



# The connection between prosodic realisations of German Wh-questions and their pragmatic embeddings

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## Abstract

We hypothesise that a speaker using falling intonation on a Wh-question, which corresponds to the default contour in German, indicates to their addressee the possibility to respond with a *null-answer* like “*nobody*” or “*nothing*”. With a rising intonation, on the other hand, the speaker is supposed to explicitly deny the possibility of such an answer due to prior knowledge that the existential implication of the question is true. We ran two perception experiments, in which participants were exposed to two types of contexts, either allowing or disallowing the *null-answer*, followed by either a rising or a falling Wh-question. Results show that participants did not integrate context and contour. Nevertheless, both variables influenced the participants’ acceptability ratings. Results are discussed in terms of semantics and pragmatics of questions.

**Key Words:** Wh-questions, prosody, semantics & pragmatics of questions, perception experiments

## 1. Introduction

Before presenting our theoretical assumptions on how prosody and the semantic-pragmatic content of a Wh-Question (WhQ) interact, we briefly introduce some background on both.

### 1.1. Denotation of Wh-Questions and the Nobody Answer

Formal semantics offer a number of suggestions on how to model the denotation of a WhQ. Out of several possibilities, one could choose the theory of *alternative semantics* (AltSem) or the theory of *partition semantics* (PartSem). Supporters of PartSem suggest that the denotation of a WhQ is most appropriately described as the partition  $P$  of a given set  $W$ , which contains every possible state of a world  $w$ . A partition is defined as a set of subsets. For example, in a world where only two individuals, A and B, are able to walk, the partition of the WhQ “*Who walks?*” would consist of exactly four cells (i.e., *Nobody walks*, *Only A walks*, *Only B walks* and *Everyone walks*) [1, 2, 3]. The theory of AltSem defines the denotation of a WhQ as the set of propositions counting as *possible* [4, 5] or *true* [6] answers to the question. Coming back to our previous example, the denotation of the WhQ “*Who walks?*” would be the set of (positive) propositions denoting *A walks*, *B walks* and *A and B walk*<sup>1</sup>. Because of the so-called *existential implication* (ExImp) of a WhQ (i.e., that there must be someone who walks) AltSem does not assume an answer equivalent to “*nobody walks*” as part of the denotation. This demonstrates very well the disagreement on the state of a WhQ-denotation in the literature: While PartSem suggests the existence of a *nobody*

<sup>1</sup>This denotation refers to the camp assuming that all answers counting as *possible* propositions make up the denotation.

*answer* (NoA)<sup>2</sup> [3], AltSem either excludes it entirely [4] or licences it through pragmatic tools like an explicit denial of the ExImp [5].

### 1.2. Prosody of German Wh-Questions

Generally speaking, the relevant literature states that the default intonation contour of German WhQ is a final fall with a low boundary tone [7, 8, 9, 10, 11]. However, most authors mention the fact that WhQ with a rising intonation exist, too: Most observed rising WhQ were either classified as *echo questions* (e.g., [8, 9, 10], but see [12]), as questions expressing some amount of epistemic uncertainty of the speaker [13, 14] or as questions with a specific discourse-theoretic function, such as committing the addressee to proceed the conversation [9, 15, 16, 17, 18]. It has also been argued that the use of rising intonation would indicate politeness [19, 20] (but see [21]). For the purpose of our research, the most relevant theoretical framework proposes a potential cardinality reduction of the denotation based on the WhQ-prosody [22, 23, 24, 25, 26]. The authors suggest that, since the fall is assumed to be the default, a rise is used to exclude certain propositions of the denotation set due to prior knowledge of the speaker. So, through the use of rising intonation, the speaker signals to the addressee that s/he is referring only to a subset of the original question denotation. A semi-formal representation is illustrated in (1)<sup>3</sup> (cf. [22]).

$$\llbracket \text{Who called? } \uparrow \rrbracket \subseteq \llbracket \text{Who called?} \rrbracket \quad (1)$$

This predicts the following pattern: For example, if A already knows that C was not able to call B (e.g., because C is on vacation), A is expected to produce a rising WhQ (since A thereby excludes “*C called*” as possible answer from the denotation). On the contrary, if A has no such knowledge, A is expected to use a falling intonation to signal to B that the whole denotation is accessible.

### 1.3. Hypotheses

In this article, we assume that a WhQ-denotation consists of all propositions counting as possible answers to that question (cf. AltSem). Therefore, we do not assume the NoA to be part of the denotation. However, we suggest that speakers have pragmatic access to a partition, which always offers exactly one more possible answer than the denotation: The NoA (this was originally proposed by [27]). Along with the idea of an explicit denial of the underlying ExImp of a WhQ [5], we suggest that the NoA

<sup>2</sup>Of course, *nobody* only applies to WhQ ranging over a set of persons. In this article, the term *NoA* relates to every *null-answer*, like ‘*never*’ or ‘*nothing*’ for the Wh-words *when* or *what*, respectively.

<sup>3</sup>Note that the symbol  $\uparrow$  indicates a rising intonation. Correspondingly,  $\downarrow$  signals falling prosody.

could be seen as the last option of a speaker in situations where no member of the denotation can be considered true. In such cases, the only possibility is to choose the NoA, and to thereby explicitly refuse the ExImp. We adopt the view sketched in the previous paragraph, that the rising contour is used to limit the denotation, but we propose another way: We assume that the rising prosody is used to explicitly exclude the possibility of the NoA, whereas the falling prosody induces the whole spectrum of possible answers, including the NoA. In our perception experiments we, therefore, expect high acceptance for rising WhQ in contexts excluding the NoA as well as for falling WhQ in contexts including the possibility of a NoA.

## 2. Experiment 1

Experiment 1 (Exp1) tested the acceptability of rising and falling WhQ in two sets of contexts, allowing or disallowing the NoA.

### 2.1. Participants

Thirty-six participants between 18 and 33 years (21 female, 15 male) took part in the first experiment. Most people originate from the southern half of Germany and all were enrolled as students at the University of Konstanz (UKon).

### 2.2. Methods

#### 2.2.1. Materials

We constructed 24 WhQ that were paired with 24 context situations. Sixteen WhQ started with the Wh-pronoun *wer* ('who'), four with *wann* (when), three with *welche(r)* ('which') and two with *was* ('what') and *wo* ('where'), each. The contexts introduced a speaker in a specific situation, who then asked a WhQ. We manipulated **context type** and **contour type**. Both independent variables had two levels. The context either *allowed* or *disallowed* the NoA ( $\pm$ NoA, respectively), see Table 1. The

Table 1: Sample contexts translated from German to English

-NoA	+NoA
Arno has just arrived at work on his bike. He runs into his office when he hears the phone ringing from his colleague Jana's room. After putting down his things, he goes into Jana's office and asks her:	Arno has been sitting in his office for some time, working intently. When he takes a break, he realizes that he hasn't heard anything from his surroundings. He is not sure if he heard the phone of his colleague Jana. He goes to her and asks:
<b>Who called?</b>	

WhQ were recorded by the first author in a soundproof booth at UKon with either *rising* ( $L^* H- \hat{H}\%$ ) or *falling* ( $L+H^* L-\%$ ) intonation (see Fig. 1). We used *Praat* [28] to cut and analyse the recordings. We used as fillers 16 contexts ending with an exhaustive WhQ (half rising, half falling), which could pragmatically be interpreted along with the so-called *Mention-Some Reading* [29, 30, 31], because of the contexts they appeared in. Four of them were used to form a short familiarisation phase at the beginning of the experiment. Both independent variables were manipulated within-subjects, but for every subject between-items, resulting in 96 trials ( $24 \times 2 \times 2$ ).

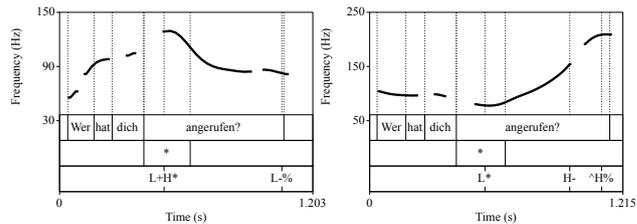


Figure 1: Sample intonation contours: Fall (left) and Rise (right). Annotated by words, stressed syllable and GTToBI.

#### 2.2.2. Procedure

We constructed four experimental lists, each containing one item in one of the four conditions, such that every participant saw every possible combination of the independent variables. For randomisation, experimental items were divided into two blocks and randomised separately to be presented in the first or second half of the experiment (counter-balanced across participants). Between blocks, there was an optional break.

The study took place in the *PhonLab (Phonetics Laboratory)* at UKon. Our study was designed as a perception experiment and all participants were placed in front of the same computer using the same over-ear headphones (beyerdynamic DT 990 Pro).

For the implementation of the experiment we used the platform *FindingFive* [32]. At the beginning of the experiment, participants were instructed to read the context, to listen to the WhQ once and to rate the acceptability of the intonation of the presented WhQ on the basis of the context on a 5-point Likert-scale from 1 “entirely unacceptable” to 5 “entirely acceptable”. The experiment started with four familiarisation trials. Each trial started with the visual presentation of the context on the left-hand side and an icon to start the audio of the WhQ on the right-hand side. After the audio had been played, the rating scale appeared automatically on the screen, below context and audio icon. Once the rating had been given, the next item started. Each experimental session lasted around 30 minutes and participants were paid for participation.

### 2.3. Results

To analyse and visualize the data we used *R* [33] and *RStudio* [34]. To test our theoretical hypotheses we built a linear mixed-effects regression model from the *lme4*-package [35, 36] treating the acceptability *rating* as outcome variable and the independent variables *contour* and *context* as fixed effects. Furthermore, we added random intercepts for *participants* and *items* as well as random slopes for *contour type* and *context type* each. Based on our hypotheses, we looked for an interaction between *context type* and *contour*, which was not significant, however ( $F(659.21) = 0.35, p = 0.55$ ). There was only a significant main effect of *contour* ( $F(37.20) = 9.59, p < 0.01$ ), but none of *context* ( $F(23.63) = 1.65, p = 0.21$ ). Fig. 2 shows that rising contours were rated better than falling ones, independent of context type. There is a numerical trend that the -NoA contexts were rated slightly higher than their counterparts, but this difference was not significant.

### 2.4. Discussion

The results of Exp1 partly contradict the theoretical hypotheses: falling WhQ were rated worse than rising ones although the lit-

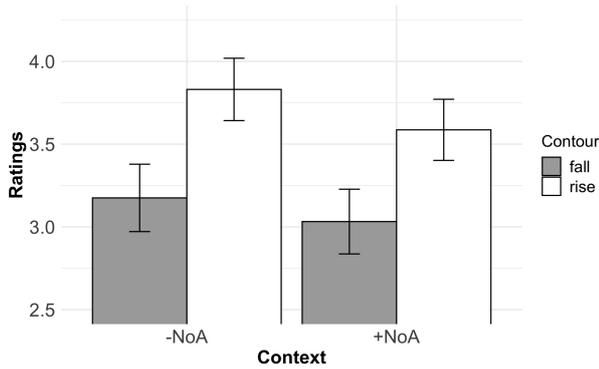


Figure 2: Average ratings with 95%-confidence interval (Exp1).

erature identifies the former as the default prosody. One may have argued that it is odd to hear a WhQ in a context in which it was not yet established *whether* an event happened or not (e.g., through a prior polar question). However, there was no effect of *context type*, so both the contexts allowing and disallowing the NoA were rated the same.

The preference for a rising intonation may be due to the instructions that explicitly focused participants on judging the intonation of the WhQ. Experiment 2 (Exp2) is a control experiment, in which participants were instructed to rate the context question pair, without mention of intonation or speech melody.

### 3. Experiment 2

Exp2 replicated Exp1 but with altered instructions.

#### 3.1. Participants

Twenty German native speakers (15 female, 5 male) between 20 and 29 years participated in total. As in Exp1, most of them were born and raised in the south-western part of Germany.

#### 3.2. Methods

The experimental items, as well as the platform used, remained the same as in Exp1, but this time we conducted the experiment online. All participants were asked to use computers only (mobile devices like phones or tablets were disallowed) and they had to assure to wear headphones during the whole experiment. The overall procedure was the same as in Exp1. The crucial difference was in the instructions: In Exp1, we explicitly asked the participants to rate the acceptability of the *intonation* of the question in relation to the context. This time we did not mention anything about intonation and requested a rating about the acceptability of the *question* itself in the given context.

#### 3.3. Results

The modelling was the same as in Exp1 and again the interaction was not significant ( $F(376.16) = 2.14, p = 0.14$ ). The final model, after removal of data points with residuals larger than 2.5, showed a significant effect of *context* ( $F(25.91) = 38.71, p < 0.001$ ) as well as of *contour* ( $F(17.99) = 5.61, p = 0.029$ ). Fig. 3 illustrates the main effect of *context type*: -NoA contexts were rated significantly higher than +NoA contexts. Also, the plot demonstrates in accordance to the second main effect a preference for rising compared to falling contours.

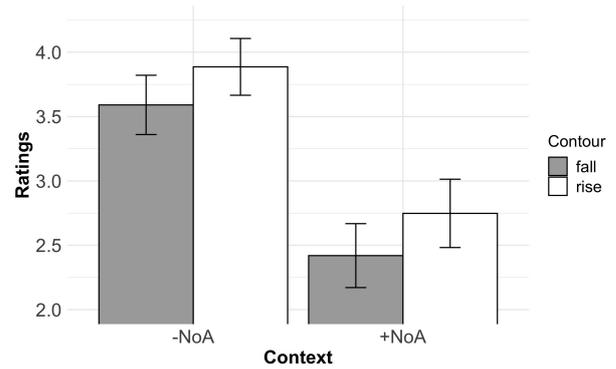


Figure 3: Average ratings with 95%-confidence interval (Exp2).

To directly compare the ratings across experiments, we pooled the data and tested for a three-way interaction between *context*, *contour* and *experiment*. The three-way interaction was not significant ( $F(1195.88) = 1.7038, p = 0.19$ ), but there was a sign of an interaction between *context* and *experiment*. Therefore, we fitted a model looking for an interaction of those two predictor variables as well as for a main effect of *contour*. Results showed a main effect of *contour* ( $F(1199.45) = 53.36, p < 0.001$ ), of *context* ( $F(1206.02) = 77.54, p < 0.001$ ) and of *experiment* ( $F(53.86) = 4.91, p = 0.031$ ) as well as the previously observed two-way interaction between the latter variables ( $F(1199.08) = 47.46, p < 0.001$ ).

#### 3.4. Discussion

Exp2 showed that instructions that do not focus the participants' attention on the intonational realisation of the stimuli lead to different evaluations of the context. Trials, in which the context allowed the NoA (+NoA) were rated significantly worse than those, in which the context disallowed it (-NoA). Regarding the role of intonation, the preference for rising intonation could be replicated. It may be argued that a wh-contour, which carries the rising features of an unspoken polar question (PQ) - *whether anything happened* - is perceived as more acceptable.

### 4. General discussion

The results of both experiments did not confirm the theoretical hypotheses. We had expected high ratings for rising WhQ in -NoA contexts and for falling ones in +NoA contexts, i.e. an interaction between intonation and context (e.g., cf.[26, 27]). It turned out, however, that participants perceived the presented contour in both experiments very prominently and the contexts in Exp2 to a bigger extent than in Exp1. Contour and context did not interact in any of the two experiments. So, we cannot confirm the theoretical framework as proposed in the introductory section and the original assumption that rising WhQ are used to explicitly exclude the NoA from the spectrum of answers was not verified.

Nevertheless, the experiments delivered interesting findings about the perception of the intonational realisation of WhQ and how they are pragmatically distributed. Three striking main effects were identified: While there was only a main effect of *contour* in Exp1, in Exp2, both *contour* and *context*, were significant. A possible explanation for the overall preference of rises could be the normative rule that questions should always have such prosody - this is at least what children typically learn in

their early years of school. Thus, people might have perceived falling WhQ as odd, although the default prosody of German WhQ in conversational speech (cf. [37]) is falling. Alternatively, the higher ratings for rises could be due to paralinguistic interpretations of prosody: Rising utterances are often perceived as more polite than other prosodic realisations [19, 20]. These interpretations suggest that participants did not take context into account in their ratings in Exp1. This could be due to a lack of an adequate discourse model or because the contour has been presented more recently, which might have increased its availability for the participants.

With the changed instruction in Exp2, the perceived relevance of contextual embeddings of the WhQ has significantly increased. The most weighty explanation for the better acceptance of -NoA contexts is the missing evidence for a sufficiently answered PQ in +NoA contexts. Participants might have been confused by those contexts because they do not deliver enough information, such that the existential implication can be considered true. Of course, this was intended because we wanted to measure exactly this phenomenon, but nevertheless, people might have missed a clarifying PQ like “*Did anybody call?*” before the WhQ “*Who called?*”. This explanation would be based on the so-called *hierarchy of questions* ([38, 39]): If A decides to ask a WhQ, B infers via a conversational implicature that the hierarchically higher positioned PQ has already been answered, such that the (subsequent) WhQ makes sense. Importantly, the PQ does not have to be explicitly answered, it does not even have to be answered at all - the only thing that matters is that B *assumes* it had been answered already (implicitly or explicitly). This could explain why the +NoA contexts have not been rated extremely bad and are, therefore, supposedly not considered to be pragmatically unnatural. Regardless of the contextual effects, peoples’ ratings got still influenced by the prosodic realisations of the WhQ, although the two were supposedly not integrated. The impact of intonation in Exp2 should therefore not differ from what we discussed in the previous paragraph.

Another semantic-pragmatic approach to explain the preference of -NoA contexts could be found by extending the work of [40] on alternative questions to WhQs<sup>4</sup>. The starting point is the observation that falling prosody is used to *exhaust* the set of alternatives to which the speaker is trying to draw attention (A-alts). Rising prosody, on the contrary, indicates a non-exhaustive set of A-alts [41]. Consider (2) by adding either rising or falling prosody to the last alternative.

The intervening stops are Gorg ↑, Verneda ↑, La Pau ↓ (2)

Additionally, in questions, the speaker typically asks the addressee to select one<sup>5</sup> alternative out of the A-alts raised. Thus, the speaker must consider that one A-alt is true and that the set of A-alts is therefore *sufficient*. Putting (non-)exhaustivity and sufficiency together, the falling, A-alt-exhaustifying question (3) presumes that either A or B was at the party, whereas the rising, non-A-alt-exhaustifying question (3) also allows another alternative to be true, like “*C was at the party*”.

Was A at the party ↑, or B ↑? (3)

By transferring this reasoning onto WhQs, we assume that the A-alts induced by the WhQ “*Who came?*” correspond

<sup>4</sup>Note that this approach also suggests an interaction between context and contour (though in the opposite direction than hypothesised), which we could not confirm.

<sup>5</sup>We intend the semantic meaning “*at least one*” of the numeral “*one*” in this article.

to the propositions in the AltSem denotation. Given A-alt-exhaustivity and sufficiency, the falling WhQ signals that the speaker assumes that one proposition in the denotation is true, making the NoA unacceptable. This is the default. In contrast, given sufficiency but non-A-alt-exhaustivity, the rising WhQ does not signal any such assumption, and it is thus compatible with the speaker considering the NoA acceptable.

Moreover, all of our findings may have been influenced by the instructions the participants received initially. In Exp1 they were explicitly asked to rate the adequacy of the *intonation*, and in Exp2 they should judge the *question* itself - both in relation to the context. Interestingly, an effect of prosody could be found in both experiments, although the participants’ focus was not put on it in Exp2. Also, despite the fact that in both experiments the participants were requested to relate their judgements to the contexts, the data reveals a context effect only in Exp2. Accordingly, the interaction between *experiment* and *context* shows that participants were biased based on how they were instructed, especially because the rest of the experimental setup did not change.

In future research, one would have to use similar sample sizes and data collection (in the lab or online) across experiments. We do not think that the different data collection was a strong factor, though, since an online replication of Exp1 yielded similar results [42].

Furthermore, we plan to conduct a production study or a corpus analysis of existing WhQ to obtain a more detailed picture of situations in which WhQ are uttered. By doing so, one could figure out more precise scenarios fitting either rising or falling WhQ and whether or not intonation is related to the status of the ExImp, the NoA, sufficiency or exhaustivity. Also, this would allow us to test whether prosodic features other than the final fall or rise may play a role [19, 43, 44]. Correspondingly, one should run another experiment to test the extent to which an alternated instruction biases the participants’ focus in perception studies.

## 5. Conclusion

A rating study investigated the adequacy of rising and falling WhQ in German, in contexts that provided evidence that an event has taken place thereby excluding a null-answer (-NoA) and in contexts that did not provide such evidence thereby allowing it (+NoA). Results showed that instructions to judge the intonation of WhQ in relation to the context showed a strong preference for rising contours, independent of context, while instructions that did not mention intonation showed main effects of both contour and context. In the latter case, contexts excluding the NoA were rated better than the ones allowing it.

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