Visually Evoked Potentials during Pattern Discrimination Tasks (II) : Further Evidence

VISUALLY EVOKED POTENTIALS DURING PATTERN DISCRIMINATION TASKS (II) : FURTHER EVIDENCE

By

HITOSHI HONDA (本田仁視)

(*Department of Psychology, Tohoku University, Sendai*)

In order to evaluate the reliability of the results obtained in our previous study, the changes in wave form of the visually evoked potentials (VEPs) were observed in human subjects during pattern discrimination tasks.

Two tasks were given to 10 *S*s. Each task forced them to focus their attention on one of the discriminative cues (size or form) of the geometrically patterned stimuli. When the *S*s were asked to count in silence the stimuli dividing them into large stimuli and small stimuli regardless of their forms, the VEP wave form was altered by the size rather than the form of the stimuli. On the other hand, when the *S*s were asked to count in silence the stimuli dividing them into square stimuli and diamond stimuli regardless of their size, the VEP wave form was alterd by the form rather than the size of the stimuli.

The results showed the orderly effects of selective attention on VEP wave form, and were interpreted to reflect the electrical brain activities closely related to pattern perceptual processing.

Introduction

Only quite recently has it become technically possible to record, from electrodes attached to the scalp, the human brain's electrical potentials elicited by sensory stimulation.

Although a number of attempts have been made to conclude the wave form of the sensory evoked potentials, the results obtained showed considerable disagreements with one another. Probably a large part of these disagreements are due to the fact that the sensory evoked potentials are very fragile and easily influenced by many factors, such as physical characteristics of the sensory stimulation, physiological states of subjects and psychological variables.

In regard to the visually evoked potentials (VEPs), many workers have reported that the VEP wave form depends on many stimulus factors, such as intensity, wave length, interstimulus intervals and so forth (Regan, 1972). Some of the most interesting works which have been done with the VEP have dealt with those responses evoked by patterned stimuli. Spelmann (1965) who studied the pattern evoked responses in normal adults, has shown that the latency and amplitude of late positive wave can be altered by presentation of patterns containing different amount of contuor. Harter & White (1970) investigated the interaction effects between checksize in checkerboard patterns and degree of focus on VEP amplitude, and demonstrated that the checksize which produced responses of maximal amplitude depended on visual acuity. John *et al.* (1967) and John (1967) studied the effects of visual form on VEPs and showed that the VEPs elicited from relaxed *S*s were different on a blank visual field from those on a field containing geometric forms, were similar for versions of the same geometric form of an unequal area and were different for different geometric forms of an equal area. These findings suggested that the wave form of VEP is not determined solely by the set of peripheral receptors which is stimulated, but it also reflects the perceptual content of the stimulus. Beatty & Uttal (1968) examined the effect of the distribution or grouping of stimuli in visual field on VEPs, and found a marked and orderly relation. Thus, the wave form of the VEP seemed to reflect the information on the spatial pattern of visual stimuli.

On the other hand, many investigations have demonstrated that changes in the subject's attention to brief stimuli are associated with alternation in the averaged cortical evoked responses to these stimuli. For example, Garcia-Austt and his colleagues (1964) studied the changes of the VEP wave form provoked by modifications of attention, and found that the focussing of attention provoked an increase in the amplitude of VEP. Donchin & Cohen (1967) observed VEPs to visual stimuli obtained when human subjects performed under different visual search instructions, and found that the stimulus to which the *S* had to respond elicited a VEP with a considerably enhanced late positive component. Generally speaking, attention, directed by sensory discrimination, psychomotor performance and counting stimuli, often, but not always, leads to an increase in the VEP (Tecce, 1970).

In order to evaluate, with accuracy, the studies which dealt with the change of VEP wave form elicited by patterned stimuli, the effect of attention on VEP must be taken into consideration. Honda (1973) examined the changes in VEP wave form recorded during pattern discrimination tasks, each of which focussed *S*'s attention on a distinctive feature(i.e. size or form)of the geometrically patterned stimuli, and found that the distinctive feature by which the *S*s discriminated appeared as the difference of the VEP wave form. However, the result mentioned above requires further investigations. The present study was designed to meet this requirement, and thus to analyze the change in VEPs obtained during pattern discrimination tasks, where the *S*s were asked to discriminate the geometrically patterned stimuli by one of their distinctive features (i.e. size or form). The experimental paradigm was about the same as that of our previous study except for the stimulus patterns employed.

Method

Subjects : Ten *S*s were tested under 2 experimental conditions. They were 8 male and 2 female students aged between 22 and 26.

Stimuli : The stimuli consisted of 4 geometrical figures, i.e. a large square, a small square, a large diamond and a small diamond. The stimulus patterns used in this experiment are shown in Fig. 1. A large square was twice as large as a small square in area. By rotating 45° these squares, a large and a small diamonds were obtained. Therefore, the area of a large diamond was equal to that of a large square, and the area of a small diamond to that of a small square.

Stimuli were binocularly presented by a modified slide projector, which had a Xenon flash as a light source. This apparatus was remote-controlled by an experimenter to exchange the stimulus patterns. The *S* sat comfortably in a reclining chair alone in an electrically shielded, soundproof and lightproof room. The stimuli were projected upon a screen (11cm × 14cm) placed at eye level in front of the sitting *S*. The distance from the *S*'s eyes to the display screen was about 50cm. The size of the stimulus image, against the dark background on the screen, was regulated so that the large sized stimuli (a large square and a large diamond) were about $20cm^2$ in area.

Procedure : The *S* was informed of the type of stimuli and was instructed to keep his eyes focussed on the centre of the display screen. Two tasks were given to all *S*s.

1) Task A; *S* was required to count in silence the patterned stimuli, dividing them into large stimuli and small stimuli regardless of their forms. In task A, therefore, the sizes of the patterns were task-relevant and the forms task-irrelevant.

2) Task B; *S* was required to count in silence the patterned stimuli, dividing them into square stimuli and diamond stimuli regardless of their sizes. In task B, the forms of the patterns were task-relevant and the sizes task-irrelevant. The order in which each *S* was exposed to the 2 tasks was counterbalanced.

The stimuli were presented by the experimenter in random order at various interstimulus-intervals of 5–8 sec. After 3–10 stimuli were presented, the *S* was asked by the experimenter about the number of stimuli displayed, and then the *S* responded by saying the number of stimuli he saw, dividing them into 2 categories according to the given task. In task B, for example, when 2 large squares, 3 small squares, 1 large diamond and 2 small diamonds were presented, the *S* answered the question saying "Five squares and three diamonds." The experimenter put a question arbitrarily and irregularly, so the *S* was not able to predict when he would be asked. The communication between the experimenter and the *S* was held through an interphone. By this means described above, the Ss were forced to focus their attention on one of the distinctive features of the patterned stimuli.

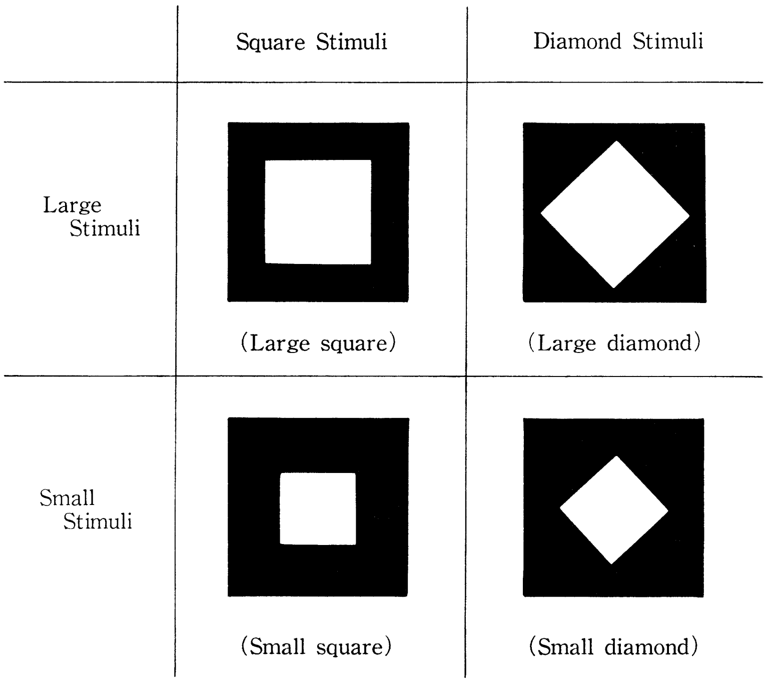


Fig. 1. Stimulus patterns used in this study.

Recording : EEG recording was made from an electrode placed on the midline 3 cm above the inion, and a left ear lobe was used for reference. In order to monitor eye movements, electro-oculogram (EOG) was recorded. The eye electrode was applied at lateral canthus of the left eye, and was referred to a left ear lobe electrode. The earth electrode was fixed on the forehead. Skin resistance was reduced to less than 5000 ohm. These electrical activities were amplified by a standard EEG apparatus (NIHON KODEN ME-92B) with time constant 0.3 sec, and stored, with stimulus marks, on magnetic tape using a data recorder (NIHON KODEN SDR-41). Averaged VEPs were obtained by a medical data processing computor (NIHON KODEN ATAC-402). Following 4 types of averaged VEPs, classified by the type of contents of the distinctive feature of the stimuli, were obtained from each individual S in each task.

1) *Large-VEP*; VEP elicited by large sized stimulus patterns. In averaging, a half of the samples was obtained from the responses to a large square and the rest from the responses to a large diamond.

2) *Small-VEP*; VEP elicited by small sized stimulus patterns. In averaging,

a half of the samples was obtained from the responses to a small square and the rest from the responses to a small diamond.

3) *Square–VEP*; VEP elicited by square stimulus patterns. In averaging, a half of the samples was obtained from the responses to a large square and the rest from the responses to a small square.

4) *Diamond–VEP*; VEP elicited by diamond stimulus patterns. In averaging, a half of the samples was obtained from the responses to a large diamond and the rest from the responses to a small diamond. In every instance, 50–60 responses were averaged, with a 500 msec analysis time. The VEPs were displayed on the ATAC osciloscope and photographed. The VEPs obtained were used for data analysis after being traced on graph paper from the photographs. Peak latencies and 3 types of amplitudes were measured on the paper (accuracy 0.5mm) for statistical treatments.

Results

The VEPs obtained were multiphasic, consisting of 6 components : a negative peak (N1) at 63 msec, a positive peak (P1) at 113 msec, a negative peak (N2) at 155 msec, a positive peak (P2) at 197 msec, a negative peak (N3) at 241 msec and a positive peak (P3) at 314 msec (times are mean peak latencies of all 80 VEPs··· 10 *S*s × 2 tasks × 4 types of VEPs). These peak latencies were somewhat different from those of our previous study; this is probably due to considerable interindividual variations in VEP wave form.

A question forming the basis for conducting this study was whether the wave form of the VEP was related to the distinctive feature of the stimuli on which the *S* focused his attention. If the complex evoked pattern is indeed correlated with the information processing activities of the brain, it may be expected that the VEP wave form evoked by the patterned stimuli will be more sensitive to the distinctive feature of the stimuli perceived as dominant than that ignored. In order to answer this question, 4 types of VEPs obtained from each *S* were compared : *Large–VEP versus Small–VEP* and *Square–VEP versus Diamond–VEP*.

The essential findings are illustrated in Fig. 2 which shows the VEPs obtained from subject S.A.. The VEPs are superimposed at the start point to clarify the difference in their wave forms. Analysis epoch was 500 msec. Negativity at occipital region resulted in an upward deflection of the graph. Arrow indicates the time of stimulus presentation. Two pairs of VEPs in the left column were recorded during task A, where the *S* was required to discriminate the patterned stimuli by their sizes irrespective of their forms, therefore the size of the stimulus was relevant to the task and the form irrelevant to the task. The difference in wave form between the *Large–VEP* and the *Small–VEP* was clear. However, the *Square–*

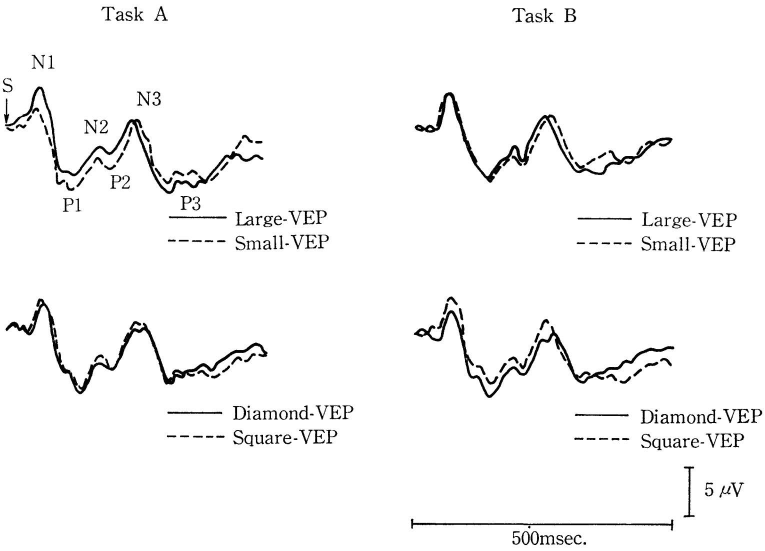


Fig. 2. An example of the changes in VEP wave forms. These VEPs were obtained from subject S. A. N=60 for each record. Details in text.

VEP and the *Diamond–VEP* showed about the same wave form. On the other hand, 2 pairs of VEPs in the right column were recorded during task B, where the *S* discriminated the patterned stimuli by their forms irrespective of their sizes. In task B, the wave form of the *Large–VEP* and that of the *Small–VEP* were superimposed rather nicely, while the *Square–VEP* showed somewhat different wave form from that of the *Diamond–VEP*.

Another example is shown in Fig. 3. These data were obtained from subject N.S..He showed similar trend in VEP change to the data in Fig.2. That is, in task A, where the size of the stimuli was relevant to the task, the difference in wave form between the *Large–VEP* and the *Small–VEP* was larger than that between the *Square–VEP* and the *Diamond–VEP*, while in task B, where the form of the stimuli was relevant to the task, the difference in wave form between the *Square–VEP* and the *Diamond–VEP* was prominent particularly in N2 component.

Similar results are shown in Figs. 4 and 5. In these cases, component P3 was relatively small. However, we can easily notice a difference between 2 VEP wave forms which correspond to the distinctive feature of the stimuli relevant to the task.

In an attempt to confirm this finding more objectively or quantitatively, the data obtained by the experiment were used in statistical treatments. The statistical analysis was carried out concerning the following 4 parameters.

1) Peak amplitude

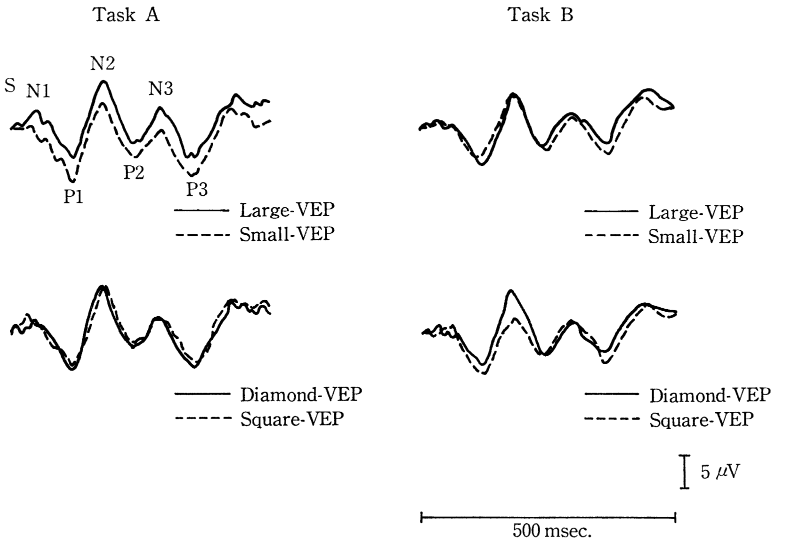


Fig. 3. VEPs from subject N. S N=54. Details in text.

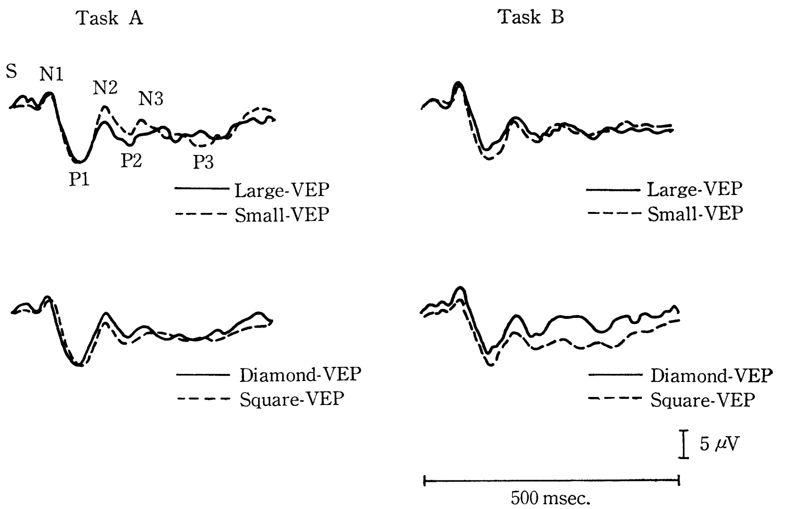


Fig. 4. VEPs from subject S.K. N=54.

2) Peak–to–peak amplitude
3) Peak–to–baseline amplitude
4) Peak latency

Peak amplitude; In this data analysis, the peak amplitude was defined as the

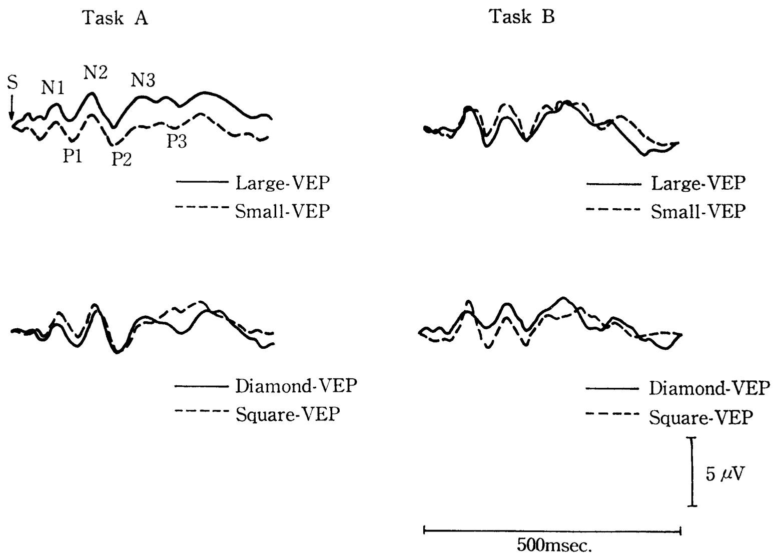


Fig. 5. VEPs from subject T.K. N=54.

length of a vertical line drawn from a given peak to a line tangent to both the preceding and the following peaks. In the leftmost column of Table 1, the definition of each peak amplitude was schematized. For the peak amplitude of component N1, the starting point of the VEP wave form was employed instead of the preceding peak. Five measurements were made for peak amplitude, i.e. N1, P1, N2, P2 and N3 peak amplitudes. The statistical treatments were carried out in the following fashion. The peak amplitude for a given peak of the *Large-VEP* and that of the *Small-VEP* were measured in each indivisual *S*, and then the absolute difference score between these 2 peak amplitudes was obtained by computing the difference without reference to sign. Separate absolute difference scores were obtained for the N1, P1, N2, P2 and N3 peak amplitudes. The same treatments were done between the *Square-VEP* and the *Diamond-VEP*. That is, the peak amplitude for a given peak of the *Square-VEP* and that of the *Diamond-VEP* were measured in each indivisual *S*, and then the absolute difference score between these 2 peak amplitudes was obtained. The means of the absolute difference scores of 10 *S*s for each task are shown in Table 1. In task A, where the sizes of the stimuli were relevant to the task, the absolute difference score between the *Large-VEP* and the *Small-VEP* (|*Large-Small*|) was significantly larger than that between the *Square-VEP* and the *Diamond-VEP* (|*Square-Diamond*|) only in N1 peak amplitude ($P < .025$, Wilcoxon's *T*-test). Conversely in task B, where the forms of the stimuli were relevant to the task, the difference between the *Square-VEP* and the *Diamond-VEP* (|*Square-Diamond*|) was larger than that between the *Large-VEP* and the

Small–VEP (|*Large–Small*|) in all peak amplitudes. The statistically significant difference was shown in N1, N2 and N3 peak amplitudes.

Table 1. The mean absolute difference scores in peak amplitude.

Peak amplitude	Mean absolute difference scores				
	Type of score	Task A		Task B	
N1	|Large-Small|[†]	1.6 μV	$p < .025$	0.3 μV	$p < .005$
	|Square-Diamond|[††]	0.8		1.1	
P1	|Large-Small|	0.9	—	0.7	—
	|Square-Diamond|	0.8		0.9	
N2	|Large-Small|	0.5	—	0.2	$p < .025$
	|Square-Diamond|	0.6		1.0	
P2	|Large-Small|	0.6	—	0.5	—
	|Square-Diamond|	0.4		0.8	
N3	|Large-Small|	0.7	—	0.4	$p < .01$
	|Square-Diamond|	0.6		0.9	

† |Large–Small|……The mean absolute difference score between the *Large–VEP* and the *Small–VEP*.
†† |Square–Diamond|……The mean absolute difference score between the *Square–VEP* and the *Diamond–VEP*.

Peak–to–peak amplitude; Five measurements were made for the peak–to–peak amplitude, i.e. N1–P1, P1–N2, N2–P2, P2–N3 and N3–P3. The results are shown in Table 2. The statistical treatments were carried out in the same fashion as those

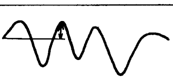
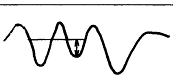
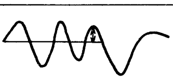
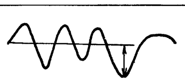
Table 2. The mean absolute difference scores in peak–to–peak amplitude.

Peak-to-peak amplitude	Mean absolute difference scores				
	Type of score	Task A		Task B	
N1-P1	|Large-Small|	1.4 μV	$p < .05$	0.6 μV	—
	|Square-Diamond|	0.7		0.8	
P1-N2	|Large-Small|	0.8	—	0.6	—
	|Square-Diamond|	0.9		0.9	
N2-P2	|Large-Small|	1.0	—	0.6	—
	|Square-Diamond|	1.0		0.9	
P2-N3	|Large-Small|	0.8	—	0.4	$p < .01$
	|Square-Diamond|	0.6		0.9	
N3-P3	|Large-Small|	1.0	—	0.5	$p < .05$
	|Square-Diamond|	1.0		1.0	

for the peak amplitude. In task A, the absolute difference score between the *Large-VEP* and the *Small-VEP* (|*Large-Small*|) was significantly larger than that between the *Square-VEP* and the *Diamond-VEP* (|*Square-Diamond*|) only in N1-P1 peak-to-peak amplitude. In task B, the absolute difference score between the *Square-VEP* and the *Diamond-VEP* (|*Square-Diamond*|) was larger than that between the *Large-VEP* and the *Small-VEP* (|*Large-Small*|) in all peak-to-peak amplitudes. The statistically significant difference was shown in P2-N3 and N3-P3 peak-to-peak amplitudes.

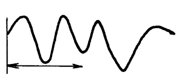
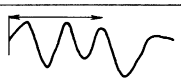
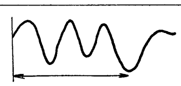
Peak-to-baseline amplitude; In this data analysis, the peak-to-baseline amplitude was defined as the length of the perpendicular line drawn from each peak of the VEP to the baseline. The baseline was drawn, for convenience' sake, horizontally through the starting point of the VEP. Peak-to-baseline amplitudes were measured for all components, i. e. N1, P1, N2, P2, N3 and P3. The statistical treatments were carried out in the same fashion as those for the peak amplitude. The results are shown in Table 3. In all peak-to-baseline amplitudes, the difference between 2 types of mean absolute difference scores was not statistically significant in both tasks.

Table 3. The mean absolute difference scores in peak-to-basline amplitude.

Peak-to-baseline amplitude	Mean absolute difference scores				
	Type of score	Task A		Task B	
N1 	|Large-Small|	1.1 μV	—	1.1 μV	—
	|Square-Diamond|	1.3		0.8	
P1 	|Large-Small|	1.8	—	1.5	—
	|Square-Diamond|	1.1		1.1	
N2 	|Large-Small|	1.8	—	1.3	—
	|Square-Diamond|	1.6		1.4	
P2 	|Large-Small|	1.6	—	1.4	—
	|Square-Diamond|	1.2		1.1	
N3 	|Large-Small|	1.6	—	1.2	—
	|Square-Diamond|	1.2		1.3	
P3 	|Large-Small|	1.4	—	1.2	—
	|Square-Diamond|	1.7		1.2	

Peak latency; Measurements were taken for all 6 peaks. The statistical treatments were carried out in the same fashion as those described above. The peak latency for a given peak of the *Large-VEP* and that of the *Small-VEP* were measured in each individual *S*, and then the absolute difference score between these 2 peak latencies was obtained by computing the difference without reference to sign. Separate absolute difference scores were obtained for the N1, P1, N2, P2, N3 and P3 peak latencies. The same treatments were done between the *Diamond-VEP* and the *Square-VEP*. The results are shown in Table 4. In all peak latencies, differences between 2 types of mean absolute difference scores were not statistically significant in both tasks.

Table 4. The mean absolute difference scores in peak latency.

Peak latency		Mean absolute difference scores				
		Type of score	Task A		Task B	
N1		|Large-Small|	10.0 msec	—	10.0 msec	—
		|Square-Diamond|	7.5		8.0	
P1		|Large-Small|	8.5	—	9.0	—
		|Square-Diamond|	5.5		9.0	
N2		|Large-Small|	10.5	—	8.5	—
		|Square-Diamond|	8.5		13.5	
P2		|Large-Small|	8.5	—	8.0	—
		|Square-Diamond	4.0		4.5	
N3		|Large-Small|	19.5	—	12.5	—
		|Square-Diamond|	8.5		18.5	
P3		|Large-Small|	17.5	—	6.5	—
		|Square-Diamond|	14.0		9.0	

In order to evaluate the effects of eye movement on VEPs, EOG was obtained from monopolar recording in 8 *S*s.* The EOG was averaged in the same way as that for brain evoked potentials. Four types of averaged EOG were obtained, i.e. *Large EOG*, *Small-EOG*, *Square-EOG* and *Diamond-EOG*. *Large-EOG* was recorded when large patterned stimuli were presented. That is, in averaging of the *Large-EOG*, half of the samples were obtained from EOGs time-locked to large square and the rest from EOGs time-locked to large diamond. In the same way, *Small-EOG*, *Square-EOG* and *Diamond-EOG* were obtained. The eye movement was estimated from the wave form of these averaged EOGs. Typical examples are seen in Fig.6. Four types of EOGs recorded in task A were superimposed at the beginning to clarify the difference in their wave forms. Averaged EOGs showed slight deflection. However, their wave forms were very similar and superimposed rather nicely. Furthermore, a comparison of wave form of averaged EOGs and that of VEPs shows that although

* The EOG results obtained from bipolar recording were examined in previous paper

deflection in averaged EOGs was presented, it resulted from wide spreading of evoked electrical activities from occipital region. Therefore, the eye movements time-locked to the stimulus presentation seem to be minimun in this experimental situation, and if any, they appear to be similar for all stimuli, since the averaged EOGs are superimposed rather nicely.

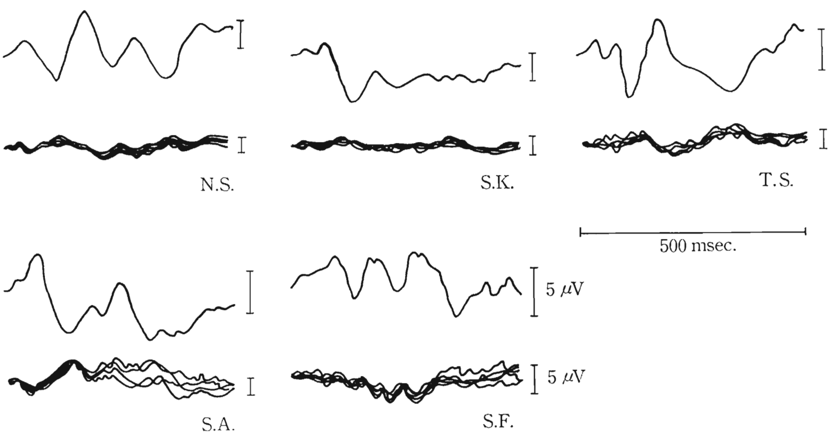


Fig. 6. Comparison of averaged EOGs and VEPs obtained from 5 subjects during task A. The upper trace in each subject is the VEP elicited by large sized stimuli, and the lower traces are 4 types of averaged EOGs which are superimposed at the beginning. N=50∼60. Negativity at occital or lateral canthus is represented by an upward deflection.

Discussion

The essential findings of this study were approximately similar to the result obtained in our previous study (Honda, 1973). The wave form of the VEP was found to be particularly sensitive to the distinctive feature (size or form) of the geometrically patterned stimuli on which the *S*s focussed their attention. That is, the distinctive feature of the stimuli, which the *S*s discriminated, appeared as the difference of the wave form of the VEPs. When the *S* was required to count the stimuli, dividing them into two categories of the size (i. e. large and small), therefore had to direct his attention toward the size of the stimuli, the wave form of the *Large-VEP* was different from that of the *Small-VEP*, and the difference was significantly larger than that between the *Square-VEP* and the *Diamond-VEP* in N1 peak amplitude and N1-P1 peak-to-peak amplitude. On the other hand, when *S* had to direct his attention toward the form of the stimuli, in order to count the stimuli dividing them into two categories of the form (i. e. square and diamond), the difference in wave form between the *Square-VEP* and the *Diamond-VEP* was significantly larger than that between the *Large-VEP* and the *Small-VEP* in N1, N2 and N3 peak amplitudes and in P2-N3 and N3-P3 peak-to-peak amplitudes. However, no significant difference was shown in peak-to-baseline amplitude and peak latency. In brief, the results obtained in this study showed that in task A, some components of the VEP were altered by the size of the stimuli, while in task B, by the form rather than the size.

The statistical treatments employed in this study demand reconsideration in order to interpret correctly the results described above. In the present data analysis, only the absolute difference scores between 2 types of VEPs were taken into statistical treatments, and the sign of difference was disregarded. For this reason, the results show us no consistent relationship between the contents of the distinctive features and the VEP wave forms. For example, in task B, some subjects showed larger N1 peak amplitude of the *Square-VEP* than that of the *Diamond-VEP*, but the others showed *vice versa*. Nevertheless, the absolute difference score in N1 peak amplitude between these 2 VEPs was statistically larger than that between the *Large-VEP* and the *Small-VEP*.

Significant difference in VEP wave form was more frequently appeared in task B than in task A. In this experimental situation, the form of the visual stimuli seems to be a more effective dimension on VEP wave form than the size. John *et al*. (1967) compared the VEP to a square with the VEP elicited by the same stimulus rotated 45° to represent a diamond, and found that the form of a geometrical figure was more potent determinant of the VEP wave form than its area. Their data will be explained by our finding. That is, VEP changes by patterned stimuli are determined by both physical characteristics of the stimuli and such psychological variables in *S*, as selective attention.

By the way, many workers have studied the effects of selective attention on evoked cortical potentials. There is considerable evidence that the amplitude of evoked cortical potentials to the stimuli attended to was greater than that to the stimuli not attended to (Garcia-Austt *et al*. 1964, Davis 1964, Gross 1964, Haider *et al*. 1964, Donchin & Cohen 1967, Shatz & Chapman 1968, Ritter & Vaughan 1969, Smith *et al*. 1970) The effects of attention are frequently attributed to the differential reaction change of subjects or differential state of preparedness of subjects (Karlin 1970). In this experimental paradigm, 4 types of stimuli were presented in random order so that the *S*s were not able to predict which type of stimulus would occur next. This randomized procedure insured that the VEP changes obtained were not due to differential arousal state prior to the stimulus presentation. Additionally, since the *S* was required to count all stimuli presented, each stimulus was expected to have equal significance for the *S*. In our study, unlike many studies which dealt with effects of attention on VEPs, the *S* had to direct his attention equally to all stimuli, since all stimuli were relevant to the task. Therefore, to count the stimuli, dividing them into 2 categories, seems not to produce such differential reactive changes, as those of arousal level in response to critical stimuli. The *S* focused his sttention on one of the 2 discriminative cues (in other words, distinctive features) of visual stimuli to perform the task which included a kind of perceptual processing. As a electrophysiological correlate of the attended and non-attended discriminative cues, we obtained 2 pairs of VEPs, which corresponded to contents of discriminative cues, and then computed the absolute difference score between the pair of VEPs. By the statistical analysis of these absolute difference scores, we found orderly VEP changes which seemed to be ascribed neither to results due to the development of differential state of preparedness nor to differential reactive changes after the presentation of critical stimuli. The peripheral effects, as contamination by eye movements, may participate in the results found in this study. Close visual inspection of averaged EOGs which were time-locked to the stimulus presentation showed us that the wave form of averaged EOGs mainly resulted from wide spreading of evoked electrical activities from occipital region, and that there occurred relatively small eye movements which hardly contaminated the VEPs.

In this study, the brain evoked potential was recorded only from the occipital region. Indeed in many works, visually evoked potentials have been frequently obtained from occipital region, but it is very interesting to compare the VEP changes recorded from several scalp positions. Our unpublished observation, in which a somewhat different experimental procedure from that of the present study reported here was employed, showed that when VEPs were obtained from various locations (Oz, P3, Cz, T5 and Fz) during visual discrimination task, the VEP changes corresponding to the perceptual discriminating processing were seen only at occipital and parietal leads. Further analysis, however, will be required to establish this finding.

In conclusion, the VEP changes obtained in this study resulted from the effects of selective attention, and seemed to reflect the electrical brain activities closely related to pattern perceptual processing, probably not the representation of neurophysiological mechanisms per se but something necessary and fundamental for visual information processing.

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(Received August 25, 1974)