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Prosody of Dual-focus in German: Interaction between Focus and Phrasing

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Abstract

This paper studies the prosodic realization of dual-focus in German, that is, two foci in a single sentence, with special consideration of the interaction between focus assignment and phrasing. In a production experiment, dual-focus was compared with its initial, final, and all-new counterparts in sentences with subject NPs and VPs of different lengths. The results showed that there were three different patterns of dual-focus realization: (1) The most frequent one was the *two-peak* pattern (57.8%), that is, a falling tone on both focused words and compressed and lowered pitch in-between; (2) the second most frequent was the *two-phrase* realization (23.5%), in which both foci were also realized as a falling tone, but in this case, a high boundary tone was inserted after the subject NP; (3) the least frequent pattern was the *hat-pattern* (18.7%), consisting of a rising tone on the first focus and a falling tone on the second one while the pitch in-between is kept as a high plateau. This was applied mostly in utterances containing a short subject NP. We interpret these results in terms of optional prosodic phrasing. A sentence with two foci can be realized in one or two intonation phrases, but in both cases, the focus is assigned within the prosodic domain derived from syntax. These results show that Culminativity, the principle requiring a one-to-one correspondence between prosodic domains and their heads, is violable in German. Two equally prominent pitch accents are allowed to co-exist in one intonation phrase. Finally, the metrical structure of dual-focus speaks for a recursive structure of German prosody.

Keywords

dual-focus, phrasing, intonation

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Introduction

The present article investigates the prosodic realization of dual-focus in German from both a phonetic and a phonological perspective. To the best of our knowledge, we are reporting on the first experiment on dual-focus for German. A sentence containing a dual-focus, or two foci, answers a sentence containing two questions, each introduced by a *wh*-phrase, for example, *Who bought a jacket for whom*? The answer contains two focused constituents in the same sentence: [*Mary*]$_F$ *bought a jacket for* [*John*]$_F$. Following a convention introduced by Jackendoff (1972), a subscripted F indicates focus and square brackets show the size of the focus. Small capitals indicate pitch accents.

The prosodic realization of single focus in German has been extensively studied. The general finding is that focus involves a main pitch accent on the focus exponent, and that this main accent comes together with both F0 raising and post-focal F0 compression (Baumann & Grice, 2006; Braun, 2006; Féry & Kügler, 2008; Grabe, 1998). Mainstream prosodic theory (Nespor & Vogel, 1986; Selkirk, 1995; Truckenbrodt, 1995) tightly connects the presence of a unique nuclear accent to a prosodic domain, and does not allow two nuclear accents in one and the same domain. Following Hyman (2006), we refer to this as "Culminativity." The Culminativity Principle can be formulated as in (1).[1]

(1) Culminativity Principle

A prosodic domain (prosodic word, prosodic phrase, and intonation phrase) has a unique head reflected as a metrical prominence. This head attracts the main accent in its domain.

In the case of a single focus, Culminativity is fulfilled. The question that arises here is how Culminativity copes with two foci in a single sentence when these two foci are expected to be located in an unique prosodic domain of the size of an intonation phrase. Can two equally prominent foci co-exist in one intonation phrase? If the answer to this question is positive, Culminativity is violated at the level of the intonation phrase (and is thus violable), whereas in the case of a negative answer, Culminativity is a hard rule and is inviolable, as generally assumed in the relevant literature, for example Jackendoff (1972), Truckenbrodt (1995), and Hyman (2006). These authors have assumed that if two foci have to co-exist in one intonational phrase, one is more prominent than the other, resulting in a sequence of a subordinated secondary accent and a primary nuclear accent. A secondary accent is felt to be less prominent than a primary accent. If this is the case, Culminativity is again fulfilled, as there is one prosodic head in the relevant domain: the primary nuclear accent.

The results of our study show that in a short sentence, two foci are indeed preferably realized as a secondary pitch accent followed by a nuclear accent. In this case, the accents associated with the two foci are not equally prominent, and Culminativity is fulfilled: the relevant intonation phrase has a single head. In long sentences, however, both foci carry primary nuclear accents that can be simultaneously present in the same intonation phrase. In this case, each of them is the head of its own prosodic phrase, but at the level of the intonation phrase, there are two equally prominent heads, in violation of the Culminativity Principle. Alternatively, each of the two foci forms its own intonation phrase. In the latter case, an optional boundary tone is inserted between the two foci (see Selkirk, 2011 for such a proposal for English), and Culminativity is fulfilled again. There is then one nuclear accent per intonation phrase. These results show that Culminativity is a violable principle in German.

Background literature and the research questions are presented in the remainder of Section 1. Sections 2 and 3 present the experiment and the results. Section 4 returns to the research questions of this study and provides elements of an answer in the discussion. Section 5 contains conclusions.

1.1 Prosodic Structure and Information Structure in German

German is an intonation language with lexical stress. It uses different pitch accents to express pragmatic contrasts and to signal syntactic boundaries (see Baumann & Grice, 2006; Braun, 2006; Büring, 1997; Féry, 2011; Grabe, 1998; Kügler, 2007; Truckenbrodt, 2002; among others). Following traditional views on the prosodic realization of German sentences, we assume that in a simple sentence uttered in an all-new context, the sentence is divided into prosodic constituents organized in a hierarchical way, as shown in (2) and (3) (see Hayes, 1990; Nespor & Vogel, 1986, Selkirk, 1984; for the prosodic hierarchy in West Germanic languages). The division of a sentence into prosodic constituents takes place according to the syntactic structure. In other words, we adhere to the *indirect reference hypothesis* of Inkelas and Zec (1990), which posits that phonological effects take place in prosodic domains. This means that phonology does not directly refer to syntax or semantics, but rather to prosodic domains that are the domains for the application of phonological rules and processes. The indirect reference hypothesis allows mismatches between prosodic constituents and their syntactic correspondents. Moreover, it also predicts that different syntactic constituents can be mapped onto specific prosodic domains. According to this model of intonation, each prosodic constituent is assumed to have a single head on the prosodic level immediately below (see Hayes, 1990; Nespor & Vogel, 1986; for this claim and (1) for the formulation of the Culminativity Principle).

Our analysis is based on a recursive model of prosodic structure in German. The prosodic structure in (2) is organized into different levels of prosodic domains, which are mapped onto the syntactic structure in the following way: a syntactic word roughly corresponds to a Prosodic Word (ω-word), a syntactic phrase corresponds to a Prosodic Phrase (Φ-phrase), and a clause corresponds to an Intonation Phrase (ι-phrase) (see also Ito & Mester, 2012). Selkirk (2011) proposed "Match Constraints" for this view of the mapping between syntax and prosody. Such a model implies recursivity of prosodic structure, because a syntactic phrase can be embedded in a larger syntactic phrase, and the same is true for prosodic constituents. It acknowledges, at the same time, the fact that prosody is simpler than syntax.

For an example of recursivity of prosodic structure, consider the sentence in (2). This is an all-new sentence answering a question such as *What happened?* Both the nominal phrase *eine Bürste* "a brush" and the larger verbal phrase *hat eine Bürste gekauft* "has bought a brush" form Φ-phrases, and the Φ-phrase of the nominal phrase (NP) is embedded into the Φ-phrase of the verbal phrase (VP). The result of embedding a Φ-phrase into a larger Φ-phrase is what is called recursivity of prosodic structure (see Ito & Mester, 2012; Selkirk, 2011; Truckenbrodt & Féry, 2015 among others). Function words like *der* "the", *hat* "has", and *eine* "a" may cliticize either at the level of the ω-word or at the level of the Φ-phrase, as shown in (2).[2]

(2)

(   ) ι-phrase

(   ) ((   )   ) Φ-phrase

(   ) (   )   (   )(   ) ω-word

Der italienische MAler hat eine BÜRste gekauft
the Italian painter has a brush bought
'The Italian painter bought a brush.'

A metrical structure expressing the relative prominence of the constituents is erected on the syntactic and prosodic constituents, marked as columns of × in (3). At the level of the ω-word, each content word has a lexical stress, which is penultimate in *Maler* "painter" and *Bürste* "brush", antepenultimate in *italienische* "Italian", and final in *gekauft* "bought".[3] Each Φ-phrase has a metrical head located on its most prominent ω-word, and the ι-phrase's head falls on the rightmost stressed Φ-phrase, fulfilling the Culminativity Principle. In (3), the object noun *Bürste* "brush" is the head of the ι-phrase, which is the head of the rightmost Φ-phrase by virtue of being the last argument of the verb (see Gussenhoven, 1992; and Selkirk, 1995, among others for this insight, and Féry, 2011, 2017, and Truckenbrodt, 1995 for German). The final verb is unaccented. The object carries the last pitch accent of the sentence. It is perceived to be more prominent than the other pitch accents of the sentence, and is called the nuclear accent (Chomsky & Halle, 1968; Jackendoff, 1972; Ladd, 2008). As a result of this structure, the relation between the prosodic domains and the metrical heads is isomorphic. Each prosodic domain has a metrical head, and each metrical head corresponds to exactly one prosodic domain (see Chomsky & Halle, 1968; Gussenhoven, 1992; Selkirk, 2011; Truckenbrodt, 1995). Since there is a metrical head in each prosodic constituent, Culminativity is achieved in (3).

(3) All-new

				×		ι-phrase
	×			×		Φ-phrase
×	×			×	×	ω-word
((Der italienische$_{\omega}$	Maler$_{\omega})_{\Phi}$	(hat	(eine	Bürste$_{\omega})_{\Phi}$	gekauft$_{\omega})_{\Phi})_{\iota}$	
the Italian	painter	has	a	brush	bought	

'The Italian painter bought a brush.'

In the case of a so-called narrow focus, when a single constituent is focused in the sentence, it is this constituent that carries the nuclear accent, the following ones being deaccented (Ladd, 1983) as a consequence of their status as given (Féry & Samek-Lodovici, 2006; Schwarzschild, 1999). Following Rooth (1992) and Krifka (2008), focus is defined in terms of a set of alternatives, as in (4). The Common Ground (CG) forms the background: new information is added to what is mutually known (or believed) to be shared by a speaker and an addressee, and this background information is continuously modified in communication (see Krifka, 2008; Stalnaker, 1974). Thus focus adds new information to the CG. In (5), *Maler* "painter" is the focus and the entire VP is given. "Givenness" is defined as the material already mentioned in the preceding question, see (6) (Baumann & Grice, 2006; Krifka, 2008), thus the material that does not introduce alternatives in the discourse. The subscript G in (5) indicates the given part of the sentence.

(4) **Focus** indicates the presence of alternatives that are relevant for the interpretation of linguistic expressions. It adds new information to the CG (Krifka, 2008).

(5) A: Who bought a brush?

B: [Der italienische MAler]$_{F}$ [hat eine Bürste gekauft.]$_{G}$

"The Italian PAINter bought a brush."

(6) **Givenness** indicates that the denotation of the given element is present in the CG.

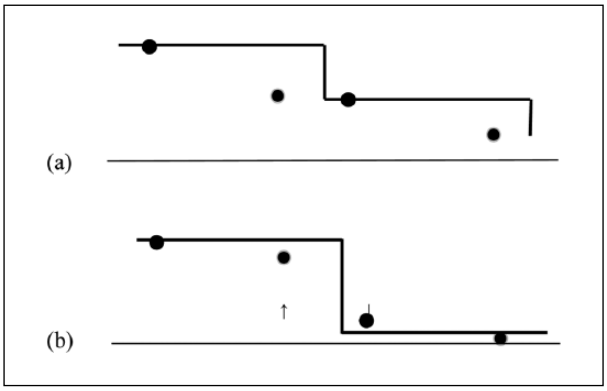

Figure 1. Schematic F0 register of an all-new sentence (a) and of a sentence with a narrow focus (b). The solid lines indicate the level of the pitch register, and the dots are the pitch accents.

The metrical structure of (5)B is presented in (7). We can see that (7) is different from (3), the same sentence in an all-new context. The metrical structure is different because of information structure. It is the focused element, or more exactly the stressed syllable of the focused word, that now carries the nuclear accent of the sentence, in our example *Maler* "painter." The general impression is that the given element is deaccented. Nevertheless, we follow Kügler and Féry (2017) in assuming that the prosodic and metrical structure of the given part of a sentence is preserved. In the post-nuclear domain, even if the register is extremely compressed, the prominence relations between the words in the given constituents are not always erased; see Figure 1 for illustration.

(7) Initial Focus

	×			ι-phrase
	×	×		Φ-phrase
×	×	×	×	ω-word

((Der italienische$_{\omega}$ MAler$_{\omega}$)$_{\Phi}$ (hat eine Bürste$_{\omega}$ gekauft$_{\omega}$)$_{\Phi}$)$_{\iota}$

"The Italian painter bought a brush."

In addition to the division of a sentence into a focused and a given part, there is also an optional partition into a topic and a comment. "Topic" is defined as in (8) (following Krifka, 2008) and exemplified in (9). In German, the global intonational contour of a short declarative sentence with a topic-comment structure usually forms what is called a *hat-pattern*, as initially proposed by Cohen and 't Hart (1967) for Dutch. A hat-pattern refers to a contour with an initial rise, a sustained (or slightly declining) high pitch, and a final fall on the nuclear accent. The metrical structure of (9) is presented in (10). We can see that (10) is actually the same as (3), the all-new condition.

(8) A **topic** is the referential element on which the remainder of a sentence makes a proposition (Krifka, 2008).

(9) A: What did you hear about the Italian painter?

B: [Der italienische MAler]$_T$ [hat eine BÜRste gekauft.]$_F$

"The Italian PAINter bought a BRUSH."

(10) Topic-Comment (hat-pattern)

		×		ι-phrase
	×	×		Φ-phrase
×	×	×	×	ω-word

((Der italienische$_\omega$ Maler$_\omega$)$_\Phi$ (hat eine Bürste$_\omega$ gekauft$_\omega$)$_\Phi$)$_\iota$

"The Italian painter bought a brush."

Let us turn briefly to the F0 relation between the pitch accents in an all-new and in a narrow focus configuration. The F0 register differences between Φ-phrases are illustrated schematically in Figure 1. The high thick staircase-like line is the top *reference line* corresponding to the highest F0 produced by a speaker in this particular sentence, and the thinner line at the very bottom is the speaker's lowest F0, the bottom line of the pitch range (Gussenhoven & Rietveld, 1992; Ladd, 2008; Pierrehumbert, 1980; Truckenbrodt, 2002). The dots stand for the higher tones in each ω-word: *italienische* "Italian," *Maler* "painter," *Bürste* "brush," and *gekauft* "bought." As illustrated in (3) and (7), this sentence is organized into two Φ-phrases. The top illustration (a) shows the realization of the high tones in an all-new sentence, as in (3). All accents are downstepped relative to each other, that is, a high tone is lower than a preceding high tone (see Ladd, 2008, and Truckenbrodt, 2004, for downstep). In addition, the two registers of the Φ-phrases are also in a downstep relation to each other. The bottom illustration (b) shows the scaling between the Φ-phrases and the pitch accents in the case of narrow focus on the subject, as in (7). The word *Maler* "painter" is higher than in the all-new context: it is upstepped to almost the same level as the high tone on the preceding word *italienische* "Italian." This is the well-known effect of F0 raising on the focus, as shown in many studies, for example, Baumann and Grice (2006), Grabe (1998), and Féry and Kügler (2008). Moreover, the second Φ-phrase is radically lower than the first one. As a result, the pitch accents following the narrow focus are realized in a compressed register. However in the post-focal region, the first dot is still higher than the second dot because of the downstepped relation of the constituents, albeit in a much compressed register (see Kügler & Féry, 2017). This is why the metrical grid in (7) preserves some prominence in the post-focal region.

In sum, it is widely agreed for Germanic languages that each prosodic constituent has a single head on the prosodic level immediately below. This view agrees with the Culminativity Principle formulated in (1), which requires exactly one metrical prominence per prosodic constituent. Many researchers assume that the formation of prosodic phrases is a necessary step for the assignment of accents (Chomsky & Halle, 1968; Féry, 2011; Hayes, 1990; Nespor & Vogel, 1986; Selkirk, 1984, 1995; Truckenbrodt, 1995; among many others). In sentences with narrow focus, the focused word carries the nuclear accent. As a result, the post-focal words are largely deaccented, even though the prosodic phrasing and metrical structure are preserved.[4]

1.2 Previous Studies of Dual-focus in Other Languages

A question which has not been asked so far and which the present article deals with is the following: What is the metrical structure of a sentence containing two foci, as in (11)?

(11) A: Who bought what?

B: [Der italienische MAler]$_F$ hat [eine BÜRste]$_F$ gekauft.

"The Italian PAINter bought a BRUSH."

Experimental studies on dual-focus are scarce. Eady, Cooper, Klouda, Mueller, and Lotts (1986) conducted the first production experiment for English. They studied sentences with dual-focus, that is, with both an initial and a final focus, and compared them with the same sentences in other conditions: with an initial-focus, a final-focus, and an all-new context. This is exactly what we did for German, but we also varied sentence length. Eady et al.'s results showed that the maximum F0 and word duration of both focused words were increased to relatively the same degree as in the corresponding single-focus conditions. Furthermore, both dual- and initial-focus conditions exhibited falling contours on focused words, and this differed from the final-focus and the all-new contexts, which had initial rising contours. The main difference between initial- and dual-focus was that post-focal F0 was significantly lowered after an initial focus. No such F0 lowering was found after the first focus in a dual-focus sentence. According to Eady et al. (1986), this suggests that the lack of post-focal F0 lowering in dual-focus sentences represents an anticipatory influence of the additional focus at the end of the sentence.

Liu (2010) also studied dual-focus realization in English, but in a more systematic way, by varying sentence length (short, long, and extra long) and sentence type (declarative sentences vs. yes/no questions) while comparing dual-focus realization (initial+medial, initial+final, and medial+final) with the single-focus realizations (initial, medial, and final). The results showed that dual-focus realization is consistent in sentences with different lengths. F0 raising and durational lengthening on the focused word were applied to both single and dual-focus. In declarative sentences, the lack of post-focus lowering after the first focus always held, independently of the distance between the two foci and the location of the two foci. On the basis of this result, Liu claimed that the lack of post-focus lowering could not be explained by the time limitation between the two foci in short sentences.

Dual-focus realization has also been studied in Mandarin Chinese, a tone language. Jia, Li, and Xiong (2010) and Wang and Féry (2015) obtained results comparable with those for English: the two foci were realized with F0 raising and duration lengthening. They also found that post-focus lowering after the first focus was lacking in the dual-focus condition, and this held both in the short and in the long sentences. Wang and Féry (2015) further found that no additional prosodic boundary was inserted after the first focus in the dual-focus cases. They argued that focus assignment does not change the way prosodic phrases are formed in dual-focus sentences. This is consistent with the findings of Wang, Xu and Ding (2018) that single-focus realization is independent of phrasal marking, that is, that a single focus does not necessarily create a prosodic boundary after the focus (see also Chen, 2004).

Kabagema-Bilan, López-Jiménez and Truckenbrodt (2011), however, found for Mandarin Chinese that when there was just one syllable between the two foci, only the second focus showed F0 raising and post-focus F0 lowering, while the first focus did not show much variation in either F0 or duration. Due to the different materials and recording procedures used in these three studies, it is hard to spot the source of the conflicting results. It may be that the realization of dual-focus is not restricted to just one pattern, but that it depends on the length of the utterance; see below for such a result for German.

The realization of dual-focus can also be partly explained by studies that have tested the prominence of sentences with two pitch accents perceptually. It has been found for several Germanic languages that when two accents are perceived as equally prominent, the peak height of the second one is downstepped relative to the first one (Gussenhoven & Rietveld, 1988; Pierrehumbert, 1979; Repp, Rump, & Terken, 1993; Rietveld & Gussenhoven, 1985; Terken, 1991, 1993). Rump and Collier (1996) also studied the relative heights of two pitch peaks in Dutch. They found that to make two foci be perceived as equally prominent in a sentence, F0 had to be adjusted to a larger degree for the first focus than for the second one. In other words, the first focus had a larger F0

value than its all-new counterpart, but the second focus did not differ from the all-new condition. These results were further confirmed in their perception experiment. The listeners were able to detect the second focus even when the F0 in the second focus was raised only slightly.

What we can learn from these studies is that dual-focus intonation amounts to more than just putting together two single foci. The upcoming focus has an influence on how the first focus is realized, especially in the post-focus region. Previous studies have not studied the phrasing strategy, an aspect that we add in the present paper. All studies so far have assumed that the two foci were realized in one intonational phrase. None of them has systematically varied the length of the first prosodic constituent. They have not gone into questions such as whether a prosodic boundary could be inserted between the two foci. However, a long initial-focused constituent may give rise to a phrase boundary, thus changing the prosodic and tonal relationship between the two foci. A short first focus constituent, on the other hand, may give rise to a more integrated intonation contour. The current study investigates these questions for German.

1.3 Research Questions

The three main research questions, presented together with our hypothesis, concerning the prosodic realization of dual-focus in German are as follows:

(I) How does F0 vary in a sentence containing two foci? Since a focus is associated with a single prominence in its domain (see Section 1.1), we expect that each focus has its own prominence. A first sub-question (I-a) concerns the relation between the two foci: is the second one always the most prominent and the first one subordinate in accordance with the Culminativity Principle and the default position of the nuclear accent, or are they equivalent in prominence, in violation of the Culminativity Principle? A second sub-question (I-b) concerns the post-focus domain of the first focus, which is the bridging part between the two foci. There are alternative solutions: either the post-focus region remains intact, or the F0 can be more or less compressed.

(II) Is the phrasing of a sentence with dual-focus affected? Speakers confronted with dual-focus sentences need to make a decision: (II-a) Are the two foci realized in one ι-phrase or does each focus need its own ι-phrase? There might be different options for realizing dual-focus. (II-b) The length of each focused constituent may affect the choice. Specifically, we expect that when the first focused constituent is long, a prosodic boundary is more likely to be inserted after the first focus, leading to a comparable degree of prominence on both foci. When the first constituent is short and the second is long, we expect to have fewer occurrences of a boundary tone between the two foci. Furthermore, when both focused constituents are short, the two foci are more likely to be realized in one ι-phrase. In this case, due to the short distance between the two foci, they may be realized with different degrees of prominence.

(III) To what degree is duration used in cases where two foci are involved? As for duration, previous studies of focus in German have shown consistent durational lengthening of the focused word (Baumann & Grice, 2006; Féry & Kügler, 2008). As mentioned in Section 1.2, the studies of English and Mandarin dual-focus also show an increase in duration in both focused words. On the basis of these findings, we expect to find longer duration for both foci in dual-focus sentences in German as well.

2 Methods

In this study, focus was elicited by means of a question-and-answer paradigm. Dual-focus was compared with its single-focus and all-new counterparts. To study the interaction between focus assignment and phrasing, the lengths of the subject NP and the VP were systematically varied.

Table 1. Number of syllables in each version of the sentences.

Version	Total	Subject NP	VP	Syllables between the two foci
A (short+short)	6	3	3	2
B (short+long)	12/13	3	9/10	5/6
C (long+short)	12/13	8	4/5	5/6
D (long+long)	17/18	8	9/10	9

2.1 Reading Materials

Five sets of sentences were constructed in which the subject NP and the VP varied in length. Four possible combinations were obtained: short+short, short+long, long+short, and long+long (respectively called the A, B, C, and D versions). The two foci were assigned to the subject noun (or the adjective in the longer NP) and to the object noun. A sample set of experimental sentences appears in (12), and see Appendix I for all reading material. The brackets indicate the NP and the VP. In these sentences, small capital letters indicate stressed syllables in the focused words. The underlined syllables are the three target syllables for the phonetic analysis (see Section 3.2). Version A is the shortest sentence with six syllables, three in the subject NP and three in the VP, two of which are the object NP. The two foci are separated by two syllables. Versions B and C are sentences of medial length with 12 to 13 syllables. The distance between the two foci is 5 to 6 syllables in both cases. The difference between versions B and C is the length of the subject NP and the length of the VP, while the number of syllables between the two foci is kept identical, as is the sentence length. Version D is the longest sentence with 17 syllables, with 9 syllables between the two foci. Table 1 gives an overview of the number of syllables in each version. By comparing the different versions, we can test whether the length of the subject NP and the length of the VP affect the choice of prosodic pattern in the case of dual-focus realization.

(12) One set of experimental sentences

A. [Der LEHrer] [lobt MAli]
the teacher praises Mali
"The teacher praises Mali."

B. [Der LEHrer] [hat heute Morgen MAli gelobt]
the teacher has today morning Mali praised
"The teacher praised Mali this morning."

C. [Der BrasiLIAnische Lehrer] [hat MAli gelobt]
the Brazilian teacher has Mali praised
"The Brazilian teacher praised Mali."

D. [Der BrasiLIAnische Lehrer] [hat heute Morgen MAli gelobt]
the Brazilian teacher has today morning Mali praised
"The Brazilian teacher praised Mali this morning."

For each sentence, the *wh*-questions elicited four focus conditions: dual-focus (DF), initial focus (IF), final focus (FF), and the all-new condition (AN). In (13) some examples are given for version C. The distance between the two foci and the overall sentence length were identical in versions B and C while the length of the subject NP varied, so that any difference in the realization of these two versions is bound to be due to the length of the subject. To test this effect, the focus on the subject NP was placed on the noun in versions A and B, and on the adjective in versions C and D. The final focus fell on the object in all versions. Except for the focused word, all words were given by virtue of their being mentioned in the preceding questions. In the all-new version, there was no given word: no part of the answer was mentioned in the question.[5]

Altogether, there were 5(sets) × 4(lengths) × 4(focus patterns) × 2(repetitions) = 160 sentences for each speaker.

(13) Background questions

Dual-focus:

Welcher von deinen Lehrern hat was gelobt?

"Which of your teachers praised what?"

Initial focus:

Welcher von deinen Lehrern hat Mali gelobt?

"Which of your teachers praised Mali?"

Final focus:

Was hat der brasilianische Lehrer gelobt?

"What did the Brazilian teacher praise?"

All-new:

Was war los?

"What happened?"

2.2 Speakers and Recording Procedure

Six female native speakers of Standard German were recruited at the University of Frankfurt. They reported no hearing or speech impairments.

The experimenter, a female German native speaker, tested the speakers. She asked the questions individually to each speaker, and the speaker uttered the target sentences accordingly.[6] Each speaker produced two repetitions with different random orders of the sentences. The recording took about an hour. The speakers were recorded at a sampling rate of 22.05 kHz with a 16-bit resolution in a soundproof booth and with a head-mounted Shure microphone.

2.3 Acoustic Measurement

The individual target sentences were extracted and saved as separate sound files. F0 and durational measurements were made using the acoustic speech analysis software Praat (Boersma & Weenink, 2013) with the script ProsodyPro (Xu, 2013). To extract continuous F0 contours, the vocal cycles were first calculated by Praat and then hand-checked for errors such as double-marking or pitch

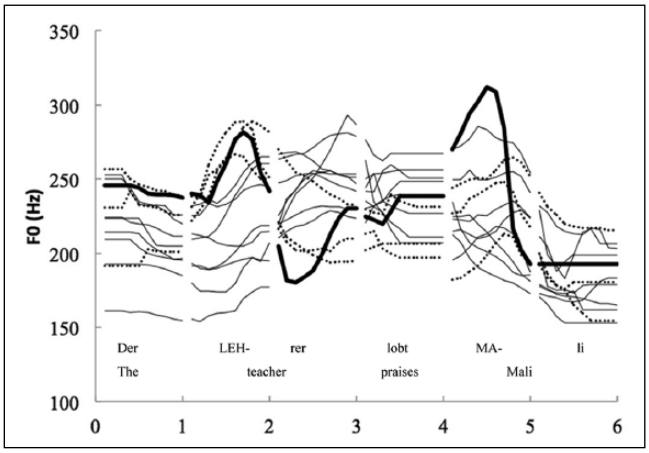

Figure 2. Intonational contours of one dual-focus sentence in version A uttered by six speakers with two repetitions each. The thin solid lines show the realization of the hat-pattern, the dotted lines are for the two-peak pattern, and the thick solid line shows the two-phrase pattern. The numbers on the *x* axis refer to syllable boundaries.

period skipping. While checking for spurious vocal pulse markings, segmentation labels were also added to mark the syllable boundaries. The duration of F0 periods was converted into F0 values automatically by ProsodyPro. The vocal pulse marking, segment labels, and F0 values were saved in separate text files for each utterance. In the next step, ProsodyPro (Xu, 2013) calculated the highest and lowest F0 values as well as the duration of each syllable. For the graphical display of the intonational contours, the F0 values were smoothed using a trimming algorithm (Xu, 1999). The F0 values in Hz were converted to semitones (st) according to the equation: $st = 12 \log_2(F0)$ using 1 Hz as the reference for all the speakers. Ten out of 240 dual-focus sentences (4.1%) were not uttered fluently and were not included in the analysis.

3 Results

3.1 Intonational Contours

First, we notice that dual-focus sentences could be realized in three different ways. Taking the A sentence in (12)A (short subject NP and short VP) as an example, Figure 2 presents the intonational contours of the dual-focus sentences uttered by six speakers with two repetitions each. We can see that the difference lies mainly in whether the contour of the first focus is falling, rising, or falling-rising, that is, a falling contour with a high boundary tone at the offset of the subject noun. The second focus is invariably realized as a falling contour and mostly as a downstepping movement to the first focus, except for in the two-phrase realization. The three patterns are presented schematically in Figure 3. The *two-peak pattern* has a falling contour on both foci while the middle part is lowered and compressed. The *two-phrase pattern* has a falling contour on both foci, but a high boundary tone is inserted after the first focus, leaving the connection between the two foci on a relatively high level. In these two cases, the first focus element has a falling pattern. The low region immediately after the pitch accent of the first focus can be analyzed as the boundary tone of a prosodic phrase, as proposed by Féry (2011), for instance (H^*L_φ), where L_φ stands for a boundary tone. In the two-phrase pattern, there is an additional high boundary tone H_ι that indicates that this

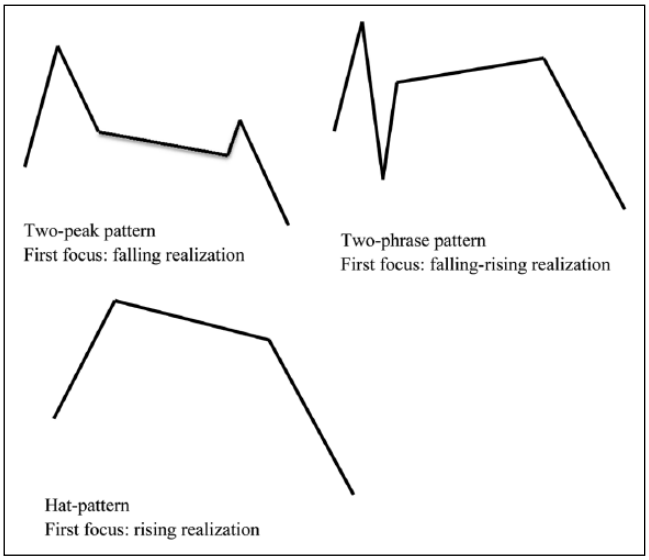

Figure 3. Three possible patterns of dual-focus intonation in German.

Table 2. The number and percentage of the three patterns of dual-focus realization in the four versions (Total missing data: *n* = 10, 4.1% of the dual-focus sentences).

	Two-peak	Two-phrase	Hat-pattern	Total
A (short+short)	16 (27.1%)	9 (15.3%)	**34 (57.6%)**	**59**
B (short+long)	**35 (59.3%)**	15 (25.4%)	9 (15.3%)	59
C (long+short)	**38 (69.1%)**	17 (30.1%)	–	55
D (long+long)	**44 (77.2%)**	13 (22.8%)	–	57
Total	**133 (57.8%)**	54 (23.5%)	43 (18.7%)	230

tone ends an ι-phrase ($H^*L_\varphi H_\iota$). The *hat-pattern* has a rising contour in the first focus element and a falling contour on the second one, while the middle part stays high. The first focus element has thus a rising contour (L^*H_φ).

Each sentence was uttered under four focus conditions by each speaker and in each repetition, and they were grouped into different classes for analysis. The grouping of the sentences was based on the type of the dual-focus sentence. For example, if a dual-focus sentence belonged to the two-peak pattern, then the same sentence uttered by the same speaker in the same repetition under the other three focus conditions was grouped together with the dual-focus sentence. The motivation for this procedure was that initial-focus, final-focus, and all-new sentences were realized in a consistent way throughout the recordings.

Table 2 presents the percentage of the three realizations in the four versions of all dual-focus sentences. As can be seen in Table 2, the two-peak pattern was the preferred one, except in the short sentences, where the hat-pattern was preferred. There were only around 25% two-phrase occurrences in the B-D sentences, and about 15% in the A sentences. The hat-pattern was the least preferred one, and was found mostly in short sentences (57.6% in version A). It was sometimes applied with a short subject NP (15.3% in version B), but never in sentences with a long subject NP (0% in

versions C and D). The chi-square test confirmed that the choice of dual-focus realization is significantly different in the four versions ($\chi^2 = 86.791$, $p < .001$).

Figures 4 to 7 illustrate the intonation contours of sentence (12) in the A to D versions separately, classified by the three types of dual-focus realization (two-peak pattern, two-phrase pattern, and hat-pattern) with the four focus conditions overlaid in one figure. In these figures, 10 time-normalized F0 points were extracted for each syllable with the Praat script ProsodyPro (Xu, 2013), and then averaged across speakers. Only the two-peak and two-phrase patterns are presented for versions C and D because there were no hat-pattern realizations of dual-focus sentences in these cases.

Consider first the two-peak pattern of dual-focus sentences. In this case, the first focus was realized similarly to the single initial focus in terms of the F0 raising on the focused constituent and post-focus F0 compression. On the second focus, the F0 peak reached roughly the same height as a final focus. In sum, both foci were fully realized, and to roughly the same degree of prominence as their single-focus counterparts.

Second, in the two-phrase realizations of dual-focus shown in Figures 4 to 7, there was a high boundary tone at the offset of the subject NP. In the A and B sentences, the subject was a disyllabic word, thus demonstrating that both focus and boundary could be realized on one word: the falling contour due to focus was on the first syllable and the high boundary tone on the second syllable. In the C and D sentences, the stressed syllable showed F0 raising and the final syllable had the high boundary tone, with three unstressed syllables between the accent and the boundary. The F0 of these three unstressed syllables was compressed in the same way as in the initial-focus condition. The second focus was always realized as a falling tone and reached roughly the same height as a final focus.

As for the third pattern, the hat-pattern of short dual-focus sentences (version A), the intonation contour of these utterances was similar to that in the all-new sentences, except for the slightly higher F0 on both foci.[7]

In all three patterns, the second focus was always realized as a falling tone and mostly in a downstepped relation to the first focus. It confirmed that the falling contour was the prototypical contour used to signal focus.

In sum, the analysis of the intonational contours showed that dual-focus can be realized in three different ways as illustrated in Figure 3. The choice of these three realizations was clearly related to sentence length and subject length. In general, speakers preferred to realize two foci in one ι-phrase with two peaks and compressed pitch in-between (two-peak pattern), but when the sentence was short, a hat-pattern contour was more frequent (hat-pattern in version A). A small portion of the dual-focus sentences were realized with a boundary tone after the first focus (the two-phrase pattern), especially when the subject was long, leading to two ι-phrases. The second focus was always realized as a falling contour and mostly in a downstepped relation to the first focus. In general, the falling tone was the preferred tonal pattern for signaling focus in both single- and dual-focus conditions. The high boundary tone was optional: the upcoming focus may give rise to a high tone at the edge of the constituent of the first focus, but this does not affect how the focus is realized.

3.2 Quantitative Analysis

This section provides a quantitative analysis of F0 maximum and duration of the target words in the four focus conditions. The sentences were analyzed separately for the three patterns of the dual-focus sentences. We are interested in a comparison between the dual-focus realization and the other focus realizations that were elicited, and we concentrate on the preferred realization of dual-focus sentences, that is, the two-peak pattern of the B to D versions and the hat-pattern of the A version.

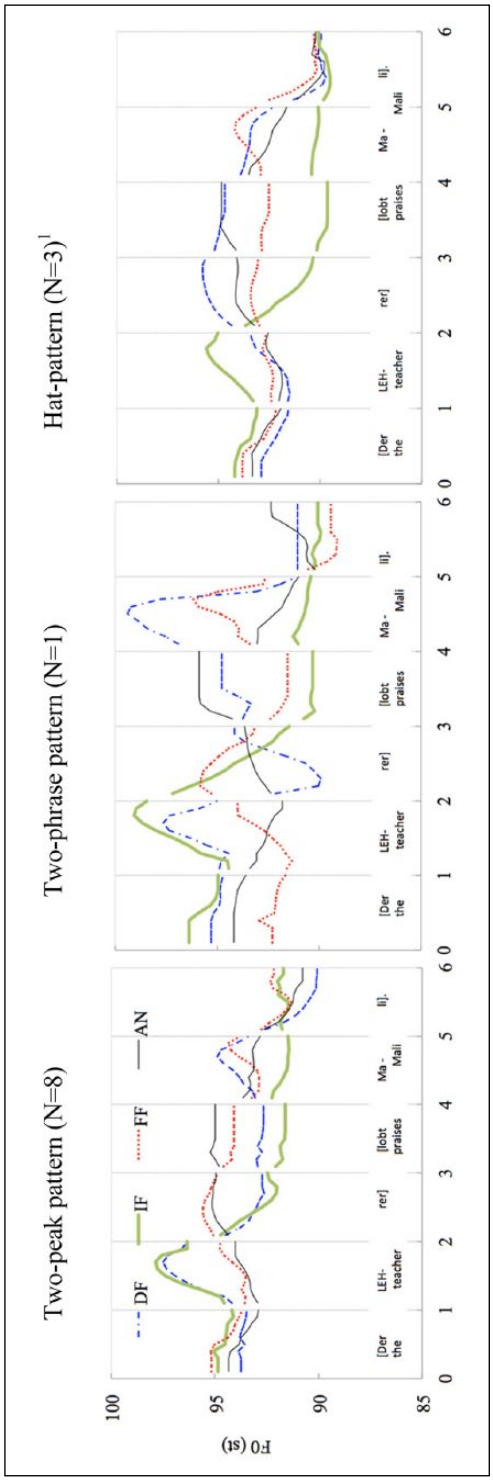

Figure 4. The three types of dual-focus contours of one A sentence overlaid with the other three corresponding focus conditions, averaged across all speakers (Total n = 12, six speakers and two repetitions each). The numbers on the x axis refer to syllable boundaries. DF, IF, FF, and AN stand for dual-focus, initial focus, final focus and all-new, respectively.

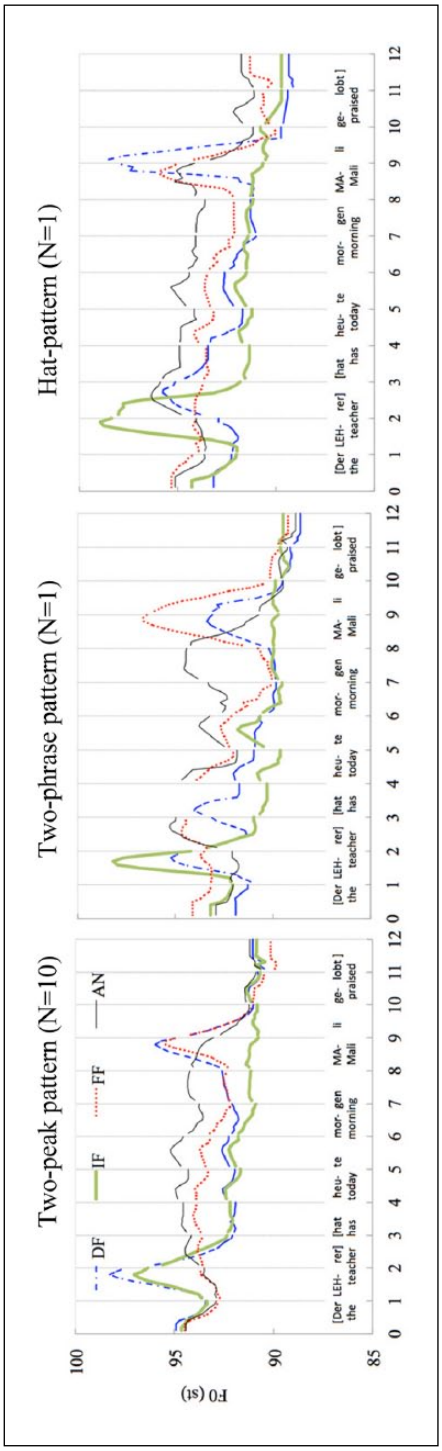

Figure 5. The three types of dual-focus contours of one B sentence overlaid with the other three corresponding focus conditions, averaged across all speakers (Total *n* = 12, six speakers and two repetitions each).

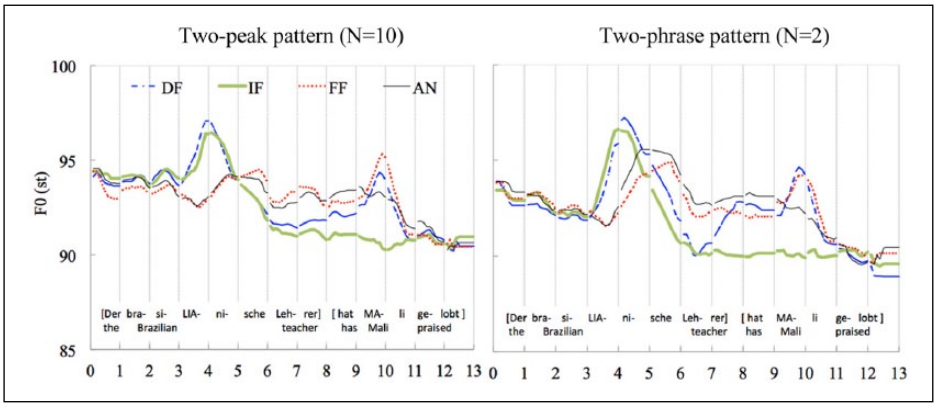

Figure 6. The two types of dual-focus contours of one C sentence overlaid with the other three corresponding focus conditions, averaged across all speakers (Total *n* = 12, six speakers and two repetitions each).

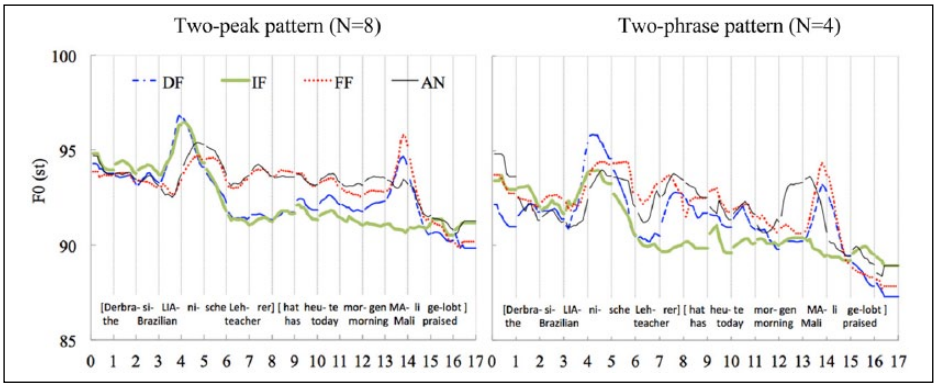

Figure 7. The two types of dual-focus contours of one D sentence overlaid with the other three corresponding focus conditions, averaged across all speakers (Total *n* = 12, six speakers and two repetitions each).

Due to the small number of hat-pattern realizations in versions B to D (only nine cases in version B), and of the two-phrase realizations in all versions (about 10 cases in each version) (see Table 2), no statistical analysis was performed for these sentences.

The following questions are to be answered here separately for the two-peak pattern and the hat-pattern: Question (1): In the two-peak realization of dual-focus, how do maximum F0 and duration of the focused words compare with the single-focus conditions? Is maximum F0 of the post-focus word lowered to the same degree in the dual-focus and the initial-focus conditions? To what degree is downstep to be found between the maximum F0 of the two focused words? Question (2): In the hat-pattern realization of the A sentences in the dual-focus condition, are the maximum F0 and duration of the two focused words greater than those in the all-new condition?

Three target syllables were defined for analyzing maximum F0: the stressed syllable of the first focused word (first focus), the first stressed syllable after the focused word (post-focus), and the stressed syllable in the second focused word (second focus). The syllable used to test post-focus

lowering was located in the VP in the A and B sentences, and in the subject NP in the C and D sentences. In (12), the target syllables are underlined. Word duration was used for duration analysis. The first content word after the first focused word was chosen to test whether focus had any influence on the duration of the post-focus words. Repeated measures ANOVAs were carried out separately for each version of the sentences, with focus condition and word position as two independent variables.

3.2.1 Two-Peak Realization of Dual-Focus Sentences. Consider first the two-peak pattern, the most common pattern of dual-focus realization of the B-D sentences. The maximum F0 of the three target syllables in versions B-D is graphically presented in Figure 8, and the mean values and standard deviation are presented in Table 3.

First, we can see in Figure 8 that the two peaks of the dual-focus sentences reached roughly the same height as their single-focus counterparts, and the post-focus words after the first focus were lowered to almost the same degree as those in the initial-focus condition. These observations were further confirmed by repeated measures ANOVAs (see Table 4). The main effect of focus came from the fact that words had significantly higher maximum F0 when they were focused than when they were given. The follow-up simple effect tests showed that there was no difference between the maximum F0 of the first word in the initial- and dual-focus conditions, and that the maximum F0 was significantly higher than that in the final-focus and all-new conditions ($p < 0.05$). In terms of post-focus lowering after the subject NP, again no difference between dual and initial focus was found. Finally, for the B, C, and D sentences, maximum F0 of the object was significantly higher in the dual- and final-focus conditions than that in the initial-focus and all-new conditions, while no difference between dual and final focus was found. In sum, both foci were realized in the same way as in the single-focus counterpart, and the post-focus part after the first focus was lowered to the bottom of the pitch range.

As can be gathered from the above analysis and Figures 5 to 7, in the two-peak contours, F0 was lowered after the first focus and started to rise before the second focus. We will show in Section 4 that this can be considered to be a phrasing strategy.

Question (1) also addresses the relation of the pitch height between the two foci. In Table 3, it can be seen that the second focus had lower maximum F0 than the first focus (96.0 st vs. 98.0 st on average). We compared the maximum F0 of the two peaks in the B to D sentences separately (see Figure 9). The second peak was mostly lower than the first peak in all sentences and for all the subjects, with only few outliers. The difference in the maximum F0 between the two foci reaches statistical significance as confirmed by a 2-way repeated measures ANOVA with sentence version and peak position as two factors (sentence: $F(2, 8) = 6.075$, $p = 0.025$; focus: $F(1, 4) = 15.438$, $p = 0.017$, with no interaction between them).

The duration of the three target words in the A-D sentences is presented in Table 5. The general observation was that focused words had a longer duration than their unfocused counterparts in both single- and dual-focus conditions; see the results of the repeated measures ANOVAs in Table 6. Due to different numbers of two-peak realizations in the B to D sentences, the statistical tests were carried out separately for each version of the sentences, with word position and focus condition as two independent variables. Simple effect tests further showed that there was no significant difference between the dual- and single-focus conditions in terms of lengthening of the focused word. Post-focal words did not show any systematic durational variation.

3.2.2 Hat-Pattern of A Sentences. The hat-pattern was the preferred dual-focus realization of the A sentences, which were six syllables long and only had two syllables between the two foci. In the hat-pattern realization of the A sentences, the whole intonation contour was similar to the all-new condition. In this section, we present statistical analyses of the maximum F0 and duration of the two focused words of a dual-focus sentence as compared to its all-new counterpart.

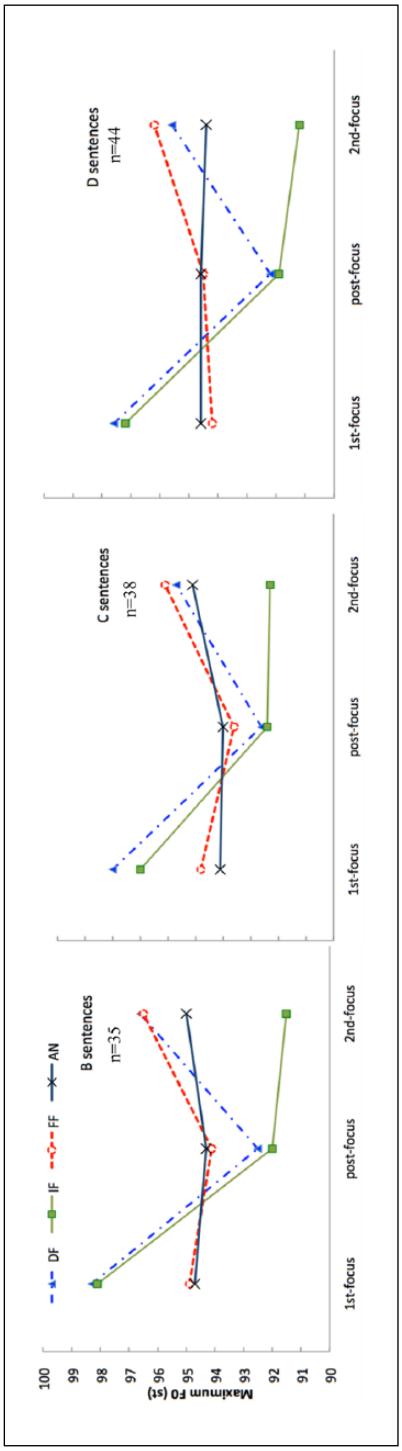

Figure 8. For the two-peak realization of dual-focus sentences, the maximum F0 of the three target syllables in the B-D sentences with the four focus conditions overlaid in one figure.

Table 3. Maximum F0 (st) of the three target words in the B-D sentences under the four focus conditions based on dual-focus sentences realized as the two-peak pattern. The bold numbers are those under focus. The numbers in brackets are the standard deviation.

		Dual Focus	Initial Focus	Final Focus	All-New
B	1st-focus	**98.3 (1.5)**	**98.1 (1.2)**	94.8 (0.5)	94.7 (1.0)
	Post-focus	92.5 (1.2)	92.0 (1.8)	94.1 (1.0)	94.3 (1.0)
	2nd-focus	**96.6 (1.7)**	91.5 (1.8)	**96.5 (1.9)**	95.0 (1.1)
C	1st-focus	**98.0 (1.4)**	**97.0 (1.7)**	94.8 (1.7)	94.1 (1.1)
	Post-focus	92.6 (1.3)	92.4 (1.9)	93.6 (1.4)	94.0 (1.2)
	2nd-focus	**95.7 (2.3)**	92.3 (2.4)	**96.1 (1.9)**	95.1 (1.4)
D	1st-focus	**97.6 (1.0)**	**97.2 (1.4)**	94.2 (1.1)	94.6 (1.0)
	Post-focus	92.2 (1.5)	91.9 (1.5)	94.5 (0.7)	94.6 (0.9)
	2nd-focus	**95.6 (1.2)**	91.2 (1.6)	**96.2 (1.9)**	94.4 (1.0)

Table 4. Two-way repeated measures ANOVAs of maximum F0 in the two-peak realizations of the B, C, and D sentences.

	Word $F(2, 10)=$	Focus $F(3, 15)=$	Word×Focus $F(6, 30)=$
B	35.584***	15.756***	32.158***
C	36.668***	7.417*	8.02*
D	36.231***	23.666***	36.272***

Note: *, **, and *** indicate that $p<.05$, $p<.01$, and $p<.001$, respectively.

The maximum F0 of the hat-pattern realization of the A sentences is presented in Table 7. A two-way repeated measures ANOVA was carried out with focus condition and word position as two independent variables. The results showed that the effects of focus condition, $F(3, 15) = 16.948$, $p = 0.006$, word position, $F(2, 10) = 9.133$, $p = 0.013$, and the interaction, $F(6, 30) = 22.640$, $p < 0.001$, were all significant. Simple effect tests further showed that initial focus had a significantly higher maximum F0 in the first word than in the other three focus conditions, whereas in the post-focus part, initial-focus sentences showed a clear lowering effect. No significant difference among dual-focus, final focus, and all-new condition was found in the first focused word and the post-focus word. The second focus showed significantly higher maximum F0 in the dual- and final-focus conditions than in the all-new and initial-focus conditions, with no difference between the dual- and final-focus conditions. In short, the hat-pattern realization of dual-focus sentences differed from the all-new contour only in the F0 height of the second focus.

Word durations of the three target words in the A sentences with hat-pattern realization are shown in Table 8. A two-way repeated measures ANOVA showed that focus condition, $F(3, 15) = 20.872$, $p < 0.001$, word position, $F(2, 10) = 138.782$, $p < 0.001$, and the interaction, $F(6, 30) = 10.217$, $p = 0.005$, all had significant effects. The simple effect tests further showed that focused words had a longer duration than non-focused words in both the single- and dual-focus conditions. Moreover, no systematic durational variation was observed in the post-focal words.

Putting together the results of maximum F0 and duration of the hat-pattern realization of short dual-focus sentences, it can be observed that the first focus was mostly marked by longer duration whereas the second focus showed both higher F0 and longer duration.

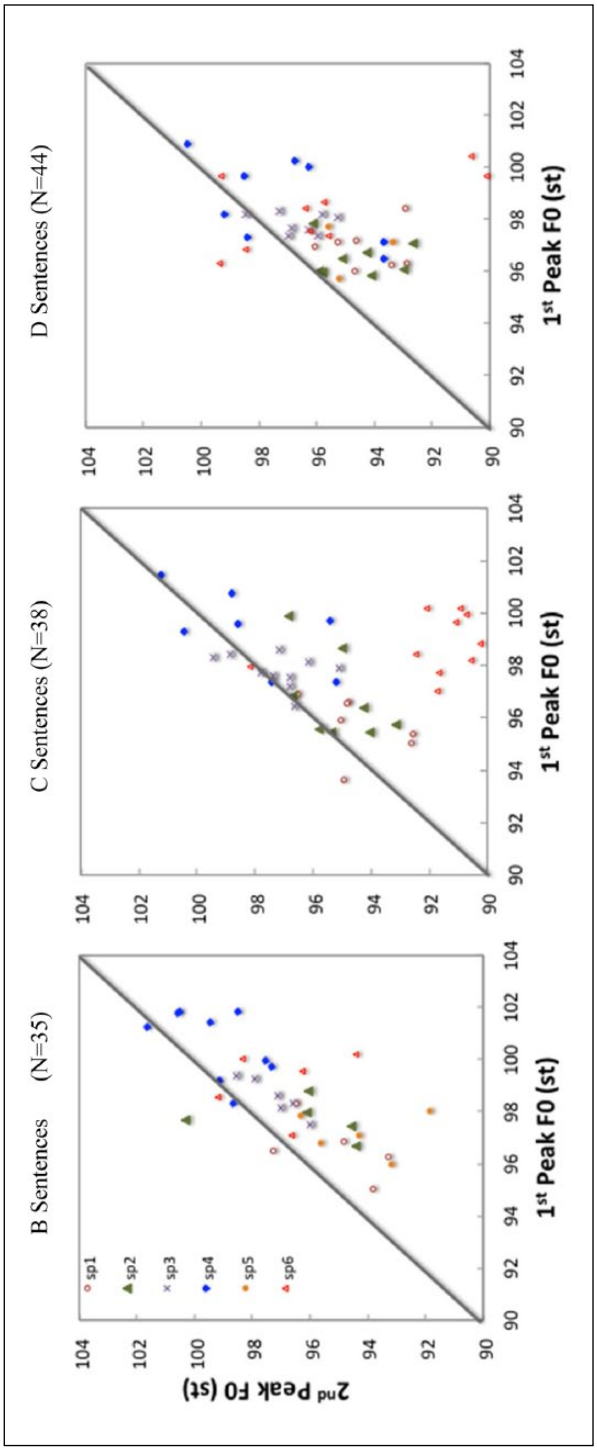

Figure 9. Maximum F0 of the two peaks in the *two-peak* realization of the B-D sentences.

Table 5. Word duration (ms) of the three target words in the two-peak pattern. The bold numbers are those under focus. The numbers in brackets are the standard deviation.

Sentences		Dual Focus	Initial Focus	Final Focus	All-New
A	1st-focus	**434 (48.6)**	**391 (49.1)**	328 (32.1)	307 (31.3)
	Post-focus	241 (50.6)	240 (53.5)	233 (44.3)	224 (35.0)
	2nd-focus	**490 (80.3)**	423 (64.8)	**504 (73.3)**	420 (49.5)
B	1st-focus	**376 (23.7)**	**348 (15.4)**	298 (24.2)	296 (20.3)
	Post-focus	286 (24.8)	287 (26.5)	279 (16.4)	274 (33.0)
	2nd-focus	**363 (30.9)**	329 (16.3)	**366 (15.7)**	317 (10.8)
C	1st-focus	**815 (99.2)**	**800 (95.3)**	744 (82.9)	728 (82.8)
	Post-focus	310 (78.0)	292 (69.8)	278 (57.6)	285 (58.0)
	2nd-focus	**396 (48.9)**	361 (21.7)	**404 (57.0)**	344 (32.5)
D	1st-focus	**765 (35.1)**	**748 (43.3)**	697 (39.8)	693 (30.4)
	Post-focus	329 (25.0)	330 (19.7)	317 (14.4)	322 (19.8)
	2nd-focus	**389 (41.5)**	353 (50.1)	**390 (49.3)**	344 (45.0)

Table 6. Two-way repeated measures ANOVAs of word duration in the two-peak realizations of the B, C, and D sentences.

	Word $F(2, 10)=$	Focus $F(3, 15)=$	Word×Focus $F(6, 30)=$
B	62.979***	22.709***	19.109***
C	162.029***	20.057***	12.18**
D	225.317***	15.274***	21.982***

Table 7. The maximum F0 (st) of the three target words in the A sentences with the *hat-pattern* realization of dual-focus. The bold numbers are those under focus. The numbers in brackets are the standard deviation.

	DF	IF	FF	AN
1st-focus (subject NP)	**94.9 (1.2)**	**97.2 (0.9)**	94.2 (1.1)	94.3 (1.1)
Post-focus (verb)	96.1 (1.0)	91.2 (1.6)	94.1 (1.4)	95.0 (0.8)
2nd-focus (object)	**95.7 (1.6)**	91.1 (1.9)	**95.6 (1.5)**	94.9 (1.2)

Table 8. Word duration (ms) of the three target syllables in the A sentences with the *hat-pattern* realization of dual-focus. The bold numbers are those under focus. The numbers in brackets are the standard deviation.

	DF	IF	FF	AN
1st-focus	**403 (35.5)**	**362 (17.6)**	305 (12.9)	309 (10.9)
Post-focus	242 (24.3)	243 (11.8)	243 (22.0)	220 (27.0)
2nd-focus	**475 (46.1)**	428 (44.5)	**469 (46.1)**	415 (37.1)

To sum up this section, the quantitative analysis confirmed that F0 maximum and duration are used to mark focus, both in dual- and in single-focus conditions. A focused word has higher F0 and

longer duration than its non-focused counterpart. A falling contour is preferred for focus, together with post-focus F0 lowering and compression. In the two-peak realization of dual-focus sentences, the F0 of post-focus words is also lowered to roughly the same degree as with the initial focus. The two peaks in dual-focus sentences are in a downstep relationship to each other. In the hat-pattern realization of short sentences, the first focus is marked by durational lengthening, whereas the second focus shows both F0 rising and durational lengthening.

4 Phonological analysis

In this study, we found that there are three types of intonational contours of dual-focus sentences in German, that is, the two-peak pattern, the two-phrase pattern, and the hat-pattern. The dual-focus realization interacts with phrasing: a sentence with two foci can be realized either as one intonation phrase or as two. However, in all cases, focus is assigned within the prosodic domain derived from syntax. We will first sum up the phonetic correlates of dual-focus, and then discuss the phonological consequences of the results.

4.1 Phonetic Correlates of Dual-Focus in German

In general, the results show that German prefers to use a falling contour to mark a focused element. When a focused word is non-final, post-focus F0 lowering and compression occur. In dual-focus sentences, speakers have more choices for the first focus: it is realized with either a rising or a falling contour, and a boundary tone to separate the two foci is optional. Both sentence length and subject NP length influence the choice between these options.

When the distance between the two foci is short and the sentence is short, there is a strong preference for the hat-pattern, in which the first focus is realized with a rising contour. In such cases, the first focus is realized as a secondary accent, and the second focus carries the nuclear accent. Notice that a hat-pattern was also realized in the all-new context. In the dual-focus condition, however, both foci are lengthened and the F0 of the second focus is raised.

As soon as a dual-focus sentence becomes longer, the hat-pattern is generally avoided and the most common pattern consists of two falling pitch accents, one for each focus, related to each other by downstep (the first one has a higher maximum F0 than the second one), here referred to as the two-peak pattern. In this case the intonation contour between the two foci is largely compressed and lowered to roughly the same degree as in the initial-focus condition. Both foci are maximally prominent.

The third alternative is to insert a high boundary tone at the end of the first focus while both foci have a falling contour. This is the two-phrase pattern and is applied more frequently in longer sentences. However, the total number of two-phrase realizations is still much smaller than that of the two-peak pattern. This indicates that speakers prefer to realize both foci in one ι-phrase.

Duration is a crucial and stable correlate of focus. Durational lengthening on focused words is found in both single- and dual-focus sentences, and in all positions. It seems to be independent of F0 variation. In the hat-pattern, when both foci do not show much variation in F0, focused words tend to be marked by durational lengthening, and in the two-peak realization, when focus is marked by a falling contour and raised F0, durational lengthening also applies.

Relating now these results to the research questions formulated in Section 1.3, it can be observed that focus is always expressed by a pitch accent the prominence of which is equal to single focus (I-a). Post-focal compression is found only in two-peak and two-phrase patterns, that is, when the pitch accent has a falling contour (I-b). Each focus of a dual-focus sentence is phrased in a separate Φ-phrase (all realizations), and in the two-phrase pattern, each focus is in a separate ι-phrase (II-a).

There is a correlation between the length of the sentence and the choice of the pattern (II-b). As for duration, a focused constituent is longer than a non-focused one (III).

In short, speakers prefer to realize the two foci as two peaks in one ι-phrase with the middle part largely flattened (the two-peak pattern). In some cases, a high boundary tone is inserted to separate the two peaks (the two-phrase pattern). The two-peak pattern requires a certain amount of time and number of syllables in order to be realized. When the distance between the two foci is not large enough and the sentence is short, the contour often forms a hat-pattern. In this pattern, there is no post-focal compression after the first focus; instead the F0 stays high and the focused word is realized by increasing word duration.

4.2 Phonological Analysis of German Dual-Focus Sentences

In this section, we turn to the phonological analysis of the dual-focus sentences. Consider first the default (all-new) prosodic and metrical pattern of the experimental sentences in (12), reproduced in (14) with added prosodic constituency. We applied the prosodic and metrical analysis displayed in Section 1.1. All five sets of experimental sentences have the same prosodic and metrical pattern.

(14) Prosodic phrasing of one experimental sentence set

A. [(Der Lehrer)$_{\Phi}$ (lobt (Mali)$_{\Phi}$)$_{\Phi}$]$_{\iota}$
the teacher praises Mali
"The teacher praises Mali."

B. [(Der Lehrer)$_{\Phi}$ ((hat (heute morgen)$_{\Phi}$)$_{\Phi}$ ((Mali)$_{\Phi}$ gelobt)$_{\Phi}$)$_{\Phi}$]$_{\iota}$
the teacher has today morning Mali praised
"The teacher praised Mali this morning."

C. [(Der brasilianische Lehrer)$_{\Phi}$ (hat (Mali)$_{\Phi}$ gelobt)$_{\Phi}$]$_{\iota}$
the Brazilian teacher has Mali praised
"The Brazilian teacher praised Mali."

D. [(Der brasilianische Lehrer)$_{\Phi}$ ((hat (heute morgen)$_{\Phi}$)$_{\Phi}$ ((Mali)$_{\Phi}$ gelobt)$_{\Phi}$)$_{\Phi}$]$_{\iota}$
the Brazilian teacher has today morning Mali praised
"The Brazilian teacher praised Mali this morning."

At the level of the prosodic word (ω-word), each content word has a lexical stress, which is trochaic in *Lehrer, heute, morgen*, and *Mali*; the word *brasilianische* has antepenultimate stress and *gelobt* has final stress. As explained in Section 1.1, the formation of the Φ-phrase in the all-new condition adheres to the following principles: The subject NP always forms a single Φ-phrase. The verb phrase is another Φ-phrase when it is short (A and C), but when it is long (B and D), it has two Φ-phrases. In this latter case, the first Φ-phrase in the VP contains the auxiliary and the temporal adjunct and the second one includes the object and the participle. Every syntactic phrase embedded in the larger constituent also forms its own Φ-phrase. According to the general principles of stress assignment in German, the last prosodic word of each Φ-phrase is the head of the Φ-phrase, and as such, carries the pitch accent of the Φ-phrase. In the last Φ-phrase, the pre-verbal argument is the head of the prosodic domain, as shown in sentence (15),

where the word *Mali* is the head. Similarly, at the level of the ι-phrase, the last prominence, that is, the last head of the last Φ-phrase, is strengthened and is therefore the nuclear accent (see Féry, 2011). Sentence (15) illustrates the prosodic and metrical pattern of the longest sentence (version D) in the all-new condition. This constellation fulfills the Culminativity Principle, which is prevalent in all Germanic languages: every prosodic domain has a unique and obligatory head. The whole sentence consists of one ι-phrase, which includes a secondary accent with a rising pattern and a final falling nuclear accent.

(15) All-New & Final Focus

								×			ι-phrase
		×				×		×			Φ-phrase
×		×			×	×		×	×		ω-word

[(Der brasilianische Lehrer)$_{\Phi}$ ((hat heute morgen)$_{\Phi}$ (MAli gelobt)$_{\Phi}$)$_{\Phi}$]$_{\iota}$

Consider next the expected changes in the prosodic and metrical pattern of the sentences in the different focus conditions examined in the experiment.

In the case of *final* focus, no change in the prosodic and metrical pattern occurs, see (15). The accents preceding the nuclear one are realized slightly lower than in the neutral condition, and the nuclear accent has a higher F0 in the final-focus condition than in the neutral pattern. Both predictions are confirmed in our results (see Figure 7 and Table 3).

In the metrical structure of the *initial*-focus condition, illustrated in (16), the initial pitch accent is also the last one in its ι-phrase, because it is the focus, and the focus carries the last prominence in its domain. The metrical pattern is considerably different: all following accents are deleted, or considerably compressed (see Kügler & Féry, 2017 for post-nuclear metrical structure).

(16) Initial Focus

×											ι-phrase
×					×	×					Φ-phrase
×		×			×	×		×		×	ω-word

[(Der brasiLIAnische$_{F}$ Lehrer)$_{\Phi}$ ((hat heute morgen)$_{\Phi}$ (Mali gelobt)$_{\Phi}$)$_{\Phi}$]$_{\iota}$

As for the intonational contour, the initial accent on the adjective of the subject is falling and prominent. It can be seen in Figure 7 that it is higher than the corresponding accents in the all-new and final-focus conditions. Moreover, the post-nuclear pitch accents are deleted and strongly compressed.

The theoretical question we are interested in this paper is whether a dual-focus is realized in one ι-phrase, or whether each focus is in its own ι-phrase. The answer to this question is that partly depending on the length of the Φ-phrases and the length of the sentence, it can be realized in one or in two ι-phrases. In (17), the metrical structure of the A sentence is illustrated when it is realized as a hat-pattern. In this case, the dual-focus resembles the all-new context, as is best seen in the rightmost pattern of Figure 4, the most frequent realization of the A sentences. Since the first focus is realized as a rising contour, it is perceptually less prominent than the second focus.

(17) Dual-focus (hat-pattern)

	×		ι-phrase
×	×		Φ-phrase
×	×	×	ω-word

[(Der LEHrer$_F$)$_Φ$ (hat MAli$_F$ gelobt)$_Φ$]$_ι$

In both the two-peak and two-phrase realizations, the first focus resembles the initial focus and the second one resembles the final focus. We propose that a dual-focus sentence can have one of the two prosodic structures presented in (18) and (19). These two prosodic structures correspond to the two-peak and two-phrase pattern, respectively. In (18), each focus is in a separate Φ-phrase, although they are in a single ι-phrase, while in (19), each of them is in a separate ι-phrase.

(18) Dual-focus (two-peak pattern)

×						×		ι-phrase
×				×		×		Φ-phrase
×	×		×	×		×	×	ω-word

[(Der brasiLIAnische$_F$ Lehrer)$_Φ$ ((hat heute morgen)$_Φ$ (MAli$_F$ gelobt)$_Φ$)$_Φ$]$_ι$

(19) Dual-focus (two-phrase pattern)

×						×		ι-phrase
×					×	×		Φ-phrase
×	×		×	×		×	×	ω-word

[[Der brasiLIAnische$_F$ Lehrer]$_ι$ [((hat heute morgen)$_Φ$ (MAli$_F$ gelobt)$_Φ$)$_Φ$]$_ι$]$_ι$

The first focus has a falling accent in both (18) and (19), but in (19) there is an additional ι-phrase that is ended by a high boundary tone. A two-peak realization like the one in (18), with two equally prominent Φ-phrases, violates the Culminativity Principle, but meets the requirement that the falling contour is associated with focus, and also that a syntactic sentence is maximally mapped onto an ι-phrase (see Selkirk, 2011 for constraints to this effect). Notice that the metrical structure is the same in both cases. However, there is a difference in the register used for the medial part, thus *hat heute morgen* "has this morning." In (19), this medial part is in a different ι-phrase from that of the first focus on *brasilianische*: it is in the pre-nuclear domain of the second focus on *Mali*, and, thus, there is no reason for it to be compressed. In (18), by contrast, *hat heute morgen* is located in the post-focus domain of the first focus, and it is thus subject to post-focal compression. In Figure 7, it can be seen that the presence of a boundary is decisive for post-focal compression.

In sum, in the two-peak pattern, the post-focal compression of the medial part resembles that found in initial focus, while in the two-phrase pattern, it is limited to the subject NP, thus providing more evidence for a difference in phrasing.

The last question that we want to address in this section is the following: does focus structure only modify the prominence assignment of the metrical structure, or does it also obligatorily change the phrasing?[8] This question is especially relevant in the case of dual-focus. Both in initial

focus and in final focus, this question cannot be answered unambiguously. In initial focus, post-nuclear prominence is systematically deleted, or at least it is very much reduced. Kügler and Féry (2017) argue for German that the optional presence of post-nuclear downstep is a clear argument in favor of keeping the phrasing intact in the post-nuclear region. As for final focus, preservation of the pre-nuclear accents seems to speak in favor of preserving the prosodic phrasing as well.

In the case of dual-focus, speakers need to make a choice between realizing the first focus as either a rising contour or a falling contour. One tendency is that the first focus is realized with a rising contour—because it is not final, and because there is a strong preference in German to realize any kind of non-final pitch accent as rising. Another tendency is for focus to be associated with a falling contour. This follows from the fact that focus is in most cases right-aligned in German and it is the last pitch accent in the ι-phrase. Our results show that—at least in our data—the preference for focus to be recognizable by its contour is stronger than the preference due to word order. From these remarks, it can be deduced that the prosodic structure may be unchanged in the case of a dual-focus, but that the correlates of focus are clearly expressed within the limits of this prosodic structure. The choice of the tones of the accent as well as an increased occurrence as tonal delimitation are the observed correlates.

The results for German dual-focus intonation suggest that the effect of focus is independent of the formation of prosodic domains or prosodic prominence assignment. As proposed by Féry and Ishihara (2010), prosodic structure is derived exclusively on the basis of syntactic information. Focus, on the other hand, cannot modify the prosodic structure directly, but only affects the implementation of material within prosodic structure. More generally, we do not think that syntax contains special positions for information structure, at least not in German (see Fanselow, 2016). Rather the information-structural needs of certain constituents have to be satisfied on basis of those structure allowed by syntax. Syntactic and prosodic structures act together to deliver the right sentence accent placement, corresponding to the intended information structure. Féry (2011) has proposed that the formation of prosodic phrases is a necessary step for the assignment of accents, and that it allows embeddedness of prosodic domains. Such a claim disagrees with the models that directly assign pitch accents to focused constituents or to syntactic constituents without going through the formation of prosodic constituents. As a result, we propose that integration of the two foci in a unique ι-phrase is the logical consequence of the embeddedness of prosodic domains into larger ones that contain them. In this way, the smaller and the larger prosodic phrases share their head, which is realized as a pitch accent. This study clearly shows that single focus does not introduce strong prosodic boundaries, even in long sentences. However for dual-focus, even though the integration of the two foci into one ι-phrase is preferred, the speakers have the option of realizing them as two ι-phrases, in compliance with the Culminativity Principle.

5 Conclusions

In this study, we found that dual-focus in German may be realized in three different ways, depending on the pitch contour of the first focus. First, there is the "two-peak pattern," which refers to a realization in which both foci have a falling tone, with the part in-between is largely compressed. Second, we find the "two-phrase pattern," where a boundary tone is inserted after the first focus, realized as a falling tone. In this case, the part between the focused syllable and the boundary tone is lowered, but the part between the boundary tone and the second focus is not. The third option is the "hat-pattern," which is similar to the contour of the all-new context and of the final-focus contour. In this case, the first focus has a rising tone while the second focus has a falling tone, and the part between the two foci stays high. The choice of these three patterns is influenced by sentence length and the length of the subject NP.

The following conclusions can be drawn.

(1) The two-peak pattern is generally the most frequent one and the two-phrase pattern is the least frequent one. Sentence length also has an influence on the realization: the hat-pattern realization is more frequent in short sentences, and it is nearly almost absent in long sentences.Speakers prefer to realize two foci as two peaks in one intonation phrase, that is, without a boundary tone closing the first focus, and leave the middle part largely flattened (two-peak contour). In some cases, a high boundary tone is inserted to separate the two peaks (two-phrase contour), but this pattern occurs much less frequently. When the distance between the two foci is short and a sentence is short, a hat-pattern is usually used, with duration as the crucial correlate of focus.
(2) The realization of the second focus is simple. In all three dual-focus patterns, it is realized as a falling contour in a downstepped relation to the first focus. It has roughly the same F0 height and duration as a final focus.
(3) In dual-focus sentences, focused constituents have longer duration than their non-focused counterpart. The degree of durational lengthening is comparable to that in the corresponding single-focus cases, in both the two-peak and the hat-pattern realizations. Durational lengthening of the focused word is thus obligatory.
(4) The three patterns have been phonologically analyzed as resulting from a difference in prosodic phrasing. The speakers had the choice between including both foci in a single ι-phrase or separating them into two ι-phrases. In the first option, when a sentence was short, the first focus was often realized as a pre-nuclear accent (hat-pattern), but when a sentence was longer, the two foci were projected onto Φ-phrases of roughly the same prominence: both foci carried falling accents (two-peak pattern). In the third case, when the two foci projected two ι-phrases, prominence of the two foci was also equal (two-phrase realization). The two-peak pattern showed that Culminativity, the principle requiring a unique head for every prosodic constituent, cannot be maintained in its strong version: dual-focus sentences allow the presence of two heads in a single ι-phrase in German.

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Notes

1. Hyman (2006: 231) restricts Culminativity, formulated as in (i), to the lexical domain.

   (i) CULMINATIVITY: every lexical word has at most one syllable marked for the highest degree of metrical prominence.

2. Besides the pure syntax-prosody mapping algorithm or constraints, well-formedness constraints can act on the form of the prosodic domains, delivering Φ-phrases that can be smaller or larger than syntactic phrases (Selkirk, 2005).
3. We ignore here lower prosodic constituents that do not play any role in the discussion in this paper.

4. Some authors assume that the post-focal prosodic phrases are deleted (see for instance Gussenhoven, 1983, 1984; Selkirk, 1984, 1995).
5. We are aware of the fact that this strategy can be considered somewhat problematic since the same sentences appeared four times in different contexts, rendering the "new" material not so new after a while. However, this is a problem that is recurrent in nearly all laboratory production experiments. We must rely on the assumption that the speakers understand the task and treat the material as "new" if it is asked as such by a preceding *wh*-question. In fact, our results showed that the speakers did realize all-new sentences in a consistent way.
6. We did not use pre-recorded questions here because we wanted to create a plausible conversational setting. In general, speakers answer questions in a more natural way when they are engaged in dialogs with real partners. The experimenter took care to maintain a similar behavior and a constant melody with all speakers.
7. Based on the figures, a reviewer expresses some doubts that hat-pattern dual-focus sentences genuinely resemble the pattern of all-new sentences. And indeed, in the B sentences, there were just nine sentences uttered with a hat-pattern, rendering any concrete conclusions difficult to draw. Figure 5 indicates that the hat-pattern realizations of the dual-focus sentences may differ from the all-new sentences. However, this is illusory. By examining other B sentences, we see that the hat-pattern realization resembles that of all-new sentences. To conclude, the first focus is realized as a rising contour and the second one as a falling contour, but the middle part presents some variation.
8. For English, Selkirk (2011), following Beckman and Pierrehumbert (1986), assumes that every focused constituent is mapped onto a separate ι-phrase. However, we do not follow this proposal for German, because if we did, there would be no way to distinguish between the two-peak and the two-phrase realizations.

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Appendix I. Reading material

Due to space restrictions, we here only present the material in German and the English translation. The small capital letters indicate the syllables which bear pitch accents when the words are under focus.

Base sentence: set 1

A. [Der GÄRTner] [sucht ROsen]
The gardener looks for roses.
B. [Der GÄRTner] [hat heute Morgen ROsen gesucht]
The gardener looked for roses this morning.
C. [Der kolumBIAnische Gärtner] [hat ROsen gesucht]
The Columbian gardener looked for roses.
D. [Der kolumBIAnische Gärtner] [hat heute Morgen ROsen gesucht]
The Columbian gardener looked for roses this morning.

Base sentence: set 2

A. [Der NACHbar] [mäht RAsen]
The neighbor mows the lawn.
B. [Der NACHbar] [hat Sonntagmorgen RAsen gemäht]
The neighbor mowed the lawn on Sunday morning.
C. [Der vietnaMEsische Nachbar] [hat RAsen gemäht]
The Vietnamese neighbor mowed the lawn.
D. [Der vietnaMEsische Nachbar] [hat Sonntagmorgen RAsen gemäht]
The Vietnamese neighbor mowed the lawn on Sunday morning.

Base sentence: set 3

A. [Der LEHrer] [lobt MAli]
The teacher praises Mali.

B. [Der LEHrer] [hat heute Morgen MAli gelobt]
The teacher praised Mali this morning.
C. [Der brasiLIAnische Lehrer] [hat MAli gelobt]
The Brazilian teacher praised Mali.
D. [Der brasiLIAnische Lehrer] [hat heute Morgen MAli gelobt]
The Brazilian teacher praised Mali this morning.

Base sentence: set 4

A. [Mein BRUder] [malt BLUmen]
My brother paints flowers.
B. [Mein BRUder] [hat gestern Abend BLUmen gemalt]
My brother painted flowers yesterday evening.
C. [Der dominiKAnische Bruder] [hat BLUmen gemalt]
The Dominican brother painted flowers.
D. [Der dominiKAnische Bruder] [hat gestern Abend BLUmen gemalt]
The Dominican brother painted flowers yesterday evening.

Base sentence: set 5

A. [Mein ONkel] [kocht NUdeln]
My uncle cooks noodle.
B. [Mein ONkel] [hat heute Mittag NUdeln gekocht]
My uncle cooked noodle today for lunch.
C. [Mein UNgarischer Onkel] [hat NUdeln gekocht]
My Hungarian uncle cooked noodle.
D. [Mein UNgarischer Onkel] [hat heute Mittag NUdeln gekocht]
My Hungarian uncle cooked noodle today for lunch.

The four questions eliciting the four focus conditions have a similar form in all sentences. The B sentence of set 1 is taken as an example:

Dual-focus:	Wer hat heute Morgen was gesucht? Who looked for what this morning?
Initial Focus:	Wer hat heute Morgen Rosen gesucht? Who looked for roses this morning?
Final focus:	Was hat der Gärtner heute Morgen gesucht? What did the gardener look for this morning?
All-new:	Was war los? What happened?