



Are you being sarcastic? Prosodic cues to irony perception in German

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Abstract

This perception study investigated the role of intonation, specifically *pitch accent position* and *pitch accent type*, in the interpretation of utterances as sarcastic. Participants from two regions in Germany, Freiburg and Trier, listened to short utterances such as *Das sieht ja umwerfend aus* (“That looks stunning”) in seven prosodic conditions. The recordings were taken from a production study [1], and participants classified them as sarcastic or sincere. Results show that in both regions, irony perception is driven by (a) the existence of a prenuclear accent and (b) the type of the nuclear accent, particularly L*+H. Reaction times for ironic responses were shorter for L*+H, as well as when a prenuclear accent was present or when the subject carried the nuclear accent. These findings underscore the importance of intonation in irony perception and have implications for the processing of non-canonical meaning in general and the interpretation of sarcasm across varieties in particular.

Index Terms: irony perception, sarcasm, prosody, intonation, German

1. Introduction

Verbal irony is a linguistic phenomenon in which the literal meaning of an utterance is at variance with its intended interpretation. This incongruity can be signaled by various cues such as contextual information, lexical markers, facial expressions, or gestures [2–6]. Moreover, prosody seems to play a crucial role [1, 7–10], which is the primary focus of this study. We concentrate on sarcastic irony in the present study and use the term ‘irony’ specifically to refer to sarcasm (for a distinction between sarcasm and irony, see e.g., [1]). While much of the existing research on irony has focused on speech production, including f0, intensity, voice quality, and speaking rate, the present study takes a perceptual approach and studies the role of intonation in the interpretation of sarcasm in German. Specifically, the study investigates whether a) the existence of prenuclear pitch accents and b) the type of the nuclear pitch accent will make listeners in two regions of Germany (Freiburg vs. Trier) interpret an utterance as sarcastic.

With respect to intonational markers of irony, no specific intonation pattern has so far been identified that will signal irony. However, the intonation contour of ironic utterances is described as rather low, narrow, and flat [11, 12]. For German, a rising-falling contour (L*+H) has been associated with sarcasm [13, 14]. Findings from perception corroborate this observation from production: [15] tested which combinations of peak alignment and register height were associated with a

sarcastic context when competing with a neutral and a surprised context. Results showed that German listeners favor a late f0 peak for sarcastic interpretation in both low and high registers [15].

The present study builds on a previous production experiment [1] that investigated the intonational pattern (pitch accent placement and pitch accent type) of specific sentence structures (*wh*-exclamatives and verb-second-declaratives) produced in an ironic and in a sincere context by speakers from two regions in Germany, Freiburg and Trier. To signal irony, speakers in both regions added prenuclear accents (e.g., *DAS sieht ja UMwerfend aus* ‘That looks stunning’; capitalization indicates pitch accents). In nuclear position (e.g., *UMwerfend* ‘stunning’), ironic utterances showed a smaller pitch range compared to sincere ones, with irony encoded phonologically by H* and sincerity by L+H*.

Building on these findings, we here focus on identifying the prosodic cues (pitch accent type and pitch accent position) that render an utterance, i.e., the verb-second-declaratives from [1], e.g., *Das sieht ja umwerfend aus* ‘That looks stunning’), more likely to be interpreted as ironic. The perception experiment is based on the following hypotheses: First, utterances are more likely to be perceived as ironic when they show a pitch accent in prenuclear position, in addition to the nuclear one (e.g., *DAS sieht ja UMwerfend aus* ‘THAT looks STUNning’). Second, the accent on the adjective (e.g., *umwerfend* ‘stunning’) is hypothesized to play a crucial role in irony interpretation. Based on prior research, H* [1] and L*+H [13–15] are expected to be strong indicators for irony.

By investigating irony perception in two regional varieties of German (regions Freiburg and Trier), the present study also aims to determine whether listeners in these regions rely on the same prosodic cues when identifying irony. Regional varieties are known to differ in the preference for certain pitch accent types [16, 17]. For instance, in Low Alemannic (i.e., the Freiburg region), the L*+H pitch accent is frequently used [16, 18], whereas it is less frequent in Moselle Franconian (i.e., the Trier region) [19]. Results from the study in [1] also indicated regional differences in pitch accent type, irrespective of whether speakers intended an utterance as ironic or sincere: Speakers from Trier generally preferred H*, while those from Freiburg used L*+H more often. These regional differences, along with the association of the L*+H accent with irony [13–15], could influence the perception of irony in each region. Specifically, we expect that listeners from Freiburg will rely less on L*+H as a cue to irony than listeners from Trier.

In addition to listeners’ meta-linguistic classifications of utterances as sarcastic or sincere, we also collect reaction times as a measure of processing effort (cf., e.g., [20–22]). In a

perception experiment from [22], listeners categorized literal and ironic short utterances in Standard Austrian German by pressing the appropriate button on a keyboard. They responded faster when their answer was correct, which is attributed to a shorter decision time for utterances with unambiguous cues. Along these lines, we expect that reaction times will reflect the processing effort in classifying utterances as ironic or sincere. The less ambiguous the prosodic cues, the faster the processing and decision-making, as unambiguous cues reduce cognitive effort and facilitate classification. Specifically, utterances with higher rates of ironic classification (i.e., those with accentuation in the prenuclear position or with the accent types H* or L*+H), are expected to show shorter reaction times in both groups.

2. Methods

We ran an online forced-choice experiment in which participants from Freiburg and Trier classified utterances as ironic or sincere. The study was approved by the Ethics Board at the Trier University and all participants gave written consent.

2.1. Materials

Five target sentences of the type *Das* ‘That’ + verb + *ja* (modal particle) + adjective (+ *aus* (verb particle)) from a previous production study [1] were selected and partially modified for the perception experiment: (1) *Das sieht ja prima aus* (‘That looks great’), (2) *Das ist ja romantisch* (‘That is so romantic’), (3) *Das klappt ja super* (‘That works well’), (4) *Das sieht ja umwerfend aus* (‘That looks stunning’), and (5) *Das sieht ja wundervoll aus* (‘That looks wonderful’). For each of these five sentences, realizations were selected that had originally been produced by speakers in sincere (N = 17 files), neutral (N = 10 files), or ironic contexts (N = 13 files).

The utterances were selected to yield seven prosodic conditions, combining different pitch accent positions (on the adjective, *Das* + adjective, or *Das*) and pitch accent types on the adjective (L+H*, H* or L*+H), see Table 1. The accent type on *Das* is always H*. The absence of a prenuclear accent on *Das* is represented as NA in Table 1.

Table 1: Overview of the prosodic conditions (PCs).

PC	Prenuc. accent	Accent position	Accent type on <i>Das</i>	Accent type on adj.	Encoding
1	no	adjective	-	L+H*	NA_L+H*
2	no	adjective	-	H*	NA_H*
3	no	adjective	-	L*+H	NA_L*+H
4	yes	<i>Das</i> + adj.	H*	L+H*	H*_L+H*
5	yes	<i>Das</i> + adj.	H*	H*	H*_H*
6	yes	<i>Das</i> + adj.	H*	L*+H	H*_L*+H
7	no	<i>Das</i>	H*	-	H*_NA

Also, realizations were selected such that each of the five sentences was spoken by a speaker from Freiburg and a speaker from Trier (samples were generated from a pool of 24 different speakers). For those conditions for which no example was found in the data from [1], an original recording from [1] was manipulated (N = 30 files). Specifically, the ‘‘missing’’ prosodic conditions were created, for example by cross-splicing an accented or unaccented syllable or by modifying the pitch and duration of individual syllables.

Stimuli thus consisted of five sentences uttered in seven prosodic conditions by two speakers, one from Trier and one Freiburg, resulting in a total of 70 utterances (5 sentences x 7 prosodic conditions x 2 regions).

The reason for using stimuli from the production experiment in [1] instead of creating new recordings was the following: We aimed at investigating natural language, specifically how irony is realized in elicited speech based on contextual scenarios. Since the stimuli from the production experiment were specifically designed to reflect natural speech in both sincere and ironic contexts, using these recordings allowed us to study how irony is recognized in ‘‘real-world’’ utterances. Additionally, the utterances were produced by 24 different speakers from two different regions (instead of only one model speaker) to increase the validity of the results.

2.2. Procedure

The perception experiment was conducted online using Labvanced [23]. The 70 utterances were played in randomized order, hence every listener received a different order. Listeners were instructed to classify each utterance as either sincere or sarcastic by pressing the keys *F* (for sincere) or *J* (for sarcastic) on the keyboard. In addition, reaction times were recorded from the end of each utterance (to ensure that speaking rate did not influence the timings). Participants were asked to use headphones to perform the task. Prior to the classification task participants filled in a background questionnaire including socio-demographic data and the participants’ use of and familiarity with their regional accent. The entire experiment took approximately 15 minutes, and participants had the chance to win a voucher as a reward for their participation.

2.3. Participants

A total of 40 listeners from Freiburg and 40 listeners from Trier participated in the experiment. All were native speakers of German and born and raised in the respective region. The participants from Freiburg were 31.0 years old on average (sd = 5.8 years), the participants from Trier were 28.4 years old on average (sd = 5.8 years). Beyond age, groups corresponded with respect to several other socio-demographic variables such as gender, level of education, and foreign language proficiency.

2.4. Data cleaning and statistical analysis

A total of 5600 responses were collected (70 utterances x 80 listeners; 400 responses per prosodic condition and region). Responses were recorded as either sarcastic or sincere. 18 additional respondents were not analyzed for various reasons, e.g., bogus answers in the questionnaire, always pressing the same reply button, or extremely short reaction times (< 1 second from the beginning of the utterance) that indicated random pressing without listening to the utterances. Also, only reaction times longer than 0 ms (from the end of the utterance) and shorter than 5000 ms were included in the analysis of reaction times, following [24]. Thus, 444 data points (7.9%) were excluded from the analysis of reaction times.

For statistical analysis, we ran mixed effects models in R [25] for the proportion of classifications as ironic vs. sincere (see 3.1) and the reaction times of the responses (see 3.2). To analyze the proportion of ironic classification (see 3.1), we fitted a logistic mixed-effects model (*glmer*) with response (*ironic* vs. *sincere*) as dependent variable. Prosodic condition, region (of the listeners), and speaking rate (syllables/sec) were

modeled as independent variables. For the analysis of reaction times (see 3.2), we fitted a linear mixed-effects model (*lmer*), with reaction time as the dependent variable. Prosodic condition, response (*ironic* vs. *sincere*), and region were modeled as independent variables. Both models included random intercepts for subjects and items. Random slopes for prosodic condition with respect to subjects and items were included if this improved the model fit [26].

3. Results

The following results comprise both the proportion of classifications as ironic (3.1) and the reaction times of the responses (3.2) for each prosodic condition and region.

3.1. Proportion of ironic classifications

Figure 1 shows the proportions of classifications as ironic per prosodic condition and listener region. In both regions, for utterances without a prenuclear accent (NA_L+H*, NA_H*, and NA_L*+H), L+H* receives the fewest ironic classifications (9% in Freiburg and 7% in Trier), the accent type H* results in moderate irony classification rates (24% in Freiburg and 30% in Trier), while utterances with a nuclear L*+H on the adjective are most often classified as ironic, with 51% in Freiburg and 60% in Trier, as illustrated in Figure 1.

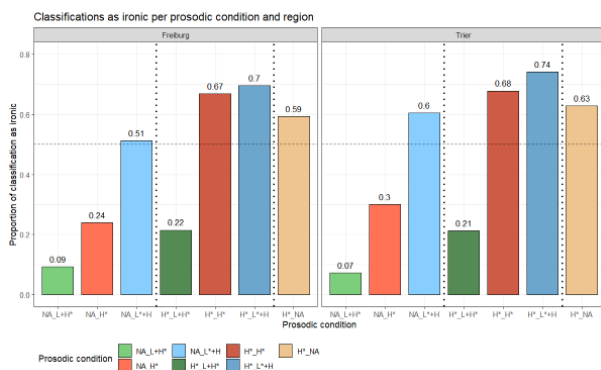


Figure 1: Proportion of ironic classifications per prosodic condition and region. Accent types are color-coded: green for L+H*, red for H*, and blue for L*+H, with darker shades indicating the presence of an additional prenuclear accent (H*). The beige bar represents accentuation solely on Das (H*).

The presence of an additional prenuclear accent (H*_L+H*, H*_H*, and H*_L*+H), makes the interpretation of an utterance as ironic more likely: for L+H*, ironic classifications reach 22% in Freiburg and 21% in Trier, while for H*, the rates increase to 67% in Freiburg and 68% in Trier. Similarly, for L*+H, irony classification rates rise to 70% in Freiburg and 74% in Trier. The prosodic condition H*_NA, with accentuation solely on *Das*, shows a proportion of ironic classifications with 59% in Freiburg and 63% in Trier.

A t-test against chance (50%, responses summarized by subjects) indicated that responses for both groups (Freiburg and Trier) were significantly different from chance in all prosodic conditions ($p < 0.05$), except for the prosodic condition NA_L*+H in the Freiburg group ($p = 0.70$). Hence, although some conditions were less clearly associated with one interpretation or the other, all conditions were systematically

assigned to a specific reading (*ironic* vs. *sincere*). This finding suggests that prosody is not arbitrary; on the contrary, it plays a crucial role in irony interpretation.

Specifically, the *glmer* revealed no interaction between prosodic condition and region ($p = 0.17$), nor a main effect of region ($p = 0.30$), but an effect of prosodic condition ($p < 0.001$), and an effect of speaking rate ($p < 0.001$): Hence, listeners from Trier vs. Freiburg were not affected differently by the prosodic cues in their judgements. They rather seemed to rely on the same cues: speaking rate and prosody. The lower the speaking rate, the higher the classification rate as ironic.

Prosody was found to play a key role in the interpretation of utterances as ironic. Specifically, post-hoc group comparisons (averaged across region), using the function *emmeans()*, revealed the following pattern for the accent on the adjective L+H* < H* < L*+H (for all comparisons $p < 0.0001$, except for H*_H* vs. H*_L*+H, where there is no difference, $p = 0.13$). In other words, L+H* was less often interpreted as ironic than H*, which in turn was less often interpreted as ironic than L*+H. Second, group comparisons revealed that prosodic conditions including a prenuclear accent were more often judged as ironic than those without a prenuclear accent (NA < H*, for all comparisons $p < 0.0001$). Hence, the perception of irony is influenced both by the nuclear accent type and the presence of a prenuclear accent.

3.2. Reaction times

Figure 2 illustrates the reaction times (in ms) for responses across prosodic conditions, categorized by response type (*ironic* vs. *sincere*). As there are no significant differences in reaction times between the Freiburg and the Trier groups ($p = 0.14$), results from both regions are combined for this analysis.

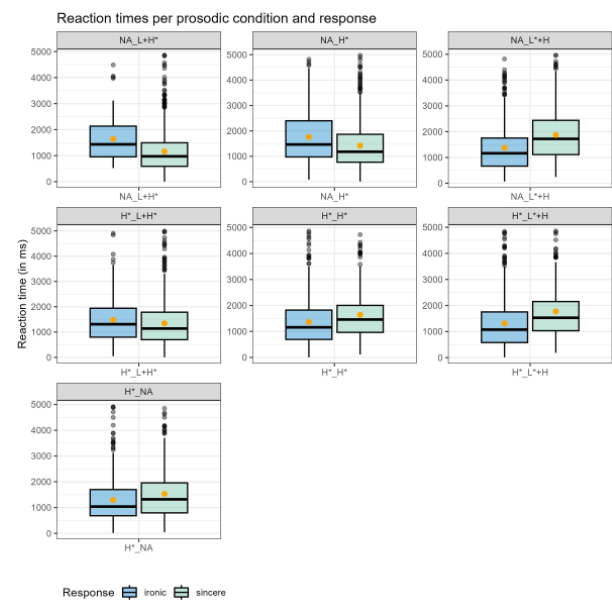


Figure 2: Reaction times (in ms) per prosodic condition and response type (*ironic* vs. *sincere*), with green bars indicating classifications as *sincere* and blue bars indicating classifications as *ironic*.

The *lmer* revealed an interaction between prosodic condition and response ($p < 0.001$) and significant differences across the prosodic conditions: Group comparisons confirm significantly shorter reaction times for sincere responses than for ironic classifications in the prosodic conditions NA_L+H* ($p < 0.0001$), and NA_H* ($p < 0.0001$), no difference in reaction times in the prosodic condition H*_L+H* ($p = 0.12$), and shorter reaction times for ironic classifications in the prosodic conditions NA_L*+H ($p < 0.0001$), H*_H* ($p < 0.0001$), H*_L*+H ($p < 0.0001$), and H*_NA ($p < 0.0001$).

Thus, without a prenuclear accent, for the accent types L+H* and H* (NA_L+H* and NA_H*), reaction times are shorter for sincere responses than for ironic classifications. In contrast, for the accent type L*+H (NA_L*+H), reaction times are shorter for ironic classifications. With a prenuclear accent present, reaction times of sarcastic and sincere responses do not differ when the accent type L+H* occurs (H*_L+H*), and are shorter for ironic responses in the prosodic conditions with the accent types L+H* and H* (H*_L+H* and H*_H*). The prosodic condition with the accentuation solely on *Das* (H*_NA) exhibits shorter reaction times for ironic classifications than for sincere ones.

In summary, reaction times for ironic responses are shorter compared to sincere responses when the accent type is L*+H (irrespective of the occurrence of a prenuclear accent), as well as when an additional prenuclear accent is present with L+H* or H* on the adjective, or when the accentuation is placed solely on *Das*. Interestingly, these are exactly the four prosodic conditions with the highest irony classification rates (NA_L*+H, H*_H*, H*_L*+H, and H*_NA). Thus, subjects were very quick to make a decision when the case was obvious.

4. Discussion

The present study investigated the role of intonation in the interpretation of utterances as ironic, focusing on both the proportion of classifications as ironic and the reaction times of responses across seven prosodic conditions. Our findings revealed that prosody is a sufficient cue to interpret irony in the absence of context. In particular, German listeners used both accent position and nuclear accent type for the classification of utterances as ironic vs. sincere.

First, as expected based on prior production data [1], utterances were more likely to be interpreted as ironic when a) there was a prenuclear prominence in addition to the nuclear accent (e.g., *DAS sieht ja UMwerfend aus* ‘THAT looks STUNning’) and b) when only *Das* carried an accent (i.e., when the focus was shifted to the first constituent). Why might the presence of prenuclear accents and early nuclear prominences be a cue to irony? As discussed in [1], the prominence on *Das* (both prenuclear and nuclear) draws listener attention to the proposition of the utterance and may thus emphasize the non-literal meaning of the sentence, which in turn could facilitate the ironic interpretation (see also [27, 28] for discussion on prominence shift and non-canonical meanings, and [29] specifically for ironic interpretation in German).

Second, the accent type on the adjective (e.g., *umwerfend* ‘stunning’) significantly influenced the interpretation as ironic, following the pattern L+H* < H* < L*+H, i.e., L*+H was most strongly associated with irony. While previous research suggested H* as a key marker for irony in production [1], our findings align more closely with [13–15], where the accent type L*+H was associated with irony. Thus, L*+H was the most

effective accent type in triggering ironic reading. Previous research on German intonation has shown that rising-falling pitch accents with a late f0 peak (L*+H) are used for signaling other pragmatically loaded phenomena, such as surprise or unexpectedness [30]. Given this link, we propose that the accent type L*+H further reinforces the non-literal meaning, making irony more salient.

The association of L*+H with sarcasm confirms some previous results [13–15], but is at variance with others [1], where speakers showed a preference in production for H* over L*+H in ironic utterances. This discrepancy suggests that the markers used for irony in production might not necessarily be the same used in perception. The late-peak accent L*+H might represent a conventionalized stereotypical intonation pattern with a strong interpretative power to irony, which in natural conversations might in fact occur less frequently.

Reaction times confirm that both accent position and accent type play a crucial role in irony interpretation, indicating that shorter reaction times reflect lower cognitive processing effort in classification (cf., [20–22]): Participants responded faster when 1) the adjective carried an L*+H accent (as opposed to H* and L+H*), 2) an additional prenuclear accent was present, or 3) *Das* was the only accented element. These prosodic characteristics, which also had the highest irony classification rates, suggest that certain prosodic patterns (NA_L*+H, H*_H*, H*_L*+H, and H*_NA) serve as strong irony cues and, as expected, thus facilitate faster irony processing. Corroborating [22], we conclude that listeners decode faster when the prosodic cues are less ambiguous, requiring less processing effort.

Another important question was whether listeners from Freiburg and Trier rely on the same prosodic cues to identify and process irony. While based on research on regional intonation in German [16, 18, 19] it could have been hypothesized that listeners from Freiburg rely less on L*+H as a cue to irony than listeners from Trier, our data showed no such regional effect: both groups used the same prosodic cues, i.e., accent position and accent type, to interpret irony. Hence, irony recognition appears to follow consistent prosodic principles that remain the same across regional varieties of German.

Taken together, our results highlight the central role of pitch accent type and accent position in irony perception, shedding light on how prosody shapes non-literal meaning interpretation in German. However, several limitations suggest directions for future research. First, while the use of naturally produced stimuli allowed us to study irony as it occurs in natural speech, these stimuli contained confounding factors, such as speaker variability or other cues to irony (e.g., differences in voice quality). Future studies using systematically manipulated stimuli could isolate the impact of the prosodic characteristics. Second, our binary classification task (sincere vs. ironic) does not allow to determine whether participants truly perceived irony or simply non-sincerity. A follow-up study using free-response tasks could clarify whether listeners explicitly interpret these utterances as ironic. Finally, we focused primarily on intonation, investigating accent position and accent type, but irony perception relies on multiple acoustic cues (e.g., [10, 22, 31]). The observed effect of speaking rate suggests that duration is another key factor in irony detection, and voice quality might also contribute (cf., [12, 32]). Future research needs to systematically investigate these additional cues to develop a more comprehensive model of irony perception.

5. References

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