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$_{GEN}$R(elative)-C(lause) 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 (P) between NP1 and NP2, while they do make a pause (P1) between NP2 and R(elative)-C(lause). P1 is longer in Forced Low attachment condition (the R(elative)-C(lause) unambiguously modifies NP2) than in Forced High attachment condition (the R(elative)-C(lause) unambiguously modifies NP1).

Index Terms: prosody, relative clauses, German

1. Introduction

Languages differ in their attachment preferences in constructions where a relative clause (RC) 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: 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 and iii) to test the IPH prediction 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 (ex.1a), ii) Forced Low Attachment (ex.1b) and iii) Ambiguous Attachment (ex.1c) in German. In (1a-b) bold indicates the NP that is modified by the RC.

(1) a. Nelle mochte **das Kissen** des Sofas das der Sammler füllte
'Nelle liked the cushion of the couch that the collector filled.'
b. Nelle mochte das Kissen **des Sofas** das der Sammler rückte
'Nelle liked the cushion of the couch that the collector moved.'
c. Nelle mochte das Kissen des Sofas das der Sammler brachte
'Nelle liked the cushion of the couch that the collector brought.'

In example (1a) the relative clause unambiguously modifies the first NP (Forced High), as *rückte* 'filled' can only be used with *Kissen* 'cushion', in (1b) the RC unambiguously modifies the second NP (Forced Low), as *rückte* 'moved' can only be used with *Sofa* 'couch', while in (1c) the RC can modify either the first or the second NP.

2. Method

2.1. Speech materials

The length of the noun phrases as well as their syllabic structure was kept constant (bi-syllable NPs and trochees were chosen). Only inanimate noun phrases were used (for an effect of animacy on attachment see [3] among others). Direct object relative clauses were constructed. 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. Both NPs were of the same gender (neuter) to ensure a local ambiguity and the second NP appeared in Genitive case. In this sense, the head of the relative clause (*e.g. das* 'that/which') did not reveal any information about the

attachment. The disambiguation only came in the end of the relative clause. In the Forced High Attachment or in the Forced Low Attachment condition the verb of the relative clause unambiguously modified NP1 or NP2.

To ensure that the sentences intended to be ambiguous (cf. (1c)) are really interpreted as 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 Sammler füllte (i) das Kissen (ii) das Sofa
the collector filled the cushion the couch
b. Der Sammler rückte (i) das Sofa (ii) das Kissen
the collector moved the couch the cushion
c. Der Sammler brachte (i) das Kissen (ii) das Sofa
the collector brought the cushion the couch

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 (age group 20-25) 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, 72 utterances in total. The recordings were digitized at a sampling frequency of 44.1kHz, 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. For deciding the length of the pause, we inspected the oscillogram and the spectrogram and took pauses that were longer than a mean closure phase of the alveolar stop. The duration of NP1, NP2, P and P1 was extracted using a Praat script; 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 starting at the subject (S) of the main clause (*Nelle* in example 1). 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.

Based on the results of the transcription, we decided to closely examine the excursion of the rising pitch associated with NP1 and NP2. So, we obtained two frequency measuring points, the minimum- and maximum F0, in NP1 and NP2, (NP1=*das Kissen* 'the cushion', NP2= *des Sofas* 'the couch' in (1)) reflecting the L* accent and the H trailing tone. Having $F0_{max}$ and $F0_{min}$ in NP1 and NP2, the excursion of pitch rise in NP1 and NP2 was calculated subtracting $F0_{min}$ from $F0_{max}$. We also examined the NP1-NP2 pitch reset (*id* the pitch range between NP1 and NP2) subtracting $F0_{min}$NP2 from $F0_{min}$NP1 and subtracting $F0_{max}$NP2 from $F0_{max}$NP1. To be able to compare the ambiguous condition with the other two conditions, we established the difference Δ (generally, defined Δ= 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 cases are given in (3), while their rephrased equivalents that were tested in the sentence completion experiment are given in (4).

(3) a. Nino filmte das Segel des Bootes das der Maler holte (S1)
'Nino filmed the sail of the boat that the painter got.'
b. Nelle mochte das Kissen des Sofas das der Sammler brachte (S2)
'Nelle liked the cushion of the couch that the collector brought.'
c. Moni holte das Kabel des Autos das der Fahrer putzte (S3)
'Moni got the cable of the car that the driver cleaned.'
d. Timo suchte das Foto des Fahrrads das der Neffe kannte (S4)
'Timo looked for the photo of the bike that the nephew knew.'

(4) a. Der Maler holte (i) das Segel (ii) das Boot (S1)
the painter got the sail the boat
b. Der Sammler brachte (i) das Kissen (ii) das Sofa (S2)
the collector brought the cushion the couch
c. Der Fahrer putzte (i) das Kabel (ii) das Auto (S3)
the driver cleaned the cable the car
d. Der Neffe kannte (i) das Fahrrad (ii) das Foto (S4)
the nephew knew the bike the photo

Examples (4a) and (4b) functioned as expected; 5 out of 10 participants chose (i) as a continuation, while the other 5 chose (ii) as a continuation. For example (4c), 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'. We decided to include in the experiment (4c) and (4d), 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 (*Nelle* in (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 S4 with a H* accent in all 3 attachment conditions. 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. 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 milliseconds) for the Forced High- and Forced Low attachment condition broken down by sentence. As shown in table 1, in all sentences, the duration of NP1 in Forced High attachment condition (Forced High= the RC unambiguously modifies NP1) is longer than the duration of NP1 in Forced Low attachment condition (Forced Low= the RC unambiguously modifies NP2). For sentence S1, this difference is statistically significant ($F_{1,1}$= 7.487, p=0.041, $\eta^2_{partial}$=0.600) according to GLM Repeated Measures Anova. The difference is not statistically significant for S2, S3 and S4. The duration of NP2 in Forced High attachment condition is generally longer than the duration of NP2 in Forced Low attachment condition, the only exception is S3, where the opposite holds. The differences are not statistically significant.

Table 1. *Mean NP1-NP2 duration (in milliseconds) with SD in parentheses for Forced High- and Forced Low attachment condition broken by sentence (n=48).*

S.	NP1		NP2	
	Forced High	Forced Low	Forced High	Forced Low
1	521(32)	481(38)	696(34)	678(80)
2	567(45)	556(59)	698(67)	690(53)
3	573(48)	554(58)	684(70)	710(80)
4	537(37)	497(32)	779(13)	731(68)

Pause duration. Among the 72 utterances, a pause P (P= pause between NP1 and NP2) was realized only once. Table 2 presents the mean P1 duration (P1= pause between NP2 and RC) for the Forced High- and Forced Low attachment condition, broken down by sentence.

Table 2. *Mean P1 duration (in milliseconds) with SD in parentheses for Forced High- and Forced Low attachment condition broken by sentence (n=48).*

S.	Forced High	Forced Low
1	59 (38)	111 (80)
2	78 (31)	92 (45)
3	57 (28)	69 (56)
4	54 (18)	79 (63)

P1 in Forced Low attachment condition (Forced Low= the RC unambiguously modifies NP2) is 26 milliseconds in average longer than P1 in Forced High attachment condition (Forced High= the RC unambiguously modifies NP1).

F0 scaling. Table 3 presents the mean pitch rise (in Hz) in NP1 for the Forced High- and Forced Low condition, broken down by sentence. 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). The mean NP2 pitch rise in Forced Low attachment condition is larger than the mean NP2 pitch rise in Forced High attachment condition in S1 and S3, while the opposite holds for S2 and S4. According to GLM, 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).*

S	NP1		NP2	
	Forced High	Forced Low	Forced High	Forced Low
1	63.5(29.8)	43.8(18.8)	94.8(26.2)	96.0(18.4)
2	54.2(19.5)	54.8(12.1)	83.6(31.0)	82.8(27.9)
3	50.0(26.8)	38.0(19.2)	106.1(31.4)	110.0(27.2)
4	64.4(48.2)	49.8(33.8)	67.9(33.5)	67.4 (37.5)

3.3. Ambiguous RCs

Duration. Table 5 presents the mean NP1 and NP2 duration (in milliseconds) for the ambiguous attachment condition and the differences Δ_{dNP1} and Δ_{dNP2} (Δ_{dNP1}= $NP1_{Amb}$–$NP1_{Forced\ High}$ and Δ_{dNP2}=$NP2_{Amb}$–$N21_{Forced\ High}$ respectively) broken by sentence. The duration of NP1 and NP2 in the ambiguous condition in S3 patterns with the Forced High Attachment condition (as their Δs equals 0). A similar observation holds for the mean duration of NP1 in S4 and NP2 in S1.

Table 5. *Mean NP1-NP2 duration (in milliseconds) in ambiguous attachment condition and their* Δs broken by sentence, SD in parentheses *(n=24).*

S	NP1		NP2	
	Amb.	Δ_{dNP1}	Amb.	Δ_{dNP2}
1	587 (71)	67 (64)	688 (59)	-8 (54)
2	542 (44)	-26 (61)	669 (93)	-29 (75)
3	573 (46)	0 (25)	681 (86)	-3 (123)
4	537 (32)	0 (39)	811 (101)	32 (39)

Pause duration. Table 6 presents the mean P1 (P1=pause between NP2 and RC) for the ambiguous attachment condition and the difference Δ_{P1} defined as Δ_{P1}=$P1_{Amb}$–$P1_{Forced\ High}$.

Table 6. *Mean P1 duration (in milliseconds) in ambiguous attachment condition and Δ_{P1} broken by sentence (n=24).*

S.	Amb.	Δ_{P1}
1	64 (24)	5 (19)
2	102 (128)	24 (126)
3	102 (88)	45 (87)
4	166 (179)	112 (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 7 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$_{Amb}$−NP1$_{Forced\ High}$ and Δ_{RNP2}=NP2$_{Amb}$−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 7. Mean pitch rise in NP1-NP2 for the ambiguous attachment condition (in Hz) and the differences Δ broken by sentence (n=24).

S	NP1		NP2	
	Amb.	Δ_{RNP1}	Amb.	Δ_{RNP2}
1	83.2(20.1)	19.7 (30.7)	93.2 (31.6)	-1.5 (23.7)
2	71.5(25.1)	17.3 (28.5)	85.2 (25.3)	1.6 (31.9)
3	45.2(28.7)	-4.8 (23.9)	118.5 (30.4)	12.4(17.6)
4	60.3(33.4)	-4.2 (44.6)	81.0 (38.9)	13.1(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 when compared to the figures for High attachment. Moreover, the ambiguous sentences S3 and S4, (recall that these sentences were 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. We would have expected a prosodic pattern in direction of the figures for Forced Low attachment. However, 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, German uses pitch scaling rather than pauses to indicate prosodic phrasing. In this respect, we may conclude that German employs different prosodic means than the ones predicted by the IPH to achieve the phrasing patterns. In particular, a prosodic boundary after NP1 would favour Low Attachment; in German, this 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]. However, it remains to be tested in speech perception whether the effect of pitch scaling is a sufficient key to signal disambiguation.

Comparing the cues for 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 there is no explicit marking for low attachment by the insertion of a phrase break after NP1, RCs are interpreted as attach high to NP1. This finding 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.

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6. References

[1] Augurykz, P. Attaching Relative Clauses in German. The Role of Implicit and Explicit Prosody in Sentence Processing. PhD Thesis, University of Leipzig, 2006.

[2] Boersma, P. and Weenink, D. Praat: doing phonetics by computer (Version 4.5), http://www.praat.org/, 2007.

[3] Desmet, T, Brysbaert, M. and De Baecke, C. "The correspondence between sentence production and corpus frequencies in modifier attachment" Quarterly Journal of Experimental Psychology, 55A, 879-896, 2002.

[4] Fernández, E. and Bradley, D. "Length effects in the attachment of relative clauses in English", poster presented at the 12th Annual CUNY Conference on Human Sentence Processing, New York, 1999.

[5] Fernández, E. Bilingual sentence processing: Relative clause attachment in English and Spanish, Ph.D CUNY, 2002.

[6] Féry, C. 1993. German Intonational Patterns. Tübingen: Niemeyer.

[7] Fodor, J.D. "Learning to Parse?", Journal of Psycholinguistic Research 27(2), 285-319, 1998.

[8] Fodor, J.D. "Prosodic Disambiguation in Silent Reading", Proceedings of the North East Linguistic Society 32, Amherst: 113-132, 2002.

[9] Gollrad, A. and Kügler, F. "Prosodic cue weighting: case ambiguity in German". Proceedings of Speech Prosody 2010, Chicago, 2010.

[10] Hemforth, B., Konieczny, L. and Scheepers, Ch. "Syntactic attachment and anaphor resolution: The two sides of relative clause attachment". In M.W. Crocker, M.J.. Pickering and C. Clifton (eds.), Architectures and mechanisms for language processing. Cambridge: Cambridge University Press, 259-281, 2000.

[11] Jun, S.-A. and Koike, C. "Default Prosody and RC Attachment in Japanese", Proceedings of the 13th Japanese-Korean Ling. Conference, CSLI, Stanford, 2003.

[12] Lovrić, N., Bradley, D., Fodor, J.D. "RC attachment in Croatian with and without preposition", Poster presented at the AMLaP Conference, Leiden, 2000.

[13] Miyamoto, E. Table listing experimental results of relative clause attachment preferences, available at http://etmc4rc.googlepages.com/table.html, 2001.

[14] Turk, A., Nakai, S., Sugahara, M. "Acoustic segment durations in prosodic research: A practical guide". In: Sudhoff, S., Lenertová, D., Meyer, R., Pappert, S., Augurzky, P., Mleinek, I., Richter, N., Schließer, J. (Eds.), Methods in empirical prosody research. Berlin: Mouton de Gruyter, 1–27, 2006.