What does prosody tell us about relative clause attachments in German?

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Abstract

The aim of this paper is threefold: (i) to examine the prosodic means that German speakers use when they intend high and low attachment interpretations in NP1-$NP2_{GEN}$ R(elative)-C(lause) constructions, (ii) to investigate the prosodic means employed by speakers when confronted with ambiguous NP1-$NP2_{GEN}$RC constructions and iii) to test the predictions made by the Implicit Prosody Hypothesis. For this purpose, a production experiment was carried out. The results show that speakers do not realize a pause between NP1 and NP2, while they do make a pause between NP2 and RC. The NP2-RC pause is longer in forced low attachment condition (the RC unambiguously modifies NP2) than in forced high attachment condition (the RC unambiguously modifies NP1).

Index Terms: prosody, relative clauses, German

1. Introduction

It is a well known fact that languages differ in their attachment preferences in constructions where a relative clause modifies either of the two nominal heads of a complex noun phrase (NP1-of/$_{GEN}$-NP2-RC). For instance, in the classic example, '*Someone shot the servant of the actress who was on the balcony*', the RC *who was on the balcony* is globally ambiguous and can modify either the first NP (*the servant*) or the second NP (*the actress*); languages differ with respect to their attachment preferences. In particular, it is argued that speakers of Arabic, English and Norwegian prefer low attachment (the RC modifies the second NP) while speakers of German, Spanish and Japanese prefer high attachment (the RC modifies NP1). (See [5] and [12] for a detailed overview).

Aiming at accounting for this cross-linguistic difference in attachment preference Fodor claims that this difference is due to prosodic differences across languages, and she states the Implicit Prosody Hypothesis (IPH) [7], [8]. According to the IPH, in silent reading, a default prosodic contour is projected onto the sentence and influences syntactic ambiguity resolution. Implicit- and overt-prosody are assumed to be the same. Moreover, IPH assumes that a prosodic boundary after NP1 is in accordance with a low attachment interpretation, (in this case NP2 is easier chunked together with the RC), while a prosodic boundary after NP2 favours a high attachment interpretation (the idea being that the boundary after NP2 blocks or makes the low attachment interpretation preferred less). Examining data from Croatian, Lovric *et al* [12] report that listeners interpret a prosodic break between NP2 and RC (the order being NP1-NP2 RC) as a strong syntactic boundary that triggers high attachment interpretation.

As German has been described as a high attachment preference language, IPH predicts that there will be a long prosodic break between NP2 and RC, reflecting a high attachment interpretation and that this break will be longer than any break between the two noun phrases.

Our study has three goals, namely, i) to scrutinize the prosodic means that are employed by German speakers to mark high and low attachment interpretations in NP1-$NP2_{GEN}$-RC constructions, ii) to investigate the prosodic means that German speakers use when confronted with an ambiguous construction with respect to the attachment interpretation. With respect to the prosodic means, following Gollrad and Kügler [9] who investigated the prosodic realization of complex NPs in Nominative-Dative\Nominative-Genitive ambiguities, we will examine the duration of the two NPs, the pause duration and the F0 scaling, as [9] found that speakers of German use these means to disambiguate Nominative Dative\Nominative- Genitive ambiguities. iii) to test the aforementioned prediction of the IPH by comparing the ambiguous constructions with forced High and forced Low interpretations.

This paper presents the results of a production experiment, examining the prosodic realization of complex nouns (NP1 $NP2_{GEN}$) followed by a relative clause in 3 attachment conditions; i) forced High Attachment (the relative clause modifies unambiguously NP1), ii) forced Low Attachment (the relative clause modifies unambiguously NP2) and iii) Ambiguous Attachment (the relative clause can modify NP1 or NP2) in German. In this study, the length of the two NPs as well as the length of the relative clause was kept constant.

2. Method

2.1. Speech materials

The length of the noun phrases was kept constant (disyllabic NPs were chosen). Both NPs were of the same gender (neuter) to ensure a local ambiguity, and the second NP appeared in Genitive case. Only inanimate noun phrases were used (for an effect of animacy on attachment see [3] among others). Direct object relative clauses were constructed. In this sense, the head of the relative clause (*e.g. das* 'that/which') did not reveal any information about the attachment. In the forced High Attachment or in the forced Low Attachment condition, the disambiguation only came in the end of the relative clause. In these conditions, the verb of the relative clause unambiguously modified NP1 or NP2.

Given the claims in the literature that the length of the relative clause has an effect on the attachment of relative clauses (see for instance [4] for English and [11] for Japanese) and given the aim of our study, we decided to keep the length of the RC constant. The RC consisted of 3 syntactic units, containing the head of the relative clause, the subject of the RC and the verb of the RC. An example of a sentence in all 3 attachment conditions is given in (1). In (1b-c) bold indicates the NP that is modified by the RC. (1a) is ambiguous.

(1) a. Nino filmte das Segel des Bootes das der Maler holte
'Nino filmed the sail of the boat that the painter got.'
b. Nino filmte **das Segel** des Bootes das der Maler raffte
'Nino filmed the sail of the boat that the painter shortened.'
c. Nino filmte das Segel **des Bootes** das der Maler taufte

'Nino filmed the sail of the boat that the painter baptized.'

To ensure that the sentences intended to be ambiguous (cf. (1a)) are really ambiguous, a small-scale sentence completion experiment was carried out (10 participants). All sentences given in (1) were rephrased as in (2), and subjects were asked to select an object for sentence completion, either NP1 (i) or NP2 (ii). To avoid any ordering effects, in half of the stimuli NP1 was presented as (i) and in the other half NP1 was presented as (ii), as in (2b).

(2) a. Der Maler holte (i) das Segel (ii) das Boot
b. Der Maler raffte (i) das Boot (ii) das Segel
c. Der Maler taufte (i) das Segel (ii) das Boot

A total of 12 sentences (4 main clauses × 3 attachment conditions) were constructed. Special attention was given to the segmental composition of the material; trochees were used. All 12 sentences were presented to each speaker in a pseudo-randomized manner; 36 sentences from an unrelated experiment were used as fillers. Two pseudo-randomized lists were prepared to avoid any ordering effects.

2.2. Recording procedures

A self-paced stimulus presentation was used. Utterances were directly recorded via a head-mounted close taking microphone (Shure SM10A) on computer disk using Audacity Software in a quiet room. Participants were instructed to speak out the sentence displayed on the screen.

2.3. Participants

6 native speakers of Standard German spoken in the Berlin region participated in the experiment. All speakers were female. Each speaker was reimbursed for participation and took approximately 20 minutes to complete the experiment.

2.4. Analysis

The productions of all 6 participants were analyzed. This resulted in a total of 72 utterances. The recordings were digitized at a sampling frequency of 44.1 kHz 16 bit resolution. The data were labeled by hand at the segment level, using Praat [2] and following conventional segmentation guidelines [14]. Furthermore, the presence of a pause between the first- and second NP (P) as well as the presence of a pause between the second NP and the head of the relative clause (P1) was marked. Clause inspection of the oscillogram and the spectrogram enabled us to decide on the exact length of the pause. The duration of NP1, NP2, P and P1 was extracted using a Praat script and saved in a database for off-line statistical analysis. The data were analyzed with paired-t-tests and GLM Repeated Measures. SPSS was used for this purpose.

The second author transcribed the tones of each utterance. The presence of pitch accent and the type of accent were transcribed on S, NP1 and NP2. In the majority of cases, the accent chosen by speakers was L*H as is the most common realization of a prenuclear accent in German [6].

Based on the results of the transcription, we decided to closely examine the excursion of the rising pitch accent associated with NP1 and NP2. So, we obtained two frequency measuring points in NP1 and NP2, the minimum and maximum F0 on NP1 (*das Segel* in (1)), and NP2 (*des Bootes* in (1)) reflecting the L* accent and H trailing tone. The data were saved in a database for off-line statistical analysis. Having the maximum- and minimum F0 in NP1 and NP2, the excursion of pitch rise in NP1 and NP2 was calculated subtracting F0 minimum from F0 maximum. The data were analyzed with GLM Repeated Measures. To be able to compare the ambiguous condition with the other two conditions, we established the difference Δ (generally defined as ambiguous – forced high). In particular, we calculated the following differences Δ: Δ_{dNP1}, Δ_{dNP2}, Δ_{RNP1}, Δ_{RNP2} and Δ_{P1}.

3. Results

We first present the results of the sentence completion experiment, then we present the phonological representation of the two noun phrases, and finally we present the prosodic means that were used by speakers, following the ordering of the goals as stated in the introduction.

In the sentence completion experiment, the crucial cases were the ones that would be used in the ambiguous condition. The 4 ambiguous cases that were tested are given in (3).

(3) a. Der Maler holte (i) das Segel (ii) das Boot (S1)
b. Der Sammler brachte (i) das Sofa (ii) das Kissen (S2)
c. Der Fahrer putzte (i) das Kabel (ii) das Auto (S3)
d. Der Neffe kannte (i) das Fahrrad (ii) das Foto (S4)

Examples (3a) and (3b) functioned as expected; 5 out of 10 participants chose (i) as a continuation, while the other 5 chose (ii) as a continuation. For example (3c), all participants chose das Auto 'the car' as a complement of the verb, while for example (4d), 9 out of 10 participants reported that they wanted to continue the sentence with das Fahrrad 'the bike'. The results show that in (3c) and (3d) the overtly ambiguous sentence (structure as in (1)) appears to be unambiguous on the semantic level. However, the semantically preferred reading forces the RC to attach low, i.e. to NP2, which goes against the general principle of high attachment reported for German [1], [7], [10]. We therefore decided to include in the experiment (3c) and (3d), as this would give us more insight with respect to our second goal.

3.1. Phonological representation

In general, the subject (S) of the main clause (*Nino* in example 1) was realized with a L*H accent fully in line with German intonation (*e.g.* [6]). The only exception is speaker 5 who uttered the subject in sentence 4 with a H* accent in all 3 attachment conditions. The first NP (NP1) was generally realized with a L*H accent. However, in a number of cases speakers chose a different strategy. In particular, a H*L accent was used by speakers 1 and 5, when uttering S2 in the ambiguous attachment condition. Moreover, accent H* was used by speakers 1, and 2, when uttering S2 in forced-high attachment condition. Speaker 1 also used H* in S4 in the same condition. Furthermore, a H* accent was used by speaker 2, in S2 and S4, in ambiguous attachment condition. The same speaker used also a H* in S2, in forced-low attachment condition. Finally, speaker 3 used a H* accent in S2, in all 3 attachment conditions. The second NP (NP2) was generally realized with a L*H accent. There was a single exception; speaker 1 employed a !H*L accent when uttering S2, in forced-high attachment condition.

A difference in accent pattern indicates a difference in phrasing [6], which in turn may affect the attachment interpretation. Thus, a H* on NP1 indicates that NP1 is phrased together with NP2. Prosodically, this corresponds to a high attachment interpretation with no pause between the two

NPs [8]. Conversely, a H*L on NP1 indicates that NP1 is phrased separately, and thus signaling low attachment.

3.2. High vs. Low Attachment

Duration. Table 1 presents the mean NP1 and NP2 duration (in seconds) for the 2 attachment conditions broken down by sentence. As shown in table 1, in all sentences, the duration of NP1 in forced High attachment condition (the RC unambiguously modifies NP1) is longer than the duration of NP1 in forced Low attachment condition (the RC unambiguously modifies NP2). For sentence 1 (S1), according to GLM Repeated Measures Anova, the difference is statistically significant ($F_{1,1}$= 7.487, p=0.041, η^2_{partial}=0.600). The difference is not statistically significant for sentences 2, 3 and 4. As indicated in table 1, in S1, S2 and S4, NP2 in forced High attachment condition is longer than NP2 in forced Low attachment condition. The opposite holds for S3. However, the differences are not statistically significant.

Table 1. Mean NP1-NP2 duration (in seconds) with SD in parentheses for 2 attachment conditions, broken by sentence (n=48).

Sent.	NP1		NP2	
	Forced High	Forced Low	Forced High	Forced Low
S1	0.521 (0.032)	0.481 (0.038)	0.696 (0.034)	0.678 (0.080)
S2	0.567 (0.045)	0.556 (0.059)	0.698 (0.067)	0.690 (0.053)
S3	0.573 (0.048)	0.554 (0.058)	0.684 (0.070)	0.710 (0.080)
S4	0.537 (0.037)	0.497 (0.032)	0.779 (0.126)	0.731 (0.068)

Pause duration. Among the 72 utterances, only once a P (pause between NP1 and NP2) was realized. Table 2 presents the mean P1 duration (pause between NP2 and RC) for the 2 attachment conditions. As shown in table 2, P1 in forced Low attachment condition (the RC unambiguously modifies NP2) is longer than P1 in forced High attachment condition (the RC unambiguously modifies NP1). This difference is statistically significant according to paired t-test (p=0.038).

Table 2. Mean P1 duration (in seconds) for 2 attachment conditions with SD in parentheses (n=48).

Attachment	Forced High	Forced Low
	0.062 (0.029)	0.087 (0.060)

F0 scaling. Table 3 presents the mean pitch rise (measured in Hz) in NP1 for the 2 attachment conditions, broken down by sentence. As indicated in table 3, the mean NP1 pitch rise in forced High attachment condition is generally larger than the mean NP1 pitch rise in forced Low attachment condition (the only exception being S2). However, according to GLM Repeated-Measures Anova, the difference is not statistically significant. As indicated in table 3, the mean NP2 pitch rise in forced Low attachment condition is larger than the mean NP2 pitch rise in forced High attachment condition in sentences 1 and 3, while the opposite holds for sentences 2 and 4. However, according to GLM Repeated-Measures Anova, the differences are not statistically significant.

Table 3. Mean pitch rise in NP1-NP2 (in Hz) for 2 attachment conditions broken by sentence with SD in parentheses (n=48).

Sent.	NP1		NP2	
	Forced High	Forced Low	Forced High	Forced Low
S1	63.5 (29.8)	43.8 (18.8)	94.8 (26.2)	96.0 (18.4)
S2	54.2 (19.5)	54.8 (12.1)	83.6 (31.0)	82.8 (27.9)
S3	50.0 (26.8)	38.0 (19.2)	106.1 (31.4)	110.0 (27.2)
S4	64.4 (48.2)	49.8 (33.8)	67.9 (33.5)	67.4 (37.5)

3.3. Ambiguous RCs

Duration. Table 4 presents the mean NP1 and NP2 duration (in seconds) for the ambiguous attachment condition and the differences Δ_{dNP1} and Δ_{dNP2} (defined as $\Delta_{dNP1}=NP1_{ambiguous}-NP1_{forced\ high}$ and $\Delta_{dNP2}=NP2_{ambiguous}-NP2_{forced\ high}$ respectively) broken by sentence. As shown in table 4, the duration of NP1 and NP2 in the ambiguous condition in S3 patterns with the forced high attachment condition (as their Δs equal 0). A similar observation holds for the mean duration of NP1 in S4, and the mean duration of NP2 in S1.

Table 4. Mean NP1-NP2 duration (in seconds) in ambiguous attachment condition and their Δs broken by sentence, SD in parentheses (n=24).

Sent.	NP1		NP2	
	Amb.	Δ_{dNP1}	Amb.	Δ_{dNP2}
S1	0.587 (0.071)	0.067 (0.064)	0.688 (0.059)	-0.008 (0.054)
S2	0.542 (0.044)	-0.026 (0.061)	0.669 (0.093)	-0.029 (0.075)
S3	0.573 (0.046)	0.000 (0.025)	0.681 (0.086)	-0.003 (0.123)
S4	0.537 (0.032)	0.000 (0.039)	0.811 (0.101)	0.032 (0.039)

Pause duration. Table 5 presents the mean P1 (pause between NP2 and RC) for the ambiguous attachment condition and the difference Δ_{P1} defined as $\Delta_{P1}=P1_{ambigous}-P1_{forced\ high}$.

Table 5. Mean P1 duration (in seconds) in ambiguous attachment condition broken by sentence (n=24).

Sent.	Ambiguous	Δ_{P1}
S1	0.064 (0.024)	0.005 (0.019)
S2	0.102 (0.128)	0.024 (0.126)
S3	0.102 (0.088)	0.045 (0.087)
S4	0.166 (0.179)	0.112 (0.117)

The mean P1 duration in ambiguous condition in sentence 1 patterns with the mean P1 duration in forced high attachment condition, as their difference equals to Δ_{P1}0.005.

F0 scaling. Table 6 presents the mean pitch rise (in Hz) in NP1 and NP2 for the ambiguous attachment condition and the

differences Δ_{RNP1} and Δ_{RNP2} (defined as Δ_{RNP1}=$NP1_{ambiguous}$–$NP1_{forced\ high}$ and Δ_{RNP2}=$NP2_{ambiguous}$–$NP2_{forced\ high}$ respectively). As shown in table 6, in general, the prosodic realization of the pitch rises in NP1 and NP2 in the ambiguous attachment condition differ from the prosodic realization of the pitch rises in the high and low attachment condition.

Table 6. Mean pitch rise in NP1-NP2 for the ambiguous attachment condition (in Hz) and the differences Δ broken by sentence (n=24).

Sent.	NP1		NP2	
	Amb.	Δ_{RNP1}	Amb.	Δ_{RNP2}
S1	83.2	19.7	93.2	-1.5
	(20.1)	(30.7)	(31.6)	(23.7)
S2	71.5	17.3	85.2	1.6
	(25.1)	(28.5)	(25.3)	(31.9)
S3	45.2	-4.8	118.5	12.4
	(28.7)	(23.9)	(30.4)	(17.6)
S4	60.3	-4.2	81.0	13.1
	(33.4)	(44.6)	(38.9)	(51.4)

4. Discussion

The first aim of this study was to examine the prosodic realization of forced high and forced low interpretations in NP1-$NP2_{GEN}$-RC constructions. Our results show that NP1 as well as NP2 are generally realized with a L*H accent, and that speakers did not realize a pause between NP1 and NP2. In both conditions, a pause was realized between NP2 and RC. This pause was longer in the forced low attachment condition. Moreover, the two conditions differed with respect to the mean duration of NP1. Specifically, the mean duration of NP1 was longer in forced high attachment condition. The mean NP1 pitch rise was found generally larger in forced high attachment condition than the mean NP1 pitch rise in forced low attachment condition.

Our second aim was to investigate the prosodic means that are employed by speakers when confronted with ambiguous constructions. In general, the results show that speakers appear to intensify their production of the prosodic cues investigated if compared to the figures for high attachment. Further, the ambiguous sentences of S3 and S4, which have been rated as forced low attachment rather than ambiguous in the completion experiment, seem to pattern with the figures for forced high attachment with respect to NP1 duration (table 1) and F0 rise (table 3). Given the rating in the completion task, this result seems rather surprising as we would have expected a prosodic pattern in direction of the figures for forced low attachment. On the other hand this strategy could be in line with the general tendency of German being classified as a high attachment preference language [1], [8], [10].

As regards our third aim, comparing our results to the predictions of the IPH, we may conclude that German employs different prosodic means to achieve the phrasing patterns that would be in line with the IPH. A prosodic boundary after NP1 would favour low attachment, and, in German, is realized by means of a higher F0 rise on NP1 and longer P1 duration before the RC. The higher F0 rise on NP1 clearly marks a boundary between the two NPs [8]. In this respect, German rather uses pitch scaling than pauses to indicate prosodic phrasing. However, the effect of pitch scaling has to be tested in speech perception to allow us to draw a conclusion whether this cue is sufficient to signal disambiguation.

Comparing the cues of high attachment sentences with the ones for low attachment, we observe no clear difference. The lack of prosodic marking for high attachment may be a consequence of German being classified as a high attachment preference language. Thus, if not explicitly marking low attachment by inserting a phrase break after NP1, RCs are interpreted as to attach high to NP1. This implication of the findings here has also to be tested perceptually in order to give a complete picture of which prosodic cues are successfully used to disambiguate the attachment ambiguity under investigation and in relation to the IPH.

5. Acknowledgements

The research presented here was funded by the Deutsche Forschungsgemeinschaft (DFG), through the project SPP-1234 on Prosody in Parsing at Potsdam University. Thanks to Franziska Reckling and Dinah Baer-Henney for assistance. Special thanks to our research group, Caroline Féry, Anja Gollrad, Gerrit Kentner and Shravan Vasishth for useful comments and suggestions.

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