Ann.Bull.RILP(1987)No.21, 83-92

# AUDITORY AND VISUAL REACTION TIMES AS A FUNCTION OF REPETITION FREQUENCY

Hirohide Yoshioka*, Miki Ishikura*, and Kenji Itoh

## Abstract

The aim of the present study was to clarify the temporal variation of verbal and tapping reaction times in response to repetitive auditory and visual stimuli. Thirteen normal adult subjects were requested either to produce the sequence /papapa--/ or to push an electrical switch in accordance with repetitive stimuli at a variety of frequency rates. It is concluded that there are some differences in terms of reaction times between auditory and visual presentations. As for auditory stimuli, repetitive reaction times are shorter than the mean of simple reaction times through a wide range of frequency rates. Furthermore, it is often noticed that such auditory reaction times become negative, i.e., the reaction is provoked in advance of a stimulus. As for visual stimuli presented at a slow rate, repetitive reaction times are almost the same as simple reaction times. In addition, the subjects were unable to keep up with fast repetitive visual stimuli.

## Introduction

Reaction time may be defined as the period of time that has elapsed between the presentation of a stimulus and the initiation of a response. Among others, discrimination reaction time (DRT) and choice reaction time (CRT), for example, simple reaction time (SRT) has been widely used in order to evaluate psychomotor performance not only in the field of psychology but also in that of physiology[1),2)]. These reaction times include the activity times of sensory, motor and information processes. Therefore, even though subjects react as fast as possible, there must be a shorter physiological limit to the reaction time in each experimental paradigm, depending on the type and degree of the stimuli as well as the manner of response. It has also been noted that the reaction time to an auditory stimulus is usually shorter than that to a visual stimulus[3),4),5)].

These experiments have mainly been administered using single isolated stimuli, and averaging the results of several trials using the same experimental paradigm. In contrast, the present paper focuses on the temporal changes of reaction times in response to repetitive auditory and visual stimuli given at equal intervals. We believe that such consecutive signals, separated by a pertinent pause, constitute one of the simplest rhythmic structures. In a preliminary experiment, we often found that the

* Institute of Human Sciences, University of Tsukuba

reaction times to such repetitive stimuli became negative after several trials, which means that the reactions had been provoked in advance of the actual appearance of stimuli. This implies that the subjects had acquired the rhythmic structure underlying the repetitive stimuli given at an equal interval. Along this line, for this paper, we compared temporal variations of reaction times in response to repetitions of auditory and visual stimuli, comparing with simple reaction times measured before the main experiment.

## Method and Procedure

13 adult males and females with normal hearing and vision served as the subjects. Prior to each experiment, 20 simple reaction times were measured and averaged, which were used as a reference for the reaction times with repetitive stimuli.

Repetitive signals with equal intervals of 2600 ms, 1300 ms, 650 ms and 330 ms, respectively, were given through the auditory and visual systems. As for the auditory stimuli, 1 kHz pure tones with a rising time of 6 ms and a duration of 40 ms were generated by SEN-3201 (Nihon Koden) at 70 dB. The visual stimuli were red LEDs (Light Emitted Diodes), also generated by SEN-3201.

Verbal and tapping responses were chosen as the reaction maneuvers. The subjects were requested either to utter consecutive sounds /papapa--/ in front of a microphone or to push a manual switch connected to an electrical circuit in accordance with repetitive stimuli presented via headphones or a screen displaying red LEDs. The electrical output of these reaction maneuvers together with the timing marks for the presentation of the stimuli were recorded on a Data Recorder (SONY FC-14). Based on the tracings of these signals on oscillograms, we determined the reaction time for each trial.

## Results

### I. Simple reaction times

Table 1 shows a sample (subject MO) of the averaged values of the simple reaction times to the auditory and visual stimuli presented at a variety of equal intervals. In general, the verbal reaction times tend to be 40-70 ms slower than those for the tapping responses, regardless of the type of stimuli. It can also be noted that there are no significant differences between the auditory and visual stimuli. Table 2 contains the results for all the subjects, including the one shown in Table 1. This table further confirms that, so far as the experimental conditions in this report are concerned, the verbal response requires a longer time than the tapping response, whereas there are no significant differences between the types of stimuli.

Table 1 Averaged simple reaction times for subject MO.
Mean (SD)

| | TAPPING | VERBAL | DIFFERENCE |
|---|---|---|---|
| AUDITORY | 269(44) | 331(46) | t=5.89*** |
| VISUAL | 253(33) | 332(35) | t=6.89*** |
| DIFFERENCE | t=0.49 | t=0.09 | |

*** p<0.01

Table 2 Averaged simple reaction times for 13 subjects.
Mean (SD)

| | TAPPING | VERBAL | DIFFERENCE |
|---|---|---|---|
| AUDITORY | 218(30) | 289(56) | t=4.13** |
| VISUAL | 233(28) | 301(49) | t=4.35** |
| DIFFERENCE | t=1.93 | t=0.47 | |

** p<0.05

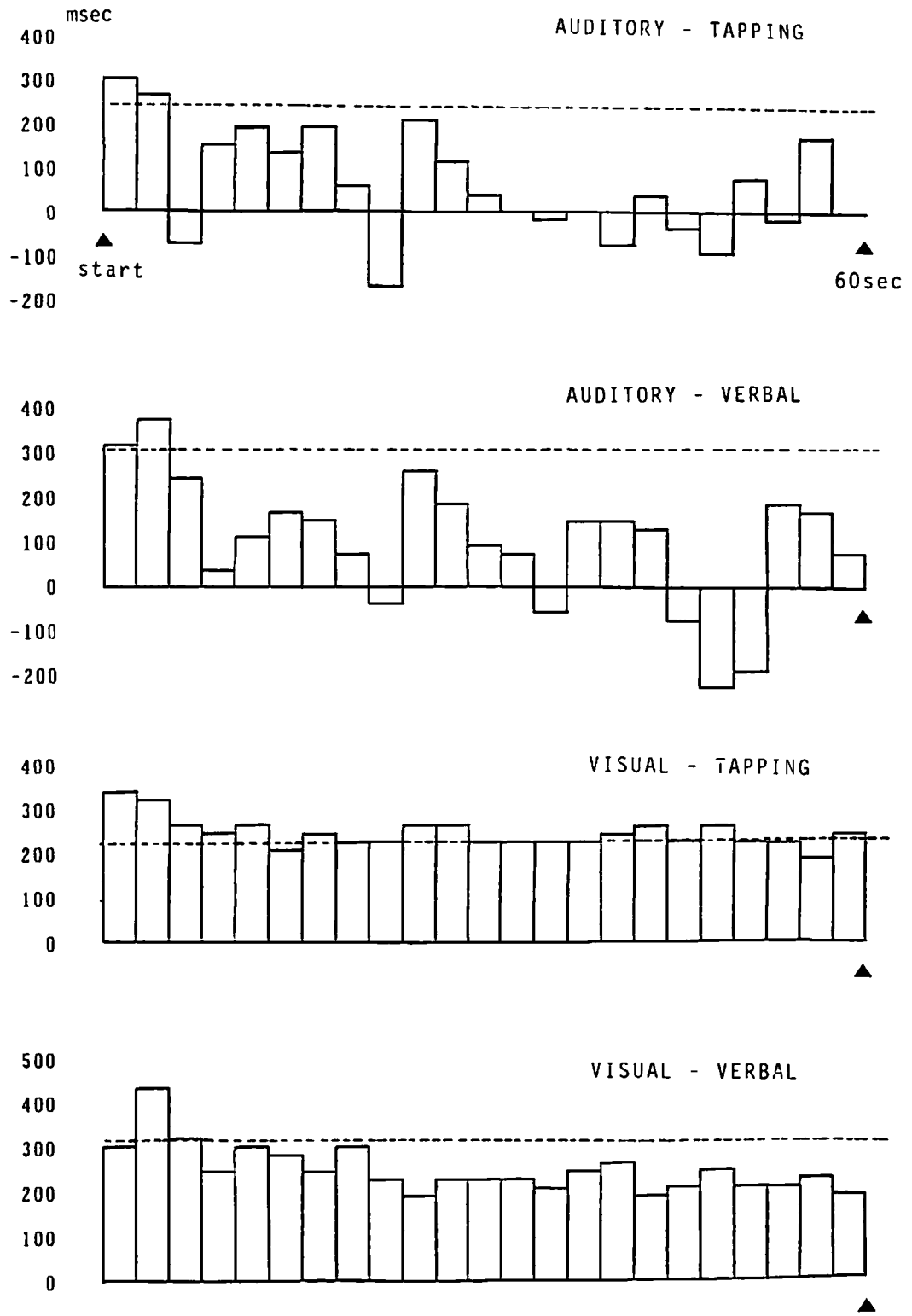


Fig. 1 Responses to repetitive stimuli with intervals of 2600 ms

## II. Temporal variations in reaction times to repetitive stimuli

The temporal variations in reaction times for 4 different durations of intervals were considered. Using the data of a typical case (subject MO), we will discuss the interesting results found across other subjects.

### II-i. Responses to repetitive stimuli with intervals of 2600 ms

Figure 1 shows the consecutive reaction times in response to repetitive stimuli given at 2600 ms intervals. From top to bottom, tapping reactions to auditory stimuli, verbal reactions to auditory stimuli, tapping reactions to visual stimuli, and verbal reactions to visual stimuli are illustrated. The dotted lines correspond to the mean values of the subject's simple reaction times.

As a whole, the averaged tapping and verbal reaction times to auditory stimuli were 44 ms and 86 ms, respectively, and were shorter than the simple reaction times. After a certain number of repetitions, the reaction times become shorter up to 0 ms, and then sometimes become negative, which means that the reactions have been provoked in advance of the stimuli. This implies that the subject anticipates the coming signals before their actual presentation. In other words, the subject has acquired the rhythmic structure even at the rather long intervals of 2600 ms. In contrast, the reaction times to visual stimuli were almost the same as the simple reaction times, averaging out at around 250 ms. Therefore, it may be concluded that slow repetitive stimuli to the visual organs are almost nothing but the mere assembly of independent simple reactions.

### II-ii. Responses to repetitive stimuli with intervals of 1300 ms

Figure 2 contains the results for the interval of 1300 ms. 5-6 sec after the initial presentation of repetitive auditory stimuli, the reaction times abruptly became short, almost reaching 0 ms. In fact, the averaged reaction times, ruling out the initial 4 responses, were -1 ms for the tapping reaction and -25 ms for the verbal reaction, respectively. As for the visual stimuli, most of the reaction times were apparently shorter than the simple reaction times. In fact, the respective averaged values were 169 ms and 226 ms, both of which are around 100 ms shorter than the simple reaction times measured earlier. This means that the subject began to anticipate their coming signals, although he seldom reacted before the actual presentation of the signals. In other words, it may be that the subject managed to acquire the rhythmic structure underlying the repetitive visual stimuli given using this interval.

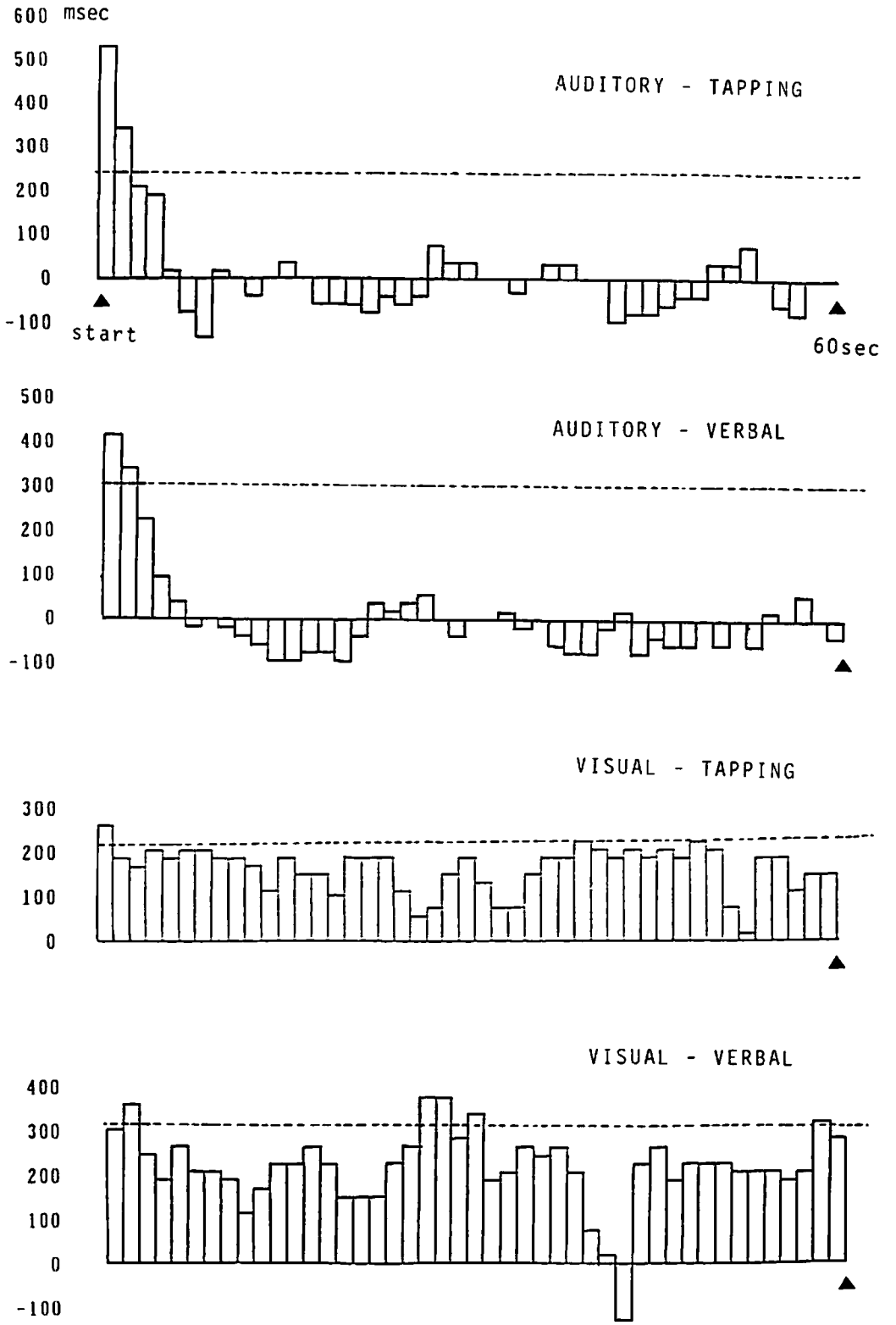


Fig. 2 Responses to repetitive stimuli with intervals of 1300 ms

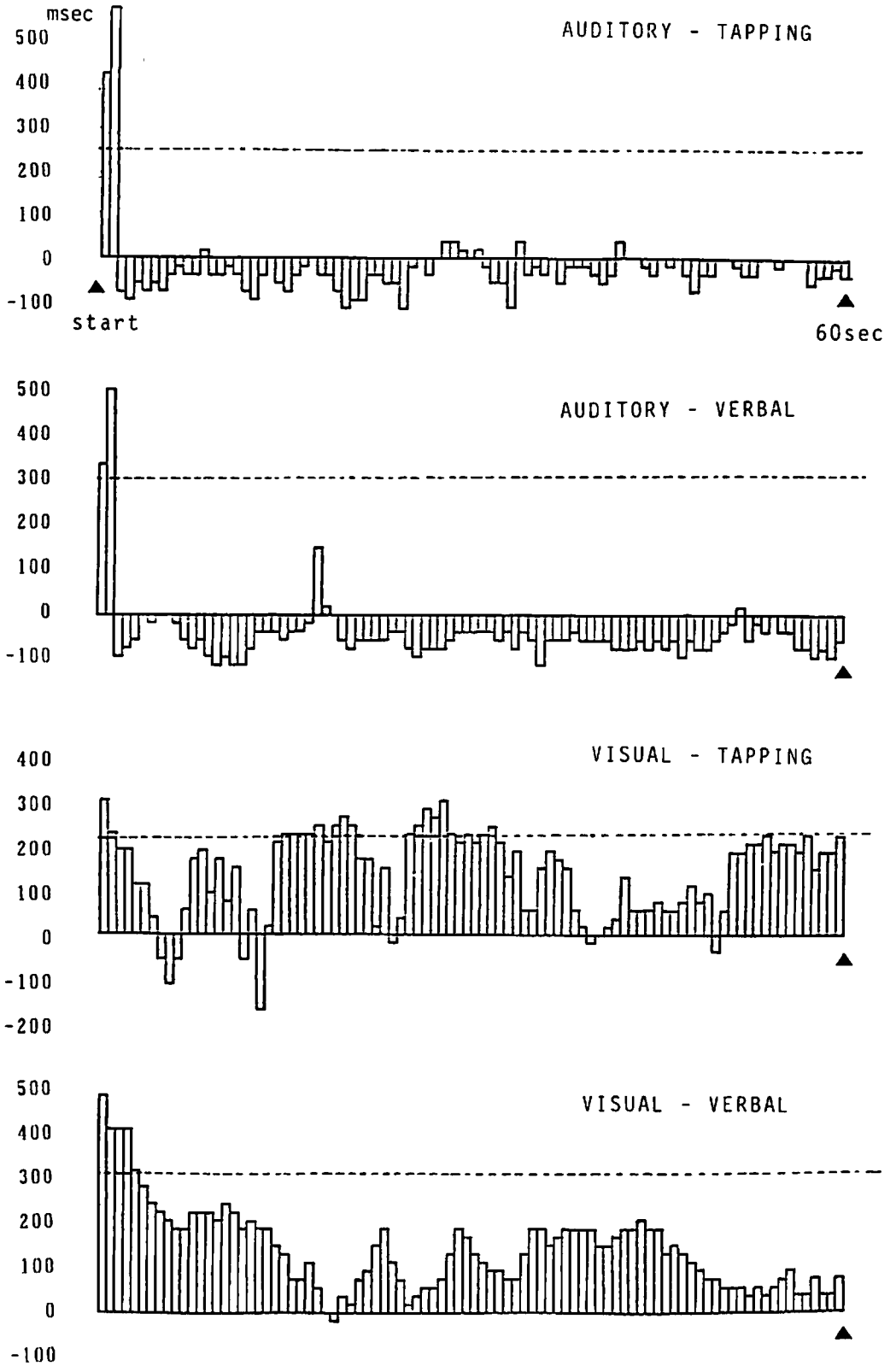


Fig. 3 Responses to repetitive stimuli with intervals of 650 ms

II-iii. Responses to repetitive stimuli with intervals of 650 ms

This interval corresponds to 90 repetitions per minute, which is often used in music. Figure 3 shows the temporal patterns of the reaction times to the repetitive stimuli given at this interval. Apparently, the subject acquired the rhythmic structure after only 2 responses to the auditory stimuli. Interestingly, most of the verbal responses to the auditory stimuli were 50-100 ms ahead of the presentation of the signals. Considering the fact that the duration of the /p/ burst required approximately 50-100 ms, the timing of the appearance of the auditory stimuli almost completely coincided with that of the production of the vowel /a/. In this sense, it can be concluded that the verbal reactions synchronize exactly with the auditory stimuli at this particular speed. As for the visual stimuli, the reaction times were much shorter than the simple reaction times, specifically after 5-6 initial repetitions. It should also be noted that the reactions seldom preceded the stimuli. Therefore, we may conclude that the subject was able to acquire the rhythmic structure with comparable ease, even though the visual presentations were conceivably disadvantageous in compared to the auditory signals.

II-iv. Responses to repetitive stimuli with intervals of 330 ms

Figure 4 contains the temporal patterns of the reaction times to the repetitive auditory stimuli. The subject followed the rhythmic structure only after 3 repetitions. The averaged reaction times are -2 ms for the tapping response and +1 ms for the verbal response. This means that the reactions literally synchronize with the stimuli. The data for the visual stimuli are omitted due to the fact that the subject was unable to keep up with such fast repetitive signals. These tendencies are found across the other subjects as well.

II-v. Temporal variations in initial repetitive reaction times

Figure 5 contains the plots of the 10 initial reaction times for the 8 subjects. It is clear that, in accordance with the number of repetitions, the reaction times become shorter, converging to 0 ms. It can also be noted that the variations across the subjects gets smaller particularly after the initial 2-4 responses. Therefore, we conclude that subjects are able to acquire rhythmic structure after several trials, on the condition that the interval between the signals falls under the appropriate length.

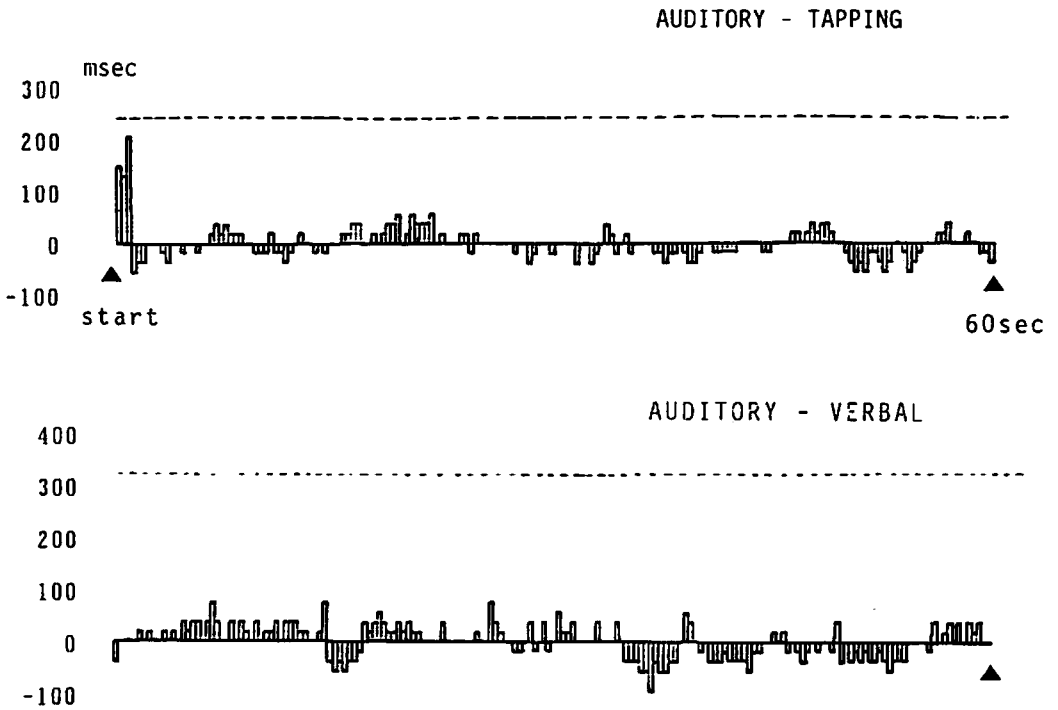


Fig. 4 Responses to repetitive stimuli with intervals of 330 ms

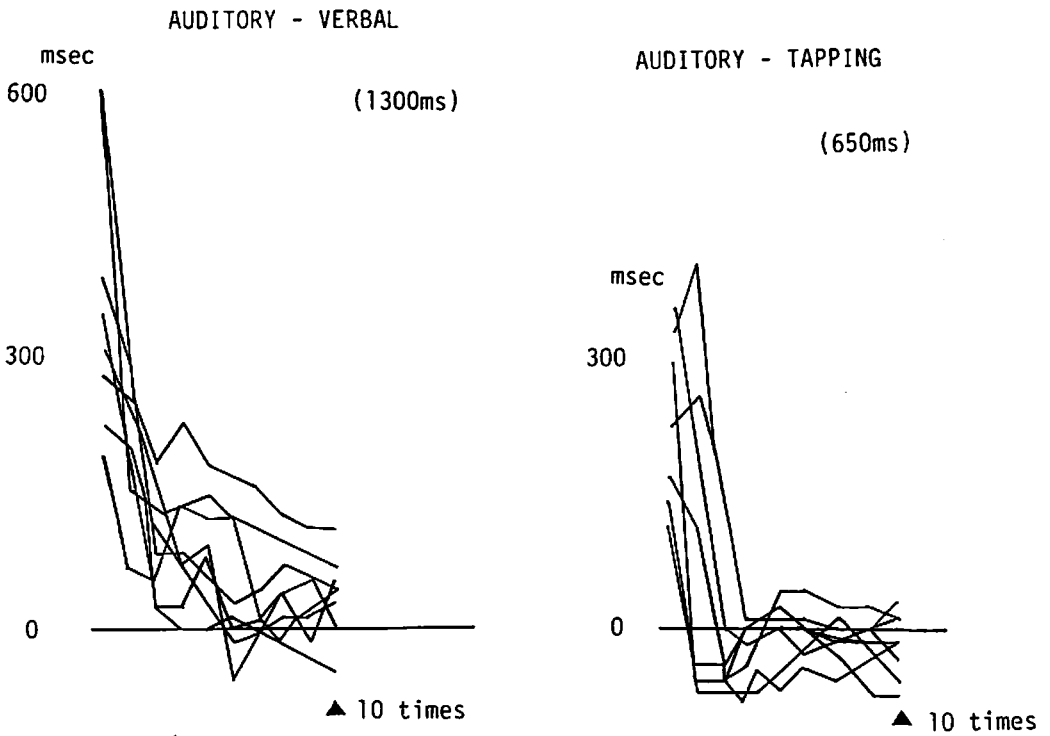


Fig. 5 Temporal variations in initial repetitive reaction times for 8 subjects.

References


1) Sternberg, S: The discovery of processing stages: Extension of Donder's method. Acta Psychologica, 30, 276-315, 1969.
2) Welford, A. T.: Reaction times. Academic Press, London, 1980.
3) Stebbins, W. C.: Auditory reaction time and the derivation of equal loudness contours for the monkey. J. Exper. Analy. Behavior, 9, 135-142, 1966.
4) Osaka, N.: Visual reaction time as a function of target size and retinal eccentricity in the pripheral visual field. Jap. Psychol. Res., 18, 183-190, 1976.
5) Oyama, T.: Historical background and the present status of reaction time studies (Jap). Ningen-kougaku, 21(2), 57-64, 1985.