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EFFECTS OF ADAPTATION TO NOISE STIMULI ON AUDITORY EVOKED POTENTIALS

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1. INTRODUCTION

Measurement and analysis of evoked potentials reveals a part of the activity of sensory information processing system in brain. In the previous report [1], we investigated the effects of attention on perception of sound from the viewpoint of AEPs (auditory evoked potentials). In this study, to obtain some suggestions about effects of adaptation on perception of sound, effects of adaptation to noise stimuli that are repeatedly presented to subjects at the same sound pressure level on AEPs are analyzed under two different hearing conditions.

Relationship between Auditory Information Processing and AEPs

If there exists both the input of sound to ears and the output of some response to the input like, for example, subjective evaluation or physiological response, the activity of central nervous system between input and output can be regarded as an auditory information processing (left side of Fig. 1). As an AEP measured by electrode attached on scalp is made of the synchronized activity of neurons within 500 ms from the input of sound to ears, the latencies of three peak components that are named N1, P2 and N2 are regarded as the response speed of auditory information processing, and the peak-to-peak amplitudes of

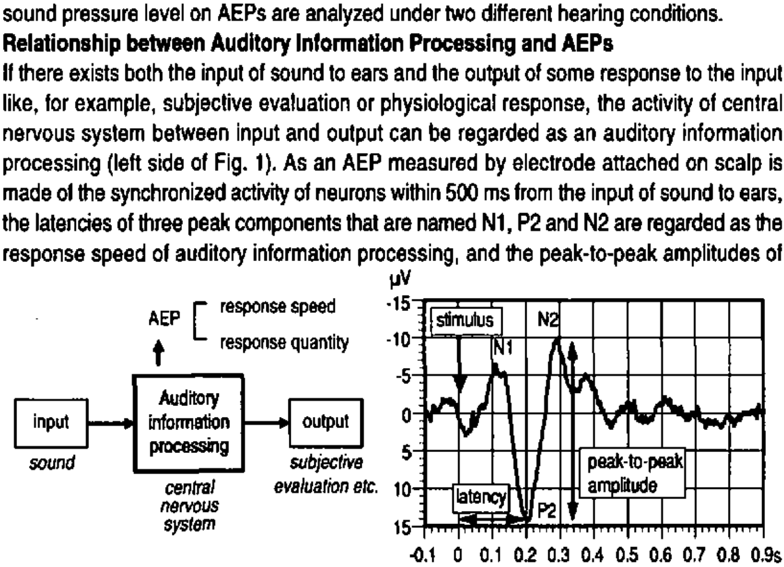

Fig. 1. A model of auditory information processing (left side), and an example of AEP (right side). The upper side of vertical axis in the example shows negative value of amplitude after the usual electroencephalogram.

N1-P2 and P2-N2 components are regarded as the response quantity of auditory information processing (right side of Fig. 1). These late components of AEP are called SVR (slow vertex response) and seem to reflect the advanced psychological process of perception. On the basis of this point of view, perception of sound that is closely concerned with auditory information processing measured as AEPs is discussed in this study.

2. ANALYSIS AND RESULTS

Experiment

Four intensities of pink noise were used as auditory stimuli in the experiment. Each auditory stimulus had a duration of 1 s including rising speed of 60 dB / 20 ms. The sound pressure level (SPL) of stimuli at the hearing position was 33, 40, 50 and 70 dB(A). In one trial of the experiment, a total of 70 auditory stimuli were repeatedly presented to a subject at the same intensity with random interstimulus interval among 1 s and 15 s through loudspeaker. The SPL of background noise was adjusted to 30 dB(A) by pink noise.

Twelve subjects (male = 10, female = 2) participated in this experiment. They were instructed to listen to auditory stimuli (hearing condition (A)) or to do calculation task without attention to stimuli (hearing condition (B)) in the soundproof room. Each trial that was carried out under one hearing condition at one SPL took about 10 minutes. All of the 8 trials were made on each subject in balanced order across subjects. Brain wave signal was measured from vertex (Cz on international 10-20 system) during each trial and recorded to data recorder digitally.

Method of Analysis

Three AEPs were obtained from one trial, that is, from the first, middle and latter part of one trial (Fig. 2). The first part of a trial nearly corresponded to the first three minutes of a trial, and so on. AEPs were brought by averaging brain waves 20 times with the rise of auditory stimuli, and by filtering the averaged wave digitally with low pass filter adapted to the frequency character of AEP. After these operation, the latencies of N1, P2 and N2 components and the peak-to-peak amplitudes of N1-P2 and P2-N2 components were measured.

Results of ANOVA

A 2-way analysis of variance (ANOVA) was performed for each latency and peak-to-peak amplitude under each hearing condition. The independent variables were SPL and the passage of time. Table 1 summarizes the results of ANOVA.

Under condition (A), the results of analysis for latencies show that latencies became short with increase of stimulus intensity and there was no difference among the condition of the

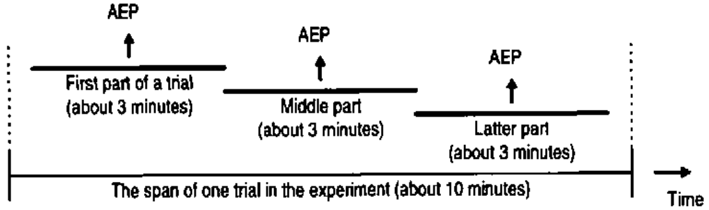

Fig. 2. An image on the way how to obtain three AEPs from one trial.

passage of time. Analysis for amplitudes reveals that each amplitude increased with increasing stimulus intensity, and that the first part of N1-P2 component was larger than the middle or latter part at 50 dB(A) and above, though there was no significant difference between the middle and latter part (Fig. 3).

Under condition (B), the results of ANOVA for latencies are reflecting that they became short with increase of stimulus intensity, and that the tendency and mean values were nearly equal to those under condition (A). The results of analysis for amplitudes show that each component increased with increasing intensity, however there was not so great difference among the condition of the passage of time in each amplitude (Fig. 4).

Table 1. Results of ANOVA. The p values are summarized under each hearing condition.

(a) Condition (A)

Source of Variance	N1 latency	P2 latency	N2 latency	N1-P2 amplitude	P2-N2 amplitude
SPL (S)	*< 0.001*	*< 0.001*	*< 0.001*	*< 0.001*	*< 0.001*
passage of time (T)				*< 0.05*	*0.084*
S x T				*< 0.05*	

(b) Condition (B)

Source of Variance	N1 latency	P2 latency	N2 latency	N1-P2 amplitude	P2-N2 amplitude
SPL (S)	*< 0.001*	*< 0.001*	*< 0.001*	*< 0.001*	*< 0.001*
passage of time (T)				*0.061*	*0.053*
S x T				*0.065*	

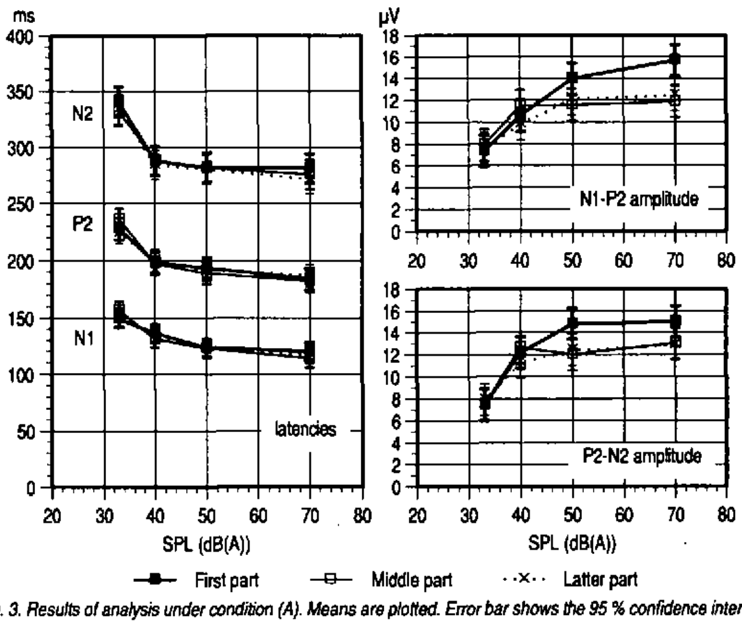

Fig. 3. Results of analysis under condition (A). Means are plotted. Error bar shows the 95 % confidence interval.

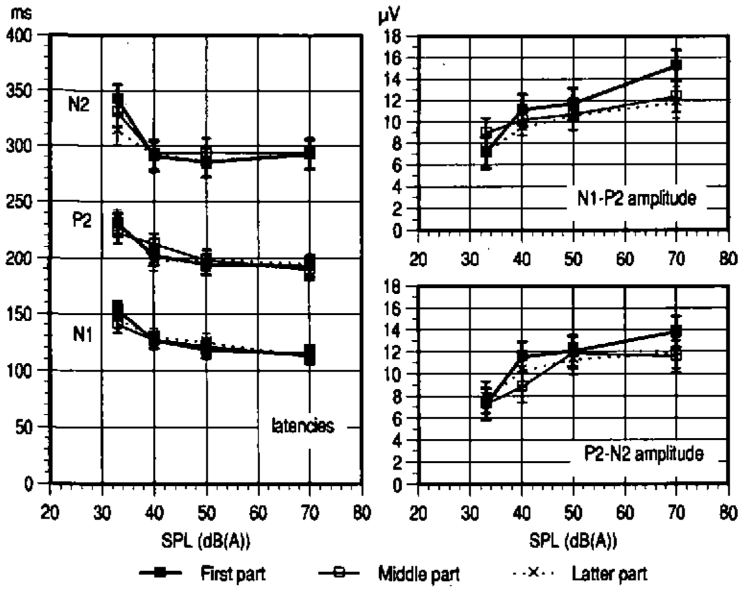

Fig. 4. Results of analysis under condition (B). Means are plotted. Error bar shows the 95 % confidence interval.

3. DISCUSSION

The results for latencies mean that the speed of auditory information processing is not affected by attention nor adaptation to auditory stimuli, if stimulus intensity is the same. It is suggested that the processing route of auditory information in the central nervous system is stable.

The result for amplitude under condition (A) indicates that, at 50 dB(A) and above, adaptation to auditory stimuli occurs in the auditory information processing system, and that the amount of neurons concerned with the processing decreases and comes to be stable with the passage of time. It is suggested that there are some effects of adaptation on perception when a person listen to the sound with such intensity.

However, the result for amplitude under condition (B) suggests that, when a person attend to their own work without attention to the sound, perceptual response to auditory information becomes little and stable, and that adaptation to strong auditory stimuli like pink noise of 70 dB(A) only occurs in the processing system. So auditory information at 50 dB(A) seems to be perceived less when it is not attended to. In other words, little attention to auditory information makes the threshold of sound intensity that is perceived fully loud and requires adaptation in processing system shift to higher value.

4. REFERENCE

[1] T. Akita, K. Hirate and M. Yasuoka. Proc. of INTER-NOISE 95, 839-842 (1995).