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ORDER EFFECT AND THE ORDER OF ACCENTS

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ABSTRACT

The order effect causes in a "same-different" task the one presentation order to be better discriminated than the reverse order. The effect was investigated in the domain of pitch perception. Phonetic/psychoacoustic explanations are given, and parallels between the order effect and the perception of accents are discussed.

1. INTRODUCTION

The order effect (OE) has been known for more than 100 years in the field of psychoacoustics [5]; it causes in a "same-different" discrimination task (AX-paradigm) the one presentation order AB to be better discriminated than the reverse order BA. We will call the order that is discriminated better the "prominent" order and the stimulus that comes second in this order the "prominent" stimulus. In phonetics, the OE has not been dealt with very often. This might be due to the experimental design mostly used in phonetics - the ABX-task. Originally, we came across the OE in pitch perception while investigating the categorical perception of intonation contours with the AX-paradigm [4,6]. The "potbelly"-phenomenon described in part 2 was point of departure for several experiments, where we addressed the following questions:

(i) Can the OE be influenced by the experimental design?

(ii) What causes a specific order to be a prominent one?

(iii) Can the OE be traced back to general psychophysical factors?

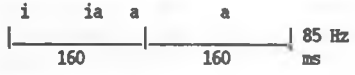
(iv) Is the OE an experimental artifact, or can it be found in real life as well?

In this paper, only a sketchy discussion of our research can be given. A thorough presentation of experiments and phonetic considerations (discussion of the state of the art) can be found in [4].

2. THE POTBELLY PHENOMENON

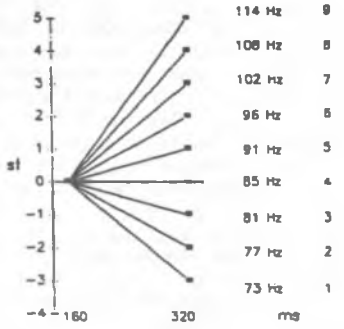
One of the authors (A.B.) produced the stimulus *ja* monotonously. The digitized stimulus (sample rate 20 kHz, cut off frequency 8 kHz) was segmented into single pitch periods. The intensity of the whole stimulus was left unchanged. The second part of the stimulus was subjected to different manipulations of the Fo contour (cf. fig.1).

Fig. 1: Segmental and durational structure



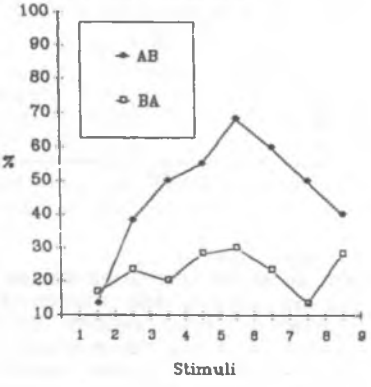
The continuum consisted of nine stimuli with a constant overall duration, three falls, one level and five rises. The duration of the manipulated part was kept constant, Fo offset and Fo slope differed. A logarithmic scale was used for the manipulation of the fundamental frequency (Fo): *semitone = 17.31*ln(Hz)*. The step from one offset height to the other was one semitone (cf. fig.2).

Fig.2: Continuum



Five repetitions of each pair (i.e. AB, BA, and the "same" order AA and BB, resp.) were presented in randomized order with an interstimulus intervall of 500 ms between the members of a pair. The pairs were separated by a pause of 3500 ms; after 10 pairs, a pause of 10 sec followed. The 12 subjects (students) were instructed to decide whether the two members of a pair were identical ("same") or different. The results are given in Fig.3. With this "potbelly shape"

Fig.3: Discrimination



function, a clear OE could be found; the order AB can be discriminated better than the order BA. The overall OE is consistent and significant in an analysis of variance, F = 60.67**. The prominent order shows a higher Fo offset in the second member of the pair.

In several other experiments, the factors duration of Fo contour, height of Fo offset, and slope were varied systematically, as well as the experimental design. The results of these experiments [4] lead to the following conclusions:

(i) The OE is no random effect, as it could be replicated in all experiments.

(ii) The OE is not an experimental artifact that can be traced back to a special design.

(iii) A stimulus is more prominent if it has a higher Fo offset and/or a longer Fo contour.

(iv) A stimulus pair is better discriminated if the prominent stimulus comes second.

3. A PHONETIC/PSYCHOACOUSTIC EXPLANATION

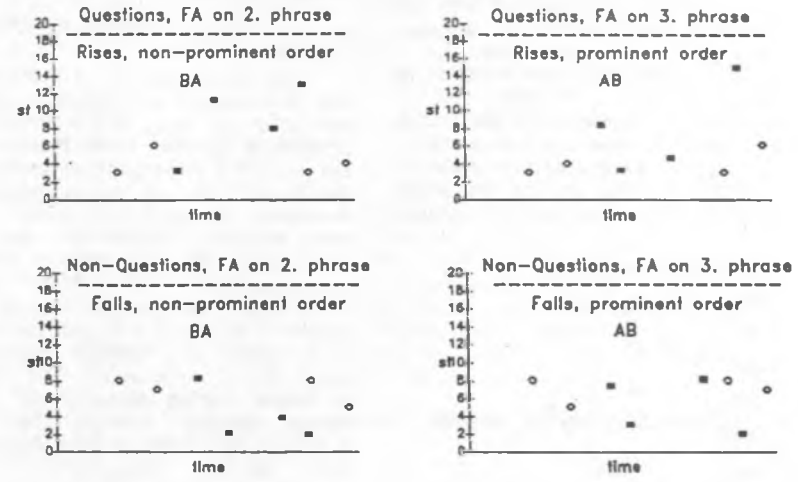
The prominence of a stimulus can be explained articulatorily and auditorily: We can assume that in production, greater pitch intervals are always connected with greater durations, and vice versa, greater durations of pitch elevations or pitch drops are related to a greater amount of pitch change. The perceptual effect of a higher Fo offset might be equal to that of a longer duration of a Fo contour, as both factors are normally interrelated. In our experiments, however, a longer lasting elevation of Fo (longer duration) does not lead to a higher Fo offset, as both factors were handled independently. At any rate, subjects seem to perceive a higher Fo offset, if the Fo contour is longer and, vice versa, a lower Fo offset if the Fo contour is shorter. The prominence of a stimulus might be caused by a greater effort in the production, i.e. a higher muscular tension needed to achieve a steeper rising or falling Fo contour and a higher or lower Fo offset as well. The prominence of a stimulus can thus be explained by articulatory and/or physiological mechanisms. But why

does the prominent stimulus come second in the prominent order? At evaluation time, the Fo information of stimulus A is still kept in memory, but it is influenced by the Fo information of stimulus B. If we substitute "weakened" for "influenced", then the prominent order can be explained: the auditory trace of stimulus A is weakened by stimulus B.

4. ORDER EFFECT AND PROMINENCE OF ACCENTS

There is at least one task for the "normal" native speaker/hearer that is comparable to the task of our subjects and that he/she has to accomplish in everyday conversation: to decide which of the phrases in an utterance carries the focal accent (FA) and thereby the "new" information. In [2,3], we investigated the acoustic structure of the FA in German. The material consisted of 360 utterances, spoken by six untrained speakers (3 male, 3 female). In these sentences, the last two phrases could be stressed depending on the surrounding context. The sentences formed minimal pairs that could only be differentiated by their intonational form: FA in final (3rd) vs. FA in prefinal (2nd) position, on the one hand, and questions (Qs) vs. non-questions (NQs), on the other hand [3:210]. In perception experiments the position of the FA was decided upon [3:211]. The task of the listeners is comparable to that in a "same-different"-task: No contextual information whatsoever is given; if we equate the two phrases that can carry the FA (2nd and 3rd phrase) with the two stimuli in the AX-task, then in both cases, the order can be "non-prominent followed by prominent stimulus", or the other way round.

Fig.4: Overlay plot



In fig.4, a sort of overlay plot is shown; the mean values of the Fo maxima and minima (full square) and their position on the time axis in the FA material (y-axis: semitones above speaker-specific lowest Fo value, x-axis: centiseconds) is compared with a schematic description of the order AB vs. the order BA (open circle). In some aspects, the OE material

and the FA material cannot be compared in the strict sense. (The "turning point" in the OE material e.g. was fixed on 84 Hz, whereas in the FA material, it could be varied by the speakers.) A thorough discussion of differences and points of comparison is beyond the limits of this paper; we will therefore confine ourselves to one of the possible explanations (i.e. not the whole truth, but a substantial part of it). As for the Q/FA constellation and the OE rises in fig.4, the point of comparison is the more pronounced rise on the prominent stimulus/phrase. The prominent order AB, where the prominent stimulus comes second, corresponds to a FA on the third (last) phrase.

As for the falls, a discrepancy between the OE material and the FA material (NQ) can be observed. In the FA material, the more pronounced fall is on the phrase that carries the FA, but in the prominent order AB, the prominent stimulus B has a less pronounced fall than the non-prominent stimulus A. We believe that a solution can be found if we take the two stimuli that follow each other (*ja-ja*) not only as two acoustic or "purely" phonetic (i.e. auditory/articulatory) events but as some linguistic "gestalt" analogous to an utterance produced by a "normal" native speaker. If we imagine a (speech specific) declination line (for the sake of the argument, an all point regression line) then, in the case of the FA on the 2nd phrase and the order BA, the declination line is steeper than in the case of the FA on the 3rd phrase and the order AB. Ceteris paribus, a rather flat declination line indicates openess and/or prominence on the final part of the utterance. (Note that we do not necessarily plead in favor of a declination line as the decisive "underlying entity"; it merely seems to be the most convenient way to sum up the traits in common.)

5. FINAL DISCUSSION

We have found that one order can be better discriminated than the other one; this was called the "prominent order". Phonetic/psychoacoustic reasoning lead us to the conclusion that in the prominent order, the second stimulus is more prominent than the first one. The concept of "prominence" is the link to the marking of the FA in natural speech. The Fo contour of the prominent stimulus in the OE material can be compared with the Fo contour of the FA of the third phrase in the natural material. As for the rises, the interpretation is straightforward. Phonetic, linguistic, and psychoacoustic factors cannot be told apart. For the falls, some additional assumptions have to be made that can be summarized under the heading "perception of linguistic gestalt".

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