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Detection of a Nonlinguistic Stimulus Is Poorest at the End of a Clause

T. G. Bever[1] and R. R. Hurtig[1]

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Subjects detected a brief near-threshold tone while encoding two-clause sentences for later report. The objective tone locations were at the end of the first clause, at the beginning of the second clause, or in the clause boundary. The effects of intensity variations of the speech signal were assessed by having subjects detect the tones in the same speech stimuli played backward. Tones at the end of a clause are relatively harder to detect than in other positions, comparing forward and backward speech. This supports the view that listeners are preoccupied with internal processes at the end of a clause.

INTRODUCTION

Recent studies have suggested that attention to a nonlinguistic stimulus is relatively poor at the end of a clause (Abrams and Bever, 1969; Seitz, 1972; Streeter and Bever, 1974). The primary method has been to show that the reaction time in response to a click objectively located at the end of a clause is slower than to a click located at the beginning. Such results have been interpreted as showing that the listener is preoccupied at the end of a clause with finding an abstract representation for it. However, latency measures involve considerable time in explicit response activity which can cause variations other than those which reflect perceptual attention. The present

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[1]Psycholinguistics Program, Columbia University in the City of New York, New York, New York.

experiment was designed to expand the force of the previous reaction time results by showing that near-threshold nonlinguistic stimuli are also detected relatively poorly at the end of a clause.

MATERIALS

The stimulus materials were those used in Bever *et al.* (1969, experiment 1). These consisted of 25 12-word sentences made up of two clauses. There were five sentences each with the clause break between words 4 and 5, 5 and 6, 6 and 7, 7 and 8, and 8 and 9. In each case, the two words preceding and following the medial clause boundary were monosyllables. Five taped copies were made of the materials, to enable the use of five syntactically defined positions for the nonlinguistic stimulus: in the clause boundary and on either of the two syllables at the end of the first clause and either of the two syllables at the beginning of the second clause. The backward speech material was constructed by playing the original stimulus material in the reverse direction on the tape recorder. In this study, a 30-msec 1000-Hz tone (as intense as the loudest vowel sound in the speech materials) was used as the nonlinguistic probe instead of clicks. This was to reduce the likelihood of confusing the nonlinguistic signal with switching noises in the experiment. In each group of 25 trials, five of the sentences were presented without tones. The sentences were spoken in a monotone to reduce variation in the intensity of the speech signal at the different syntactic positions. After recording the materials, we analyzed the relative intensity of the speech for the 30-msec period corresponding to the tone. Table I shows that the speech at the different positions was similar in intensity except for the last syllable of the first clause, which was more intense than the speech at other positions. This is consistent with Oller (1971), who suggests that constituent-final syllables are spoken louder than others.

PROCEDURE

Since in the original studies the nonlinguistic probes (clicks) were well above threshold, it was necessary to overlay broad-band white noise in order

Table I. Speech Intensity (db) at Each Tone Position[a]

−2 Syllable	−1 Syllable	Between clause	1 Syllable	2 Syllable
−6	−1.5	−12.3	−7.5	−4.7

[a]1 volt = 0 db Ref.

to make the tone detection near threshold. The noise level was set in a pilot study to yield an average hit rate of 70%, with the forward speech materials.

The tone, white noise, and speech were presented to both ears. Subjects were instructed to tell the experimenter whether a tone was present or not and then to give a 3-point confidence rating of his/her judgment. "No" responses were similarly rated. Subjects in the forward condition were further instructed to write out each sentence after judging the presence of the tone. Each subject initially received six practice trials. The experimental materials were divided into two counterbalanced blocks which differed in payoff schedule, one for relatively high payoff on true positives (20 cents for TP, 5 cents for TN) and the other on true negatives (20 cents for TN, 5 cents for TP). Order of payoff matrices was counterbalanced across subjects.

SUBJECTS

Subjects were college students from the New York City area who were paid for their participation; 16 subjects were run in the forward condition and 27 subjects were run in the backward condition.

RESULTS

Table II presents the main results.[2] Overall discriminability of the tones was higher in the forward speech condition. This difference was due to the relatively higher true positive rate ($\chi^2 = 4.04$, $p < 0.05$, across subjects, $p < 0.005$ by a Wilcoxon matched-pairs signed-ranks test, one-tailed, across stimuli). There were no significant differences in the false positive rates, although numerically they were lower in the forward speech condition.

There were differential effects of the tone position when heard in the context of forward and backward speech. Table III presents the true positive

[2]In this paper, we use nonparametric statistics across subjects and stimuli for reasons outlined in Clark (1973).

Table II. Overall Percentage of True Positives and False Positives

	True "yes"	False "yes"
Forward	69	8
Backward	58	10

Table III. Percentage True Positive by Tone Position

	−2 Syllable	−1 Syllable	Between clause	1 Syllable	2 Syllable
Forward	75 (n = 63)	38 (n = 65)	81 (n = 63)	81 (n = 62)	69 (n = 63)
Backward	73 (n = 109)	34 (n = 104)	64 (n = 108)	64 (n = 108)	56 (n = 108)
Δ Forward-backward	2	4	17	17	13

rates by tone position defined in terms of its syntactic location in the forward sentences (see Appendix). (This was done in order to compare the true positive rates for the acoustically identical segments of the forward and backward speech. The minor variation in the *n*s in Table III is due to the fact that on a few trials subjects made unscorable responses; they failed to write out the sentence correctly, or failed to indicate a confidence level, or insisted that they were "unsure.") Since we were concerned with the unique effects of syntax, our analysis considers primarily the differences between the forward and backward stimuli; that is, the discriminability of the tones in the backward material provides an acoustic control that factors out the effects of variations in the intensity of the physical signal of the speech surrounding the tone. Figure 1A presents this difference for each syntactically defined tone position. It is clear that the clause-final positions do not differ as a function of hearing the stimuli forward or backward, while the clause-initial positions are relatively easier to detect when the stimuli are forward. We tested the significance of this by comparing the two clause-final positions against the two clause-initial positions (χ^2 = 5.36, $p < 0.03$ comparing the differences in the two groups of subjects, $p < 0.025$ by a Wilcoxon matched-pairs signed-ranks test, one-tailed, across stimuli). (The difference in the clause-medial position was not significantly greater than in the prebreak positions.)

The distribution of the ratings allowed us to assess the influence of responses when listeners were confident of their answers: 51% of the responses were in the "most confident" category in forward speech, 60% in the backward speech. The same asymmetries occur; in particular, the difference in correct responses to the clause-final and clause-initial positions is larger in forward speech than backward speech, when only the most confident "yes" and "no" responses are included as shown in Fig. 1B (χ^2 = 5.08, $p < 0.03$ across subjects, $p < 0.01$ by a Wilcoxon matched-pairs signed-ranks test across stimuli). Finally, the overall higher discriminability of the tones in the forward

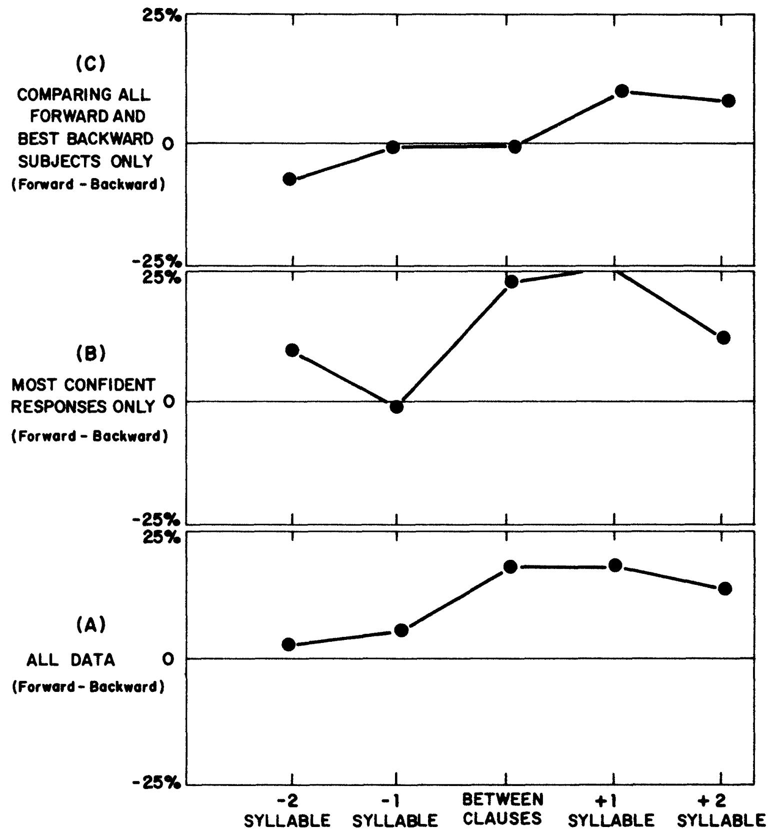

Fig. 1. Difference in true positive responses between forward and backward speech displayed according to the syntactic position of the tones in the forward stimuli.

speech condition might be thought to cause the relatively larger difference between the clause-final and other positions. The better half of the subjects (n = 13) with backward speech had a true positive rate of about 70% and a false positive rate of 12%, which are close to the overall rates of the subjects who heard forward speech (69% TP, 8% FP). When the forward and backward speech groups were equated in this way for overall true positive rate, the relative detectability of clause-initial tone positions remained higher in the forward speech (shown in Fig. 1C) (χ^2 = 3.51, $p < 0.06$ comparing the immediate clause-final and clause-initial positions by subject groups, $p < 0.05$ by a Wilcoxon matched-pairs signed ranks test, one-tailed, across stimuli).

DISCUSSION

These results confirm the prediction that detection of the tones is relatively poor in clause-final positions when encoding speech. The backward sentences provide a relevant control, since the acoustic material surrounding the tone is exactly the same as in the forward materials (integrated over the 30 msec duration of the tone). Also, the backward results show that there is no general serial position effect that could account for the results obtained with the forward sentence materials.

This study supports the previous claims that attention to extraneous stimuli is relatively low at the end of a clause, when subjects must pay attention to the speech. This supports the model of speech perception in which listeners are passively accumulating the external signal at the beginning of a clause while at the end of a clause they are actively organizing an internal representation of what they have just heard.

APPENDIX

There was no effect of payoff matrix on either true positive or false positive rates. Ideally, one should construct different ROC curves and calculate d' [$d' = Z(\text{FP}) - Z(\text{TP})$] to assess the relative detectability of tones in different positions. However, we did not have a separate false positive rate that corresponds to each true positive location separately, so d' analysis can only be suggestive. Assuming the same false positive rate for each syntactic location (8% forward speech and 10% backward speech), the d' are

	Before	In	After
Forward	1.35	2.36	2.14
Backward	1.33	1.64	1.53

and the main significant differences referred to in the text remain significant, by the test proposed in Gourevitch and Galanter (1967). The calculation of β (response bias) [$\beta = f(\text{TP})/f(\text{FP})$], that is, the ratio of the ordinate value of hits divided by the ordinate value of the false alarms (see Luce, 1963, for discussion), which can also only be suggestive, supports the notion that there is an effect of syntax independent of the acoustic effect related to the intensity of the speech signal in the prebreak position:

	Before	In	After
Forward	2.65	1.70	2.04
Backward	2.45	2.30	2.38

Note that while in the forward condition β appears to vary inversely with d'. This is not the case in the backward condition, where β remains relatively constant across positions.

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