The aim of this study is to identify the relationship between subjective preference (primitive response) and the human brain responses to visual motion under changing its period. In this study, a single circular target moving horizontally was displayed. At first, subjective preference judgments using the paired-comparison method were performed. From the results of the scale value of subjective preference, the most preferred and the least preferred periods were selected as paired stimuli for recording MEG data. The effective duration of the envelope of the normalized ACF ($\tau_e$) of the $\alpha$-waves was analyzed to examine whether a relationship exists between the subjective preference and the effective duration ($\tau_e$).

II. METHODOLOGY

1) Stimuli and Subjects

The stimulus was a single circular target with sinusoidal movements. The diameter of the target is subtended 1.0 deg of visual angle. The amplitude was fixed 0.5 deg of visual angle. The white target on a black background was displayed on a screen. The period of stimulus was varied at six levels (0.6, 0.8, 1.2, 1.6, 2.0 s). The movement of the stimulus is given by

$$h(t) = A \cos(2\pi \frac{t}{T})$$

(1)

where $A$ is mean amplitude, $T$ is the period of the stimulus. The stimulus projected on a screen placed in a dark chamber by a projector in front of subject’s eye position at a distance of 130 cm. And they started to move from right field to left field of the subject. Ten subjects (A-J, two women and eight men, 22-25 years old) all had normal or corrected-to-normal vision.

Fig. 1. A single circular target with sinusoidal movement in the horizontal direction as a visual stimulus.
2) Subjective preference test

Following the paired-comparison method, subjective preference tests were conducted changing period of the stimulus in a dark chamber. Twenty pairs were combined randomly in a session, and five sessions were conducted for each subject. The interval between the stimuli presentations was 1.0 s and that between comparison pairs lasted 4.0 s in order to allow for subject’s responses. Subjects reported which is more subjectively preferred movement by pushing a button. The preference scores of all subjects were evaluated for each period. The scale values of the subjective judgments of each subject were calculated according to Case V of Thurstone’s theory [6]. The model of Case V for all data was reconfirmed by a goodness of fit test [7].

Fig. 2 shows global scale values of preferences of ten subjects. The most preferred period was 1.2 s, and least preferred was 0.6 s among ten subjects. Effects of period on the scale values of preference were examined with all 10 subjects using the one-way analysis of variance (ANOVA). The ANOVA results clearly indicate that the effects of period were found to be significant (p < 0.001) for all subjects.

The result of goodness of fit for the model had a good match between fitted values and the observed values except that of subject A ($\chi^2 = 12.6 = \chi^2_{0.05} (0.05)$).

3) Recording MEG

Magnetoencephalograms (MEGs) were recorded by using a 122 channel whole-head SQUID (Neuromag-122). The experiment was performed in a magnetically shielded room. The subjects and the conditions of presenting stimuli were the same as for subjective preference test. In order to clear whether the effects on MEGs came from subjective preference or periods, two kinds of pairs were presented. As pair 1, to find a significant effect of subjective preference on MEGs, the most preferred period and the least preferred period were selected as a pair stimuli (Fig. 2, [0.6 and 1.2] s pair). As pair 2, the stimuli having the opposite relationship about periods to pair 1 were chosen (Fig. 2, [1.2 and 2.0] s pair). According to individual differences of the subjective preference, the pairs were set for each subject. The subjects watched the most and the least preferred period alternatively. Each pair was presented successively ten times (one series) with a 1.0 s repetitive interval and three series were conducted for all subjects. Therefore 30 MEG data were recorded in each pair from each subject. The MEGs were filtered from 0.1 to 30.0 Hz and digitized with sampling rate of 400 Hz. Fig. 3 shows an example of the distribution of MEG signals over the scalp using the whole-head system. The figure shows that the channels at the temporo-occipital area have the stronger amplitude, especially in the left hemisphere. It is for this reason that the visual stimulus started to move from right field of the subject.

To discuss brain activity in relation to the human’s behavioral states, Lindsley reported that EEG well corresponds to $\alpha$-waves which is always shown in relaxed states and is associated with free creative thought [8]. Therefore for further analysis of the effective duration of ACF ($\tau_e$), MEG data were filtered in $\alpha$-wave ranges (from 8 to 13 Hz).

4) Autocorrelation function (ACF) Analysis

The autocorrelation function (ACF) and power density spectrum mathematically contain the same information. Four physical factors are obtained from the ACF [2]: (1) energy represented at the origin of the delay, $\Phi(0)$; (2) effective duration of the envelope of the normalized ACF, $\tau_e$, representing a kind of repetitive feature containing the signal itself; (3, 4) fine structure, including peaks and dips with their delays, the delay time and amplitude of the first peak—namely, $\tau_1$ and $\phi_1$.

The normalized ACF is defined by
effective duration

de time. The envelope decay of the initial part of the ACF can be
test for the scale values of the subjective judgments.

Subject A didn’t have a confident result to a goodness of fit
Subject A and B were omitted from the results because
there was no significant difference in their judgments.
where 2T is the integral interval, τ is the time delay, and
α(t) is the alpha wave of an MEG.

Fig. 4 demonstrates an example of the logarithm of the
absolute value of the ACF plotted as a function of the delay
time. The envelope decay of the initial part of the ACF can be
fitted by a straight line in a range from 0 dB to -5 dB, and the
effective duration τe of the ACF can be easily obtained from
the decay rate extrapolated at -10 dB [3]. The integration time
duration (2T) was set at 2.5 s for our ACF analysis of τe,
which is the shortest duration needed to make subjective
preference judgments [3]. Calculating τe of ACF in alpha-
wave range, the occipital area in both left and right
hemispheres of each subject’s head (Fig. 3 81-84 ch, 101-104
ch) was selected.

\[
\phi(\tau) = \frac{\Phi(\tau)}{\Phi(0)},
\]

where

\[
\Phi(\tau) = \frac{1}{2T} \int_{-T}^{+T} \alpha(t)\alpha(t+\tau)dt;
\]

III. RESULTS

Subject A and B were omitted from the results because
subject A didn’t have a confident result to a goodness of fit
test for the scale values of the subjective judgments.

A. Values of τe in alpha-wave range

The ratios of the averaged τe values at most preferred
stimuli to those at least preferred stimuli for each subject
were calculated to compare with the differences in scale
values of preference. Fig. 5 shows the typical examples in
both kinds of pairs.

```plaintext
(a) Left hemisphere Right hemisphere

(b) Left hemisphere Right hemisphere

(c) Left hemisphere Right hemisphere

(d) Left hemisphere Right hemisphere
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Fig. 5. Ratios of τe value in alpha-wave range which responded to
the change of the period for four subjects.

[τe value at preferred period] / [τe value at non preferred period]
(a) Subject D at pair 1 (b) Subject E at pair 2
(c) Subject H at pair 1 (d) Subject I at pair 1
B. Hemispheric Dominance

Fig. 6 shows the differences between the ratio of the averaged $\tau_e$ of the channel at which it changed the most largely in the left hemisphere when two stimuli were presenting and that in the right hemisphere for each subject except A and B.

![Graph showing differences in ratios for each subject]

IV. DISCUSSION

The ratios of the averaged $\tau_e$ values at most preferred stimuli to those at least preferred stimuli tended to be greater than unity at the occipital area, especially in the left hemisphere during presentations of both kinds of pairs as shown in Fig. 5. The value of $\tau_e$ of ACF for $\alpha$-waves is prolonged with a certain degree of coherent at the preferred condition. This may be interpreted in such a way that a similar repetitive feature in the $\alpha$-waves is evoked due to comfortable relaxation that may be repeated in the mind. However, large individual differences were shown among all subjects. There are probably several causes for this result, one is the individual difference of sensitivity to the movement of stimuli. Another is due to area of analysis, because the numbers of MEG channel don’t located on the same positions of subject’s cortex. Thus, there is room for further investigation on the area of analysis.

Fig. 6 was shown in order to discuss hemisphere dominance. The ratio of the averaged $\tau_e$ values at most preferred stimuli to those at least preferred stimuli indicates a degree of changes of $\tau_e$ for two stimuli. If the values of $\tau_e$ at two stimuli are the same, the ratio is unity. As the ratio is apart from unity, it can be regarded that the values of $\tau_e$ changed greatly. Therefore the ratio that changed the most largely in the left hemisphere and that in the right hemisphere were selected, then the differences between them were investigated. It is obvious for all eight subjects that the differences are consistently greater than zero. So it can be said that the left hemisphere of the subject was activated greatly for visual motion under changing its period ($p < 0.01$). This may indicate the left hemisphere dominance for changing periods. The above mention might be explained by specialization of human brain. As is well known, our left cerebral hemisphere is associated with the temporal features of the environment, and the right hemisphere is associated with spatial features [2]. This tendency of our result in visual field is similar to previous studied in a sound field. When the spatial factor, the listening level of a continuous speech signal was changed, the right hemisphere was activated significantly [9]. And when the temporal factors, the noise-burst tempo, the delay time of the single reflection ($\Delta t_1$), and the subsequence reverberation time ($T_{1/2m}$), were changed, the left hemisphere was activated significantly [2-4]. The result of our experiment in a visual field is considered to be due to changing the temporal factor, the period of visual stimulus.

V. CONCLUSION

At the preferred period of the motion stimulus, values of $\tau_e$ in alpha wave range are longer than those at the least preferred period at the occipital area, especially in the left hemisphere. In regard to the hemispheric specialization, the left hemisphere is activated when the periods of the motion stimuli are changed.

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