. The sentence would be either in the active or passive voice. 2000 ms post sentence presentation, the drawing of one of the female characters would appear on the screen, which would signal the participant to repeat the prime sentence out loud. After the participant repeated the sentence, the examiner would press the control button and the target part of the experiment would begin (see Figure 4.2).

In the target segment, a fixation cross in the center of the screen was present for 500 ms, after which a new image was presented. After 2000 ms on-screen, the image was followed by the target sentence spoken in English. The sentence always had one of the two identical animals on the sides as its first NP. In this way, a temporary ambiguity was created, which would be resolved only as more of the sentence structure was presented. In a sentence such as "*The frog is combed by the monkey*", only at the end of the lexical verb does it become clear whether the sentence is in the passive – *combed* – or active voice – *combs*. Consequently, only after the VP

does it become clear whether the first NP is the agent or the theme. At this point, one of the two identical animals in the target drawing becomes the target animal, since it corresponds to the thematic role of the animal which was named in the target sentence. The other animal becomes the distractor since its thematic role is not present in the target sentence. Only an incorrect interpretation of the target sentence would lead to more looks towards the distractor animal. The image stayed on-screen for an additional 2000 ms, after which the female character asked what color the first NP animal in the sentence was ("*What color is the monkey / the frog / the bird / the rabbit?*").

The question was used to increase (enhance) the attention of participants of the task, and to ensure they properly understood the sentences. If they gave an incorrect answer by saying that the animal in question was of the wrong/other color, this would indicate that they had misinterpreted the role assignment in the sentence (Adani, 2011; Arai & Mazuka, 2014). For instance, in the sentence "*The frog is combed by the monkey*", if the frog doing the combing is yellow and the frog being combed is blue, the correct answer would be "blue". If, however, the participant answered "yellow", this would signal that they interpreted the sentence as an active voice structure. This accuracy data was later used in determining which participants to include in the study, based on a 2/3 accuracy cutoff. It was further used to compare the bilingual group´s performance with the monolingual group´s performance.

## Data analysis

The data analysis was done on the log transformed data from the proportion of looks towards the target versus looks to the distractor animal during sentence presentation. The eye tracking data of each participant was aligned to the onset of the spoken sentence of each item (see Figure 3). For the analysis, Mixed Effects Model was used with the R program (R Core Team, 2015) and the lme4 package (Bates, Maechler, Bolker & Walker, 2012). The proportions

of looks were divided into 11 time windows for analysis, from the onset of the auditorily presented sentence. Each time window was 200 ms in length. The 200 ms time windows were chosen because that is the average time needed to program an eye movement saccade after a fixation (Huang et al., 2013). The first 2000 ms post sentence onset were included into the analysis, which generally corresponds to the average length of an entire sentence. As fixed effects, the target sentence type (passive and active) and prime sentence type (passive and active) were entered. The active primes and active targets were considered to be control items in the experiment. No priming effect from active to passive voice was expected since previous literature did not find one either (Messenger, Branigan & McLean, 2012; Arai & Mazuka, 2014; Gámez & Vasilyeva, 2015). Individual participants and items were included into the analysis as random effects. A two-way interaction between the variables was also entered into the model. Sum Contrast was used for the prime sentence type and target sentence type. Active prime sentences and passive target sentences (i.e. the control passive sentence condition) were used as intercepts for the final model. The plotted residuals of the final model were normally distributed upon visual inspection. See Figure 4.3 for results.

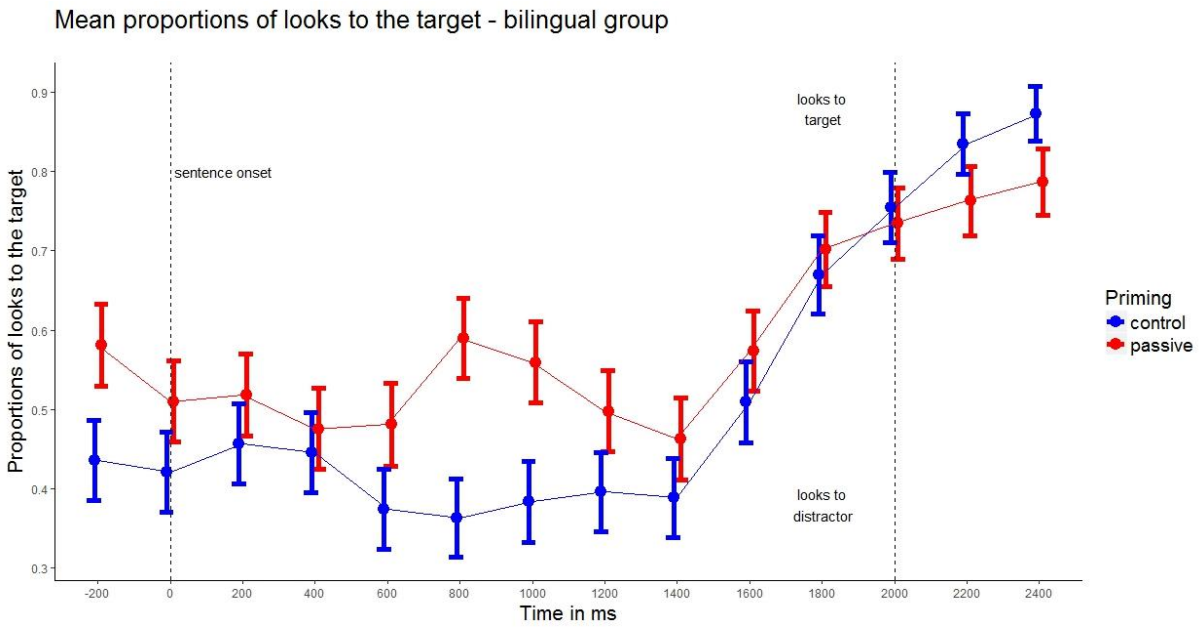


Figure 4.18. Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time, divided into 200 ms windows for passive target sentences

## Results

An interaction between the passive target sentence factor and passive prime sentence factor in the time window at 600 ms was found ($\beta$= 0.101; *SE*= 0.0484; *z*= 2.090; *p*= 0.043). The same interaction was also present in the time window at 800 ms ($\beta$=0.186; *SE*=0.061; *z*= 3.037; *p*=0.004). Also, in time window at 1000 ms, the interaction between the prime and target passive sentence factors was found ($\beta$= 0.13018; *SE*= 0.05419; *z*= 2.402; *p*= 0.020). This means that in the time window between 600 and 1000 ms from the passive sentence onset, the participants primed with passive sentences diverted their gaze towards the character which corresponded to a passive interpretation of the target sentence. In all other time windows, no significant priming effect was found between any of the conditions. See Figure 4.4. for results.

The accuracy data did not show any significant differences between the priming conditions. In other words, the participants gave a similar number of correct answers to the color questions regardless of the prime sentence type or the target sentence type. The accuracy scores were significantly above chance for all conditions and close to ceiling.

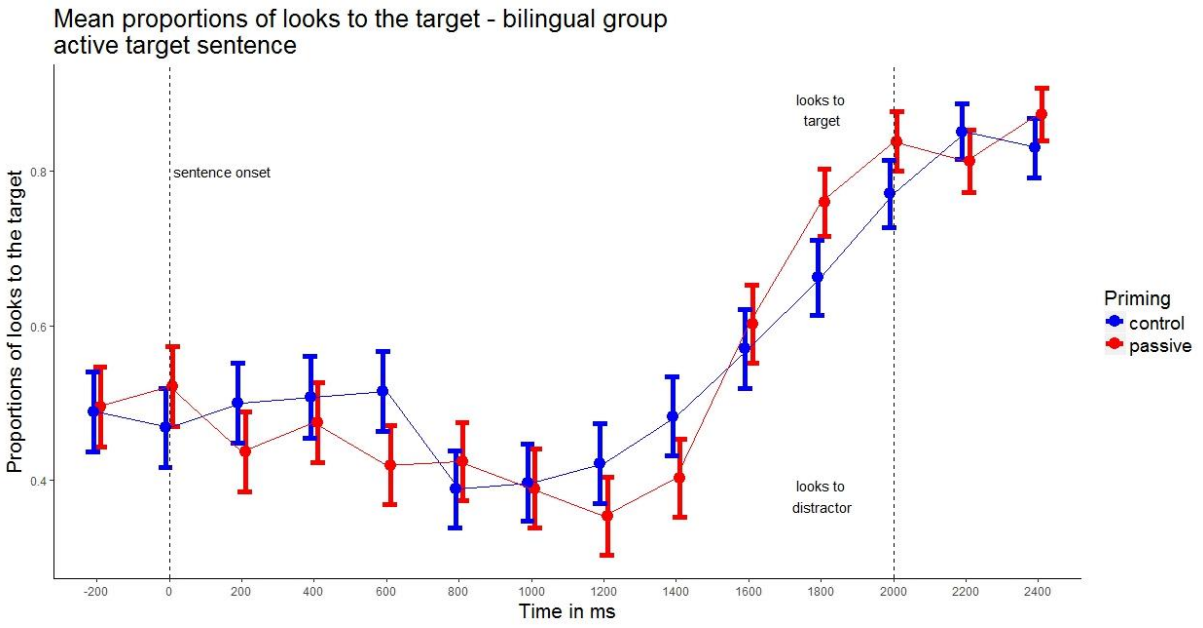


Figure 4.19. Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 200 ms windows, with the target sentence in active voice

### Discussion

The Study 1 data shows how previous exposure to a passive priming sentence in Mandarin Chinese significantly affects the comprehension of English passive sentences in bilinguals. This means that cross-linguistic priming of passive sentences in comprehension from Mandarin to English occurs rather quickly, and only a small part of the target sentence, i.e. the first 600 ms, is needed for participants to expect to hear a passive sentence in English. This timing corresponds to the average offset of the first NP and the beginning of the verb phrase. The data shows that before the end of the VP, and while the target sentence is still ambiguous and could yield an active interpretation, primed participants opt for the passive interpretation instead, having been exposed to it in a different language immediately before. As expected, the effect is not seen in active sentences. Actives, as a predominant and more frequent sentence form in both Mandarin and in English, would not typically be subject to priming, which usually exists only with infrequent or less expected structures (Arai & Mazuka, 2014). In this way, cross-linguistic priming between two unrelated languages with different word orders has been shown. This means that the syntactic structure itself, or at the very least, the eye movement experienced at the beginning of the sentence, can be primed in comprehension between languages.

## Study II

### Methods

**Participants** – 33 monolingual English-speaking students were tested (8 male, mean age: 25). They were recruited from the general student population at Newcastle University, and participated for class credits or a cash reward. They filled in a simplified version of the bilingual questionnaire from study 1, with only general information on their language background,

ensuring that they were not bilingual. They also filled out the same version of the written consent form approved by the Ethics Committee of the Newcastle University.

**Materials** – all the materials used were identical to those in study 1, including the images, filler items and target sentences. The exception were the priming sentences, which in this case were presented in English, to conduct this study with a monolingual demographic. These priming sentences were recorded by the same speaker who recorded the English target sentences.

**Procedure** – the procedure was identical to that of study 1. There was only one female character to explain the procedure in English. The participants were exposed to the priming image and sentence in English first, and then after repeating the prime sentence, they were presented the target image and sentence, followed by the comprehension question.

## Data Analysis

Data analysis was performed in the same way as in the first experiment.

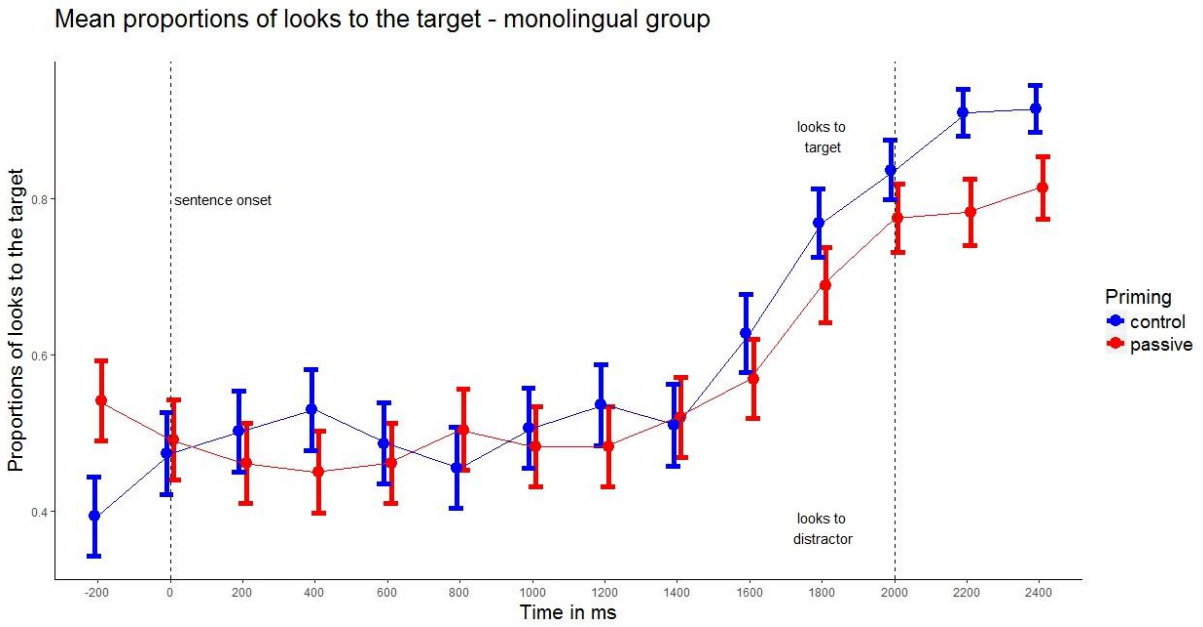


Figure 4.20. Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 200 ms windows for the English-speaking monolingual group

## Results

In the final model for the monolingual group, there was no significant interaction between the passive prime and the passive target sentence in any of the time windows between 0 ms and 2000 ms post sentence onset. In the control condition with active target sentences and active prime sentences, there was a significant interaction between the active target sentence and an active prime in the time window at 1400 ms post sentence onset (β=0.136; SE=0.062; z=2.193; p=0.034). The residuals of the final model were normally distributed upon visual inspection.

The accuracy scores were also analyzed, but no significant differences were found between different priming conditions. Also, the participants´ accuracy scores were above chance in all experimental conditions and close to ceiling. See Figures 4.5 and 4.6 for detailed results.

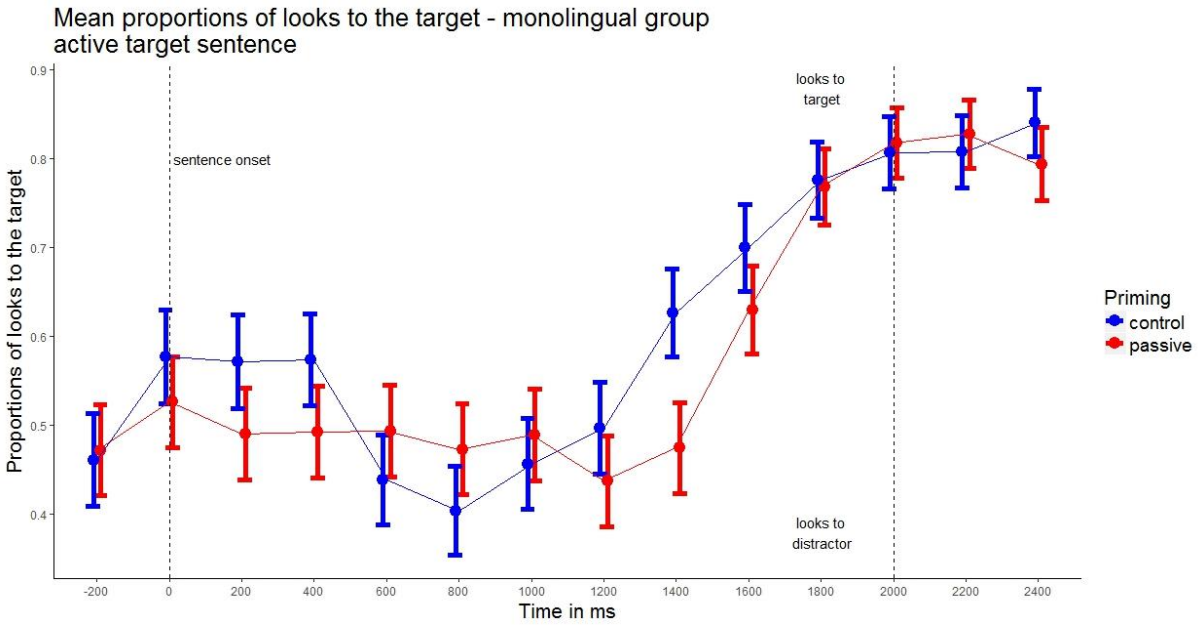


Figure 4.21.Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 200 ms windows for the English-speaking monolingual group, with the target sentence in active voice

## Discussion

Passive target sentences were not more likely to be anticipated by the monolinguals after exposure to priming with another passive sentence. In the current study, the data analysis in any of the time windows did not yield a significant difference between the looks to the target character after exposure to the passive prime and exposure to the active or control prime

sentence. This finding matches those from some of the previous eye tracking studies on monolingual syntactic priming where previous exposure to a certain structure (i.e. object dative or prepositional object dative) led to more looks towards the target image, but only when the verbs in the priming sentence and in the target sentence were identical (Arai et al., 2007). In the current study, the verbs between the priming and the target sentences comprised two different sets of verbs and none of the priming verbs were ever used in the targets. The current study extends the findings of Arai and colleagues' work from datives to passive sentences comprehension, reaffirming the idea that the repetition of the verb between the prime and the target, also known as the lexical boost effect, plays a significant role in successful structural priming with monolinguals.

The small but significant priming / inhibition effect found in the active target sentences in the time window at 1400 ms post sentence onset needs further clarification. Neither priming nor inhibition were expected with active target sentences, since actives are the preferred structure and outnumber the use of passive sentences in English. Previous research clearly shows that canonical and highly-frequent, expected structures are not suitable for priming, since syntactic priming itself requires raising the expectation of anticipating a less frequent sentence type, which then leads to the faster or easier processing of those structures (Chang et al., 2006; Hartsuiker & Bernolet, 2017). Active sentences in English, as with canonical sentence structures, already have a high level of expectation and it is unlikely that this can be increased further. With this in mind, it is possible that exposure to passive sentences affected the comprehension of active target sentences negatively, meaning it might have led to the inhibition effect. However, this is not expected, and previous research has not reached this conclusion. Further studies are needed to investigate the inhibition effects that infrequent structures have on more frequent ones, and further conclusions based on this finding are outside the scope of

the current study. Also, a test group with no priming (active or passive) would be needed, for a clearer reference point.

## General Discussion

In the two studies presented here, an attempt was made to investigate the comprehension of the English passive voice by bilingual Mandarin-English speakers via cross-linguistic priming, and to test whether syntactic structures share the same processing capacities between languages in bilinguals. Since the passive structures in Mandarin and English have large surface differences, a successful cross-linguistic priming would signal similarities on the abstract syntactic level that are not only related to surface structures between the languages, nor to the surface structure of the sentence, but more precisely, to the word order and morphological cues. This was measured by anticipatory looks of a target image in a visual-world paradigm. The results show that the bilingual participants viewed the correct image earlier when listening to a target passive sentence in English after they had been exposed to a passive voice priming sentence in Mandarin Chinese. This means that after being exposed to a Mandarin passive sentence, which served as a prime, they were more likely to anticipate a passive sentence in English. The effect was observed only in passive target sentences and in time windows from 500 to 1000 ms and 1000 to 1500 ms. The time window corresponds to the end of the first NP and the beginning of the VP (mean=591 ms; SD= 42 ms). The participants did not wait to hear the entire verb phrase before opting for a passive sentence interpretation.

On the other hand, a similar effect was not seen in the monolingual English-speaking group. When exposed to an English passive prime sentence, the native speakers were not more likely to anticipate a passive sentence afterwards. This finding supports previous work, which found that priming in comprehension in monolinguals is only or noticeable when the lexical boost effect is present.

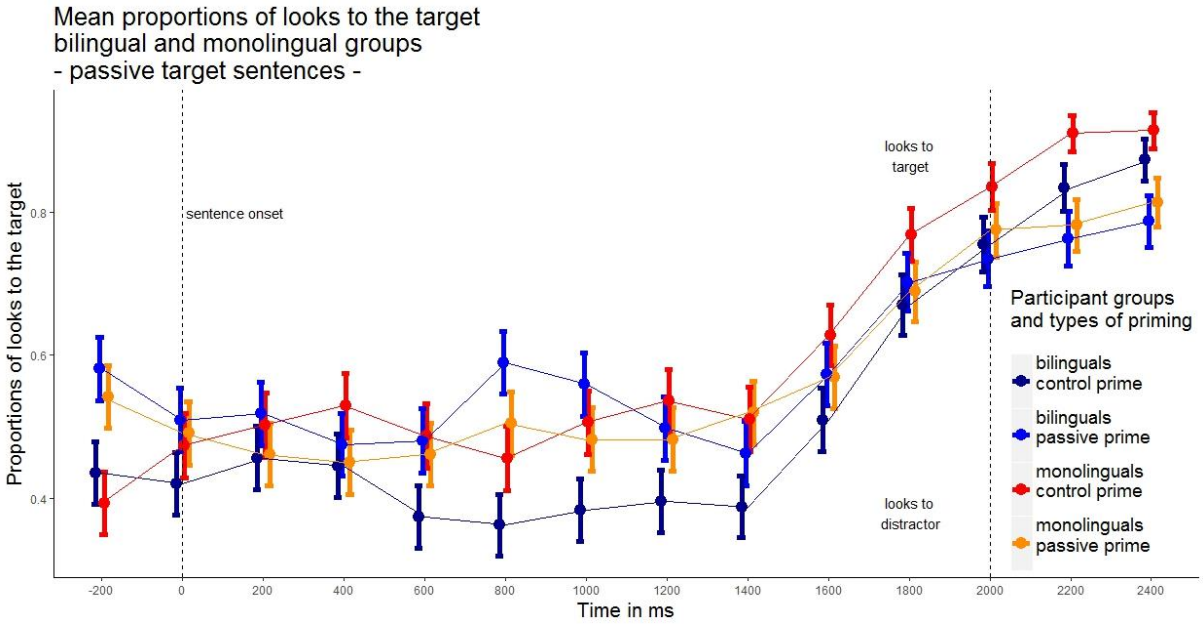


Figure 4.22: Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 200 ms windows for both groups, with the target sentence in passive voice

## Combined analysis

The data sets from both eye tracking experiments have been merged for the combined analysis. The goal was to directly compare the comprehension of passive sentences between the bilinguals and the monolinguals, and to compare the priming effects between the two groups. A new model was fitted over groups, target sentence type and prime sentence type. No significant difference was found between the groups and the overall conditions in the period between the sentence onset and 2000 ms post sentence onset, which was the period of analysis in both studies. The only significant difference was on the level of particular time windows, where in the time window at 800 ms post sentence onset, the target looking when presented with passive target sentences primed with passives of the bilingual group, differed from the passive sentences in the control condition of the monolingual group ($\beta$=0.1272; SE=0.0588; z=2.163; p=0.030). The same difference between the passives primed with passives bilingual group and the passives primed with passives monolingual group was observed at 1000 ms post sentence onset ($\beta$=0.1178; SE=0.0592; z=1.991; p=0.047).

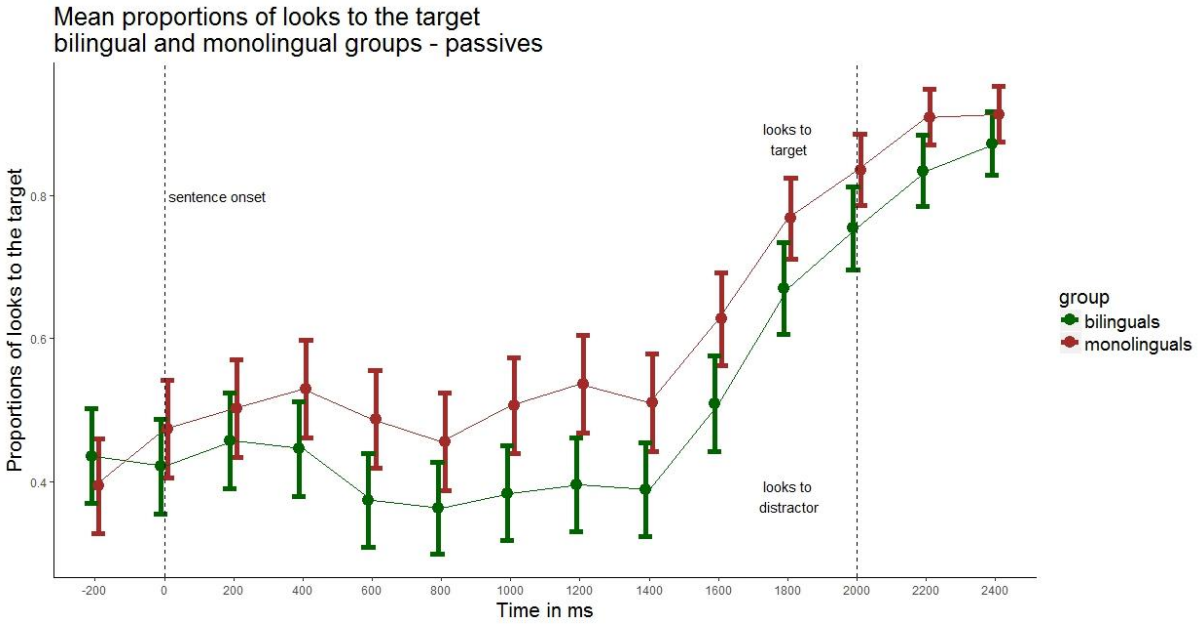


Figure 4.23: Proportions of looks towards the target image (up) versus the looks towards the distractor image (down) over time divided into 200 ms windows for monolinguals and bilinguals, with the target sentence in passive voice

## Combined analysis discussion

The results of the combined analysis of the data from the bilingual and monolingual studies show that no significant difference exists in the overall performance between the two groups. Only in the two time windows, namely at 800 and 1000 ms after the onset of the sentence, does the data from the bilinguals differ from that of the monolinguals. When primed with a passive sentence, the bilinguals tend to look more towards the target image than the monolinguals, who saw active priming sentences instead. In this respect, the results simply confirm the previous analysis of the two studies separately, that structural priming influenced the performance of the bilingual group and not the performance of the monolingual group. Furthermore, since no significant difference was found in overall performance between the two groups, it is safe to conclude that both groups showed similar processing patterns for passive voice sentences overall. Over the course of both experiments, accuracy data was collected, in which the participants were asked which color the animal described in the target sentence was. No significant difference was found, although the monolinguals did make fewer errors in total.

This further confirms that the difference in performance between the groups was not significantly different.

The only difference between the two groups was that the bilinguals were successfully primed when exposed to passives in their own L1, which led them to anticipate hearing a passive sentence in English as well. This effect was not present in the monolingual group, possibly because they were performing near ceiling with the structure, which was corroborated by fewer errors made, although the score was not significant overall. Cross-linguistic priming from L1 to L2 in comprehension proved successful, in this case from Mandarin Chinese to English, further enhancing the argument that syntactic priming works independently of lexical or phonetic influence. More importantly, priming was observed independently to the surface structure of the sentence – its word order and morphological structure. The two languages investigated here had different word orders in the passive voice. Furthermore, in Mandarin, the passive voice is signaled by the "*bei*" marker. In English, this is done with the "*by-phrase*" and the form of the verb combined. The priming was effective in the time window between 600 and 1200 ms after the onset of the sentence. This time corresponds to the average onset of the verb phrase in both the passive and the active sentences. This means that the bilingual participants who were exposed to passive primes in Mandarin expected to hear a passive sentence in English as soon as they heard the first noun phrase and the beginning of the verb phrase. As previously mentioned, this would indicate that the bilinguals primed with passives were more likely to interpret the target sentence as a passive one at the point at which the sentence was still being produced and was still ambiguous, meaning that it could still have developed as an active sentence. No similar effect was found in the active priming sentences control condition, nor with the active target sentences (control condition).

The results of the current study add new and relevant findings to previous work on both structural priming and L2 processing. The current study looked at how the comprehension and

expectation of bilinguals is affected by structural priming. By the end of the passive voice target sentence, the looks of bilinguals in this study were directed towards the target image. The priming effect occurred earlier during sentence comprehension. These findings indicate that bilinguals process passives from both of their languages combined. This outcome supports the approach which states that syntactic processing of bilinguals is shared between their languages. The syntactic nodes for the passive voice of proficient bilinguals are shared for their L1 and L2. Bearing in mind that the two languages investigated here have passive voice structures which are distinct from each other, the priming effect must have occurred on the syntactic level.

Another important contribution of the current work is the comparison between the processing of bilinguals and monolinguals of the L2. As mentioned in the introduction, previous studies usually compared the performance of bilinguals to that of the monolinguals with the same L1. This left the question open as to how the bilinguals compare to the native speakers of their L2. The results of the combined analysis of the two experiments show that differences in parsing exist, whereas many of the same patterns are present in both groups. This would lend support for language theories stating that bilinguals – even highly proficient ones – process their second language differently than native speakers of that language (Clahsen & Felser, 2006). The absence of priming in the monolingual group, and the difference in looking patterns between the bilingual group after passive prime and the monolingual group in the active prime / control condition confirm these differences in processing. Testing additional groups unexposed to any priming and testing the same groups on priming from L2 to L1, would give an even fuller picture of the underlying parsing process.

## Conclusions

The current study looked at cross-linguistic priming effects for passive structures from L1 to L2 in Mandarin-English bilinguals. A significant priming effect was found after

approximately 600 to 800 ms, which represents the onset of the verb phrase. The bilinguals who had heard a passive sentence in their L1 were more likely to have already chosen a passive interpretation of a sentence in English before the entire verb phrase was heard, while the sentence was still ambiguous, in the sense that an active sentence was still a viable option. Since the word order between the passive structures in the two languages differed, and there were no other lexical overlaps, the priming must have occurred at the syntactic level from one language to the other. The only similarity between the languages is the syntactic structure of the passive sentence, thus it being the only possible vehicle for the priming effect.

The current study also tested a monolingual English-speaking group, in order to compare its performance with the bilingual participants. This is the first time that a monolingual control group which uses the L2 of the participants has been tested in such a study, since up to now a typical control group, if used, was monolinguals speaking the first language of the bilingual participants. By using the English-speaking monolinguals as controls, it was possible to compare the performance of bilinguals as L2 learners to that of monolinguals. The current study showed no significant difference between the two groups on their overall performance on passives, with bilinguals looking more towards the target in the time window 800 ms post sentence onset, at the approximate onset of the verb phrase. This means that bilinguals were even more likely to anticipate a passive sentence after priming than the monolinguals without the prime. Even though the difference was not found when bilinguals´ performance was compared to that of monolinguals primed with passives, the results do show that bilinguals can expect the passive sentence even more than monolinguals under these circumstances. The performance of bilinguals was similar to that of the monolingual group. This is also an interesting finding of the current study, since in previous research it was not possible to directly estimate the performance of bilinguals in language comprehension studies and cross-linguistic priming tasks.

Another reason the bilinguals exhibited this pattern of looking towards the target in the current study when compared to the monolingual group may have to do with the fact that they were highly-proficient bilinguals who were living in the country where their L2 is spoken, and where they were studying in the language and were immersed in it daily. Previous research on cross-linguistic priming usually tested students of a given second language from universities in the country of origin or where their L1 is spoken. In order to confirm this claim, further studies with such bilinguals would need to be conducted using a method similar to the one in the current study.

The findings of the current study support previous research stating that bilinguals, even the highly proficient ones, do not process their L2 in the same way as native speakers (Clahsen & Felser, 2006). In the current study, even though there was no overall difference between the passive comprehension of the two groups, the fact that only the bilingual group was successfully primed could be interpreted as evidence for the difference in how the two categories – the bilinguals and the monolinguals – comprehend the structure.

The only priming effect in the monolingual group was found in the analysis of the comprehension of active sentences. Here, in one of the time windows, namely 1400 ms post sentence onset, those exposed to a passive sentence prime performed worse than those who were not. This could mean that at this time point, which corresponds to the average end of the verb phrase and onset of the second noun phrase, monolingual participants were expecting a passive sentence instead of an active one. If this is the case, then it might also be true that in the bilingual group, the strong difference between the priming with passives and the control condition, i.e. priming with actives, might have been enhanced by the inhibitory effect the active prime had on the language processing of bilinguals and their expectation of the upcoming sentence. This effect could be disentangled by having two groups of participants – one which would be primed only with passive prime sentences and another one which one is primed only

with active prime sentences. In other words, using a between-subject experiment design, instead of the within-subject design, could better show what the effect of each type of priming sentence is on the comprehension of passives. This approach has been used before (Gámez & Vasilyeva, 2015). However, this study did not find any significant effect of the active voice sentences on the comprehension of the sentences in the passive voice.

It is, however, unlikely that this priming with active sentences effect is the reason for either the inhibitory effects seen in the comprehension of active sentences by monolinguals, nor the priming seen in the bilingual group. Active sentences in their regular form are the preferred structure in both Mandarin Chinese and in English. Actives are the form acquired first in childhood (Slobin & Bever, 1982; see also Ellis, 2002). The priming effect typically entails a less frequent form, since priming requires the raising of expectation for the primed form (Bock, 1986). Passives, as the less frequent of the two, could be used for this purpose, whereas actives, as the more frequent form, would not be expected to have any particular effect on the comprehension of actives nor passives. Previous research had not looked at the effects of the inhibition of one structure on the comprehension of the more frequent one, and further studies are needed in this respect in order to fully understand the effect found within the monolingual group in the current study.

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# CHAPTER V - CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH QUESTIONS

# Conclusions, Limitations and Further Research Questions

The purpose of this chapter is manifold: it will summarize the findings from the three experiments, further review the conclusions from each of the experiments and make additional conclusions based on all of the findings. Then, it will reiterate the novelty and impact of the current thesis, point out the limitations of the current work and establish a platform for possible further research in the future.

This thesis investigated the processing of sentences in the passive voice among three populations – healthy adult speakers of German, children acquiring German as their L1 who are at an early stage of properly understanding passives, and fluent consecutive bilingual speakers of Mandarin and English (their L2). The aim was to extend the scope of the current understanding of how these populations understand and acquire the passive voice and to look into possible effects that structural priming may have on this process in general. The experiments in this thesis primarily used eye tracking with the visual-world paradigm, which, together with the commonly used sentence-reading paradigm, represents a suitable tool for investigating syntactic parsing in real time.

The first study investigated the comprehension of the passive voice by adult German speakers. The findings add to our existing understanding of adults' processing of German syntax and the passive voice in general. The overall findings match previous results on the comprehension of passives by adults in other languages that were investigated. In our work, adult German speakers did not exhibit any problems understanding the structure. They parsed the sentences correctly by the end of the auditorily presented stimuli, since most of their looks in the visual-world paradigm experiment were directed towards the image corresponding to the passive interpretation of the target sentence.

The main aim of this study was the direct comparison of the effects of structural priming from comprehension – **receptive priming** – and structural priming from production – **productive priming**. Before this experiment, only one other study had directly compared the two priming modalities (Bock, Dell, Chang & Onishi, 2007). This study investigated the effects of receptive and productive priming on language production. The first experiment of the current thesis aimed at extending the work by Bock and colleagues to the realm of language comprehension. A similar experiment to that of Bock and colleagues' study was designed in which the effects of the two priming modalities were compared. These priming effects were measured on language comprehension. This was done to reach a deeper understanding of how the two language modalities affect each other and language comprehension.

Bock and colleagues focused on the effects of receptive and productive priming on language production (i.e. *production* → *production* effect and *comprehension* → *production* effect). However, in order to obtain a full picture of the relationship between language production and language comprehension, the current study investigated what effects the two priming modalities have on language comprehension (i.e. *production* → *comprehension* effect and *comprehension* → *comprehension* effect). All directions of priming should be investigated in order for the complete picture to emerge regarding the effects that language production and comprehension have on one another. Any possible differences between the two priming modalities would indicate potential differences between the comprehension and the production of language. If language production and comprehension use the same cognitive resources, it could be expected for them to have the same effect when used as primes. That was the premise of Bock and colleagues' study (2007), and their findings showed that, indeed, both priming modalities had the same effect on language production – more target structures were produced that matched the prime, regardless of the prime type.

The outcomes of the first experiment in the current thesis did not completely match the findings of Bock and colleagues' study (2007). In their work, there was no difference in the effect size between the two priming modalities. Productive priming and receptive priming both led to increased usage of the primed structure to the same extent. In the present experiment, both priming modalities did have a faciliatory effect on the comprehension of passives when compared to the control group exposed to no priming at all, but a significant difference between the receptive and productive priming modalities was evident. Productive priming – exposure to the prime sentence which the participant was requested to repeat out loud (i.e. to produce the prime) had a significantly stronger effect than the receptive priming – silent listening to the prime sentence – on the comprehension of passives in adults. Productive priming led to more looks towards the target image on the screen during the presentation of the target passive voice sentence, as compared to receptive priming. However, the group that was exposed to receptive priming still showed more looks towards the target image on the screen than the control group that was not exposed to any priming.

The conclusion drawn from the experiment is that there appears to be a difference between the influences that previous comprehension and previous production have on future parsing of sentences. The two language modalities – production and comprehension – are mutually connected and share numerous features, exhibited by the fact that both had a priming effect on language production (in Bock and colleagues' study) and on language comprehension (in the first experiment of the current thesis). This connection, however, is not as close as some language theories have suggested, since priming from language production and from language comprehension exhibited different effects on the comprehension of passive voice sentences. The advantage of our experiment over the Bock and colleagues study was that it used eye tracking as a measure of language comprehension, which allowed for more detailed and subtler differences between the two language modalities to become visible. Additionally, the first

experiment showed that priming of the passive voice in comprehension can be achieved in German-speaking adults, which adds to the large body of literature on the matter of structural priming overall.

The second experiment extended the scope of the first and investigated the comprehension of passives by German-acquiring children, as well as the effect of structural priming on their comprehension. Children were between 5;6 and 6;0 years old and fell into the age group that should be able to understand the passive voice at least to some extent and perform close to adults in understanding sentences in the passive voice. Previous research on German (and other languages, for that matter) has established that German-speaking children at about the age of 5 start to understand passives in some restricted contexts – with particular verbs or in situations where they have heard passives before. By the age of 6, their processing of passives should be approaching the adult level (Haendler & Adani, 2013; Armon-Lotem et al., 2016). The second experiment in this thesis used productive structural priming to investigate which of the main theories behind the late acquisition of passives would be the most likely explanation for this rather late acquisition. Each of the main theories had a different prediction for the possible outcome of the priming study. This was a specifically designed experiment that enabled direct comparison between the three different theories. The A-chain deficit hypothesis would predict no priming effect if the structure is not fully acquired (Borer & Wexler, 1987; Hirsch & Wexler, 2006), the frequentist theories would predict an increased number of looks to the target after priming (Demuth, 1990; Ellis, 2002), and the theory that points to the *by-phrase* as the main cause behind the impaired understanding of the structure would predict chance-level or below chance-level performance after priming, since the participants would not know how to parse the agent in the *by-phrase* (Fox & Grodzinsky, 1998; Guasti, 2004). Before the onset of the *by-phrase*, however, it might be possible to expect more looks towards the

image that match the passive interpretation of the target sentence, since short passives should be less of an issue for children, according to this theory.

The results of the experiment did not completely match previous findings on the acquisition and processing of the passive voice in German-acquiring children. The participants in this experiment had difficulties with the passive voice structure. The results of this experiment are in line mostly with the predictions made by the A-chain deficit hypothesis. It states that children before a certain age do not possess the necessary mechanisms to understand the Argument-chain and the movement, which are relevant in passive voice sentences. By the same token, structural priming also did not seem to contribute significantly to the children´s comprehension of the structure. This further reinforces the assumption that the A-chain deficit hypothesis explains the problems that children show in their understanding of passives. Since structural priming denotes an unconscious activation and reinforcement of already known structures, children who cannot comprehend passives also cannot be primed by this structure to comprehend them better. Other possible reasons for such an outcome were discussed in the chapter dedicated to the study itself and will be expanded upon later in this chapter.

This study was similar to the first experiment on adults, with minor changes added to enable additional behavioral data collection from the children. Still, they exhibited difficulties understanding the passive voice and did not benefit from structural priming. There are two possible reasons, apart from the A-chain deficit hypothesis, to explain this outcome. Either German-speaking children acquire the structure to a full extent later than previously thought, after the age of 6, or children at this age still require additional semantic information to properly understand it. The current study used reversible verbs and animal actors in order to reduce the effects of real-world knowledge and non-linguistic tools available to children for understanding the passive voice. It is possible that children at the age tested still cannot use only the syntactic information to understand such a complex structure as the passive, and tend to rely on additional

real-world cues as well. The experiment does not provide an answer to the question of which of the two options might be at fault here, but it does provide a clear-cut reference for future research into the comprehension of the passive voice in German-acquiring children. Future studies should look either at children of a different age or focus on the semantic, phonetic and other additional cues that could help children understand passives properly.

The third experiment in this thesis investigated the processing of passives cross-linguistically. Fluent adult bilingual speakers of Mandarin and English were tested on their comprehension of the structure in English – their L2. The main goal was to see what effect cross-linguistic structural priming has on the comprehension of passives. Both English and Mandarin have a syntactically marked passive voice. Apart from the syntactic structure, other elements of the passive differ significantly between the two languages – most importantly, the word order. The only other element that is shared between the two languages regarding this structure is the positioning of the theme as the first noun phrase in the sentence. If structural priming is effective cross-linguistically, that would land support for the theories which state that syntax is processed separately from semantics and is shared between languages (e.g. Bernolet, Hartsuiker & Pickering, 2013; Hartsuiker, Beerts, Loncke, Desmet, & Bernolet, 2016).

A cross-linguistic priming effect was found in the eye-tracking data of the experiment. The bilingual participants who were exposed to a passive voice structure in Mandarin were faster at looking towards the image matching the passive voice interpretation of the target sentence in English. The interpretation of this data is that passive voice syntax and the fronted theme role can lead to cross-linguistic priming. The data supports findings on cross-linguistic priming in language production (e.g. Loebell & Bock, 2003; Salamoura and Williams, 2007; Chen, Jia, Wang, Dunlap, & Shin, 2013), where the participants were first primed in one language and then asked to use their other language to describe an image or situation. In these

studies, cross-linguistic priming was also found between several pairs of languages, including Mandarin and English. As far as the timing of the effect goes, in the current experiment the effect was found 800 ms after the onset of the sentence, which corresponds to the average onset of the *by-phrase*. In other words, already after the first NP and during the VP, the bilingual participants were successfully primed to expect a passive sentence in their second language. The timing of the cross-linguistic priming effect (i.e. the discovery that the priming effect is present after the first NP already and before the disambiguating VP) and comprehension of English passives by Mandarin speakers is another important contribution of this thesis. To my knowledge, previous research has not investigated cross-linguistic priming between Mandarin and English passives in comprehension (but, see Hsieh, 2017 for a reaction time cross-linguistic priming study for passive relative clauses between Mandarin and English). Therefore, the contribution of the current thesis in this area is significant.

In addition to the bilingual group, a monolingual group of English-speaking participants was tested with the same setup, except that the priming was done in English. No significant priming effect was found with this group, since the proportions of looks were similar regardless of the priming condition – passive voice or active voice. In direct comparison to the bilingual group, a difference was found between the bilinguals exposed to priming and the monolinguals who were not exposed to the same primes (i.e. they were exposed to active voice sentences in the priming part of the experiment). The bilinguals primed with passives had more looks towards the target image than the non-primed monolinguals. This was interpreted as a support for the theories on language processing which state that monolinguals and bilinguals process language differently even when the bilinguals are highly fluent in their L2 (Clahsen & Felser, 2006). The study was able to provide further support for this theory on bilingual language processing, because in the experiment the monolingual and bilingual participants reacted

differently to syntactic priming, which indicates a difference in language comprehension between the L1 and L2 speakers.

The experiment also provided a better understanding of the role that word order plays in syntactic priming. Since Mandarin and English have a different word order in the passive voice concerning the position of the VP, the conclusion is that structural priming can function without the word order overlap. This, then, means that word order and the syntactic structure are not inherently connected but are processed as separate elements during language comprehension. In this respect, the current experiment goes against the claims that word order is necessary for priming to be successful, as the word order and morpho-syntax are processed together (Loebel & Bock, 2003; Bernolet et al., 2013).

In summary, the three experiments which constitute this thesis examined the processing of the passive voice in three different populations – monolingual adults, monolingual children and bilingual adults. The adult German speakers had no difficulty processing the structure, and previous exposure to the passive affected their processing of subsequent sentences in the passive voice. They were more likely to expect a passive voice sentence if they had been exposed to it beforehand. Furthermore, productive priming affected this processing to a greater extent than receptive priming. Monolingual children had difficulties with the structure and did not benefit from structural priming. The findings fit best within the scope of the A-chain deficit hypothesis. Bilinguals benefited from structural priming from their L1 to their L2, since it increased their expectations of the structure.

The contribution of the current thesis are then three relevant discoveries in the field of language comprehension:

- The first is the discovery of the distinction between the effect sizes of receptive and productive priming in language comprehension, and the discovery that

productive priming has a strong cross-modal effect. No previous research, to my knowledge, has investigated the differences between the two priming modalities on language comprehension. Only one other study looked at the distinction between the two modalities in language production. Their conclusions were that both receptive and productive priming have the same effect on production. The current study showed a clear difference between the two priming modalities in terms of language comprehension, with the productive priming having a greater effect, leading to more looks towards the target image than the receptive priming. The productive priming has a strong cross-modal effect here. A more general conclusion from this would be that when we speak we more strongly influence the way we understand the sentences of others than when we listen to others speak. Both listening / comprehension and speaking / production affect language comprehension constantly. When speaking, humans first need to process and prepare the sentence, then utter it and finally hear themselves say the sentence. This has a strong effect on our comprehension of sentences. There are two possible explanations for this. It is possible that the sentence remains in the working memory for a longer period of time. Alternatively, both language comprehension and production are engaged in this process, which enhances the effect size. The current thesis did not focus directly on the mechanisms behind this, so future research would be needed to determine the exact cause of this effect.

- The second major contribution of this thesis is the successful cross-linguistic priming of the passive voice for comprehension between two languages with different word orders. Previous research has focused only on cross-linguistic priming in production, with mixed conclusions regarding the relevance of word-order overlaps between the languages. The current thesis is the first, to my

knowledge, to look at the effect on comprehension using eye tracking. The results are clear – word-order similarity is not necessary for successful cross-linguistic priming in terms of the comprehension of the passive voice. The conclusions from this are that morpho-syntax and word order are processed separately. Some language models propose a two-step processing, with syntax being assigned to one level and word order to another. The current thesis would align with this claim.

- The third contribution of the current thesis is the discovery of processing difficulties with the passive voice in German-acquiring children. Previous research has been almost unanimous in the claim that children after the age of 5 or 6 process passives with more ease and close to an adult level. The absence of a clearly detectable priming effect, as well as looks to the target that were only above chance-level performance at the very end of the passive sentence would indicate that German-speaking children fully master the passive voice later than previously thought, probably after the age of 6. This was further supported by the behavioral data which clearly shows better understanding of the active voice sentences than that of the passive. Alternatively, at the initial stages of their understanding of passives, German-speaking children rely more heavily on additional linguistic and non-linguistic cues when parsing the passive voice. The current experimental format tried to eliminate the possibility of understanding passives from these non-linguistic cues, so it is possible that the methodological setup was not adequate for testing the comprehension of passives by German-speaking children at this age. Future research would need to pinpoint which elements are required for children to understand passives better (i.e. real-world knowledge, animacy, non-reversible verbs etc.).

## Directions for Further Research

As with every research study, the scope of the work done in this thesis was limited due to various constraints. Some of the limiting factors of a technical nature were the locations where the data could be collected, the time spent in certain testing locations and the technical support available there, the ability to find a suitable number of participants for a certain group, and others. The limitations of a methodological and theoretical nature involved the languages that could be tested and the number of items used, as well as the selection of items, the type of structural priming and the behavioral data collection. Potential future steps for each of the three studies will be described separately.

The first experiment, which directly compared productive and receptive priming, found differences between these two modalities and the timing of processing passives in German-speaking adults. As mentioned in the introduction, the German language has two distinct types of passive voice – the eventive and the stative. The experiment looked at processing only of the eventive type. Possible inter-structural priming from one type to the other could look at the effects of theta-role expectation priming in German. On the other hand, possible priming from a structure containing an A-chain but a different theta role assignment would be a good study to pursue in search of the pure syntactic priming. This kind of experiment would be useful because, in the current thesis, it was not possible to sufficiently separate the syntactic structure of the passive from the thematic role assignment. Investigating cross-structural priming would provide the answer as to how much thematic roles contribute to our understanding of the passive voice. Also, more directly related to the experiment itself, the control group in the experiment was not exposed to any priming and the target items followed each other. Having an unrelated structure between each of the target sentences might have affected their performance in the study, since it would have given them additional language input and would have made the

control group experiment even more similar to the two priming groups. Adding the additional language material between the trials would have additionally prevented accidental priming from previous items in the experiment. Since the control group only saw the target items, it might be the case that some of the items, or in fact all of them, primed the participants in the control group to some degree. Adding dummy primes or other types of fillers would probably prevent this from happening, or at the very least decrease it. In the second study, the most beneficial direction for future research would entail testing older children. The findings of the experiment did not match the results of other studies in the area, so testing children age 6 and older might be a good option for further research to investigate how the comprehension of passives develops in children over time. In priming experiments with children, the lexical overlap between the prime and target materials has led to greater priming effects in the past. The current experiment made sure that there was no overlap between the verbs and that the overlap between the nouns was minimized. Furthermore, a control group of children not exposed to any priming would be beneficial as the baseline for a priming study. Similarly, separating the primes – the passive voice sentences and the active voice sentences – into blocks might affect the outcome of the priming effect, since the cumulative effect of priming is another well-known phenomenon seen in priming studies with children. In the current study, both active and passive primes were used as within-subject factors. Turning the prime into a between-subject factor would lead to a much denser exposure to primes in the sense that the children would only be exposed to one type of prime sentences and then to the targets. This might increase the priming effect due to the well-known cumulative effect of priming.

The experiment on cross-linguistic priming would have obviously benefited from testing all directions of this priming. Besides the Mandarin-English and English-English priming, testing the processing in English-Mandarin and in monolingual speakers Mandarin-Mandarin would provide an additional dimension and better insight into the cross-linguistic

priming and language processing of bilinguals. Exploring all the directions of priming would show whether the effects differ in other directions or whether they remain the same. This could offer important insights into the processing of different languages and their relationships to one another – whether the effect of Mandarin on English is identical to the effect of English on Mandarin, for example.

Since the current thesis tested the comprehension of passives in German L1 speakers (adults and children) and Mandarin-English bilinguals, an additional study testing comprehension in Mandarin-German speakers would contribute to our understanding of how theta roles and word-order similarities affect syntactic knowledge. Mandarin and German share the same word order (NP-NP-VP) and theta role assignment in passive sentences, so the similarity is greater than between Mandarin and English. By the same token, a similar study on the processing of passives in German-English bilinguals would potentially be required to shed additional light on word-order similarities and their effect on syntactic processing.

In conclusion, the current thesis´ scope is limited due to certain constraints, primarily some methodological ones, and several potential future directions for research could help expand the understanding of how passives are comprehended and how structural priming affects this process in different populations. The selection of participants, items and syntactic structures are the main possible improvements for future work in this area.

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