Ann. Bull. RILP, No. 15, 63 - 70 (1981)

A PRIMARY STUDY ON THE EFFECTS OF LOUDNESS, DURATION AND NUMBER OF REPETITIONS OF CONTEXT STIMULUS UPON VOWEL PERCEPTION

Sumi Shigeno* and Hiroya Fujisaki**

1. Introduction

It is widely recognized that "context effect" is influenced by the range and distribution of target stimuli, and by the inter-stimulus intervals. The experimental results on context effects have shown that "assimilation" or "contrast" is observed in the identification for the target stimuli with context, and that the magnitude of the context effects can be represented quantitatively by measuring the shift of the category boundary in identifying the target stimuli.

Context effects have been investigated on various parameters, but the results are not conclusive. In vowel perception, Fry et al. (1962) investigated context effects between steady-state vowels presented in an ABX test, while Kanamori and Kido (1976) studied context effects between vowels in synthetic disyllables such as V_1CV_2 and V_1V_2. The present authors (1979) investigated the forward context effect, using pure tones, complex tones with a formant-like structure, and synthetic vowels. In almost all the experiments, the context effect was found to vary continuously from assimilation to contrast as the context-target separation is increased on the stimulus continuum or on the time axis. The tendency toward contrast was found to increase with stimulus complexity. A model for the perceptual mechanisms and processes was presented to account for these results, taking into consideration two kinds of short-term memory (i.e., precategorical and categorical). It was hypothesized that the magnitude of the influence of the two short-term memories upon the shift of category boundary varies depending on the attributes of the stimuli.

A number of recent studies on selective adaptation (e.g.,

* Department of Psychology, University of Tokyo
** Department of Electrical Engineering, University of Tokyo

Eimas and Corbit, 1973) on the other hand, can be regarded as studying extreme cases of the context effect. The results of selective adaptation experiments strongly indicate the enhancement of contrast by repeated presentation of identical stimuli within a short span of time. We do not have enough data to conclude that the other presentation conditions would tend to influence the context effect.

The purpose of the present study is to investigate (1) the effect of the intensity of context stimulus (2) the effect of the duration of context stimulus, and (3) the effect of the repetition of context stimulus, upon the categorical judgment of a target stimulus preceded by a context stimulus.

2. Experiment 1: Intensity of context stimulus

2-1 Method

Subjects

Two female adults with normal hearing participated in the experiment. They had previously taken part in experiments using synthetic sound stimuli.

Stimuli

The stimuli were synthetic vowels with five formants, generated by computer simulation using a terminal-analog speech synthesizer. The stimuli were read out at a sampling rate of 10 kHz with an accuracy of 10 bits, and converted into the analog waveform. They were recorded through a lowpass filter with a cutoff frequency of 4.5 kHz.

Figure 1 shows the placement of the context stimulus C relative to the ten target stimuli T selected at equal step (Δ) on the stimulus continuum ranging from /u/ (472, 1690) to /e/ (526, 1857). The context stimulus is separated from the highest-numbered target stimulus by 4Δ. Other formant frequencies (F_3, F_4, and F_5) were held constant at 2750, 3500, and 4500 Hz, respectively. All the stimuli were 200 msec in duration and had 20 msec rise-fall times. The bandwidths of these formants were also held constant at 60, 100, 120, 175 and 280 Hz, respectively.

The experiment consisted of five conditions, distinguished by the sound pressure level of the context stimuli: 45, 52, 60,

68, or 75 dB SPL. The sound pressure level of the target stimuli were held constant at 60 dB SPL.

All the stimuli were recorded directly from the synthesizer onto magnetic tape.

2-2 Procedure

The experiment consisted of two sessions. In the "absolute identification session," the ten target stimuli were randomly presented to subjects at intervals of 6 sec, with a click signal presented 1 sec before/after the target, as shown in Fig. 2. The subjects were requested to identify each target stimulus as either /u/ or /e/. In the "identification with a context stimulus session," each target stimulus was preceded by the context stimulus. The silent inter-stimulus interval (ISI) between context and target was 1.0 sec. The subjects were again asked to identify the target stimulus as /u/ or /e/. The intertrial interval was 6 sec with a click signal presented 1 sec before/after the context-target pair, as shown in Fig. 2. More than forty judgments per each target stimulus were obtained from each subject for the absolute identification and the five presentation levels. The subjects were seated in an anechoic room and listened to the stimuli over headphones.

2-3 Results

In the case of categorical judgment, the distribution of the response probability on the stimulus continuum can be approximated by a cumulative normal distribution. The probability of /e/ response was calculated, and the mean μ and the standard deviation σ were estimated from measured probabilities by the maximum likelihood method. A and C indicate the "absolute identification" and "identification with a context stimulus" sessions, respectively. The mean corresponds to the category boundary, while the standard deviation serves as an index for the accuracy of identification. If we denote the increase/decrease in μ from the absolute identification session by $\Delta\mu$, the ratio of $\Delta\mu$ over σ_A can then be regarded as an index of the context effect. A plus sign for $\Delta\mu/\sigma_A$ indicates a shift of category boundary toward the context stimulus

(meaning contrast), while a minus sign indicates a shift in the opposite direction (meaning assimilation).

The results for the two subjects are shown separately in Fig. 3. Though they show considerable individual differences, the shift toward contrast is most conspicuous when the presentation level of the context stimulus is equal to that of the target: 60 dB SPL. Though contrast reduced with the decrease/increase of the presentation level, the context effect appeared to be contrastive at every presentation loudness.

3. Experiment 2: Duration of context stimulus

3-1 Method

Subjects

The two females who had participated in Experiment 1 served as subjects.

Stimuli

The procedure of generating stimuli was the same as in Experiment 1. The stimuli were similar to those used in Experiment 1, except that the duration of context stimulus was either 80, 200, or 500 msec.

3-2 Procedure

The procedure in this experiment was identical to those in Experiment 1 except for the hearing level. In this experiment, the stimuli were presented through a loudspeaker at a sound pressure level of approximately 78 dB(c).

3-3 Results

The method of estimation for the mean and the standard deviation from the responses was identical to that used in Experiment 1.

The results are shown in Fig. 4. The shift toward contrast becomes more intense as the duration of context varies from 80 msec to 200 msec and almost constant at more than 200 msec. The context effect appears to be contrastive at every duration.

4. Experiment 3: Number of repetition of context stimulus

4-1 Method

Subjects

The subjects were the same as in Experiments 1 and 2.

Stimuli

The procedure of generating stimuli was the same as in Experiments 1 and 2. The stimuli were identical to those in Experiment 1, except that the loudness of context stimulus was held constant and equal to that of the target stimulus.

4-2 Procedure

The procedure and apparatus were essentially identical to those in Experiment 2; all the stimuli were presented to the subjects through a loudspeaker at approximately 78 dB(c).

4-3 Results

The method of estimation for the mean and the standard deviation from the responses was identical to that used in Experiments 1 and 2. The results are shown in Fig. 5. There is a considerable increase in boundary shift as the number of repetitions increases from 1 to 15. Between 8 to 15 repetitions, there is no increase in boundary shift for subject KO.

5. Comments

The results of our present study indicate that the duration, the intensity and the number of repetitions of context stimulus influence the context effects. This suggests that the magnitude of the context effect is determined not only by the spatial and temporal relationship between target and context, but also by their presentation conditions.

Reference

Eimas, P.D. and J.D. Corbit (1973); Selective adaptation of linguistic feature detectors. Cog. Psychol. 4, 99-109.

Fry, D.B., A.S. Abramson, P.D. Eimas, and A.M. Liberman (1962); The identification and discrimination of synthetic vowels. Lang. Speech 5, 171-189.

Kanamori, Y., and K. Kido (1976); Effect of context on vowel perception. J.A.S.J., 32, 3-11 (in Japanese).

Shigeno, S. and H. Fujisaki (1979); Effect of a preceding anchor upon the categorical judgment of speech and non-speech stimuli. J. Psychol. Res., 21, 165-173.

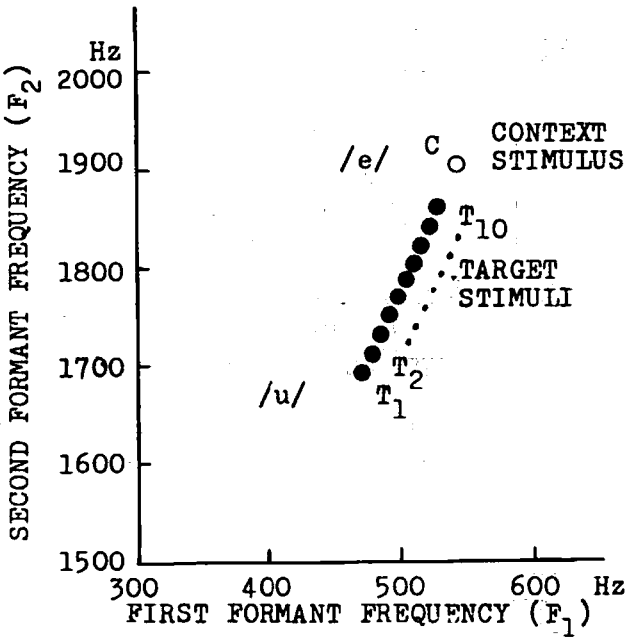

Fig. 1 Stimuli used in the Experiments

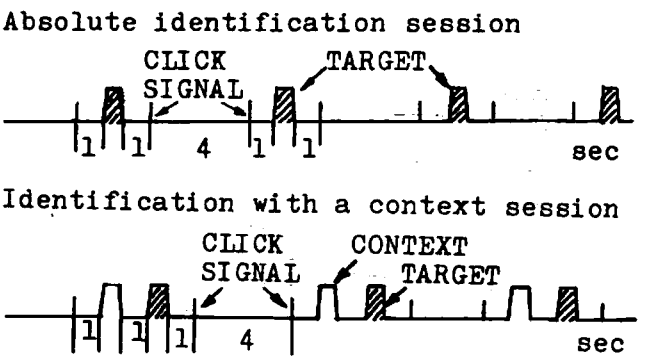

Fig. 2 Presentation of stimuli

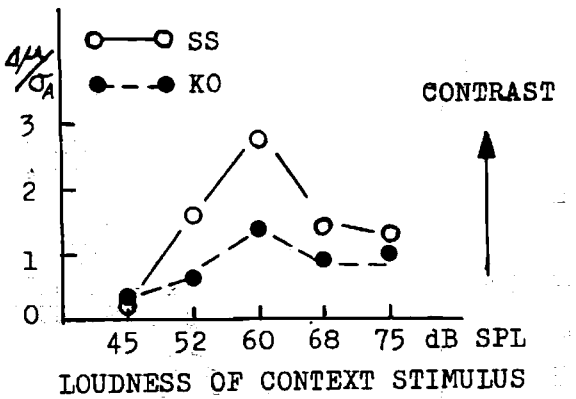

Fig. 3 Context effects shown as the function of loudness of context stimulus

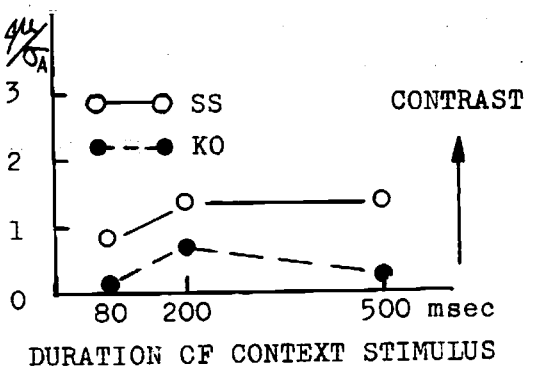

Fig. 4 Context effects shown as the function of duration of context stimulus

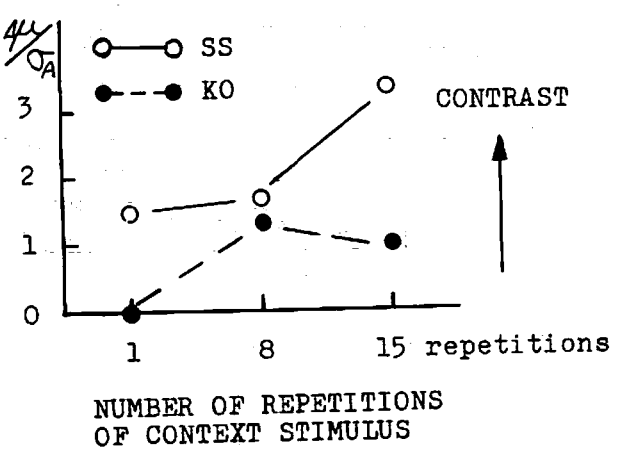

Fig. 5 Context effects shown as the function of repetition of context stimulus