

Physiological Interaction Between Human And Visual Media: Approach By Measuring Of Human Brain Wave

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Abstract

The difference of physiological interactions with the human of visual media such as softcopy and hardcopy was assessed by using the electroencephalograph. The EEG (Electroencephalograph) of the subjects reading an editorial article with each media were measured. Positive factor (α-EEG and θ-EEG) and negative factor (β-EEG) were evaluated by the results of analyzing the EEG data. We have found some differences in EEG of three types of human interfaces. Results suggest the effectiveness of the EEG measurement as one of the methods for measuring the physiological interaction between human and visual media.

Introduction

The digital information technology is deeply and widely penetrating into our social life in last decennial. Therefore, many persons contact with display terminal (Softcopy) every day and get the information by seeing and reading the softcopy. Softcopies, as a new visual media, are usually light emitting or light source image displays. On the other hand, hardcopies, which are the inked images on paper, give reflection images and have been intimate and friendly with human for a log time. Does the difference exist for the physiological interaction on the human brain in seeing visual media of the different type? This is a very interesting problem in imaging technology. We reported the results of IQ test method.[1)] In this paper, we used electroencephalograph to measure the degree of physiological interaction of three interfaces to human.

Brain wave (EEG)[2)]

The brain is electrically active and always generates electrical signals. The EEG is measured as the induced current by the electrodes contacted on the scalp. It is possible to examine the condition of the consciousness by measuring the EEG of frontal lobe, because the activity that is related to the consciousness of the cerebrum exists locally in the part of frontal lobe. Also, it is possible to classify by signal frequency, which is responsible to the EEG of frontal lobe, as follows:

*β-EEG (14 ~ 26Hz):	Tenses,
*Fast α-EEG (12-13Hz):	Concentrated condition with tension,
*Mid α-EEG (10-11Hz):	Concentrated condition without tension,
*Slow α-EEG (8-9Hz):	Concentrated sleeping and lowering of consciousness,
*θ-EEG (4-7Hz):	Shallow sleeping state and lowering of consciousness,
*δ-EEG (0.4-4Hz):	Deep sleeping state and disappearing of consciousness.

When the fraction of EEG in some frequency band may be much, the brain activity will show the features in its frequency band. Consequently, it is necessary for understanding the characteristics of EEG to classify from the original wave forms to each frequency band as shown in Figure 1.

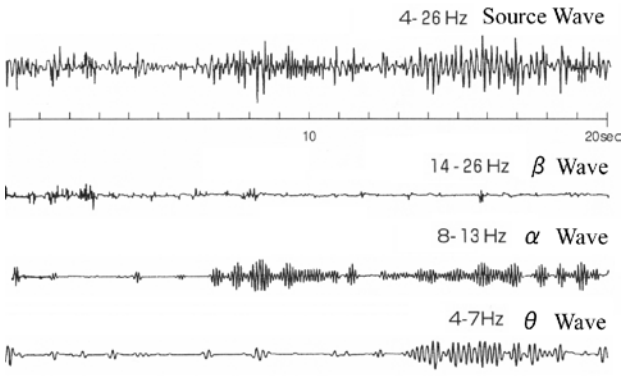

Figure 1. Examples of measured EEG.

Electroencephalograph

In the electroencephalograph, the differential amplifier is used in order to remove the electrical noise. Two elec-

trodes should be separated as much as possible in order to examine the condition of the wide area of the brain. The one electrode is set to position which want to take out the EEG and other is to earlobe. This is referential derivation method. Used electroencephalograph was "mind NAVI" made of HITACHI ULSI systems.

The EEG was measured by referential derivation method in conformity to electrode layout of 10/20 system. The photograph of used electroencephalograph is shown in Figure 2. The merits of this electroencephalograph are as follows. The load of the subject may be small and EEG can be measured easily. The two channel electrodes can separately measure the information of right brain and left brain. The EEG data was processed by FFT (Fast Fourier Transform) and was analyzed.

Figure 2. Photo of electroencephalograph apparatus.

Human Brain[2)]

Figure 3 shows the functional activity of the brain. There are right and left brains in human brain and are the functional difference for each brain. Right brain is the control center for mind activities such as general intelligence for space, intuition, hunch, rhythm, music, art, physical, response or activity, synthetic and prolific thinking and so on. On the other hand, left brain is the control center for a mind activity such as special intelligence for memory, language, time, number, calculation, logic, analytic and convergent thinking and so on.

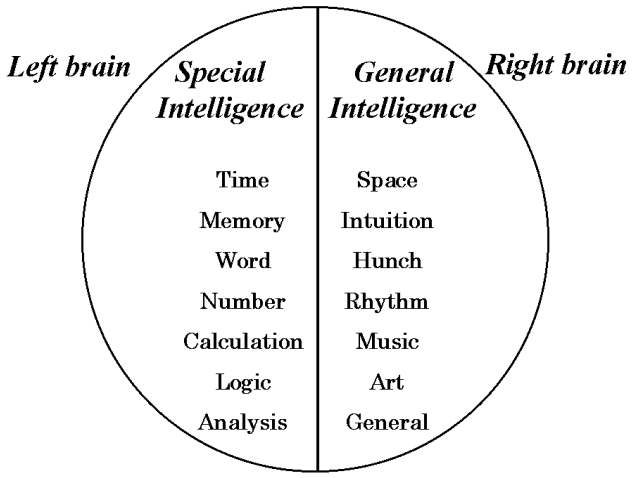

Figure 3. Mind activities of the right brain and left brain.

Table 1 Experimental conditions.

Type	CRT	LCD	Paper
Medium	Iiyama A702H	SHARP LL-T1510A	EPSON Super Fine Paper
Size	17inch(XGA)	15inch(XGA)	A4
Refresh Rate	75Hz	70Hz	—
Luminance	65cd/m^2	70cd/m^2	—
Environment	Illumination:500 lux (Fluorescent light)		
Room Temp.	22~24℃		

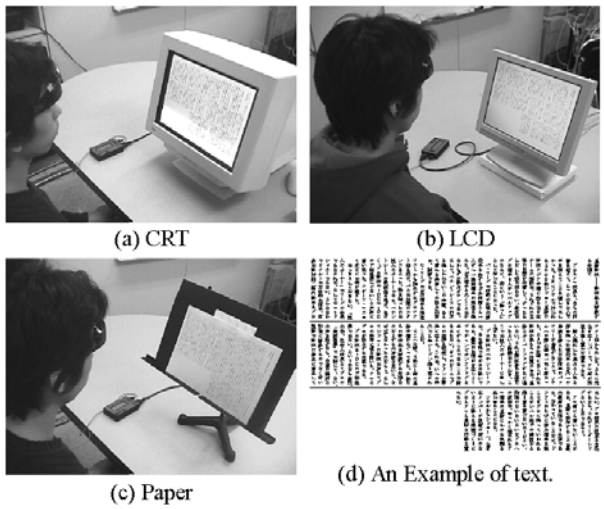

Figure 4. Scenes of experiments.

Experimental

Subjects

Subjects were 10 persons for experiment 1 and for experiment 2, respectively and the age of 21 to 24. All persons have experienced the visual display terminal working.

Procedure

The sentence was presented for the subjects as two media of hardcopy (paper) and softcopy (CRT and LCD), and the silent reading for 15 min. was respectively done by subjects, who put electroencephalograph on his head. The comparison of CRT and paper is experiment 1, and the comparison of paper and LCD is experiment 2. After the end of reading experiments, the subjects were made to replay to the questions on the degree of fatigue and readability. The brain wave measured by the EEG was analyzed according to analysis program, and evaluation and examination were carried out.

The experimental conditions were shown in Table 1. Used sentence was an editorial article of Mainichi Shimbun. In the case of softcopy, the display was controlled by Power-Point of Microsoft Corporation. In the case of hardcopy, the pages were turned over manually. Used hardcopies were printed by laser printer. The character size (3.7mm x 3.7mm) in paper, CRT and LCD was all the same. The reading angle of the display unit (CRT,

LCD, paper) to the subject was made an angle of 75° to the level table, and the height of chair and the position of display unit were of free for the subject. However, the experiments for softcopy and hardcopy were done under the equal condition. Figure 4 is a photograph of experimental scene.

Results and Discussion

Subjective Evaluation (Inquiry To Impression On Working)

First, we asked working over person, "Which do you feel more easy of reading". This is the question about subjective easiness of reading in two interfaces. Figure 4 shows the results of the asking. The 8 persons in experiment 1 and the 9 persons in experiment 2 answered more easily in reading of hardcopy.

Second, we asked "Which human interface are tired for you". This is the question about subjective fatigue. Figure 5 shows the comparison of the degree of fatigue in two interfaces. The persons that answered to feel more fatigued in softcopy are 9 persons in experiment 1 and 8 persons in experiment 2. It is suggested that there will be the close relation between easiness of fatigue and of thinking in two interfaces.

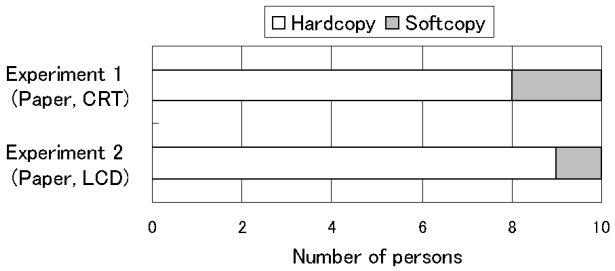

Figure 5. Number of persons choosing comfortable medium.

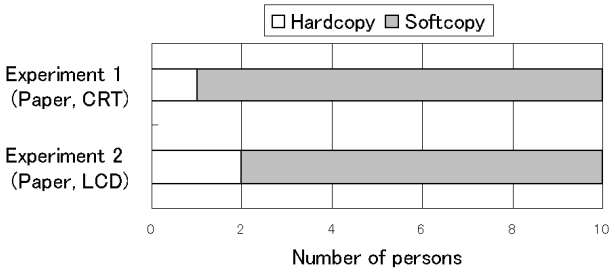

Figure 6.Number of persons choosing more tired medium.

Objective Evaluation

The objective evaluation by using EEG was carried out by P-value in each visual media. P-value is the appeared fraction of predominant brain wave in a measuring time(for T second) by EEG analysis program (Mind Sensor II) and P = 300 is required as maximum value. P-value is determined by the following equation (1),

$$P = \frac{1}{T}\sum_{t=0}^{T}(2\theta + 2S\alpha + 3M\alpha + F\alpha)\,, \qquad (1)$$

where, θ (θ-EEG), Sα (Slow α-EEG), Mα (Mid α-EEG) and Fα (Fast α-EEG) are the appeared fraction of predominant brain wave (%) in unit measurement time (for 1 second), respectively. It can be considered that the person may be in the better consciousness concentration condition (CCC) when this value is larger.

$$\Delta P = [(P\text{-value at H.C.}) - (P\text{-value at S.C.})] \qquad (2)$$

When ΔP is plus, hardcopy may give the person the better CCC. When ΔP is minus, softcopy may give the better CCC. Figure 6 (Exp.1, paper & CRT) and Figure 7 (Exp.2, paper & LCD) are the histogram of ΔP vs. number of person. The mean value of ΔP in plus and minus value range, respectively, and the total mean value of ΔP are shown in the figures. It is seen in Figure 6 and Figure 7 that the subject numbers having large P-value in hardcopy are much more than in softcopy, but there may not be an extreme difference in P-value between hardcopy and softcopy. It is estimated in both figures that the plus ΔP-value of left brain is larger than that of right brain. This result suggest that the activity of left brain will be mainly responsible for the work of character reading, because it seems to relate to the function of the language existing locally in the left brain.

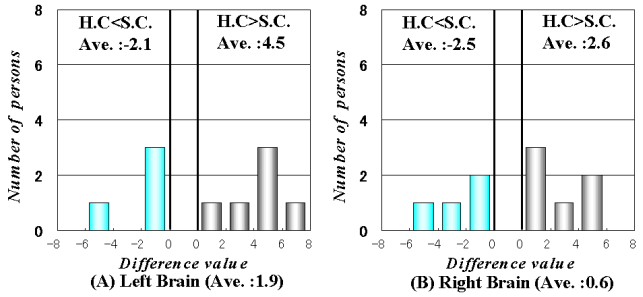

Figure 7. ΔP-value histogram between paper and CRT.

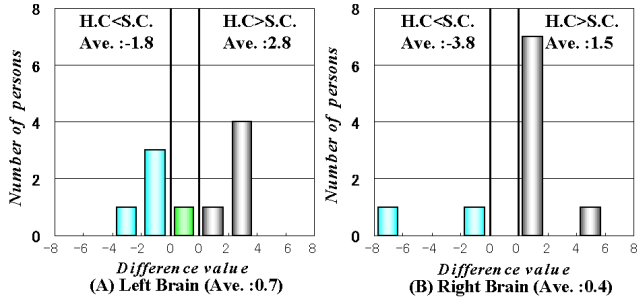

Figure 8. ΔP-value histogram between paper and LCD.

β-EEG does not contain in the P-value, but is a brain wave that shows the tension state. Therefore, it can be said

that small β-signal may mean better condition for human. Q_h is the predominant appearance frequency of β-rhythm for 15 min. of EEG measurement in hardcopy and Q_s is that in softcopy. Now, we can introduce the characteristic value in order to estimate the degree of human interaction as follows,

$$\Delta Q = Q_h - Q_s . \qquad (3)$$

It is thought that in the case of plus ΔQ, hardcopy will be in poor condition and in the case of minus ΔQ, it will be in good condition. The relationship between ΔQ and number of subject is shown in Figure 9 for experiment 1 (paper and CRT) and in Figure 10 for experiment 2 (paper and LCD). In these figures, though there is little difference between Q_h and Q_s in the right brain, it seems that there is some difference between Q_h and Q_s in the left brain.

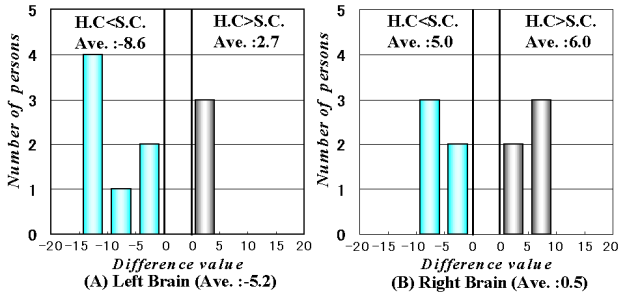

Figure 9. ΔQ-value histogram between paper and CRT.

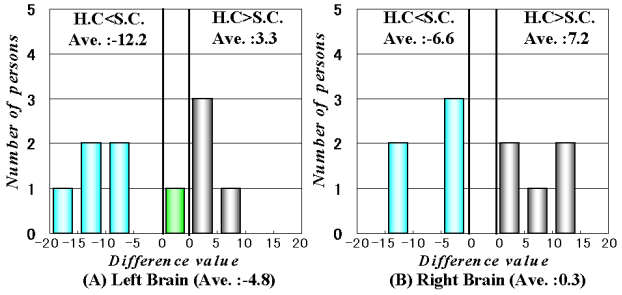

Figure 10. ΔQ-value histogram between paper and CRT.

Summary

When the sentence was read with different visual media such as hardcopy and softcopy, it was measured by using EEG what kind of difference could exist for the consciousness concentration. In the action of reading the sentence with hardcopy and softcopy, the subjects who get high evaluation point to consciousness concentration are many in hardcopy. The subjects, who have the large difference of evaluation point showing the consciousness concentra-tion, may be many in paper-CRT experiment than in paper-LCD experiment. In comparison of three media, that is, CRT, LCD and paper, CRT may not be suitable for the action to read the sentence. It may be considered that there will be much the effect by a flicker of the CRT, which is not contained in paper and LCD. The subjects who greatly appear in predominant appearance frequency of β-rhythm in the left brain may become dominant in softcopy than in hardcopy. The subjects who the difference of P value becomes larger in left brain than right brain may be found in both experiment 1 and experiment 2. Some possibility in using the electroencephalograph to detect the difference in human interaction with visual media of the different type may be suggest in this paper.

References

1. H.Watanabe: “Softcopy and Hardcopy as an Information Carrier” Proceedings of IS&T's NIP15, 1999, pg. 390-393.
2. K.Shiga: “Senzaino” Diamond Lab., pg. 76-115.

Biography

Hirotaka Watanabe received his B.S. degree in 1999 from Tokai University. He is expected to receive his M.S. degree from Graduate School of Tokai University in 2001. His interest is the problems of Human interface in Imaging technology.