Abstract

We report a production experiment and two perception studies examining the prosodic characteristics of constituents associated with the stressed variant of the German particle auch ‘also’ in potentially ambiguous constructions. The results show that these elements are marked by perceptually relevant rising pitch accents, but that there is no 1:1 mapping between the prosodic realization and the status of being associated with auch.

1. Introduction

It is a well known fact that the stressed variant of the German additive focus particle auch ‘also’ – in contrast to its unstressed counterpart – associates with a constituent to its left. The associated constituent (AC), which is not confined to a specific syntactic position, represents the element added to a contextually given set by means of the particle – in (1), Martin is added to the set of hungry beings.

(1) [Martin]AC hat AUCH Hunger.

The syntactic, semantic, and information structural properties of constructions with stressed auch have been subject to much discussion, see [5] and [3], among others. At the same time, the relevance of prosodic factors did not go unnoticed. Krifka [3] argues that ACs of stressed auch are contrastive topics, which, however, are not obligatorily marked by a rising contrastive accent. Previous experimental work (cf. [1]) showed that the marking of contrastive topics is gradual and involves a characteristic interplay of fo, duration, and alignment variables.

Concerning the prosodic marking of association with stressed auch, constructions with two potential ACs to the left of the particle provide a suitable subject for investigation, as they should call for a disambiguation by prosody. A production study was designed to explore the individual prosodic parameters (Sec. 2); subsequent perception studies (Sec. 3 and 4) tested the impact of the marking on the interpretation.²

2. Experiment 1: Production study

In Exp. 1, minimal pairs of utterances were elicited by contextually triggering auch to associate with one of two possible elements. In this way, prosodic factors relevant for the marking of ACs in two different positions (sentence initial vs. non-initial) could be identified.

²We wish to thank Bettina Braun for discussion and D. R. Ladd for helpful comments on earlier stages of this work. The project was funded by the DFG research group ‘Linguistic Foundations of Cognitive Science’ (FOR 349, D1).

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2.1. Data elicitation

Participants. 7 female native speakers of German (aged 20 to 26) without any linguistic background or awareness of our analysis intentions participated in the experiment.

Materials. 5 pairs of sentences ambiguous with respect to the AC of auch were constructed, the potential ACs always being the subject and a temporal adverbial realized by three-syllabic constituents with penultimate stress. The two sentences of each pair only differ in the relative order of the potential ACs, located in the so-called prefix field (PF) and middle field (MF), i.e., preceding and following the finite verb, respectively (cf. (2)).

(2) Der Rudi hat im Juni ... / Im Juni hat der Rudi ...
    the Rudi has in June ... in June has the Rudi ...
    wahrscheinlich auch einen Vortrag gehalten. probably also a talk given

In the 5 lexicalizations, the number of syllables is identical before the particle and roughly the same after it. Within each sentence, the potential ACs are kept parallel with respect to syllable structure, vowel length and vowel height (stressed and post-stressed syllable) to control the effects of the phonetic properties (e.g., intrinsic fo, cf. [4]). For every lexicalization, two contexts were constructed, each triggering one of the possible associations with auch, cf. the English translations in (3) and (4).

(3) Can you tell me who of the PhD students gave a talk in June? I heard that only Martin gave one at that time.
(4) Can you tell me when Rudi gave talks this term? I only know of the one in May.

The combination of the two contexts with the two target sentence versions results in 4 experimental conditions, the independent variables being the position (PF vs. MF) and function (subject vs. adverbial) of the intended AC. The 20 critical items were supplemented by 20 filler items also involving the context-dependent resolution of ambiguity.

Procedure. Subjects had to read a visually presented combination of context and target item silently, listen to the auditory presentation of the context (which had been recorded by a professional speaker) and produce the target sentence. Repeated productions (with the context replayed each time) were allowed when subjects believed their utterances to be unnatural or inappropriate. The target utterances were digitally recorded.

The 40 items were randomized anew for each subject in such a way that the minimal pairs are disguised. A short practice session (5 items) served to familiarize the subjects with the task. In the course of the actual experiment, subjects could take several short breaks. Items produced with pauses, hesitations, or slips of the tongue were repeated at the end of the session, again...
randomized and interspersed with fillers. The total duration of the experiment was about 45min.

2.2. Data analysis

Data selection. The utterances of one speaker were excluded from the analysis as a post-experimental interview revealed that the sentences with stressed arch had attracted her attention. 13 utterances had to be excluded for various reasons (production of the unstressed variant of arch, change of the prosodic strategy in the middle of the utterance, hesitation, defective recording). Altogether, 107 utterances could be included in the analysis.

Annotation and measurements. On the basis of the GToBI system (cf. [2]), pitch accents were annotated. Syllable boundaries and the onsets of the stressed vowels for the two potential ACs in each utterance were labeled using information from waveform and spectrogram. f0 was extracted,\(^2\) and after a manual correction of artifacts, the contours were linearly interpolated and smoothed. As the f0-contours are highly consistent within all 4 conditions, mean contours could be computed.

For both potential ACs in each utterance, the following dependent variables were determined: f0-min (local f0-minimum preceding the rise), f0-max (local f0-maximum), df0 (difference between f0-max and f0-min), dur-s23 (duration of the stressed and post-stressed syllable), al-min and al-max (alignment of the f0-minimum and -maximum with respect to the onset of the stressed vowel). The choice of the variables was based on the observed contour shape and the hypotheses (see below).

2.3. Hypotheses

H1: ACs of stressed arch are marked by L*H accents.

H2: ACs of stressed arch show a greater f0-rise (caused by a lower f0-minimum or a higher f0-peak or both), a longer duration (due to lengthening of the stressed syllable or larger domains), and a later accent alignment than non-ACs (i) in the same position (comparison between utterances) and (ii) in a different position (comparison within utterances).

2.4. Results

2.4.1. Qualitative results

ACs are always marked by rising accents: L*H (81.3%) or LH*. Non-ACs, however, also frequently (prefield: 80.8%; middlefield: 29.1%) carry an accent: L*H, LH*, or H*. The accent type of the ACs does not affect the overall contour shapes, which are illustrated by the mean contours in Fig. 1. Together with the mean values of the dependent variables, the contours suggest that the prosodic marking of the ACs is independent of their syntactic function. Consequently, no difference was made between subjects and adverbials in the statistical comparisons.

2.4.2. Quantitative results

Comparison between utterances. In the minimal pairs of lexically identical utterances, comparisons were made between associated and non-associated constituents in identical positions. The mean values of the individual variables as well as the statistical results are given in Tab. 1. The ACs show a significantly lower f0-minimum, higher f0-peak, longer duration,\(^2\) and later peak alignment than their non-associated counterparts. There is no significant effect for the alignment of the local minimum.

Comparison within utterances. Due to the controlled materials (cf. Sec. 2.1), ACs and non-ACs could also be compared within utterances (except for f0-min and al-min, the local minimum being mostly located in the non-controlled pre-stressed syllable). PF and MF association were evaluated separately, as their respective patterns differ considerably (cf. Fig. 1). Significant effects for the relevant variables were found for both PF and MF association, with the exception of al-max for MF association, cf. Tab. 2. The direction of the effects is the same as in the comparison between utterances. In addition, for all 4 variables, the differences between ACs and non-ACs are significantly greater for PF association than for MF association.\(^7\)

2.5. Discussion

H1 was confirmed to the extent that ACs of stressed arch are marked by rising pitch accents. However, the identification of ACs cannot be based on their accents, as non-ACs often carry accents of the same type. Here, the quantitative analysis reveals the decisive factors: ACs and non-ACs significantly differ with respect to f0-minimum, -maximum, and -rise, duration, and peak alignment, which substantially confirms H2.

The syntactic function of the ACs seems not to have any influence on their prosodic realization. In contrast, the prosodic marking is affected by the position of the AC: With respect to the relevant variables, the differences between ACs and non-ACs are greater for PF association. The marking of middlefield ACs is only slightly stronger than the marking of the respective non-associated prefield elements. Nevertheless, we expect the second accent to be perceived as more salient, facilitating a correct interpretation in these cases as well. This is one of the issues to be discussed in connection with the perception studies.

\(^1\)using Praat’s autocorrelation algorithm

\(^2\)To determine the domain of lengthening, all 3 syllables were independently compared, showing significant differences only for the 2nd and 3rd syllable. Therefore, dur-s23 was used for the overall statistics.

\(^4\)t-test for unrelated measures, two tailed, p < .001 for f0-max, df0, and al-max, and p < .009 for dur-s23

![Figure 1: Mean contours for PF (upper panel) and MF association (lower panel); gray: AC = subject, black: AC = adverbial](image-url)
### 3. Experiment 2: Perception study

By means of a completion task, Exp. 2 investigates to what extent hearers use the encoded prosodic information for the disambiguation of the utterances produced in Exp. 1.

#### 3.1. Method

**Participants.** 32 native speakers of German (mean age 24.8) participated in the experiment. They were naive with respect to the problem examined.

**Materials.** The original utterances of 5 speakers from Exp. 1 (except the defective or unacceptable utterances that had not been included in the analysis) served as stimuli. The 91 critical responses in the perception experiment.

**Procedure.** Subjects had to listen to an auditorily presented utterance and select one of the two continuations (pre-sented on a computer screen in a randomized left-right order). Repeated listening was possible. The 160 items were pseudo-randomized and divided into 4 blocks to enable subjects to take short breaks in between. The order of the blocks was systematically varied. The entire experiment took about 30min.

#### 3.2. Hypothesis

**H3:** The percentage of correct responses for the utterances positively correlates with \( p_{-f_{0\text{-max}}}, p_{-d_{f_{0}}}, p_{-dur_{-s_{23}}}, p_{-al_{-max}} \).

#### 3.3. Results and discussion

Of the total of 2912 responses, 72.4% were correct. However, the percentage of matching answers differs between PF (84.5%) and MF association (58.3%). Crucially, both PF and MF association show a significant correlation between the proportion of correct responses and \( p_{-f_{0\text{-max}}}, p_{-d_{f_{0}}}, \) and \( p_{-dur_{-s_{23}}} \), cf. Table 3. H3 is thus essentially confirmed.

There is, however, no significant effect for \( p_{-al_{-max}} \). Still, we cannot conclude that peak alignment is perceptually irrelevant: Its possible effects could be outweighed by effects of the other parameters. Moreover, the proportion of the contribution might differ between the parameters with significant effects, especially since the parameters are probably interrelated. A comprehensive examination of the interaction between the individual parameters and perception is beyond the scope of this study.

### 4. Experiment 3: Perception study (manipulated stimuli)

Exp. 3 has a similar design, but is based on manipulated materials. This allows us to address two open issues from Exp. 2: (i) the source of the different proportions of correct responses for PF and MF association (unbalanced materials vs. general tendency) and (ii) the possibility of establishing perceptual categories on the basis of the prosodic variables examined in Exp. 1.

#### 4.1. Method

**Participants.** 44 native speakers of German (mean age 24.0) participated in the experiment.

**Materials.** 11 versions of an utterance of (5) were produced by a systematic joint manipulation of \( f_{0\text{-min}}, f_{0\text{-max}}, dur_{-s_{23}}, \) and \( al_{-max} \) on both potential ACs using Praat’s PSOLA algorithm.

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5A simple scenario is that the parameters with significant effects are equally strong perceptual cues. Although \( r \) differs between PF and MF association and between the parameters, the correlation with the sum of \( p_{-f_{0\text{-max}}}, p_{-d_{f_{0}}}, \) and \( p_{-dur_{-s_{23}}} \) is of similar strength for PF (\( r = .555, p < .001 \)) and MF association (\( r = .557; p < .001 \)).

6The variation of \( f_{0\text{-min}} \) and \( f_{0\text{-max}} \) is automatically accompanied by a variation of \( d_{f_{0}}, al_{-min} \) was not manipulated as it did not show any significant effects in the production study.
(5) Der Wiener hat um sieben wahrscheinlich auch einen Anruf bekommen. 'The Viennese fellow probably received a call at seven, too.'

A trained female speaker produced (5), taken from the materials of Exp. 1, with a neutral intonation and a similar prominence on both potential ACs. For the two extremes – the clear cases of PF (stimulus 1) and MF association (stimulus 11) – the manipulation parameters are based on prototypical utterances of (5) in Exp. 1 that had received good results in Exp. 2, thus resembling the mean contours in Fig. 1. The target values for the 9 intermediate stimulus versions represent equal steps on the scale between the two extremes, cf. the plotted f0-tracks in Fig. 2. The resulting stimuli still sounded natural; uninformed hearers did not recognize them as being manipulated. The continuations for (5) and the fillers were taken from Exp. 2.

Figure 2: f0-tracks of the 11 stimulus versions

Procedures. The task and mode of presentation were the same as in Exp. 2. Each stimulus version was included 6 times. The resulting 66 critical items were interspersed with 66 fillers and randomized anew for each subject. A filler always separated two critical items to prevent subjects from making direct comparisons between the different versions. Subjects were informed that they would have to judge many instances of the same sentence and instructed to decide afresh each time. They could take short breaks at any time; the experiment took about 30min.

4.2. Hypothesis

H4: The two extreme stimuli show the clearest interpretation preferences: Stimulus 1 receives the highest percentage of decisions for PF association and stimulus 11 for MF association. The respective percentages are similarly high.

4.3. Results and discussion

A manual inspection of the individual subjects’ results with respect to the distribution of the judgements revealed two different patterns. From 1/3 of the subjects (group A), all 11 versions received about the same percentage of choices for PF and MF association. The results of the remaining subjects (group B) clearly differ across the stimulus versions. The aggregated results of the two groups are given in Fig. 3.

Group A obviously did not pay attention to the prosody of the critical items. As for group B, the results of Exp. 2 could be replicated: The interpretive preferences depend on the prosodic realization. Specifically, stimulus 1 was assigned the highest percentage of decisions for PF association (87.4%) and stimulus 11 for MF association (84.5%), the percentages being similar. This confirms H4. Contrary to what one might expect, the results do not show an s-shaped curve, but a rather linear relationship between the number of decisions for a particular association position and the prosodic parameters of the stimulus versions. Subjects did not assign the gradually differing stimuli to distinct perceptual categories.8

5. Conclusions

The production study revealed that ACs of stressed auch are marked by rising pitch accents, but that there is often no difference with respect to the accent type between ACs and non-ACs. However, the constituents differ in a number of prosodic properties, supporting a description in terms of continuous phonetic parameters (see Sec. 2.2) rather than categorical distinctions.8 This is in line with conclusions drawn in [1].

The perception studies have shown that the identification of the ACs is governed by the relative magnitude of the prosodic parameters characterizing the candidates. Importantly, for the comparison between the potential ACs, their positions must be taken into account: The differences between ACs and non-ACs are greater for PF association than for MF association. This is reflected in the manipulated stimuli of Exp. 3. Nevertheless, subjects recognized the extremes equally well. This also supports the conclusion that the preference for PF association, which seems to arise when prosodic information is neglected – as for group A in Exp. 3, is not at play here.

In sum, although a 1:1 mapping between association status and prosodic realization cannot be maintained, prosody clearly affects the production and perception of constructions with stressed auch.

6. References


8Note that the manipulation of al-max is not clearly visible in the middlefield in Fig. 2, as the lengthening in the prefield shifts the contours with early alignment on the middlefield constituent to the right.

8Interestingly, peak alignment, being the only phonetic variable at least to some extent reflected in the GToBI labels, does not correlate with the percentage of correct responses in Exp. 2.