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Prepositional Phrase Attachment Ambiguities in German

A Cross-Dialectal Experimental Study

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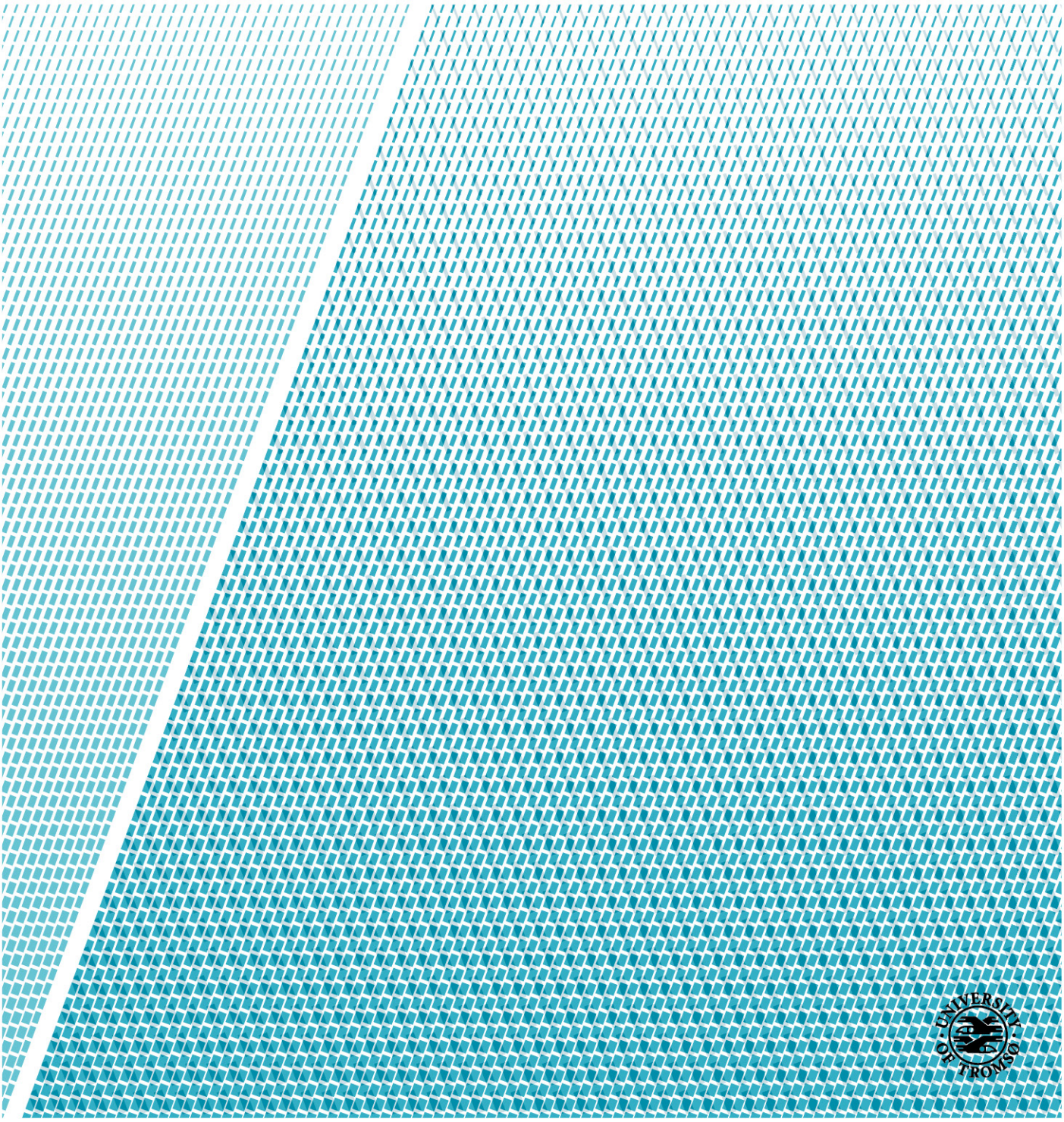
Master's thesis in Theoretical Linguistics … May 2018



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1 Abstract

This thesis addresses the production and perception of sentences with ambiguous prepositional phrase attachment in Standard German. In the first part of the study, an informed native speaker produced prosodically disambiguated sentences, which were analysed acoustically for disambiguation cues. In the second part, these sentences were then presented in a perception test where respondents were asked to choose which attachment type the sentence represents. Respondents varied by membership in a dialect group (Bavarian, Alemannic or Northern).

Experimental sentence types varied by syntactic clause type. Since verb placement in German varies between simple sentences (verb-second) and embedded clauses (verb-final), variation in surface structure of the VP-phrase between simple and embedded sentences might be expected to influence disambiguation if syntactic theories of attachment preference are correct. On the other hand, prosody was also hypothesized to be an important source of disambiguation in the auditory materials presented to respondents. The materials also varied with respect to semantic bias, i.e. with respect to whether sentences gave rise to a more meaningful unit for one intended reading than for the other.

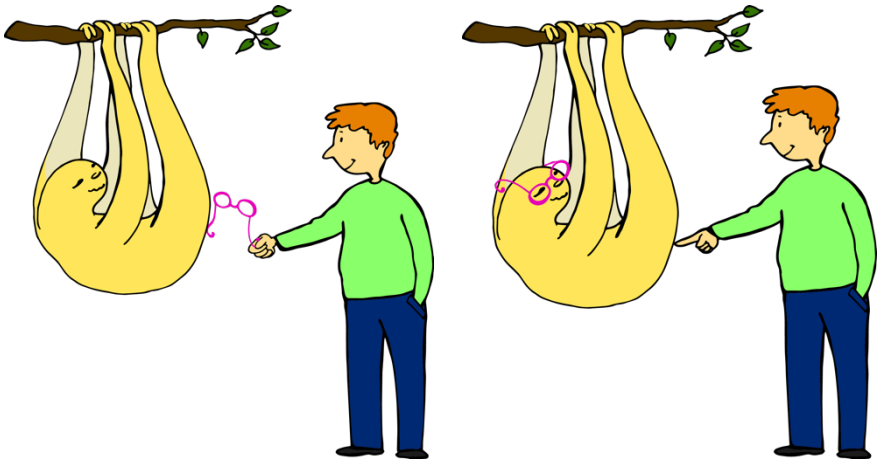
The results of the study indicated that prosody had a significant effect on attachment choice equally across all dialect groups, and that the syntactic effect of clause type was not a significant factor overall. Semantic plausibility also gave rise to no significant effects in this particular task. However, even the effect of prosody was swamped by the overwhelming preference for high attachment found for all speakers and clause types. The thesis argues that this preference is probably driven by the lexical distributional properties of the preposition *mit* which was the sole preposition used in the experimental materials.

2 Introduction and Literature Review

2.1 Introduction

In many cases, language cognition relies on the processing and resolution of ambiguity. In English, as well as many other languages where instrumentality is not explicitly marked, a sentence such as *He touches the sloth with the glasses* licenses two possible readings (1). This is due to the fact that the prepositional phrase *with the glasses* can be attached to either the verb phrase (VP) or the noun phrase (NP) to create grammatically correct sentences.

(1)



So, what are speakers to do? How do they resolve attachment ambiguities? What accounts for the fact that even though both readings presented in (1) are possible, most, if not all of us, will have an instinctive preference for one of the two options? Cross-linguistic research into the field of attachment ambiguities has shown that attachment preferences are often consistent within a given language. To hasten language processing, default readings are assigned automatically and sentences only reanalysed when necessary. The means by which the allocation of the default phrasing occurs is debated. Pragmatic context will aid disambiguation, In context-less situations, a variety of competing factors such as lexical or semantic bias, syntactic structure and the availability of interpretable prosodic cues have been brought forth as explanations for attachment choice.

This paper will address the production and the perception of sentences with ambiguous prepositional phrase attachment in Standard German. An informed

speaker prosodically disambiguates sentences, which are then presented in a perception test where respondents are asked to choose the attachment scenario they think the sentence represents. The internet-based nature of the perception test allows for correlating attachment choice with demographic factors such as gender, age or membership in a dialect group.

In German, verb placement varies between simple sentences (verb-second) and embedded clauses (verb-final). The variation in surface structure of the VP-phrase between simple and embedded sentences might provide insight on what motivates phrasing decisions: a change in attachment preference between the two sentence types would point to the importance of syntactic structuring mechanisms such as *Minimal Attachment*. Additionally, the sentence production of an informed speaker will be analysed phonetically to access the placement of prosodic boundary markers such as pauses or lengthened segments to achieve an intended reading. Lastly, the effect of semantic bias will be addressed by investigating whether sentences with verb-object-prepositional phrase-combinations that form a more meaningful unit for one intended reading than for the other, drive attachment choice into the semantically primed direction.

This section will provide a general discussion of ambiguity and its importance in the parsing literature, followed by background on the literature relating parsing strategies to syntactic structure and the effects of universal versus language particular tendencies. It will then move on to prosodic structure and its potential role in parsing disambiguation. Finally, previous studies on prosodic disambiguation in English and German will be introduced and the motivation and hypotheses for the present study will be presented.

2.2 Ambiguity

2.2.1 Language Parsing and Ambiguity

Gaining an understanding of sentence processing is paramount for the field of psycholinguistics. Sequentially received visual or audio stimuli not only form units with lexical meaning but have to encode structural information about how these units relate to each other. Below the surface structure of a sentence lies a rich network of

structural dependencies and interconnections. Researchers have traditionally relied on eye-tracking and self-paced reading experiments (Frazier & Rayner 1982) as well as questionnaires with judgement tasks to observe the mechanisms of sentence parsing. More recently, methodologies have expanded to include the monitoring and visualisation of brain function such as the spread of event-related potentials (Drury et al. 2016) or area specific brain activation (den Ouden et al. 2016) in language processing tasks.

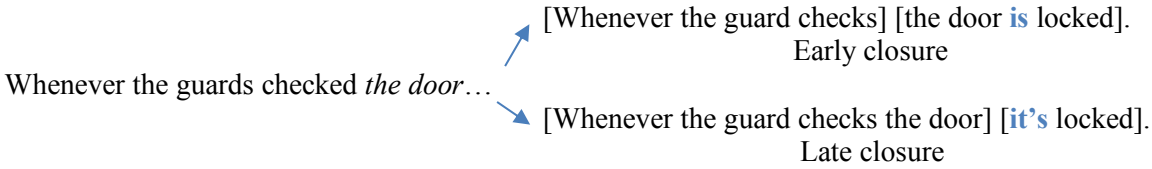
Throughout the years, a plethora of models to explain language processing and comprehension has been brought forth (see van Gompel & Pickering 2007 for a more extensive overview of different theories). In short, the models can be categorized into those following *interactive* or *constraint-based* accounts (*inter alia* MacDonald et al. 1994; McRae et al. 1998; Trueswell et al. 1994) and those following *modular* accounts (*inter alia:* Fodor 1983; Frazier 1987). While interactive models grant the parser simultaneous access to all available material (van Gompel & Pickering 2007), strictly modular models assume that information coming from different sources (syntactic, semantic, lexical) is processed separately (Zschernitz 2011). Within the modular approaches, the *Parallel Processing Hypothesis* states that because the parser cannot predict which analysis will ultimately be felicitous, it has to start out computing all possible analyses (Frazier 1979). Incoming material gradually reduces the number of possible versions down to the winning one. The *Serial Processing Hypothesis*, on the other hand, assumes that only one analysis is pursued at a given time and rejected if necessary. The parser will then return to the beginning and start reanalysis (Frazier 1979, 1987).

Far from being rare, ambiguity is an integral part of communication and poses challenges for language perception and understanding. Amongst other reasons, this is due to the gradual nature in which information is conveyed during communication As Féry (2016: 284) puts it: 'Because the beginning of sentences usually do [*sic*] not provide much information on how they will be continued, linguistic structures are ambiguous most of the time.' One subgroup of ambiguity, often discussed in relationship with syntactic parsing, is structural attachment ambiguity.

2.2.2 Local Structural Ambiguity

Local Ambiguities arise temporarily during sentence creation when a particular string of words cannot unequivocally be assigned to one syntactic structure alone. (2) –-an example adapted from Kjelgaard and Speer (1999)—explores a case of temporary ambiguous syntactic closure. When it arises in the sentence, it is unclear whether the NP *the door* will be attached to the preceding clause (late closure) or integrated within the successive clause (early closure). Crucially, this uncertainty is alleviated by material provided downstream, and the completed sentence shows no sign of structural ambiguity.

(2)



Local ambiguities arise frequently—especially in languages with comparatively poor morphological systems (Chernova & Chernigovskaya 2015)–but don't seem to provide a challenge for the language processing mechanism (Sedivy & Spivey-Knowlton 2015). Semantic and pragmatic context, as well as the lexical frequency (Sedivy & Spivey-Knowlton 2015) or the plausibility (Zahn, & Scheepers 2015) of co-occurring constructions, have been proposed as mechanisms to reduce the ongoing processing cost of language understanding.

A special group of locally ambiguous sentences, the so-called *garden-path sentences* (Bever 1970, Frazier 1987), offer insight into parsing strategies and the recovery from misinterpretation. These sentences are constructed in a way to facilitate a misparsing of their syntactic structure (Féry 2016). The sentence in (3), for example, exploits the relatively higher prominence of *man* as a noun than a as verb and the low frequency of substantivized adjectives in English to force an initially wrong reading.

(3) The old man the sea. -> [The old man] the sea -> [The old] [(man) the sea]

Once the original interpretation has to be abandoned, the sentence is reanalysed, enabling researchers to closely observe coping mechanisms of the language processing system.
Reinterpretation of garden-path sentences is usually complete, but an experiment by Ferreira et al. 2001 shows that effects of the original (incorrect) structuring may linger. When presented with the sentence *While Anna dressed the baby spat up,* a majority of participants who could correctly identify the referent of *spat up*, continued to believe that Anna had dressed the baby. This suggest that the earlier parsing was never completely abandoned (Ferreira et al. 2001).

2.2.3 Global Structural Ambiguity

In the case of *Global Ambiguities*, on the other hand, the structural ambiguity persists at sentence end. The following examples of ambiguous relative clause attachment (4) and prepositional phrase attachment (5)[1] are taken from Jun (2003) and Frazier (1979) respectively. In both instances, surface structure does not suffice to convey the intended meaning. One constituent can successfully attach either higher (4a and 5a) or lower (4b and 5b) within the syntactic structure.

(4) a. Someone shot the **servant$_i$** of the actress$_j$ who$_i$ was on the balcony.
b. Someone shot the servant$_i$ of the **actress$_j$** who$_j$ was on the balcony.
(5) a. Sam (hit (the girl with the flower)).
b. Sam (hit (the girl) with the flower).

Global ambiguities have the potential to cause a mismatch of interpretation between the transmitter and the perceiver of a given sentence (Féry 2016). It is therefore important to develop hypotheses on how they are parsed and disambiguated.

[1] The brackets provided in (5) emphasize differences between the two attachment conditions. They do not present a full analysis of the sentence structure.

2.3 Syntax

2.3.1 Syntactic Parsing Strategies

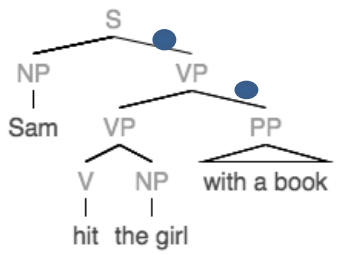
Frazier's *Garden-Path Model* (named after and developed by investigating the aforementioned garden-path sentences) proposes that the parser relies on two principles to subset and structure incoming material. These principles are *Minimal Attachment* and *Late Closure*. *Minimal Attachment* (6) favours the simplest available syntactic structure by militating against the implementation of unnecessary nodes on a syntactic tree.

(6) MINIMAL ATTACHMENT
Do not postulate any potentially unnecessary nodes (Frazier, 1987)

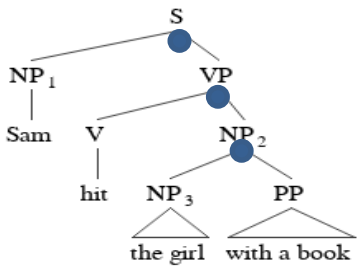
In case of ambiguous PP-phrase attachment, such as (5), *Minimal Attachment* clearly favours attaching the prepositional phrase directly to the VP (7a corresponding to 5a) rather than the NP (7b corresponding to 5b).

(7)

a)



b)



Late Closure (8) is only employed should the application of *Minimal Attachment* not result in a preferred structure. It focusses the scope of the parser to recent input ensuring incremental processing and integration.

(8) LATE CLOSURE
If grammatically permissible, attach new items into the clause or phrase currently being processed (i.e. the phrase or clause postulated most recently) (Frazier, 1987)

Minimal Attachment and *Late Closure* are not always sufficient in predicting attachment preferences, however. Cross-linguistically, the default attachment site of relative clauses varies even between languages where these principles would not anticipate a difference (Fernández 2003, Jun 2003, Hemforth et al. 2015).

Alguien disparó contra la criada de la actriz que estaba en el balcón, the Spanish translation of (4), is structurally identical to its English counterpart. But while English speakers show a bias for low attachment of the relative clause, Spanish speakers prefer high attachment (Fernández 2003, Hemforth et al. 2015).

Likewise, attachment preference does not seem to align along the lines of head directionality or word order. Jun (2003) investigated the prosodic realisation of ambiguous relative clause attachment for a diverse group of languages. Out of seven languages, three (Farsi, Korean and Japanese) were head-final whereas the rest (Greek, Spanish, English and French) were head-initial. Farsi, Korean, Japanese and Greek were classified as possessing relatively free word order, whereas the word order of English, Spanish and French was considered fixed. Previously published data indicated that Japanese, Greek, French and Spanish preferred high attachment, and English attached low (Jun 2003). Preference tests for the two hitherto unclassified languages yielded ambiguous results. Four out of five Korean respondents preferred high attachment making a population-wide bias for high attachment plausible. The four Farsi respondents, on the other hand, could not come to an agreement. One preferred high and one low attachment, while no consistent pattern emerged from the other two native speakers (Jun 2003). These findings indicate that attachment choice is either easily manipulated by pragmatic factors such as focus[2], or that the classification of languages with regard to relative clause attachment preference is not as easily achieved or as discrete as published data suggests.

Any cross-linguistically applicable theory to explain attachment choice must therefore expand its scope or allow a certain amount of information from other modules to seep into the syntax in order to account for the observed outcomes.

[2] Focus creates prosodic boundaries in Korean and Japanese, but not in Farsi, Greek, Spanish, French or English (Jun, 2003).

Konieczny et al. (1997), for example, combine structural and semantic considerations in their *Parametrized Head Attachment Hypothesis.* Attachment choice is correlated with lexical heads that are already read and thus available to the parser (9a) as well as the preferred thematic role of an ambiguous constituent (9b). Finally, attachment is said to show a recency bias (9c). The choice between two attachment sites deemed equally suitable by (9a) and (9b), falls to the site whose head has been read most recently (Konieczny et al. 1997). This provides a way to account for locality and interference effects on sentence processing (Lewis et al. 2006). The serialised steps proposed in Konieczny et al. 1997 are replicated in (9):

(9)

a. HEAD ATTACHMENT (Konieczny et al. 1991)
If possible, attach a constituent g to a phrase with its lexical head already read.

If further attachment possibilities exist for g, then

b. PREFERRED ROLE ATTACHMENT
attach the constituent g to a phrase whose head provides a requested or expected theta- or place/time- role for g.

If further attachment possibilities exist for g, then

c. RECENT HEAD ATTACHMENT
attach the constituent g to the phrase whose lexical head was read most recently.

Attachment preference thus seems to result from syntactic structure interacting with a variety of parsing mechanisms and the interplay of these mechanisms. Universal parsing preferences such as *Minimal Attachment* and *Late Closure* create an easily interpretable default that can be modified by language specific parsing preferences. These arise from a sentence's surface structure, and are therefore, at least partially, motivated by word order and head directionality. A closer look at cross-linguistic data, however, establishes more complex relationships between surface structure and language specific attachment choice.

The processing of ambiguities is furthermore receptive to cues from discourse and pragmatic context and to the effect of semantic plausibility. In an overview of existing research, van Gompel and Pickering (2007) show that discourse and frequency information rapidly affects sentence processing and cannot be accounted for by a strictly modular approach. One way of accounting for the almost isochronous

influence of discourse and pragmatic context is to move the moment of disambiguation from the syntactic into the prosodic plane. There, information such as focus and givenness is represented by tonal contours (Féry 2016). Viewing the prosodic module as site of disambiguation would also explain the strong and immediate effect that prosodic cues can have on the perception of the structure of a variety of ambiguous and non-ambiguous sentence types (Price et al. 1991).

2.4 Prosody

2.4.1 Prosodic Structure

Given the need for a syntax-phonology interface to translate abstract thought into spoken language, how much contact do the two components have in a generative grammar framework? Proponents of a *direct-reference approach* of the syntax-phonology interface deny the need for separate prosodic constituents. Phonology interacts directly with syntactic structure (Adger 2007). *Indirect-reference theories*, on the other hand, suggest that prosody functions as a mediator between syntactic surface structure and the phonetic form and forms prosodic constituents that need not perfectly match syntactic constituents (Selkirk 1986) Prosodic phrasing is seen as *syntactically informed* but not *syntax-driven* (Cheng & Downing 2016). The presence of an intermediary step, as predicted in the indirect-reference approach, seems affirmed by the observation that the syntactic structure and the application of a variety of phonological processes (e.g. the assignment of prosodic stress as described in Chomsky & Halle 1968) are correlated and dependent on each other (Zschernitz 2011). The presence of a prosodic level is furthermore affirmed when phonetic context would require the application of phonological rules, such as the Tuscan Italian *raddoppiamento sintattico*, but prosodic boundaries block it[3].

[3] RS applies in the context of a word ends in a stressed short vowel and the following word in the same φ-phrase starts with a consonant. In order to fulfil the requirement that stressed syllables must be bimoraic, the consonant geminates and fills the unused mora of the preceding vowel. RS applies for post nominal adjectives (tè [ff]rédo)$_{\varphi}$, but does not apply across φ-phrase boundaries (La veritá)$_{\varphi}$ (*[vv]ínce)$_{\varphi}$ (Nespor & Vogel 1986, Ghini 1993).

In the 1980s, Selkirk (1986), Nespor and Vogel (1986), and Pierrehumbert and Beckman (1988) helped develop a *'standard theory'* of prosodic structure' in which the relationship between syntax and prosody is guided by interface constraints (Selkirk 2011). The prosodic hierarchy consists of a set of category types that are ordered in hierarchic fashion as shown in (10). The higher prosodic levels (ω-word, φ-phrase and ι -phrase) operate on an interface-level. They don't arise independently, but out of an interplay with morphosyntax (Féry 2016).

(10)

Intonational Phrase (ι)	Interface categories
Phonological Phrase (φ)	
Prosodic Word (ω)	
Foot (Ft)	Rhythmic categories
Syllable (σ)	
Mora (μ)	

The levels of the prosodic hierarchy presented in (10) interact with different grammatical subsystems (Selkirk 1986). Phonological words (ω) operate in relation to a morphological and lexical level. They often correspond to grammatical words, except in the case of grammatical *function words.* This mismatch happens when function words violate a language's minimum size requirements for phonological words and are merged with an adjacent ω-word as a result (Selkirk 1984, 1996, Truckenbrodt 1999). The phonological phrase (φ) is postulated to be the most important level with regard to the interplay of syntax and phonology (Nespor & Vogel 1986). It consists of a phrasal head and its maximal projection (Selkirk 1986) and corresponds to either lexical XPs (Truckenbrodt 1999, Selkirk 2011) or spell-out domains (Marvin 2003, Ishihara 2003, Newell 2005) on the syntactic plane. Lastly, the intonation phrase (ι) is formed with help of syntactic, semantic (Nespor & Vogel 1986) and pragmatic (Hamlaoui & Szendrői 2015) influence.

It is the *Strict Layer Hypothesis (SLH)* that most clearly sets phonological structure apart from syntax because it results in a non-recursive structure (Selkirk 1986, Nespor & Vogel 1986).

(11) Strict Layer Hypothesis (Nespor & Vogel 1986)

(i) A given non-terminal unit of the prosodic hierarchy, XP, is composed of one or more units of the immediately lower category XP-1.
(ii) A unit of a given level of the hierarchy is exhaustively contained in the superordinate unit of which it is part.

Stated in Nespor & Vogel's terms in (11), it requires that all phonological levels must be dominated by material of the category immediately higher in prominence and must dominate material of the category immediately lower in prominence. All terminal material must be of the lowest level in the hierarchy and must be exhaustively parsed. Thus, the SLH disallows level-skipping and recursion. Since the SLH has first been stated, data from a variety of languages has called the impossibility of recursivity into question (Selkirk, 2011; Ito & Mester 2007, Truckenbrodt 1999). Especially Ito and Mester's work on Japanese (e.g. Ito & Mester 2007) has proven very influential. Their *Min-Max Model* assumes recursivity (level repetition of ω-words, φ-phrases and ι-phrases) and projection (minimal and maximal projections of a prosodic category) as crucial parts of the analysis. Within *Optimality Theory (OT),* a violable constraint, such as NONRECURSIVITY (Selkirk 1996), can be ranked low to allow for recursion.

While prosodic and syntactic structure is often isomorphic, the principles of *prosodic hierarchy* and *strict layering,* restrict prosody's ability to branch which results in syntax-prosody mismatches (Myrberg 2013). Prosody can likewise rearrange phrase boundaries in order to meet well-formedness requirements (Féry 2016). Grammatical function words that violate a well-formedness constraint because of their small size/weight are unable to form an ω-word, or, in the case of a pronominal subject, a φ-phrase. The preference of Italian φ-phrases to form units of the same size that preferably are symmetrically weighed (Ghini 1993) and the enclitization[4] of function words are represented in (12).

[4] Represented with #

(12) a) $[[Ho]_{AUX}\ [mangiato]_{V}\ [[biscotti]_{N}\ [ripieni]_{AP}]_{NP}]_{VP}$
(Ho#mangiato)$_{\varphi}$ (biscotti ripieni)$_{\varphi}$
I have eaten filled cookies.

b) $[[Ho]_{AUX}\ [mangiato]_{V}\ [[biscotti]_{N}\ [[ripieni]_{A}\ [[di]_{P}\ [crema]_{NP}]_{PP}]_{AP}]_{NP}]_{VP}$
(Ho#mangiato)$_{\varphi}$ (biscotti ripieni)$_{\varphi}$ (di#crema)$_{\varphi}$
(Ho#mangiato biscotti)$_{\varphi}$ (ripieni di#crema)$_{\varphi}$
I have eaten cookies filled with cream.

The prosody follows its own rules to establish a hierarchy within categories, which begs the question of how a mapping between syntax and prosody is established. The *Alignment Strategy* of syntax-phonology mapping postulates that syntactic constituents are mapped to prosodic constituents at one of their edges (Selkirk 1986). Alignment can occur both on the left or the right edge of a constituent. Following McCarthy and Prince's (1993) Generalized Alignment constraint (13), Selkirk (2000) provides an account for mapping an XP to the right edge of its phonological equivalent—a φ-phrase (14).

(13) Generalized Alignment

Align(Cat1, Edge1, Cat2, Edge2) =$_{def}$
∀ Cat1 ∃ Cat2 such that Edge1 of Cat1 and Edge2 of Cat2 coincide.
Where
Cat1, Cat2 ∈ PCat ∪ GCat
Edge1, Edge2 ∈ {Right, Left}

(14) $ALIGN_{R}XP$[5]

Align (XP, R; φ-phrase, R)
"The right edge of any XP in syntactic structure must be aligned with the right
edge of a φ-phrase in prosodic structure. "

Mapping occurs only to one edge of the involved constituents and disregards the other edge. Thus, an alignment-based approach allows for the prosodic constituent to be both larger or smaller than the syntactic one. While this approach manages to correctly predict prosodic phenomena occurring on only one edge of a prosodic

[5] Selkirk (2000) mapped the XP to a MaP (major phonological phrase). The notation has been modified to follow the notation used in this thesis.

domain such as the lengthening of the penultimate vowel of a prosodic phrase domain observed in Zulu and Chichewa (Cheng & Downing 2016). Mismatches between syntactic and prosodic structure are predicted with higher frequency than they are observed.

In order to better represent the largely isomorphic relationship between syntax and prosody, align constraints often are applied pairwise. Selkirk (1995), for example, firmly links lexical words to prosodic words[6] through targeting both edges of the lexical word with ALIGN(Lex, L, ω, L) and ALIGN(Lex, R, ω, R). It is not uncommon for phonological phenomena to spread throughout a prosodic constituent. In Luganda a high tone spreads leftwards crossing prosodic word, but not prosodic phrase boundaries (Cheng & Downing 2016). Truckenbrodt (1995, 1999) furthermore observes examples[7] where the right edge of an XP does not trigger a φ-boundary formation as long as it embedded in a VP. This observation is not easily accounted for by an edge-based approach.

Truckenbrodt (1995) addresses these inconsistencies by changing the focus of the mapping mechanism away from the edges of a given constituent and towards its entirety. His WRAP-XP (15) necessitates that an XP be fully *contained* (or wrapped) in a φ -phrase. More precisely, it predicts the existence of a phonological phrase (φ), whose size is equivalent to the lexical XP to which it relates or its maximal projection (Truckenbrodt 1995).

(15) WRAP-XP
for every XP, XP a projection of a lexical category, there is a phonological phrase φ, such that all terminal elements that are dominated by XP are also dominated by φ.

Because its only prerogative is the containment of its associated XP, WRAP-XP is tolerant to a variety of φ-structures. In (16), an embedded XP can be mapped to two different acceptable prosodic structures according to WRAP-XP. Because the φ -phrase wrapping the maximal projection of the XP simultaneously contains the

[6] Pwd in Selkirk 1995.
[7] Accounts for Tohono O'odham (Truckenbrodt 1995) and Chichewa (Truckenbrodt 1999)

dominated XP, WRAP-XP offers no incentive to discard or to preserve internal syntactic phrase boundaries.

(16)

		[XP [XP]]…	WRAP-XP
?	a)	[[ ]φ]φ	
?	b)	[ ]φ	
	c)	[ ]φ	*!

WRAP-XP is overly permissive. Unless combined with constraints rewarding XP-faithfulness (16b), or militating against recursion (16a), WRAP-XP fails in motivating a definite prosodic structure.

Selkirk's *Match Theory* also includes the notion of the φ-phrase as a complete entity but simultaneously keeps much of the strict size alignment found in her ALIGN-constraints. Match Theory establishes a one-to-one relationship between syntactic and prosodic constituents causing them to form isomorphic pairs (Selkirk 2011). As syntax is recursive, the resulting structures are intrinsically recursive as well. Mismatches between syntax and prosody are predicted to be exceedingly rare (Féry 2016). As shown in (17) and (18) –MATCH constraints reproduced from Ito & Mester (2007), but in accordance with Selkirk's theory,--mapping can occur in two directions: from syntax to prosody or *vice versa*.

(17) MATCH-φ
A phonological phrase φ in phonological representation is matched by a corresponding syntactic constituent in syntactic representation.

(18) MATCH-XP-TO-φ
A phrase XP in syntactic constituent structure is matched by a corresponding phonological phrase φ in phonological representation. Assign one violation to an XP not matched to a φ.

Unlike WRAP-XP (16), its stricter association with the underlying syntactic structure allows MATCH-XP-TO-φ to arrive at a definite prosodic structure for the embedded XP (19).

(19)

	[XP [XP]]	MATCH-XP-TO- φ
☞	[[ ]φ]φ	
	[ ]φ	*!
	[ ]φ	*!

2.4.2 The Representation of Prosodic Structure by Phonetic Cues

Once a prosodic structure has been established, it has to be applied. Fodor's *Implicit Prosody Hypothesis* postulates that when reading silently, the mind of the reader projects prosody—crucially in its default contour—onto a text in order to aid sentence processing (Fodor 2002). More commonly, prosodic structure is translated into acoustic elements that make up intonation:

> *Intonation* is the tonal structure of speech expressed by the melody produced by our larynx. It has a phonetic aspect the fundamental frequency (F_0), and a grammatical (phonological) aspect. (Fèry 2016).

Its role is to account for the grouping and the prominence relationships within a sentence or a group of sentences (Bruce 2005). In pitch-accent languages such as German and English, changes in fundamental frequency (high and low tones) are not assigned lexically. Instead, tones represent the skeleton of a sentence and mark stress and prosodic boundaries (boundary tones). Because they are phonetic representations of the prosodic hierarchy, tones exist both in an absolute sense and relative to each other (Price et al. 1991). When intonation associates with stress, stressed vowels are pronounced more slowly than unstressed ones (Wightman et al. 1992). As a result, speech slows down at points of increased stress such as the end of German φ- and ι-phrases (Féry 1998) resulting in the 'final lengthening' of the last segment or word (Wightman et al. 1992).

The strongest indicator of the prosodic structure of an utterance, however, is the distribution of its breaks. Price et al. (1991) recorded 35 pairs of phonetically similar sentences made unambiguous by context, orthography or punctuation. These sentences represented seven types of structural contrast[8], and were later cut so that only the 'ambiguous' parts remained. Both the speakers and the listeners to the audio stimuli tended to associate larger [*i.e.* longer] prosodic breaks with larger [*i.e.* spanning a greater hierarchical distance] syntactic breaks. (Price et al. 1991). Investigating the role of prosodic breaks in the parsing of locally ambiguous NP_1+ V + NP_2 + PP sentences in French, Pynte (1996) found that prosodic breaks behind the verb blocked the attachment of the PP to the verb. A second break inserted between NP_2 and the PP, mitigated the prohibitory effect of the first break (Pynte 1996).

In contrast to abstract principles governing syntactic or prosodic structure, prosodic cues are readily available to the listener. Because cues indicating prosodic boundaries are existent throughout a sentence, not just at sites of ambiguity, their existence continuously guides attachment decisions. During speech perception, it is therefore possible that incoming material is first structured on the basis of this explicit prosodic structure (20), while lexical and semantic factors apply much later in the processing (Zschernitz 2011).

(20) *Prosodic Structuring Hypothesis (PSH)*
Prosodic boundary information (if available) is used by the parser to (pre-) structure incoming material.

While the theoretic approaches to language parsing are plentiful, their strengths and weaknesses can only be assessed in regard to their reliability when it comes to the avoidance of misanalysis and their flexibility and nimbleness when confronted with ambiguous constituents.

[8] (1) parenthetical clauses vs. non-parenthetical subordinate clauses, (2) appositions vs. attached noun (or prepositional) phrases, (3) main clauses linked by coordinating conjunctions vs. main clause plus subordinate clause, (4) tag questions vs. attached noun phrase, (5) far vs. near attachment of final phrase, (6) left vs. right attachment of middle phrase, (7) particles vs. prepositions (Price et al. 1991)

2.5 Disambiguation of Prepositional Phrase Attachment

Several influential studies of prepositional phrase attachment in ambiguous sentences in general and of the ambiguity resolution for English prepositional phrases headed by the preposition *with*, in particular, have been undertaken (Warren et al. 2000, Snedeker & Trueswell 2003; Kraljic & Brennan 2005 *inter alia).* The preposition *with* lends itself to these investigations because the phrases it introduces effortlessly attach to both verb phrases and noun phrases in a VP-NP-PP-construction (e.g. (5)).

Allbritton et al. (1996) analyzed the prosody that trained and untrained speakers produced for elements facilitating the disambiguation of globally ambiguous sentences (including *with*-PPs). They found that trained speakers only produced reliably different prosody when they were aware of the ambiguity, while trained and untrained speakers presented with the sentences placed within disambiguating context did not. Informed untrained speakers also disambiguated sentences, but not consistently so. When sentences were disambiguated prosodically, phrase-final lengthening was identified as denoting phrase boundaries. (Allbritton et al. 1996).

Trying to elicit utterances in a more natural and less scripted environment, Warren et al. (2000) had naïve pairs of participants perform a *cooperative game task* (Warren et al. 2000). The participants were asked to cooperate on a board game with one player telling the other to move tokens by using a set of predetermined phrases. Depending on the lay-out of the board game and the positions and availability of the tokens, the context could be either ambiguous or unambiguous[9]. Players were never implicitly informed of the purpose of the study and naiveté was not controlled for by questions after the task had ended. The experiment showed that high versus low

[9] Commands in Warren et al. (2000) included:
- I want to change the position of the square with the [cylinder / triangle / square with the triangle].
- I want to change the position of the [cylinder / triangle / square with the triangle].

attachment was marked consistently and independent of contextual ambiguity. Recipients of the commands were able to use these cues in the context of the game.

Snedeker & Trueswell (2003) performed an act-out study where one member of an untrained pair of participants instructed the other to perform tasks with a set of puppets. Commands were globally ambiguous[10] and potentially disambiguated by the puppet inventory[11]. Although not explicitly informed, the vast majority of speakers (97 per cent) reported being aware of the attachment ambiguities after completion of the task. Contrary to Warren et al.'s (2000) findings, this study found that prosodic differentiation was only provided when the context required it.

Following up on Snedeker and Trueswell's (2003) experiment, Kraljic and Brennan (2005) employed a similar game set-up but relied on participant generated utterances rather than written out commands. They found a reliable production of disambiguating prosodic cues regardless of referential context and speaker awareness. The study struggled with loss of usable material due to the articulatory freedom of its participants, however (Kraljic & Brennan 2005).

2.6 PP-Attachment in German

Considerably less work has been done on German ambiguity disambiguation. The most concerted effort to classify the overall attachment preferences of German prepositions was undertaken in 2003 by Martin Volk. He compared 66 German prepositions (*in, von, für, mit*—to name the most frequent) and preposition-related classes such as contracted prepositions (*im, zum, zur, vom…*), pronominal adverbs (*dabei, hierfür, womit,…)*, and reciprocal pronouns (*miteinander, untereinander, durcheinander,…)* with regard to their corpus frequency in the *Computer-Zeitung Corpus* and their registered attachment. While pronominal adverbs and reciprocal

[10] Commands in Snedeker & Truewell's 2003 study followed the pattern:
- [Tap [the frog]with the flower].
- [Tap [the frog with the flower]].

[11] The sentence *Tap the frog with the flower*! can only be interpreted as contextually ambiguous if puppets of a frog, a flower, and a frog with a flower are provided.

pronouns showed an attachment preference to the VP, prepositions and contracted prepositions exhibited an attachment tendency towards the NP (Volk 2003).

Susann Zschernitz, on the other hand, focused specifically on the attachment preferences of prepositional phrases introduced by the preposition *mit* (with), investigating the German counterpart of (5). Her doctoral thesis encompasses a number of studies employing a variety of methods such as phonetic analysis, eye-tracking, sentence completion tasks, and judgement tasks in order to gain insight into the disambiguation of prepositional phrase attachment in German (Zschernitz 2011).

Zschernitz points out that German, intriguingly, offers a way to distinguish between syntactically driven and prosodically driven attachment decisions (Zschernitz 2011). Due to the fact that main and subordinate clauses are realized structurally differently, syntactic attachment preference driven by mechanisms such as *Minimal Attachment* or *Parametrized Head Attachment* differs for the two conditions. Given audio stimuli that reliably distinguish between high and low attachment readings, the attachment choice of listeners can therefore be said to be influenced by syntactic factors if it differs between clause types but not between sentences of the same type read with varying prosody. Conversely, attachment choice would be influenced mainly by prosodic factors if attachment preference remained constant between sentence type but changed when the prosody changes (Table 1).

Table 1. Predictions presented in Zschernitz (2011) to respondent attachment choice in verb-second and verb-final sentences made by a parser following a prosodic approach (PHA) or a syntactic approach (PSH).

Verb position	Prosody	Example[12]	Predicted Attachment	
			PSH	PHA
V2	VP	(Der Junge berührt gleich den Adler)$_{\varphi}$ # (mit der Socke)$_{\varphi}$	high	high
V2	NP	(Der Junge berührt gleich)$_{\varphi}$ # (den Adler mit der Socke)$_{\varphi}$	low	high
VF	VP	(Der Junge überlegt,)$_{\varphi}$ (ob er gleich den Adler)$_{\varphi}$ # (mit der Socke berühren soll)$_{\varphi}$	high	low
VF	NP	(Der Junge überlegt,)$_{\varphi}$ (ob er gleich) # (den Adler mit der Socke)$_{\varphi}$ # (berühren soll)$_{\varphi}$	low	low

Zschernitz's results indicate that prosodic disambiguation of prepositional phrase attachment was clearly possible, but that the intonation resembled that of the preferred structure—previously determined to be high attachment—when speakers were not instructed to vary their speech patterns. Experiments further determined that while the manipulation of the prosodic boundary marking changed respondent attachment choice, the same could not be said for the manipulation of clause type (Zschernitz 2011). This suggests that an interactive effect of general preference and prosody exists when it comes to attachment choice.

2.7 Prosodic Variation in German

German is a pluricentric language most common in a group of neighboring countries in Central and Western Europe. It is the national majority language in Germany, Austria, and Liechtenstein and an officially recognized regional majority

[12] *Der Junge berührt gleich den Adler mit der Socke.*
The boy touches shortly the eagle with the sock.

Der Junge überlegt, ob er gleich den Adler mit der Socke berühren soll
The boy considers, whether he shortly the eagle with the sock touch$_{INF}$ should.

language in Switzerland, Italy, Belgium, and Luxembourg (Ammon 1995). Consequently, it experiences a large amount of internal dialectal variation due to geographic spread[13]. Exposure to mass media and 'socially triggered dialect switching' promote a standard superstrate, however (Gibbon 1998). As the countries with the highest amount of native German speakers, Switzerland, Austria and Germany, each have an official national standard that is used as the language of government, schooling and media in that country (Ulbrich 2002). Standards are determined in Berlin (German Standard German), Vienna (Austrian Standard German) and Zurich (Swiss Standard German) (Gibbon 1998). This means that the centres of the national standard varieties are situated in three areas with a distinctly different dialectal backdrop. The dialect in Vienna is of a Bavarian variety and the dialect spoken in Zurich belongs to the Alemannic dialect group. The Berliner dialect is classified as Western Central German (Keller 1961) and will be considered part of the *Northern* dialect group in this study[14].

Prosodic variation between the standard varieties occurs around intensity and pitch. Speakers of Swiss German distinguish stressed from unstressed syllables through a change in pitch rather than a change in intensity (Panizzolo 1982). Southern dialects[15] have furthermore been observed to have a right displaced prominence peak (Gibbon 1998) and a rising accent (upstetp) at the right edge of prosodic phrases (Truckenbrodt 2005).

Ulbrich (2002) compared the prosody of newscasters on national television channels —*i.e.* trained speakers professionally required to adhere to a national language standard—with regard to prosodic variation. She found that speakers from Germany accompanied an early sharp fall of the fundamental frequency with a sharp fall in intensity when pronouncing nuclear accents. Swiss (and to a lesser extent Austrian) speakers realized the fall in F_0 extremely late and without a fall in intensity (Ulbrich 2002). Swiss and Austrian nuclear tones involved two boundary tones—one

[13] see Keller (196) for a dialect atlas of the *Deutscher Sprachraum* that provides a discussion of the major dialect groups along with phonetically transcribed dialect samples
[14] Please consult the methods section of Experiment 2 for an explanation.
[15] Because Germany is the most populous of the three countries, most research into German is conducted in universities within Germany. The term 'Southern' might refer to dialects of Bavarian, Alemannic and even Central German variety depending on the location of the research center. Most commonly, 'Southern' used in the given context refers to Bavarian dialects.

stress-seeking and one denoting the external boundary of the intonational phrases. German German utterances lacked a second boundary tone (Ulbrich 2002).

Regional differences in prosodic realization of phrasal boundaries might affect attachment choice if parsing is prosodically driven. To my knowledge, this subject has not yet been assessed in field of attachment ambiguity and resolution.

2.8 Aim of the Present Study

The present study's goals are threefold. First, to see whether the central findings of Zschernitz's work can be replicated and to create sentences that more closely resemble natural speech than the ones presented in Table 1. Second, to embed the investigation of PP-attachment in a contemporary theoretical framework. Third, to investigate the effect of demographic variation (age, gender, origin) on attachment choice. Specific attention will be paid to the question of whether familiarity with a dialect (and its prosody) is correlated with attachment choice.

Experiment 1 will be concerned with the production of globally ambiguous sentences. It is designed to answer the following questions: Can an informed speaker reliably produce phonetic differences between sentences with high and low attachment? If so, what type of phonetic cues are used to disambiguate sentences with high and low attachment? What does the prosodic grouping of the spoken sentences reveal about the syntax to prosody mapping of German?

Experiment 2 will use the aural material obtained in experiment 1 in an internet-based survey. The following questions will be addressed: Do listeners use prosodic cues to understand the speaker's intended meaning when there is no pragmatic context? Is the listeners' understanding affected by demographic factors such as age, gender, and membership of a specific dialect group? Are the listeners' understanding and attachment choices influenced by the syntactic structure of the sentence?

3 Ambiguity Resolution in Production

3.1 Experiment 1

3.1.1 Aim

Experiment 1 focused of the production of sentences with global attachment ambiguities. It tested whether an informed and trained speaker is able to reliably disambiguate between high and low attachment by means of prosodic cues. Sentences varied in attachment type (high versus low) as well as sentence type (simple versus embedded). The length of critical constituents and of the pauses between the constituents was measured as the dependent variable. Additional information came from the fundamental frequency profile of the sample sentences.

3.1.2 Methodology

3.1.2.1 Test Sentences

A total of 64 unique sentences was recorded for the experiment (Appendix I, sentence type 1-4). Sentences were ordered into 16 clusters of four sentences each. A cluster was characterized by containing the same direct object (a bi-syllabic[16] animal) and the same object within the prepositional phrase (*mit* + object). Table 2 presents one such cluster and illustrates the variables manipulated between the different sentences in the same group. Half of the sentences (I, III) show high attachment, while the remaining sentences (II, IV) show low attachment. Sentences I, II are simple, V2 sentences. Verb-final sentences (III, IV) introduced with the matrix clause *Ich sehe, dass* (I see that), embed the clause containing the PP, thus releasing it from the V2 requirement. The two verb-final sentences, III and IV, are minimal pairs in regard to PP-attachment; as are the V2 sentences I and II. Because minimal pairs form the same cluster are comprised of the same lexical words, differences in the duration of sentence and unit length as well as intonation contour can reasonably be attributed to a speaker's disambiguation attempts.

[16] Both lexically bi-syllabic animal names (e.g. *Biene*-bee) and monosyllabic names which become bi-syllabic due to the addition of a morpheme marking the accusative case (e.g. *Bär*-bear; *Bär*+*en* bear_{ACC}) were used.

Table 2. Overview over the four different sentence types contained in one thematic cluster and the conditions (sentence type and attachment type) manipulated.

Sentence type	#	Sample sentence	Attachment type	Surface ambiguity
V-second	I	*Er **verjagt** den Adler **mit dem Socken**.* He **chases away** the eagle **with the sock.**	VP modifying	ambiguous
V-second	II	*Er verjagt **den Adler mit dem Socken**.* He chases away **the eagle with the sock**	NP modifying	ambiguous
V-final	III	*Ich sehe, dass er den Adler **mit dem Socken verjagt.*** I see that he **chases away** the eagle **with the sock.**	VP modifying	ambiguous
V-final	IV	*Ich sehe, dass er **den Adler mit dem Socken** verjagt.* I see that he chases away **the eagle with the sock.**	NP modifying	ambiguous

The sentences listed in Appendix I, show that while all other constituents changed, the subject (*er*-he) and the matrix clause in embedded sentences (*Ich sehe, dass* - I see that) remained unaltered throughout the experiment.

Four verbs different verbs were used (*verjagen* (chase away), *grüßen* (greet/wave at), a*ttackieren* (attack), and *berühren* (touch) within the experiment. They were chosen because of their ability to form plausible scenarios in both NP- and VP-modifying readings. Two of the verbs (*verjagen, attackieren*) carried negative connotations, whereas the connotations of the other two (berühren, grüßen) were neutral to positive. When used in the third person singular required by the setup of the sample sentences, one verb (*attackiert*) became trisyllabic, two verbs (*verjagt, berührt*) bisyllabic and one verb was monosyllabic (*grüßt*). This difference was unintended as the verbs were primarily picked for their ability to produce a sufficient number of plausible- if fanciful-scenarios. Verb length still might have been an important (yet uncontrolled for) influence. Especially in the case of the disambiguation of V2 sentences where the monosyllabic *grüßt* and the subject *er* form a phonological phrase at the lower size boundary for German[17].

[17] Milotte et al. (2007) argue that Snedeker and Trueswell's participants failed to produce the expected results in [Tap[the frog with the flower]]-type of sentences because monosyllabic phonologic phrases

Sentences were written in Standard Austrian German (SAG) and differed from Standard German German (SGG) in vocabulary choice (e. g. using the term *Schlecker*—SAG for lollipop—instead of a SGG alternative) and grammatical gender (*der Socken* (masc.) instead of *die Socke* (fem.) –the sock).

The experiment made no effort to keep its sole participant in the dark about the purpose of the experiment. As prior experiments into English disambiguation of prepositional phrases already established, disambiguation improves when speakers are aware of the referential context (Kraljic & Brennan 2005) or trained (Albritton et al. 1996). The experiment did not wish to replicate these facts but rather to extract sound files sufficiently clear and standardized for analysis. Informing a speaker about the meaning of the sentences was furthermore deemed more closely related to natural speech. Language's main function is a communicative one, so a speaker in a conversation is expected to know what type of information to transfer.

3.1.2.2 Recording Session

The recording session for the experiment took place in January of 2017. Choice of speaker fell on a female student of musical theatre in her mid-twenties. The speaker grew up in the *Waldviertel* region of Lower Austria. Privately, she speaks the local dialect—a subtype of the Central or Danube Bavarian dialect group (Kranzmayer 1956). She is also proficient in Standard Austrian German, the recording language of this study.

A researcher, a sound engineer and the speaker were present at the recording session held in a professional sound studio. There, the speaker was provided with a list of the test sentences. The intended interpretation of the attachment was indicated by bolding and by setting the sentence to be read into pragmatic context, but not by orthographic signs (e.g. commas) that could be mistaken for scripted pauses. The speaker was instructed to read the sentence for herself until she understood the intended meaning and provided as much time as needed to prepare for recording. Once she indicated that she had understood the meaning of the sentence and

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are not felicitous as prosodic units. They voice similar concerns for the bisyllabic '[They rose] [early in May]' vs. '[They rose early][in May]'.

conceived of a way to convey this meaning, recording ensued. No instructions as to how the sentences ought to be pronounced were given. The speaker was told to rely on her native speaker intuition. The recorded sound file was then played back and judged for satisfactory execution of the task. Sentences were re-recorded for several reasons:

- Failure to produce sentences with sufficient sound quality, as judged by the sound engineer. This included the speaker standing too far away from microphone or mumbling as well as the technician having started the recording too late.
- Failure to produce sentences in neutral speech as judged by the experimenter or the speaker. This occurred when exaggerated stress was placed on one phrase or lexical word; when the pitch contour of a sentence sounded "too theatrical; " or when the speaker used word initial voiced alveolar fricatives [z] which are absent in natural Austrian German (Moosmüller et al. 2015) but used in theatre because of the way they carry in large rooms[18].
- Failure to convey the intended meaning of the sentence as judged by the speaker herself.

Each sentence was recorded in GarageBand and saved as individual MP3 files.

3.1.2.3 Analysis of Recorded Material in PRAAT

In order to understand which auditory cues a speaker of Austrian German uses to convey a specific attachment reading in sentences with ambiguous PP-attachment, and which cues, in turn, are available to listeners trying to disambiguate the sentence—the recorded sound files were examined with the help of the computer programme *PRAAT* (Boersma & Weeninck, 2017).

The spoken sentences were separated into segments small enough as to not differ in either attachment condition. In case of the recorded sentences, the smallest common denominator frequently overlapped with φ-phrases. An exception is a

[18] Personal communication with the speaker

segment containing two prosodically invisible function words—the complementizer and the pronomial subject of the embedded clause of verb final sentences. The reasoning behind establishing this unit, nonetheless, instead of attaching it to the direct object was that the resulting structure enabled a comparison of the length of the direct object in V-second and V-final sentences.

Segmentation resulted in verb-second sentences being divided into three separate constituents. Verb-final, embedded sentences were divided into five segments as illustrated below:

(21)

***Verb*-second:**

[Er verjagt]	//	[den Adler]	//	[mit dem Socken].
[*He chases away*]		[*the eagle*]		[*with the sock*].
[subject +verb]	//	[direct object]	//	[prepositional phrase].

Verb-final:

[Ich sehe,]	//	[dass er]	[den Adler]	//	[mit dem Socken]	//	[verjagt].
[*I see*]		[*that he*]	[*the eagle*]		[*with the sock*]		[*chases away*].
[matrix clause]//[comp+subject]			[direct object]//[prepositional phrase]			//	[verb].

PRAAT extracted the overall length of utterance, the length of each segment, and the length of the breaks between two neighbouring constituents. Additionally, the overall pitch as well as the minimum, maximum and mean pitch of each constituent was determined. The data recorded for sentences where the speaker had been instructed to form high attachment were then compared to those where the speaker had tried to produce sentences with low PP-attachment to shed light on the hierarchical organisation within the sentence structure.

3.1.3 Results

3.1.3.1 Constituent Length and Pauses

3.1.3.1.1 Verb-second

In V2-sentences, relative constituent length—that is the length of a constituent expressed as the relative proportion it occupies within an utterance—varied between sentences with an intended high or low attachment reading.

An average V2 sentence with an intended high attachment reading lasted for 2.15 seconds. The subject and verb took up an average of 28.42, the object an average of 31 and the prepositional phrase on average of 33.58 per cent of the spoken sentence. The pause between the direct object and the prepositional phrase occupied an average 6.98 per cent of the sentence (Table2).

In contrast, sentences with an intended NP-attachment reading were 1.78 seconds long, on average. The average relative length of the subject and verb measured 33.14, that of the direct object 28.44 and that of the prepositional phrase 38.12 per cent of the complete utterance. The length of the pause between direct object and prepositional phrase was reduced by approximately 95 per cent to 0.29 per cent of the length of the complete utterance.

The segment containing the subject and the verb and segment containing the prepositional phrase took up more space within the sentence when attachment was. Conversely, the break and the object were lengthened when the speaker tried to form a sentence with high attachment (Table 3). All differences in length were significant (p-values of: 0.000265 (verb/subject); 5.59e-11 (pause), and 0.000313 (PP)) apart from that between the object in VP-modifying and NP-modifying sentences (p-value: 0.0708).

Table 3. Relative length of the constituents of a V2 sentences with high or low attachment constituents in relationship to the complete utterance in percent. Bolded p-values indicate significant difference between the relative lengths of the constituent.

	subject+verb	**object**	**pause**	**PP**
	Er verjagt	*den Adler*		*mit dem Socken.*
High	28.42	31.00	6.98	33.58
Low	33.14	28.44	0.29	38.12
p-value	**0.000265**	0.0708	**5.59e-11**	**0.000313**

Figure 1 showcases the different realization of constituent length and the lengthening of the pause between direct object and prepositional phrase within a sample sentence read with contrasting attachment.

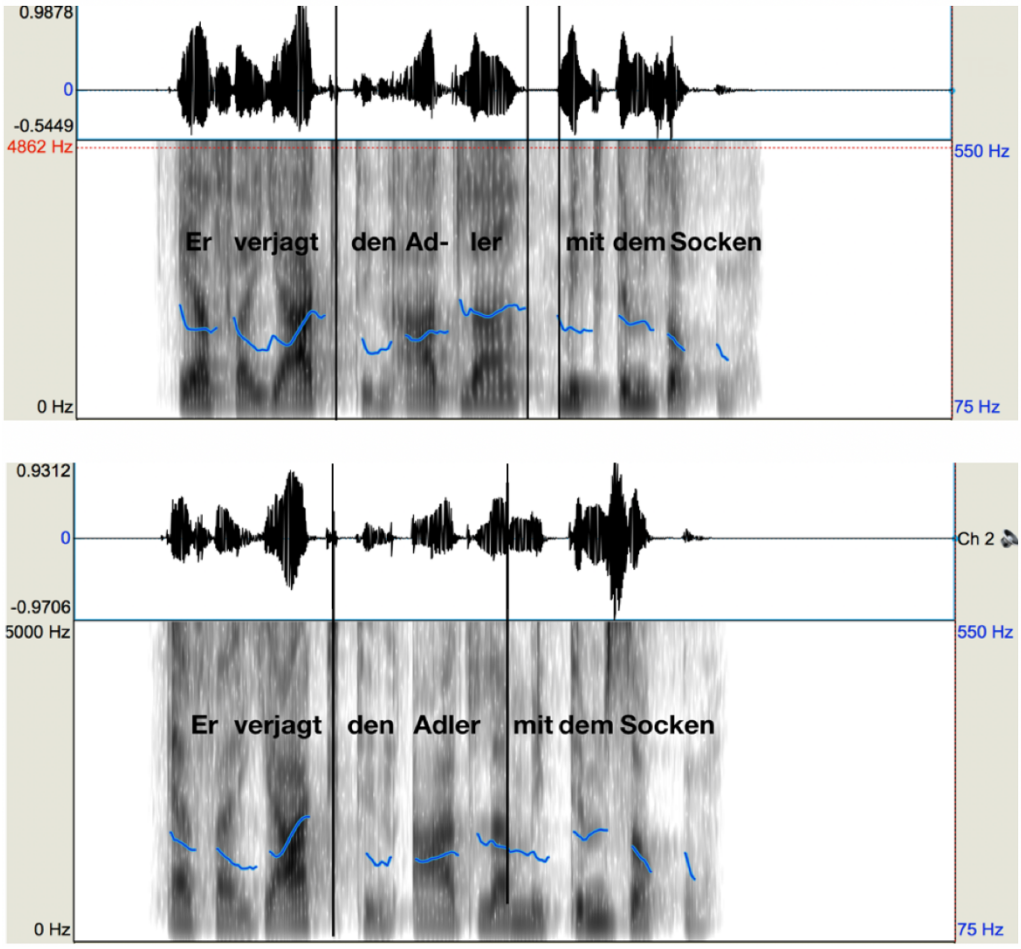


Figure 1. Spectrograms and F_0-contours for the sentence *Er verjagt den Adler mit dem Socken* pronounced with an intended high (top) and low (bottom) attachment reading. Horizontal lines represent the segmentation employed in the experiment (when far enough apart to be distinguished). Words are roughly aligned to represent their position in the spectrogram.

3.1.3.1.2 Verb-final

In verb-final matrix sentences, the length of the matrix clause and the associated pause between the matrix and the embedded clause did not vary significantly between sentences with high and low attachment. In both cases, the matrix clause and the first pause (pause 1) took up approximately a third of the utterance—33.67 per cent in high attachment sentences and 32.59 per cent in low attachment sentences (Table 4). Sentences lasted for an average of 3.01 seconds when they were intending to show high attachment, and 2.88 seconds when the speaker wanted to convey low attachment.

Of the four constituents in the embedded clause, the relative length of the direct object was significantly longer in high attachment sentences compared to low attachment sentences (15.01 compared to 12.59 per cent; p-value: 0.000517); and low attachment sentences led to a longer realization of the prepositional phrase that was approaching significance (18.57 compared to 17.41 percent; p-value: 0.056). Neither the length of the constituent containing the complimentizer and the subject, nor that of the verb varied significantly between the two attachment conditions (Table 4). Of the three pauses measured, only the pause between the direct object of the sentence and the prepositional phrase –i.e. pause 2—showed a significant length difference.

Table 4. Relative length of the constituents of a verb-final sentences with high or low attachment constituents in relationship to the complete utterance in percent. Bolded p-values indicate significant difference, a bolded exclamation marks a difference between the relative length of the constituent that nears significance.

	matrix	**pause 1**	**comp+ subject**	**object**	**pause 2**	**PP**	**pause 3**	**verb**
	Ich sehe,		*dass er*	*den Adler*		*mit dem Socken*		*verjagt.*
High	29.69	3.96	5.69	15.01	2.52	17.41	0.88	11.08
Low	28.20	4.38	5.99	12.59	0.09	18.57	1,42	13.18
p-value	0.3688	0.644	0.3169	**0.000517**	**8.07e-06**	0.05597 **(!)**	0.1485	0.1984

3.1.3.2 Fundamental frequency and pitch

The average pitch for all sentences lay at 253.63 Hz with a standard deviation of 21,34 Hz. Mennen et al. (2012) registered an average pitch of 218 Hz for female speakers of Northern German, with a normalized pitch range of 164.26 to 313,98 Hz, which places the speaker in a medium pitch range with a slightly heightened pitch average[19].

Sentences started out with a high pitch relative to their average pitch value and experienced steady declination (Vaissiére 1983) resulting in an utterance-final lowering. Pitch realization of sentences had to be scaled in relationship to each other to account for inter-sentence pitch variation. To give a full normalized pitch track of the sentences was outside the scope of the experiment and would have required repeated recordings per sentence and a possible variation in speaker. Instead, the mean pitch for each segment was extracted to give an overview of how pitch varied throughout the sentence (Figure 2). Thus, results from these endeavours can only be seen as anecdotal evidence not as an expression of statistical analysis with predictive power.

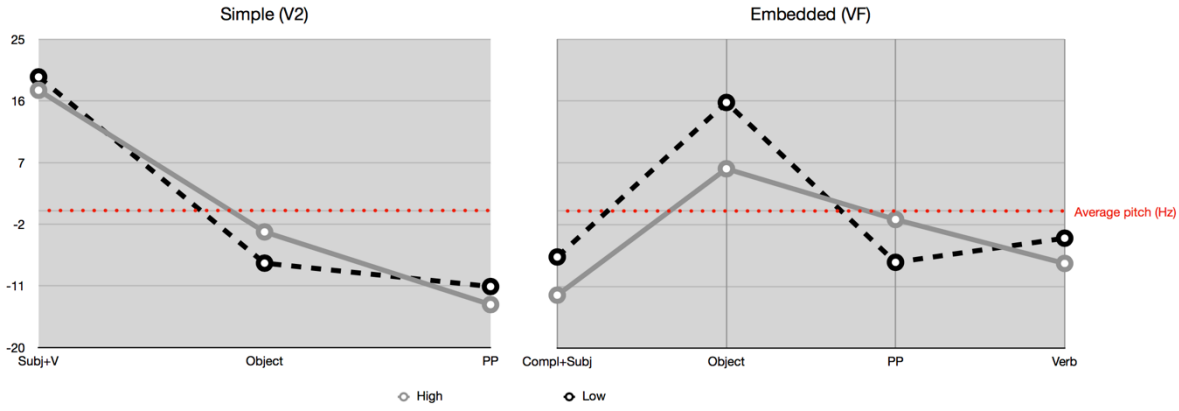


Figure 2. Comparison of relative deviation from average pitch in sentences with high (solid, grey) or low attachments (broken, black line) in Hertz (Hz). Values have been scaled by subtracting the sentence's average pitch from each of its constituents in order to account for differences in pitch between various sentences. Embedded sentences are presented without the matrix clause.

[19] In personal communication, the speaker mentioned that her singing voice is classified as Mezzo-Soprano.

3.1.4 Discussion

Experiment 1 was conducted to answer the question of whether an informed speaker reliably produces phonetic differences between sentences with high and low attachment. To this end, we observed that clear, consistent and significant differences were made in the production of sentences recorded with intended high, and, alternatively, low attachment.

The results obtained suggest that informed speakers use prosodic cues to differentiate between two syntactic structures. Whether this differentiation occurs automatically as the speaker parses ambiguous syntactic information—akin to Fodor's *Implicit Prosody Hypothesis* for silent reading (Fodor 2002)—or whether the cues were employed as part of a communicative effort to convey syntactic structure cannot be asserted in the current set-up. Multiple studies (e.g. Allbritton et al. 1996, Kraljic & Brennan 2005) have found that speakers are more reliable in producing phonetic cues that aid in disambiguation when they are aware of ambiguity. Additionally, the speaker of this study was aware that the sentences would later be used in a perception study and might have thus tried to exaggerate the difference. Since the speaker had not been instructed on what cues to use, the repeated and reliable employment of cues nevertheless points to an instinct as to how to prosodically mark phrase boundaries.

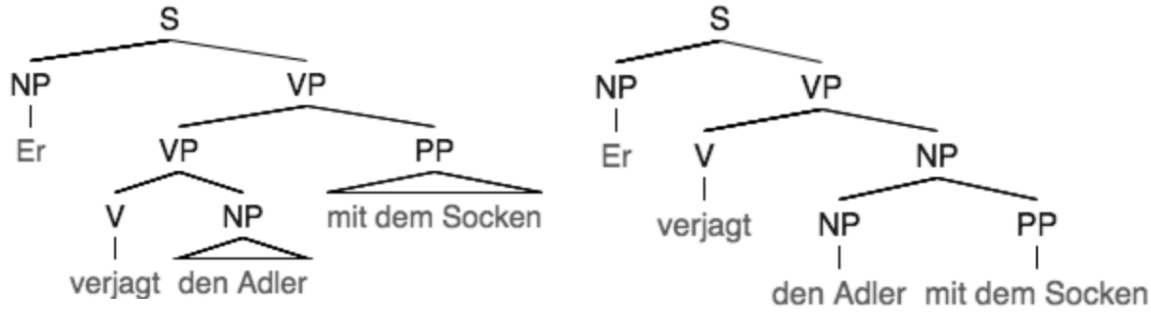
3.1.4.1 Types of Cues

The length of the various segments and pauses vary reliably between the two attachment conditions. In V2-sentences, the length of the subject-verb constituent, the pause between direct object and the prepositional phrase and the length of the prepositional phrase differed significantly between sentences pronounced with intended high and low attachment (Table 4). In embedded sentences, the length of the direct object and the length of the pause between said object and the prepositional phrase varied significantly (Table 4).

Comparing sentences of both sentence types (V2 and V-final), the only cue to consistently mark a difference between the two attachment options is the length of the

pause between direct object and prepositional phrase. The longer pause in a high attachment condition corresponds to a syntactically (and by extension prosodically) larger hierarchical difference (22).

(22)



The insignificant length of the pause in low attachment cases (0.29 or 0.09 per cent of the whole utterance depending on sentence type) begs the question whether the speaker intentionally chose to set a break to mark prosodic phrase boundaries or whether the pause simply results from a short break that is routinely placed between lexical and non-cliticized functional words. Rather than consciously modifying pause length, the speaker would then have inserted a break to mark the steeper boundary in VP-modifying conditions.

Break insertion or lengthening to denote a prosodic break could furthermore only be observed on the right edge of a φ-phrase. Should the syntactic VP be faithfully mapped from syntax to prosody into a recursive structure (23), the left φ-phrase boundary between the verb and the complex object would be ignored in the phonetic realization of the sentence. In fact, a cursory look at the available data before analysis negated the need to measure the break between these two constituents because it was virtually invisible for all sentence and attachment types. This is especially noticeable because the article[20] initiating the φ-phrase starts with a voiced plosive, which is easily picked up in PRAAT's spectrogram.

[20] *die* (FEM), *der* (MASC) or *das* (NEUTR) depending of the grammatical gender of the preceding noun

(23)

((… verjagt (den Adler)$_{\varphi}$ mit dem Socken)$_{\varphi}$)$_{t.}$ High Attachment
((…verjagt (den Adler mit dem Socken)$_{\varphi}$)$_{\varphi}$)$_{t.}$ Low Attachment

Language parsing requires considerable computing power. The existence of reliable ways to indicate a hierarchical difference within an ambiguous sentence guides the parser by reducing available options. The fact that pauses signify syntactic and prosodic breaks in a variety of languages regardless of their relatedness further bolsters the claim that pauses are a default method to represent prosodic boundaries in speech. The data have thus replicated a cross-linguistically observed phenomenon. The speaker intuitively modified the length of the pause when trying to modify attachment.

Pre-final lengthening before a right φ -phrase boundary was observed for the direct object in both simple and embedded sentences, but the difference was only significant in embedded sentences. The existence of pre-final lengthening at a phrase boundary has been discussed as an important prosodic cue for languages in general (Féry 2016) and German in particular (Féry 1993, Truckenbrodt 1999, Inozuka 2003). The speaker's failure to produce a difference large enough to be significant for the phrase boundary in V2 sentences is therefore counterintuitive and could be caused by the small number of sentences recorded for each condition. Alternatively, it could be assumed that break insertion serves as an unmistakable cue for prosodic structuring. Pre-final lengthening provides a subtler cue. Speakers will only employ it to create a significant difference in more complex situations (i.e. a subordinate clause) to provide additional guidance.

As discussed above, the extraction of segment-specific mean pitch values didn't have predictive force. Regardless of force, there were no differences observed in the simple sentences. In embedded sentences, the observed differences were larger. The pitch value for high attachment didn't sink as far between the object and the prepositional phrase. In low low attachment sentences pitch further rose for the unit containing the verb (Figure 2). Considering where (23) situates phrase boundaries,

these differences might be evidence for partial reset at different parts of sentence. Again, this might indicate that a wider variety of cues will be employed when trying to disambiguate more complex sentences.

3.1.4.2 Syntax-Prosody Mapping Revisited

The analysis of the aural material raises the question of whether the observed prosodic cues can be used to connect syntax and prosody using previously existing knowledge about German intonation, the prosodic from, and mapping tools.

Prolonged pauses along with breathing breaks are reliable indicators for the presence of phrase boundaries (Truckenbrodt 2009). An additional cue for phrase boundaries in German is pre-final lengthening (Truckenbrodt 2005).
If prosodic structure were isomorphic to syntactic structure, the prosodic structure presented in (23) would be expected for the VP. This isomorphic matching is achieved by a MATCH-constraint such as Selkirk's (2011) MATCHPHRASE (24). In the case of the recordings, lexical XPs are matched to φ-phrases as result of the prosodic hierarchy outlined in the introductory chapter.

(24) MATCHPHRASE (Selkirk 2011)
A phrase in syntactic constituent structure must be matched by a constituent of a corresponding prosodic type, in phonological representation, call it φ.

Indeed, experiment 1 shows that the relative length of the pause between direct object and prepositional phrase is significantly longer in cases of high attachment where (24) would place the right boundary of a phonological phrase.

An isomorph structure violates SLH's prohibition of recursivity. Any constraint militating against recursive structures, such as Truckenbrodt's NONRECURSIVITY (25), must therefore be ranked low relative to the matching constraint (26) in order to obtain the observed output.

(25) NONRECURSIVITY (*NONREC*) (Truckenbrodt 1999)
Any two p-phrases that are not disjoint in extension are identical in extension.

(26) MATCHPHRASE >> NONRECURSIVITY

While MATCHPHRASE provides the structure corroborated by the prosody of the speaker's utterances in main clauses[21], a mismatch occurs in subordinate clauses. The decisive part of the sentence is presented in (27):

(27) ((… den Adler)$_{\varphi}$ mit dem Socken verjagt)$_{\varphi}$. High Attachment
((…den Adler mit dem Socken)$_{\varphi}$ verjagt)$_{\varphi}$. Low Attachment

Faithfully mapped verb-final sentences can develop sentence internal right φ-phrase boundaries at two distinct loci: between direct object and prepositional phrase in cases of high attachment—where it is marked by a significantly longer pause—and between prepositional phrase and the verb—where it is not, in fact, realized.

Whether constraints embracing or rejecting recursivity are used, they are bound to cause an infelicitous mapping between prediction and observed boundary cues for one of the two attachment conditions in subordinate clauses. The problem could be mitigated by additional constraints. The fact that the recursive φ-phrase is alternatingly left or right aligned within the major φ-phrase might matter. Additionally, the difference in the size between the two phrases in low attachment cases might be of influence. But these speculations are not motivated by the findings in experiment 1. Additional research is needed to support a decision.

Functional words making up syntactic XPs offer another problem to an isomorphic mapping of syntax and prosody. The left edge of the recorded utterance, or, alternatively, the embedded clause, is occupied by the male pronoun *er* (V2) or the complementiser *dass* followed by *er* (VF). A faithful syntax-to-prosody mapping expects the creation of distinct φ-phrase corresponding to TPs and CPs. This is impossible under Selkirk's *Principle of the Categorial Invisibility of Function Words* (Selkirk 1984) or Truckenbrodt's *Lexical Category Condition (28)* (Truckenbrodt 1999). Both state that the mapping mechanism is blind to the presence of functional

[21] The status of the pronominal subject will be discussed below.

constituents. Therefore, functional projections cannot inhabit their own prosodic category. The relative prosodic unimportance of the complementizer and the pronoun are shown in Figure 2, where the segment containing them remains unaccented even though a partial reset at the beginning of the subordinate clause is expected (Truckenbrodt & Féry 2015).

(28) LEXICAL CATEGORY CONDITION (*LCC*)
Constraints relating syntactic and prosodic categories apply to lexical syntactic elements and their projections, but not to functional elements and their projections, or to empty syntactic elements *and their projections.*

A high ranked LCC-constraint causes the function words invisible to a prosodic parser to either remain unparsed or be integrated into the closest constituent containing a lexical word. Even though Féry shows that constraints ensuring exhaustive parsing (e.g. Prince and Smolensky's PARSESYLLABLE (1993/2004)) are ranked low in the case of German stress assignment (Féry 1998), an unparsed object at the clausal left edge is unlikely to occur. Previous research—amongst others Harizanov (2014) for utterance initial clitics in Macedonian and Bulgarian and Elfner (2015) for L-H rises in Conamara Irish—has established the clausal left edge as a region fortified against prosodically empty material by means of the STRONG START constraint (29).

(29) STRONG START (Selkirk 2011)
Assign one violation mark for every prosodic constituent whose leftmost daughter constituent is lower in the prosodic hierarchy than a sister constituent immediately to its right:
*(n n+1 ...)

In V2-sentences, STRONG START is predicted to interact with the pronominal subject causing it to attach to the verb as a clitic. The intonational contours of all recorded main V2 clauses reveal no markers for a phrase boundary such as a prolonged pause, an upstep or a partial reset between the pronoun and the verb. (Table 3).

A possible ranking of the STRONG START, LCC and MATCHPHRASE resulting in the integration of the pronoun into the phonological phrase occupied by the verb is provided in (30)

(30)

	[(Pron(V...)$_{VP}$)$_{IP}$]	STRONG START	LCC	MATCHPHRASE
☞	[(Pron V...)$_{\varphi}$]$_{\iota}$			*
	[Pron (V...)$_{\varphi}$]$_{\iota}$	*!		
	[(Pron (V...)$_{\varphi}$)$_{\varphi}$]$_{\iota}$		*!	

In verb-final sentences, the intonational phrase encompassing the embedded clause, is introduced by two consecutive, non-incorporated function words: the complementiser *dass,* and the male pronoun *er.* In their 2006 paper, Kabak and Schiering argue that in case of a [Func Func Lex]-string, the two function words first attach to each other and form a special phonological unit before adjoining to the closest lexical word. In this process, the rightmost function word *may* undergo phonological reduction (Kabak and Schiering 2006).

This section has shown that the aural material obtained by experiment 1 often matches syntactic structure in a way predicted by established phonological theory. While the observed mismatches are interesting, the extent and form of the experiment do not license theoretical musings as to the reasons behind the mismatches or a way to alleviate them. Further studies focused on obtaining a greater sample of data and closer cue matching will be needed to advance the problem.

4 Perceiving Ambiguity -- What Drives Attachment Choice?

4.1 Experiment 2

4.1.1 Aim

Experiment 1 established that phonological differences are reliably produced in order to disambiguate attachment for globally ambiguous prepositional phrase attachment in Austrian German. This follow-up experiment seeks to address the perception side of language processing. Do native speakers of German use these cues indicating prosodic structuring when asked to disambiguate? Or are perceptible cues overwritten by a language parser following a syntactic parsing mechanism such as Frazier's (1987) or Konieczny et al.'s (1997)? Is understanding of the cues guided by a person's own linguistic origins?

To try and answer these questions, the sentences recorded in Experiment 1 were used in an internet-based sentence selection test. Respondents were asked to match an auditory stimulus (i.e. an experimental sentence) with the picture that best represented what they had heard. They could either select a picture that depicted the attachment reading intended in the recorded sentence or a picture that represented the conflicting attachment reading. The recorded sentences varied in the attachment they conveyed (high versus low) as well as in sentence type (simple versus embedded).

If prosodic cues are decisive in comprehension, pictures depicting high attachment should be chosen significantly more often than those depicting low attachment when high prosody is presented. Likewise, significantly more pictures depicting low attachment than high attachment situations should be chosen when low attachment prosody is heard. This effect should persist throughout all sentence types.

If, one the other hand, the perception of attachment is based on syntactic structure, pictures with low attachment readings should be chosen over those depicting high attachment when the syntactic structure licenses it. The sentence final position of the verb in subordinate German clauses causes a parser relying on syntactic structure to prefer attaching material to the (already filled) NP instead of the VP. A marked difference in attachment choice between simple and embedded

sentences should be observed. Attachment choice between sentences with varying prosody, on the other hand should not be affected. Table 5 illustrates the predictions to respondent attachment choice made by parsers relying on syntactic surface structure or on prosodic structure.

Table 5. Predictions to respondent attachment choice made by a parser following prosodic or syntactic surface structure alone.

Verb position	Prosody		Prosody-based prediction	Syntax-based prediction
V2	VP	(Er berührt den Adler)$_{\varphi}$ # (mit dem Socken)$_{\varphi}$	high	high
V2	NP	(Er berührt)$_{\varphi}$ # (den Adler mit dem Socken)$_{\varphi}$	low	high
VF	VP	(Ich sehe,)$_{\varphi}$ (dass er den Adler)$_{\varphi}$ # (mit dem Socken berührt)$_{\varphi}$	high	low
VF	NP	(Ich sehe,)$_{\varphi}$ (dass er den Adler mit dem Socken)$_{\varphi}$ # (berührt)$_{\varphi}$	low	low

In order to assess the effect of inter-language variation on intonation, the experimental set-up asked respondents to indicate where they had grown up so that they could be sorted into broad dialect categories. It was predicted that while all speakers of German might pick up on strong prosodic cues, speakers coming from areas that are dialectally similar to that of the speaker producing the prosodic cues might be more attune to subtle difference in prosody. A closer knowledge of the speaker's prosody might enable them to choose the target attachment reading more frequently, especially in more complex sentences such as the verb-final embedded sentences.

4.1.2 Methodology

4.1.2.1 Test sentences

Additional 32 sentences with unambiguous attachment conditions—2 for each cluster of sentences—were recorded roughly one month after the recording session for sentences with ambiguous PP attachment. The same sound engineer and speaker, were present at the second recording but the researcher was missing.
The additional recordings increased the number of sentences used in the study to 96 (see Appendix I for full list). Sentence V was constructed with a fronted PP that unambiguously attached to the VP, while sentence VI was a passivized construction and attached the PP to the NP. Table 6 presents all six sentence types of sentences used in experiment 2 and elaborates on which factors are manipulated by them.

Table 6. Updated overview about the 6 different sentence types contained in one thematic cluster and the conditions (sentence type, attachment type and ambiguity) manipulated.

Sentence type	#	Sample sentence	Intended interpretation	Surface ambiguity
V-second	I	*Er* ***verjagt*** *den Adler* ***mit dem Socken***. He **chases away** the eagle **with the sock.**	VP modifying	ambiguous
V-second	II	*Er verjagt* ***den Adler mit dem Socken***. He chases away **the eagle with the sock**	NP modifying	ambiguous
V-final	III	*Ich sehe, dass er den Adler* ***mit dem Socken verjagt.*** I see that he **chases away** the eagle **with the sock.**	VP modifying	ambiguous
V-final	IV	*Ich sehe, dass er* ***den Adler mit dem Socken*** *verjagt.* I see that he chases away **the eagle with the sock.**	NP modifying	ambiguous
V-second	V	***Mit dem Socken verjagt*** *er den Adler.* **With the sock**, he **chases away** the eagle.	VP modifying	unambiguous
V-second	VI	***Der Adler mit dem Socken*** *wird von ihm verjagt.* **The eagle with the sock** is being chased away by him.	NP modifying	unambiguous

The additional sentences functioned both as filler sentences allowing the brain to relax[22] and to test survey takers for their understanding of and involvement in the task given. Native Germans speakers sufficiently engaged with the task are expected to have an error rate of close to zero per cent on unambiguous sentences. Participants who made more than two mistakes in twenty-four[23] unambiguous questions asked by the survey (i.e. had an error rate of 8 per cent or more) were excluded from further analysis.

4.1.2.2 Illustrations

When constructing the verb-direct object-prepositional phrase combinations for each cluster, attention had to be paid to phonological constraints such as object length. Another factor was the plausibility of the combinations. It was impossible to devise 16 groupings where an instrumental and an object-modifying reading were equally plausible. Informal pre-testing showed a persistent bias towards the instrumental option. Using pictures, especially pictures drawn in a whimsical style and not written sentences in the online questionnaire was expected to have a positive effect on the acceptance of originally less plausible interpretations. Thus, illustrations were commissioned in part to help suspend disbelief about their semantic or lexical plausibility

A professional illustrator illustrated the contrasting meaning of the minimal pairs. Funds for the illustrations came from the CASTL-FISH research group at the University of Tromsø. The illustrator was told to keep the pictures as simple as possible and to focus only on the change of meaning between VP- and NP-attachment. This was done to avoid any distraction or unintended persuasion stemming from the pictures themselves. Even so, the pictures needed to be engaging for the experimental subject. Contact between the illustrator and the researcher during the drawing process was important to resolve issues regarding the amount of variation allowed between each sentence cluster. Continuous communication proved especially important because the sentences to be illustrated were presented to the illustrator in

[22] Feedback given by one of the participants clearly stated that she was relieved when an unambiguous sentence came, because it was easy to provide an answer she knew to be correct.
[23] Refer to Section 1.1.2.5 for an explanation of this number.

translation, which led to unforeseen minor mismatches between the recorded sentences and their illustration (e.g. a snake with a *recorder* not a *flute*). These errors were easily fixed once noticed.

After receiving the raw files, some had to be rescaled in order to ensure that the two images to be compared were of similar size (a fixed width of 350 pixels with height values varying depending on the orientation of the original illustration but similar to the picture depicting the alternative attachment type). These manipulations were conducted in the image processing programme ImageJ2 (Rueden et al. 2017). The illustrator has asked permission to eventually display some of the original images on her website (http://www.tanjarussita.com).

4.1.2.3 Online Survey

An online survey was created using the German platform Soscisurvey (Leiner 2014). The platform was chosen due to the possibilities to customize the execution of the survey and the high privacy protection provided by the site. The questionnaire went online in March 2017 and stayed accessibly for 42 days (i.e. six weeks). Once the online questionnaire was active, participants were recruited via social media.

Survey participants were instructed to listen to the audio file of one of the recorded sentences and to select between two pictures deepicting the sentence heard which differed in the attachment of the prepositional phrase (Figure 3). The order in which the individual slides were presented was randomized using a self-written PHP-script in cooperation with the options provided by Soscisurvey. The position of the pictures (left versus right) depicting high and low attachment in a given question were also randomized.

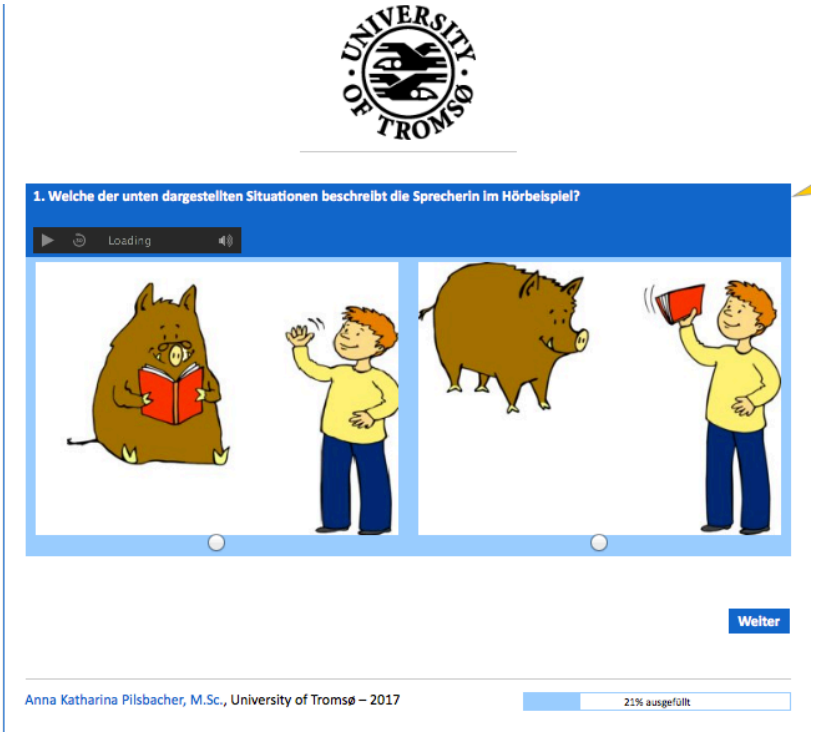


Fig. 3 Example of questionnaire page including the audio file and two interpretation choices. The sentence illustrated in this example: *Er grüßt den Eber mit dem Buch-He greets the male boar with the book.*

4.1.2.4 Beta-Testing and Adjustments

Before publicizing the questionnaire, it was beta-tested by three German speakers, who offered feedback and helped discover bugs regarding technical implementation. Due to comments of the testers, it was decided to shorten the questionnaire by one fourth (i.e. from 96 to 72 question) so that continuous engagement with the survey questions was provided and to prevent participants from tiring and failing to finish the questionnaire.

In order to prevent data loss, four versions of the questionnaire, each leaving out a different block (i.e. ¼) of the original dataset were designed (Table 7). This meant that in comparing two different versions of the questionnaire, half of the questions would be asked in both versions, while ¼ of the questions unique to either one. When three versions were compared, only ¼ of the questions (i.e. one block) were represented in all three versions. In order to ensure an even distribution of the different versions of the questionnaire, the page was coded in a manner that when a

participant clicked the survey-link, he or she was assigned to one of the four versions by a random and unweighted algorithm.

Table 7 Visual representation of the 4 different versions (I, II; III; IV) of the questionnaire and the questions left out in each of them.

I:	ABCD	EFGH	IJKL	MNOP
II:	ABCD	EFGH	IJKL	MNOP
III:	ABCD	EFGH	IJKL	MNOP
VI:	ABCD	EFGH	IJKL	MNOP

Decreasing the questions asked to an individual survey taker by a fourth, reduced the estimated time for survey completion from approximately 30 to 20-25 minutes. After the survey had been online for 12 days, the unweighted algorithm that distributed participants to one of the four versions of the questionnaire had to be changed to a weighted one. This was due to the fact that even though each of the versions was started at a close to equal rate, participants had quit one of the versions at a disproportional rate. In order to even out the distribution of finished questionnaires, the version that had fallen behind was coded as being twice as likely to be chosen when compared to the rest until it had caught up.

4.1.2.5 Demographic Questions

One distinct advantage of using an internet based experiential set-up is its possibility to better reflect the diversity of a population. Many academic studies recruit their subjects from the university campus, creating a very homogenous respondent group in regard to age, level of education and (to a lesser extent) geographic origin. Consequently, results from markedly homogeneous sampling populations are extrapolated to predict an outcome amongst a more heterogeneous public. This might lead researchers to overlook influences of these demographic factors.

In order to obtain data on the demographic and sociolinguistic background of participants, they were asked to indicate their age, gender, and their geographic origin. Participants could choose between large administrative districts in the three

largest German speaking countries—federal states (B*undesländer*) in case of Austria and Germany and cantons (*Kantone)* in the case of Switzerland— when answering the question where they had spent their childhood[24]. Participants coming from other countries or having a parent from another country were asked to elaborate in a window allowing free data input. Respondents were then separated into 4 groups that roughly represented 3 dialectal groups and heritage speakers. The concept of *convenience sampling* (Robinson 2014) predicts higher concentrations of respondents in areas closely tied to an experimenter's place of origin or residence. In this case, this would lead to an overrepresentation of Austrian (and especially Eastern Austrian) respondents not expected if sampling was random or based on population-size. This fact is important insofar as the separation into dialectal group should strive to produce categories as similar to each other as possible.

Alemannic and Bavarian –the two large dialect groups represented in Austria (Keller 1961) were chosen because of the context of the study. Respondents reporting coming from Vorarlberg, Baden-Württemberg, and Switzerland were counted as belonging to the Alemannic dialect group. This distinction roughly coincides with the [haʊ̯s]/[huːs]; [aɪ̯s]/[iːs] isogloss (Keller 1961). Participants from the remaining Austrian states, the Italian Alto Adige, and Bavaria were considered members of the Bavarian dialect group. The remaining participants hailing from Germany were grouped together. The [iː]/ [iɐ̯] or [ʏː]/ [ʏɐ̯] isogloss in e.g. *müde* (tired) was set as the Southern boundary for this dialect group (Keller 1961). The isogloss approximately follows the Northern borders of Bavaria and Baden-Württemberg. All respondents falling to the North of this line were grouped together as speaking a "Northern" dialect. It is understood that using administrative regions such as countries or states as a means to identify dialect groups does not faithfully reflect linguistic reality as dialects rarely perfectly follow political borders (Keller 1961). Participants from regions without a German speaking majority were grouped together under the category "Other" to retain a separate measure for those exposed to strong influences from an ambient language that is not German.

[24] Even moving to a different part of the country in adulthood, participants were expected to be influenced most strongly and persistently in their dialect specific parameters when acquiring language.

In order to elicit responses from lesser-studied groups and to increase the geographic and dialectal spread of respondents, certain people (e.g. German speakers from the Alto Adige region in Italy or Alemannic speakers), were especially encouraged to participate.

4.1.2.6 Semantic Analysis

The necessity for investigating whether attachment choice could be ascribed to attachment bias caused by semantics became obvious during the testing phase. Comments received from survey takers pointed out the importance of semantic bias in their decision-making process. Semantic biases were assessed in a *posthoc* test. A subset of the data comprised of 1506 answered questions was investigated. The subset consisted of three sentence clusters judged by native speakers to have either a bias towards low attachment (J)[25], a bias towards high attachment (C) or no established bias (M):

Bias for high attachment (J)
Er attackiert den Esel mit dem Stock.
He attacks the donkey with the cane.

Bias for low attachment (C)
Er berührt den Bären mit dem Fisch.
He touches the bear with the fish.

No bias (M)
Er verjagt das Kamel mit der Pfeife.
He chases away the camel with the pipe.

4.1.2.7 Statistical Analysis of Survey Results

Data were extracted as a comma separated values (csv) file and prepared for analysis using the reshape package in R version 3.3.2 (R Core Team 2018). All subsequent analyses were conducted in R.

[25] The letters in parenthesis refer to the coding given to sentence groups as observable in the full list of experimental sentences in Appendix I.

4.1.3 Results

4.1.3.1 Overall Participation and Response Time

166 people participated in the online survey. Out of these participants, 33 answered version I of the survey, 44 version II, 41 version III, and 48 participants answered version IV. A chi-square test showed no significant difference between the different version of the questionnaire (p-value: 0.3626). Respondents took an average of 26.25 minutes (±11.03 minutes) to answer the questionnaire.

4.1.3.2 Demographic Data

4.1.3.2.1 Age

The age distribution of participants was leftward-skewed. Ten respondents were between eleven and twenty years old, 45 respondents were in their twenties, 41 in their thirties, 39 in their forties, 22 in their fifties, six participants were aged between sixty-one and seventy years, and 3 participants were over seventy years old. The average participant was in his or her thirties.

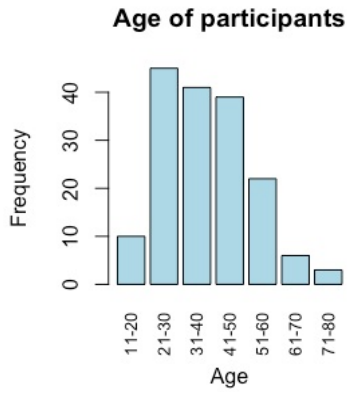


Figure 3 Age of respondents sorted into ten-year categories.

A chi-square test showed that age was a significant factor influencing attachment choice (p-value: <0.0001).

Acceptability of low attachment decreased with increasing age. Twenty-year olds exhibited the highest percentage of sentences judged to have low attachment with (30.19 per cent). Over seventy-year olds, on the other end of the spectrum, only judged 11.81 per cent of the sentences to show low attachment.

Table 8. Relationship between age and attachment choice represented by the total number of times high and low attachment were chosen respectively in unambiguous questions. The age groups with the lowest and highest acceptance for low attachment are shown in bold font and marked with a superscript asterisk (highest acceptance) or a superscript plus (lowest acceptance).

Age Category	High Attachment	Low Attachment	Total answers	% Low Attachment
11-20	352	128	480	26.67
21-30*	1508	652	2160	**30.19***
31-40	1504	464	1968	23.58
41-50	1446	426	1872	22.76
51-60	804	252	1056	23.86
61-70	241	47	288	16.31
71-80+	127	17	144	**11.81+**

In order to ensure that the observed effect was not caused by a skewed age distribution within the sampling population[26], the data was split into dialectal subgroups and re-analyzed.

The median age[27] of respondents from the Bavarian and the Northern group was 31-40. Alemannic survey takers were altogether younger with a median age of 21-30. Chi-square tests confirmed that the age effect was highly significant (p-value <0.0001) for all three data subsets. Additionally, the trend of strengthening high attachment preference with age was observed for all three groups.

4.1.3.2.2 Gender

73,49 per cent of questionnaires—that is 122 out of 166—were filled out by females. Gender had no significant influence on attachment choice, according to a chi-square test performed on the data (p-value: 0.2159).

[26] A potential example for this might be that Bavarian speakers who a higher likelihood of choosing low attachment and are all consistently, and considerably younger than respondents from the other groups. Consequently, this preference would be observed not only for Bavarians, but also for younger respondents.

[27] Ages were recorded in 10-year clusters (11-20; 21-30, etc.), it was therefore only possible to determine median and not mean respondent age.

4.1.3.2.3 Country of origin

Respondents of the survey came from seven different countries. 87 questionnaires were completed by Germans. 64 responses came from Austrians, followed by six from Italy[28], three from the United States of America, two from Switzerland and one response from the Netherlands and Norway each. One participant identified both Austria and the United States as place of origin. Another indicated coming from a different country than the three automatic choices (Austria, Germany, Switzerland), but did not specify.

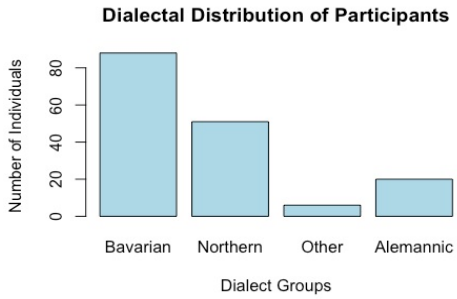


Figure 4 Distribution of dialect groups in the responding population

4.1.3.2.4 Dialect Group

88 respondents belonged to the Bavarian dialect group, 52 to the Northern dialect group and 20 were members of the Alemannic dialect group. The six remaining respondents were classified as "Other."

4.1.3.3 Unambiguous Sentences

Unambiguous sentences were answered correctly in 98.97 per cent of cases. 19 individuals answered one unambiguous question incorrectly, while five individuals erred twice. One individual answered twelve of 24 unambiguous questions (50 per cent) incorrectly and was removed from the analysis. Accuracy in unambiguous sentences rose to 99.27 per cent after removal.

[28] Of the six Italian participants, all six came from *Südtirol* (Alto Adige)—an autonomous region in Northern Italy. Census data from 2011 shows that 69,41 per cent of its inhabitants claim membership to the German speaking population[28], 26,06 per cent define themselves as Italian speaking, and 4,35 per cent define themselves as belonging to the Ladin[28]-speaking minority (astat.provinz.bz.it). Census data from past decades place identification as German-speaking as stably above 60 per cent for the past four decades (census data from 1971-2011 provided by: astat.provinz.bz.it). Of the six Italian participants, four claimed to be in their twenties, one to be between 41 to 50, and one to be between 51 to 60 years old. This means that the available census data supports most of them having grown up in an area with German as the majority language[28].

4.1.3.4 Ambiguous Sentences

4.1.3.4.1 Descriptive

On average, 75.08 per cent of sentences were identified as high attachment sentences, while 24.92 were believed to reflect low attachment. In V2-sentences, respondents classified 79.07 per cent as high and 20.93 as low attachment. In V-final clauses, 71.08 per cent of sentences were perceived to have high attachment and 28.92 per cent to have low attachment. Figure 5 illustrates respondent attachment choice subdivided by sentence type and dialect of respondents.

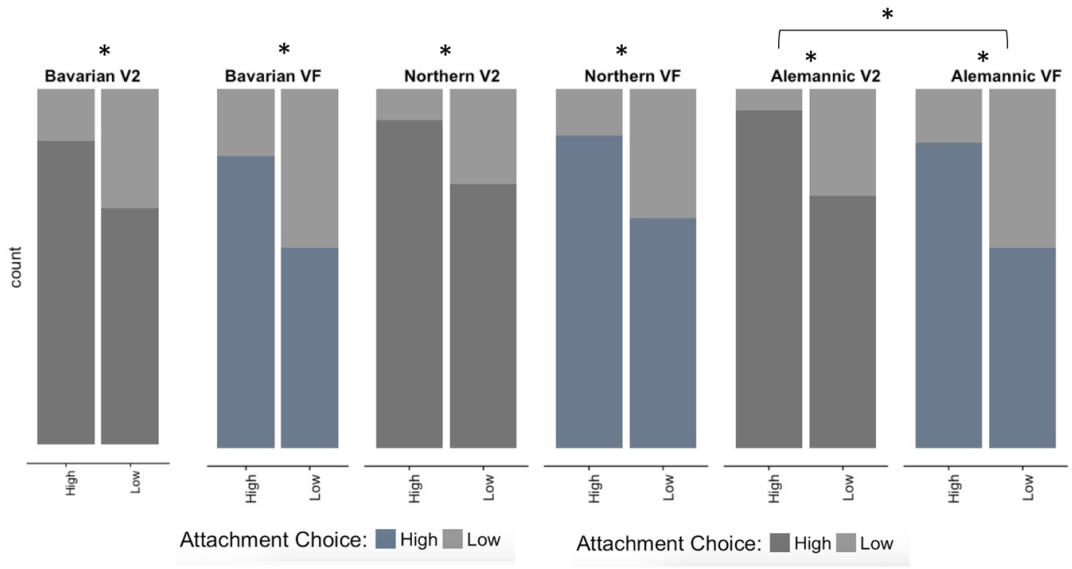


Figure 5. Dialect-determined attachment choice in V2- (grey) and verb -final clauses (blue). Stars in-between two columns of same sentence type and dialect symbolize a significant difference between sentences with varying attachment prosody A star in between different sentence types symbolize that attachment choice was significantly different between different syntactic structures.

4.1.3.4.2 Modeling

Attachment choice was modelled with a linear mixed effects regression model providing the best fit determined by AIC and ANOVA analyses. In the best fitting model (31), attachment choice was modelled with attachment-reading (as intended by the speaker of the sentence in the production task), sentence type, and dialect group were assumed as independent variables. Subject and item were random effects.

Because of the set-up of the experiment[29], an interaction between subject and item could not be assumed as random effect for fear of confounding the analysis.

(31)

Attachment Choice ~ Attachment Reading*Sentence Type* Dialect group+ (1 | Subject)+ (1|Item)

The model showed significant main effects of attachment reading (p-value: <0.0001) and dialect (p-value for Alemannic speakers: 0.011, p-value for Northern speakers: 0.001) but not sentence type (p-value: 0.217). Further, significant interactive effects between Low attachment and Alemannic speakers (p-value: 0.01) and verb-final sentences and Alemannic speakers (p-value: 0.029) were observed. The odds ratios of all fixed effects are presented in Figure 6.

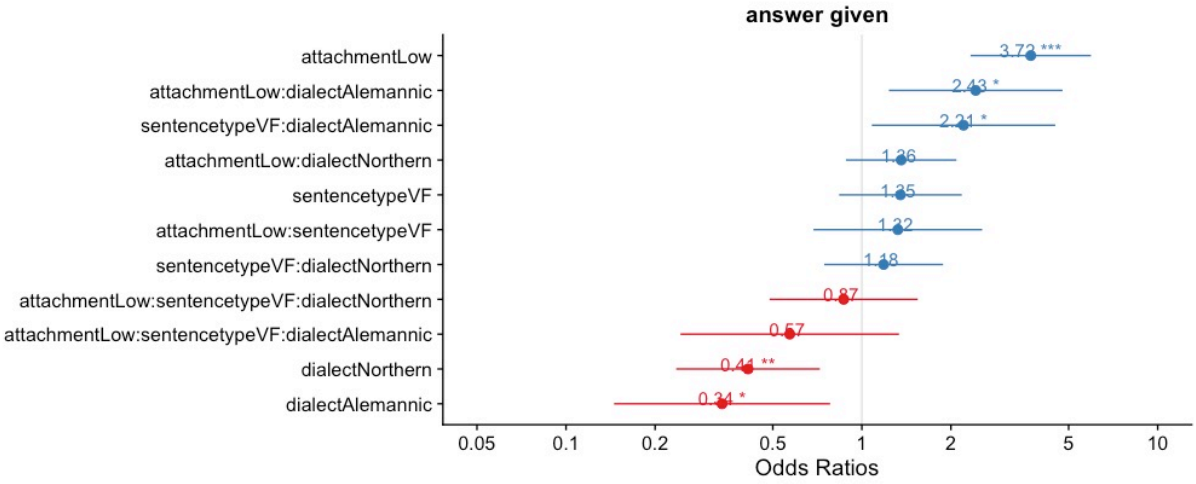


Figure 6. Fixed effects odds ratios of attachment choice. The intercept represents a default of a V2-sentence with high attachment prosody judged by Bavarian speakers.

In order to confirm that the observed effect of speaker intended attachment reading is significant for each dialect group and that the effect of clause type in the Alemannic group is a main effect and not an interaction with prosody, separate analyses were run for each dialect group (32).

(32)

Attachment Choice ~ Attachment Reading*Sentence Type + (1 |Subject) + (1|Item)

[29] No respondent answered all 96 questions. Instead, every contestant answered ¾ of the full set of questions.

Speaker-intended attachment reading was a main effect for all three subsets (p-values: <0.0001, <0.0001, and <0.0001 for Alemannic, Bavarian and Northern speakers respectively). For Alemannic speakers, clause type also significantly influenced attachment choice (p-value: 0.008), but no interaction between attachment reading and clause type was observed (p-value: 0.499).

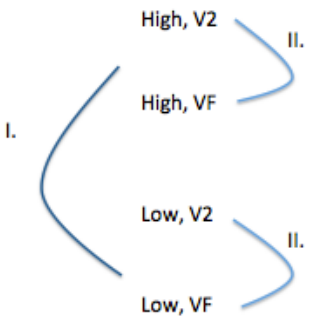


Figure 7. Visual representation of the chronological order of analysis of the independent variables attachment type (High, Low) and sentence type (V2, VF).

Based on the strong effect intended attachment reading had on the model output, it was decided to use contrast coding as part of the regression analysis to avoid that weaker effects of the remaining independent variables as well as interactive effects between the variables being masked by the strong effect intended attachment had on attachment choice (Davis 2010, Kaufman & Sweet 1974). As illustrated in Figure 7, the dataset was first analysed for the effect of intended attachment on attachment reference (I.). Then, the contrast between sentence type (and dialect group) was assessed for the two subgroups "high attachment" and "low attachment" (II.) separately. Contrast coding revealed that attachment choice did not significantly differ in sentences with an intended high attachment (p-value: 0.32327). In sentences that were recorded with an intended low attachment interpretation, on the other hand, the difference in sentence type significantly influenced attachment choice (p-value: <0.0001).

Table 9. illustrates the estimated likelihood of attachment choice dependent on sentence type, attachment reading and dialect group. It shows that in V2 sentences, almost all sentences with a high attachment reading are identified as such by Alemannic speakers (94.2 percent) followed by speakers of Northern (91.3 per cent) and Bavarian dialects (85.3 per cent). V2-sentences with low attachment readings will be misinterpreted as having high attachment 73. 5 per cent of the time by speakers of Northern dialects, 70.4 per cent of the time by Alemannic respondents and 66.5 per cent of the time by Bavarians. The estimated likelihood for high attachment sentences

being perceived as possessing high attachment is lower in verb-final sentences while the likelihood of sentences with low attachment prosody being identified as having low attachment rises. The likelihood that a verb-final sentence with high attachment will be perceived as such was estimated to be 87.1 per cent for Northern respondents, 85 per cent for Alemannic respondent, and 81.4 per cent for Bavarian respondents. Conversely, the likelihood of respondents choosing a low attachment interpretation for a sentence with a low attachment reading lay at 44.93 (100-55.7) per cent for Bavarian speakers, 44.2 per cent for respondents with Alemannic dialects and 35.9 per cent for Northern respondents.

Table 9. Estimated likelihood of sentences being perceived as having a high attachment reading dependent on sentence type, intended attachment, and membership to a certain dialect group. A score of one indicates that respondents selected a high attachment reading in 100 per cent of cases; a score of zero indicates that respondents selected a low attachment reading in 100 per cent of cases.

	Bavarian	**Alemannic**	**Northern**
V2-High	0.853	0.942	0.913
V2-Low	0.665	0.704	0.735
VF-High	0.814	0.850	0.871
VF-Low	0.557	0.558	0.641

4.1.3.5 Semantic Analysis

Despite the *post-hoc* comments of some of the respondents, semantic plausibility was not actively a significant determiner of attachment choice. A regression analysis taking attachment choice as dependent variable, semantic bias as independent variable and respondent identity as random effect, showed that compared to the sentence group without bias, neither sentences with a bias for high attachment (p-value: 0.3082) nor sentences with a bias for low attachment (0.6035) produced significantly different estimates (Figure 9).

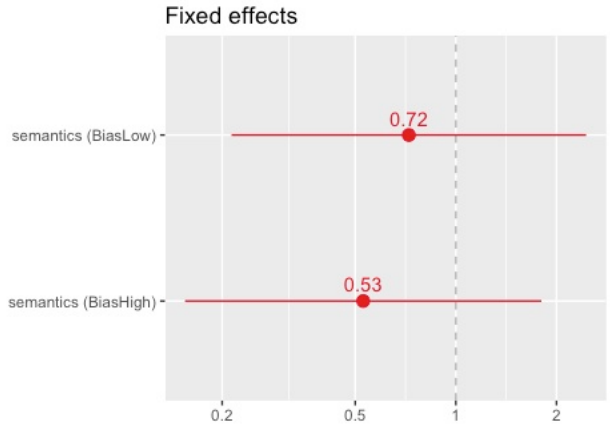


Figure 9. Fixed effects odds ratios of attachment choice of low attachment bias (top) and high attachment bias (bottom) compared to no bias (intercept).

4.1.4 Discussion

Experiment 2 arrived at three main conclusions. I) There exists an overall preference for high attachment that is not caused by syntactic structure or syntactic plausibility. II) Listeners are able to employ prosodic cues to modify their attachment choice. III) Intended attachment reading had an effect on speakers of all dialects, but speakers of Alemannic varieties of German were also affected by sentence structure when making attachment choices. The following section will investigate these three findings and their implications in greater detail.

4.1.4.1 High Attachment Preference

An overall preference for high attachment was observed (see Figure 5 or Table 9). This preference was present in both verb-second and verb-final sentences where parsing strategies relying on syntactic structure—Frazier's *Minimal Attachment* and *Late Closure* or Konieczny et al. 1997 's *Parametrized Head Attachment*—would have predicted a preference for attachment to the NP instead. The findings corroborate those of Zschernitz (2011) who found a similar preference for high attachment that transcended variations in clause type. The experiment provided no evidence that syntactic structure is a decisive factor in the disambiguation of prepositional phrase attachment.

An explanation for this bias that is not swayed by a verb-second to verb-final contrast would be that German attachment preference is lexically driven. Storing a default attachment reading in the lexicon greatly reduces processing time in language perception and would therefore be beneficial in streamlining understanding (Yang 2016).

German has been described as a language preferring high attachment when it comes to the resolution of globally ambiguous relative clause attachment of type (5) Hemforth et al. 2000). Previous research on attachment preferences of the attachment preference of German prepositional phrases introduced by *mit* have yielded contradictory results. Volk (2003) used an online corpus to show that the 66 most common German prepositions preferably attach to a noun rather than a verb (low attachment). A study solely concerned with the perception of globally ambiguous *imperative+ object+ prepositions phrase* -sentences[30] in which the prepositional phrase is started with *mit,* on the other hand, found that a strong bias for high attachment existed in German native speakers (Zschernitz 2011), consistent with the present study.

The discovery of an age effect on attachment choice consistent throughout all three dialect groups is therefore intriguing. Ryskin et al. (2017) found that the interpretation of ambiguous prepositional phrases headed with *with* in English was influenced by newly acquired verb biases such as syntactic plausibility. Likewise, a priming effect of previous encountered syntactic structures has been previously established (Thothathiri & Snedeker 2008). While semantic plausibility biases (used to modify verb attachment preferences in Ryskin et al. (2017)) were not a significant effect in this experiment, the insight that the learning of biases is a life-long and on-going process suggests that cumulative priming might occur. Should the distribution of examples that inform selection bias be skewed, repeated input could strengthen these effects and get stronger as one ages. In order to check for a distributional skew in Austrian German, a middle grade novel written in colloquial Viennese—Das Austauschkind by Christine Nöstlinger (1992)—was scanned for prepositional

[30] E.g. *Berühre den Adler mit der Socke!* - Touch the eagle with the sock!

phrases introduced by the preposition *mit.* Out of 144 occurrences, the prepositional phrase attached to the VP in 123 cases (85.42 per cent). The prepositional phrase attached to the NP in only 21 (14.58 per cent) of the sentences found in the book. An alternative, though premature conclusion, given the scope and principal objective of the study, would be to consider the seemingly reduced strength of the high attachment bias in young people as sign of an on-going language change in which lexical preference weightings are being renegotiated. This, however, cannot easily be confirmed in lieu of intensive testing with an age-graded German corpus.

The facts presented provide accumulating evidence that attachment choice is lexically driven. The differences between the findings of Volk (2003) on the attachment preference of the 66 most common German prepositions and of Zschernitz (2011) and this study on prepositional phrases headed with *mit* (with) show that the parameter can't be language-global. Instead, preferences appear to be very fine-grained, perhaps specific to each preposition.

4.1.4.2 Sensitivity to Prosodic Modulation

Linear regression analysis showed that respondents of all dialect groups were sensitive to prosodic manipulation both in main and in subordinate clauses. Although both clause types differentiated between attachment using a variety of cues (Table 3 and Table 4), the consistent effect of attachment prosody regardless of sentence type makes it necessary that the cue driving disambiguation is produced in both instances. The only cue to differ significantly between high and low attachment readings regardless of clause type in experiment 1 was simultaneously the strongest: the length of the pause between direct object and prepositional phrase. Analysis in experiment 1 showed that this cue was produced reliably and offered a highly significant differentiation (p-value: <0.0001)

Given the reliability and highly significant difference with which this constituent is produced, its relative weakness in affecting attachment choice might be surprising. While the main effect between attachment choice and attachment prosody was highly significant in all combinations, and a low attachment prosody caused a higher proportion of respondents to categorize sentences as possessing low

attachment, the preference for high attachment persisted. Respondents misidentified low attachment sentence as having high attachment in 55 to 73 per cent of cases (Table 9). That means, they consistently did worse than if sentences had been assigned attachment interpretations by chance.

The imperfect implication of prosodic disambiguation proves that cues are not employed categorically, but rather as a relative measure. As discussed above, high attachment seems to be lexically driven and the preference for it dominates both semantic plausibility and prosodic cues. Out of these two, prosody doubtlessly possesses a stronger relative weight and is used implicitly to modulate high attachment preference.

4.1.4.3 Effect of dialect

All dialect groups were able to pick up on prosodic cues—most probably the strongest (*i. e.* the length of the pause between direct object and prepositional phrase)—to guide attachment choice. This cross-dialectal uniformity when faced with a strong prosodic cue is to be expected as it enables communication and understanding between inhabitants of various areas with a common language. A fact important for pluricentric languages with a large geographic spread or high dialectal variability.

The speaker in the experiment came from an area in Austria belonging to the Bavarian dialect region. Even in a set-up where test sentences had been produced in Standard (Austrian) German expected to be understood throughout the German speaking world and not in dialect, the sentences still carried instances of the phonology and intonation typical to speakers of Bavarian dialects[31]. Nonetheless, the salient cue for a modulation of attachment choice to respondents was reliably conveyed to respondents regardless of their country of origin or membership in a dialect group. Comments received from respondents show that instances where lexical word-choice (*Schlecker* for lollipop) or grammatical gender (*der Socken* instead of *die*

[31] e.g. a lack of a voiced alveolar fricatives [z] in the consonant inventory

Socke) did not conform with the local standard version of the language or dialect were experienced as much more disruptive and jolting as any prosodic variation.

The working hypothesis devising this part of the experiment had been that respondents with dialects more closely related to the one of the speaker would be able to pick up on subtler prosodic cues. They were expected to better be able to assign attachment interpretations matching the prosodically conveyed intended reading than respondents from other dialect groups especially in the more complex embedded sentences. This hypothesis was not supported by the data. While attachment choice of Almannic (p-value: 0.011) and Northern respondents (p-value: 0.001) varied significantly from that of Bavarians, a significant influence of sentence type on attachment choice was only observed for respondents from the Alemannic group. The interaction is not likely to be caused by prosody because analysis revealed that no interaction between attachment prosody and clause type was observed (p-value: 0.499). Dialectal differences furthermore resulted in relationships more complex than one group consistently outperforming the others. Because these effects were not specifically tested for, the experiment offers no explanation for the observed variation. All attempts of interpretation are therefore purely speculative.

4.1.4.3.1 Overall Strength of High Attachment Preference

Speakers of Bavarian dialects exhibited an altogether lower baseline than speakers of Alemannic and Northern dialects. Recalling Table 9, Bavarian speakers were, for example, only predicted to identify 85.3 per cent of high-attached V2-sentences as such compared to 94.2 for Alemannic speakers and 91.3 per cent of Northern speakers. This lower tendency to interpret sentence as being high attached was consistent. Regardless of sentence type or attachment prosody, Bavarians always had the least likelihood to choose a high attachment reading and the highest likelihood to choose a low attachment reading for a sentence. Speakers of Northern dialects, on the other hand, showed an altogether strong preference for high attachment. In three out of four possible sentence type-attachment prosody combinations, Northern speaker were most likely to interpret a sentence as having high attachment. The overall likelihood that a sentence would be interpreted as being attached high was

highest for Northerners and lay 6.78 per cent points over that of speakers of Bavarian and 2.65 per cent over that of speakers of Alemannic dialects. Because the attachment choice of Alemannic speakers varied strongly depending on clause type, estimating an overall attachment preference was harder, but seemed to lie somewhere in between that of Bavarian and Northern dialects. The reason for these differing baselines when it comes to attachment choice are unknown but might be caused by a dialect-group specific difference in strength of the lexically-driven high attachment bias for *mit*.

4.1.4.3.2 Sensitivity of Attachment Choice to Sentence-type Alterations

Speakers of the Alemannic dialects proved to be most significantly influenced by the effects of sentence type in their attachment choice. Table 9 shows that the likelihood of a sentence receiving a high attachment interpretation from Alemannic respondents dropped from 94.2 to 85 per cent for high attached sentences and from 70.4 to 55.8 per cent for low attached sentences when the sentence type changed from verb-second to verb-final. The change of clause type thus caused a drop in high attachment acceptability of 10.5 percentage points (p-value:0.00855) compared to a 7.35 per cent drop in Bavarian (p-value: 0.178) and a 6.8 per cent drop in Northern speakers (p.value: 0.076).

What would cause speakers of Alemannic dialects to be most affected by clause type when making attachment decisions? As discussed above, this change in attachment preference is not driven by prosody and Alemannic people are not, counterintuitively, better equipped to interpret and utilize the prosodic cues that Bavarian speakers produce when they try to disambiguate prepositional phrase attachment.

Two alternative explanations come to mind. Of all dialect groups, the Alemannic one is that with the least—that is 20—respondents. Data diagnostics run before analysis commenced showed that the group size was sufficient to be included in the study[32]. Still, the observed effect might be spurious and caused because outliers

[32] A condition not met by the groups of respondents from region with a language other than German as majority language (4 accepted respondents) which was excluded from models in which dialect group was a dependent variable.

receive relatively more weight in smaller samples than in larger samples. If this theory were true, the clause effect on Alemannic speakers would be mitigated in a follow-up experiment that evenly balances the number of respondents from each dialect group.

Alternatively, the effect is not spurious. Alemannic speakers respond to the syntactic differences—but not categorically so. Rather, a low attachment preference driven by syntactic information (e.g. *Minimal Attachment* and *Late Closure*) is used to tone down the effect of the lexical high attachment bias. Processing a subordinate, German clause is more complex than processing a main clause, because the parsing mechanism has to wait longer for the verb. Other than in instances in which closure can result in grammatically sound structures, the parser knows to keep the sentence at least partially open until the required verb is pronounced. This requires more processing power and larger junks of data stored in the working memory, especially if syntactic structure has to be taken into account when making attachment decisions. Listeners familiar with a dialect[33] might choose to process quickly, relying on the lexically driven default. Listeners less familiar with a dialect, on the other hand, might be slowed down in their online processing sufficiently long for the syntactically effect of clause type to apply. If this is the case, a follow-up experiment using non-standardized dialectal utterances would potentially slow down the speech processing of all other dialect groups and increase their sensitivity to a clause effect.

[33] Alemannic speakers were mostly recruited from the German Baden-Württemberg (17 out of 20). Speakers there are exposed to Alemannic through the surrounding and to Northern German dialects through national German media. Exposure to Bavarian dialects is expected to be lowest.

5 Concluding Remarks and Path into the Future

This study sought to gain insight on the question as to what drives ambiguity resolution in German. Rivalling theories about the main driver of prepositional phrase attachment choices exist, the most common being that syntactic structure, context or intonation drive disambiguation.

In Experiment 1, a trained, informed speaker reliably produced sentences with distinct prosodies when asked to differentiate between high and low attachment, thus establishing the possibility for a *prosody-first* approach to sentence parsing. While various prosodic cues differentiated attachment type in either verb-second or verb-final sentences, only the strongest—pause length between the direct object and the preposition phrase—was significant in both contexts making it the most probable salient cue for disambiguation. The prosodic structure derived from the experimental sentences fit into established theories of syntax to prosody-mapping but the data underdetermined choice of theoretical analysis.
Further research should focus on increasing the amount of material available for phonetic analysis by recording, both, more sentences of one speaker and by varying speakers. A larger stock of usable sentence would provide the prosodic strength for pitch contour analysis that was lacking this time.

Experiment 2 manipulated the syntactic structure and attachment prosody of globally ambiguous sentences. Context was only manipulated in terms of the sentence internal context (semantic plausibility) with which verbs and nouns were paired, but not in terms of pragmatics. Semantic plausibility did not affect attachment choice. While a prosodic effect on attachment choice was observed, it was swamped by a lexically driven bias for high attachment that might be traced back to the language specific distributional frequency of high versus low attachment. Research into the overall attachment preferences of German prepositions and prepositional phrases specifically introduced by *mit* yield conflicting results. This raises the question as to whether there is a general syntactic parsing strategy or whether lexical bias is more fine-grained and determined on a proposition-to-preposition or preposition class-to-preposition class basis.

Further research should therefore strive to increase the variety of prepositions used to introduce the prepositional phrases of sentences globally ambiguous for PP-attachment. It would also be interesting to see whether this parsing strategy is specific to German. An account where prosody or syntax fine-tune a lexically given bias specified for preposition identity might shed light on inconsistencies in the literature when language specific attachment preferences are reported. Attachment preference could be specific to the preposition used and not a language wide phenomenon. In the light of this, a cross linguistic study should aim to establish a baseline attachment preference of different languages for ambiguously attached PPs introduced by a variety of different prepositions.

Contrary to expectation, experiment 2 also showed that familiarity with a dialect's intonation does not result in a heightened ability to correctly identify the intended attachment of an audio stimulus. Instead, unfamiliarity with the cues of a specific dialect might slow down online processing of complex sentences just enough to allow for the effect of syntactic structure to become influential. Alternatively, the parser might default to judgements derived from syntactic structure instead of relying on subtle, and unfamiliar, prosodic cues in the absence of clearly marked differentiations. The observed differences dialect had on attachment choice were significant, but, at the same time, complex and unexpected.
More research in this area is needed. While the study showed a way in which dialect does not affect the disambiguation, it did not offer an explanation of how it does. In order to test the intuition that clause effect is related to the slowed processing of unfamiliar speech, experiments should be conducted that that don't only manipulate the origin of the respondents but also the origin of the speakers providing the auditory stimuli. Alternatively, using non-standardized dialectal utterances would potentially slow down the speech processing of the other dialect groups even further and increase their sensitivity to a clause effect.

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7 Appendices

7.1 Appendix I

Experimental sentences. Experiment 1 made use of sentence types 1-4. Experiment 2 used sentence types 1-4 to analyze attachment preference; sentence types 5-6 as fillers and as quality control to uphold a satisfactory level of respondent engagement and knowledge of German grammar.

Every verb-direct object-prepositional phrase combination is presented in the following 6 ways:

1: simple sentence, VP-attachment intended, ambiguous
2: simple sentence, NP-attachment intended, ambiguous
3: embedded sentence, VP-attachment intended, ambiguous
4: embedded sentence, NP-attachment intended, ambiguous
5: fronted PP, VP-attachment, unambiguous
6: passivized, NP-attachment, unambiguous

A: verjagen-Adler-Socken /chase away-eagle-sock

A1: Er **verjagt** den Adler **mit dem Socken.**
A2: Er verjagt **den Adler mit dem Socken**.
A3: Ich sehe, dass er den Adler **mit dem Socken verjagt.**
A4: Ich sehe, dass er **den Adler mit dem Socken** verjagt.
A5: Mit dem Socken verjagt er den Adler.
A6: Der Adler mit dem Socken wird von ihm verjagt.

B: berühren-Igel-Apfel /touch-hedgehog-apple

B1: Er **berührt** den Igel **mit dem Apfel.**
B2: Er berührt **den Igel mit dem Apfel.**
B3: Ich sehe, dass er den Igel **mit dem Apfel berüht**.
B4: Ich sehe, dass er **den Igel mit dem Apfel** berüht.
B5: Mit dem Apfel berührt er den Igel.

B6: Der Igel mit dem Apfel wird von ihm berührt.

C: attackieren-Esel-Stock /attack-donkey-stick

C1: Er **attackiert** den Esel **mit dem Stock**.

C2: Er attackiert **den Esel mit dem Stock**.

C3: Ich sehe, dass er den Esel **mit dem Stock attackiert**.

C4: Ich sehe, dass er **den Esel mit dem Stock** attackiert.

C5: Mit dem Stock attackiert er den Esel.

C6: Der Esel mit dem Stock wird von ihm attackiert.

D: grüßen-Löwe-Blume /greet-lion-flower

D1: Er **grüßt** den Löwen **mit der Blume.**

D2: Er grüßt **den Löwen mit der Blume**.

D3: Ich sehe, dass er den Löwen **mit der Blume grüßt.**

D4: Ich sehe, dass er **den Löwen mit der Blume** grüßt.

D5: Mit der Blume grüßt er den Löwen.

D6: Der Löwe mit der Blume wird von ihm gegrüßt.

E: verjagen-Möwe-Handy /chase away-seagull-mobile phone

E1: Er **verjagt** die Möwe **mit dem Handy**.

E2: Er verjagt **die Möwe mit dem Handy**.

E3: Ich sehe, dass er die Möwe **mit dem Handy verjagt.**

E4: Ich sehe, dass er **die Möwe mit dem Handy** verjagt.

E5: Mit dem Handy verjagt er die Möwe.

E6: Die Möwe mit dem Handy wird von ihm verjagt.

F: berühren-Fautier-Brille /touch-sloth-glasses

5: Er **berührt** das Faultier **mit der Brille**.

6: Er berührt **das Faultier mit der Brille**.

F3: Ich sehe, dass er das Faultier **mit der Brille berührt**.

F4: Ich sehe, dass er **das Faultier mit der Brille** berührt.

F5: Mit der Brille berührt er das Faultier.

F6: Das Faultier mit der Brille wird von ihm berührt.

G: attackieren-Biber-Knochen /attack-beaver-bone

G1: Er **attackiert** den Biber **mit dem Knochen**.

G2: Er attackiert **den Biber mit dem Knochen**.

G3: Ich sehe, dass er den Biber **mit dem Knochen attackiert**.

G4: Ich sehe, dass er **den Biber mit dem Knochen** attackiert.

G5: Mit dem Knochen attackiert er den Biber.

G6: Der Biber mit dem Knochen wird von ihm attackiert.

H: grüßen-Tiger-Schlecker /greets-tiger-lollipop

H1: Er **grüßt** den Tiger **mit dem Schlecker.**

H2: Er grüßt **den Tiger mit dem Schlecker.**

H3: Ich sehe, dass er den Tiger **mit dem Schlecker grüßt.**

H4: Ich sehe, dass er **den Tiger mit dem Schlecker** grüßt.

H5: Mit dem Schlecker grüßt er den Tiger.

H6: Der Tiger mit dem Schlecker wird von ihm gegrüßt.

I: verjagen-Kamel-Pfeife /chase away-camel-pipe

I1: Er **verjagt** das Kamel **mit der Pfeife.**

I2: Er verjagt **das Kamel mit der Pfeife.**

I3: Ich sehe, dass er das Kamel **mit der Pfeife verjagt**.

I4: Ich sehe, dass er **das Kamel mit der Pfeife** verjagt.

I5: Mit der Pfeife verjagt er das Kamel.

I6: Das Kamel mit der Pfeife wird von ihm verjagt.

J: berühren-Bär-Fisch /touch-bear-fish

J1: Er **berührt** den Bären **mit dem Fisch**.

J2: Er berührt **den Bären mit dem Fisch**.

J3: Ich sehe, dass er den Bären **mit dem Fisch berührt**.

J4: Ich sehe, dass er **den Bären mit dem Fisch** berührt.

J5: Mit dem Fisch berührt er den Bären.

J6: Der Bär mit dem Fisch wird von ihm berührt.

K: attackieren-Ziege-Koffer /attack-goat-suitcase

K1: Er **attackiert** die Ziege **mit dem Koffer.**

K2: Er attackiert **die Ziege mit dem Koffer.**

K3: Ich sehe, dass er die Ziege **mit dem Koffer attackiert**.

K4: Ich sehe, dass er **die Ziege mit dem Koffer** attackiert.

K5: Mit dem Koffer attackiert er die Ziege

K6: Die Ziege mit dem Koffer wird von ihm attackiert.

L: grüßen-Eber-Buch /greet-male boar-book

L1: Er **grüßt** den Eber **mit dem Buch.**

L2: Er grüßt **den Eber mit dem Buch**.

L3: Ich sehe, dass er den Eber **mit dem Buch grüßt.**

L4: Ich sehe, dass er **den Eber mit dem Buch** grüßt.

L5: Mit dem Buch grüßt er den Eber.

L6: Der Eber mit dem Buch wird von ihm gegrüßt.

M: verjagen-Biene-Tasche /chase away-bee-purse

M1: Er **verjagt** die Biene **mit der Tasche.**

M2: Er verjagt **die Biene mit der Tasche**.

M3: Ich sehe, dass er die Biene **mit der Tasche verjagt.**

M4: Ich sehe, dass er **die Biene mit der Tasche** verjagt.

M5: Mit der Tasche verjagt er die Biene.

M6: Die Biene mit der Tasche wird von ihm verjagt.

N: berühren-Schlange-Föte /touch-snake-flute

N1: Er **berührt** die Schlange **mit der Flöte**.

N2: Er berührt **die Schlange mit der Flöte.**

N3: Ich sehe, dass er die Schlange **mit der Flöte berührt**.

N4: Ich sehe, dass er **die Schlange mit der Flöte** berührt.

N5: Mit der Flöte berührt er die Schlange.

N6: Die Schlange mit der Föte wird von ihm berührt.

O: attackieren-Zebra-Puppe /attack-zebra-doll

O1: Er **attackiert** das Zebra **mit der Puppe**.

O2: Er attackiert **das Zebra mit der Puppe**.

O3: Ich sehe, dass er das Zebra **mit der Puppe attackiert**.

O4: Ich sehe, dass er **das Zebra mit der Puppe** attackiert.

O5: Mit der Puppe attackiert er das Zebra.

O6: Das Zebra mit der Puppe wird von ihm attackiert.

P: grüßen-Amsel-Flasche /greet-blackbird-bottle

P1: Er **grüßt** die Amsel **mit der Flasche**.

P2: Er grüßt **die Amsel mit der Flasche**.

P3: Ich sehe, dass er die Amsel **mit der Flasche grüßt.**

P4: Ich sehe, dass er **die Amsel mit der Flasche** grüßt.

P5: Mit der Flasche grüßt er die Amsel.

P6: Die Amsel mit der Flasche wird von ihm gegrüßt.

7.2 Appendix II

Output of regression model used to analyze data in experiment 2.

```
Generalized linear mixed model fit by maximum likelihood (Laplace Approximation)
['glmerMod']
 Family: binomial  ( logit )
Formula: answer ~ attachment * sentencetype * dialect + (1 | ID) + (1 |question)
   Data: subset(newdata1, dialect != "other")

     AIC      BIC   logLik deviance df.resid
  6958.2   7055.3  -3465.1   6930.2     7618

Scaled residuals:
    Min      1Q  Median      3Q     Max
-8.9571 -0.2438  0.2804  0.5056  3.4978

Random effects:
 Groups   Name        Variance Std.Dev.
 ID       (Intercept) 1.4986   1.2242
 question (Intercept) 0.3404   0.5835
Number of obs: 7632, groups:  ID, 159; question, 64

 Fixed effects:
                                                Estimate Error      z          Pr(>|z|)
                                                Std.                value
 (Intercept)                                    2.2213   0.2196     10.115     < 2e-16    ***
 attachmentLow                                  -1.3148  0.2392     -5.497     3.86e-08   ***
 sentencetypeVF                                 -0.3004  0.2437     -1.233     0.21765
 dialectNorthern                                0.8852   0.2852     3.104      0.00191    **
 dialectAlemannic                               1.0872   0.4292     2.533      0.01131    *
 attachmentLow:sentencetypeVF                   -0.2798  0.3352     -0.835     0.40372
 attachmentLow:dialectNorthern                  -0.3053  0.2194     -1.391     0.16409
 attachmentLow:dialectAlemannic                 -0.8854  0.3449     -2.567     0.01024    *
 sentencetypeVF:dialectNorthern                 -0.1689  0.2361     -0.715     0.47435
 sentencetypeVF:dialectAlemannic                -0.7910  0.3646     -2.170     0.03003    *
 attachmentLow:sentencetypeVF:dialectNorthern   0.1407   0.2943     0.478      0.63266
 attachmentLow:sentencetypeVF:dialectAlemannic  0.5609   0.4343     1.292      0.19651
 ---
 Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1


Correlation of Fixed Effects:
            (Intr) attchL sntnVF dlctNr dlctAl atL:VF attL:N attL:A snVF:N snVF:A aL:VF:N
attachmntLw -0.584
sentnctypVF -0.567  0.520
dilctNrthrn -0.417  0.129  0.125
dilctAlmnnc -0.278  0.086  0.083  0.218
attchmnL:VF  0.410 -0.710 -0.727 -0.090 -0.059
attchmntL:N  0.184 -0.270 -0.163 -0.518 -0.098  0.190
attchmntL:A  0.116 -0.171 -0.103 -0.094 -0.608  0.121  0.193
sntnctyVF:N  0.168 -0.154 -0.279 -0.469 -0.089  0.203  0.607  0.110
```

sntnctyVF:A	0.108	-0.099	-0.179	-0.087	-0.567	0.130	0.112	0.704	0.192	
attchL:VF:N	-0.133	0.199	0.224	0.368	0.070	-0.268	-0.734	-0.141	-0.801	-0.154
attchL:VF:A	-0.089	0.134	0.150	0.072	0.470	-0.181	-0.151	-0.785	-0.161	-0.838	0.211