映像視聴時の脳血流活動の計測に基づく、好ましさの第一印象と前頭葉活動の関係の分析

Analysis between First Impression of Likability and
Change of Oxy-Hb in Frontal Cortex during Watching Video

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1. Introduction

A traditional evaluation method for video contents has been based on customers' review and feedback such as questionnaire about impression with using scores from small sample of people. However, the method has some problems on reliability and, needs to embrace scientific approaches regarding to brain activity [1]. Thus, in this study, we focused on brain activities, and analyzed the relationship between impressions of video contents and brain activities. We observed brain activities at frontal cortex during watching video contents, as frontal cortex was related to higher-level cognitive function. We used an optical topography based on near infrared spectroscopy (NIRS), because it was non-invasive and restraint-free, less noise than electroencephalography (EEG), and higher temporal resolution than functional magnetic resonance imaging (fMRI) [2]. Consequently we found a decreased oxygenated hemoglobin (oxy-Hb) change during watching a video. In addition, there are significant differences among excellent videos, normal videos, and poor videos in oxy-Hb changes in Brodmann area 46 (Dorsolateral prefrontal cortex) in right hemisphere. These results suggested that the decrease in oxy-Hb change of Right Brodmann area 46 (Dorsolateral prefrontal cortex) was related to the subjective evaluation, especially the first impression of likability, for video contents.

2. Experiment for Measurement of Frontal Cortex by Optical Topography

2.1. Participants

Twenty healthy participants (all were men, mean age 22.45± 1.0 years and right-handed) participated in this optical topography experiment.

2.2. Instruments

We used ETG-4000 optical topography system (HITACHI Medical Corporation, Japan) to measure brain activities in frontal cortex. ETG-4000 is a neuroimaging method based on near infrared spectroscopy, and can measure the change of oxygen levels in cerebral tissue [3]. We measured 22 positions (channels) in frontal cortex area according to the international 10-20 system in electroencephalography (Figure 1) [4].

We used 17-inch display (Mitsubishi Electric Corporation) to show the videos. The distance from display to participants was 60 cm. The sound was outputted from earphones (Audio-Technica Corporation).

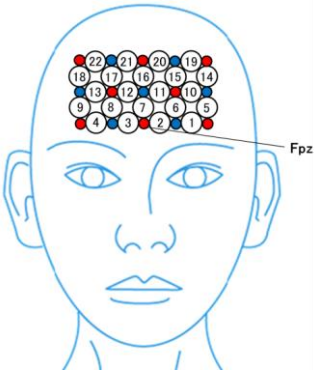

Figure 1.　22 channels positions in frontal cortex.

We located the middle of channel 2 and channel 3 at Fpz which was defined in the international 10-20 system. 8 light source (red dots) positions and 7 detecting positions (blue dots) were in this figure.

2.3. Procedure of optical topography experiment

Measurement of brain activities during watching videos and subjective evaluation for videos were conducted. Each participant was seated in front of the table on which 17-inch display was placed. Changes in the concentration of oxy-Hb

were measured at 22 channels with an ETG-4000 during the watching of six videos in Table 2. Each participant watched and evaluated the overall impression of likability for the six videos one by one using the 5-point rating with a hand. The six videos were presented on the display in random for each participant to avoid order effect. A block paradigm was used in a design of experiment for watching six videos sequence [5]. A sequence was a 30-second period of video with a 40-second period of rest. The rest consisted of 25-second rest time, 5-second evaluation time by a hand, and 10-second rest time (Figure 2).

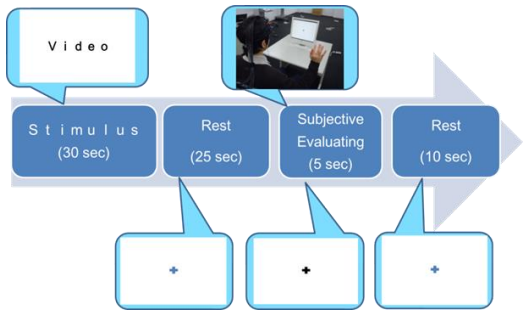

Figure 2. Design of experiment.

This sequence was in succession for each participant. Participants evaluated the videos by a hand when the color of cross mark changed from blue to black on display.

2.4 Procedure of analysis for oxy-Hb changes

2.4.1. Peak search for statistical score

Average waveforms were calculated by MATLAB in Figure 3. Nineteen participants (one participant was removed because oxy-Hb data was clearly noisy) and all six videos oxy-Hb data were used. A chart represented change in the concentration of oxy-Hb on a channel, so 22 charts were in Figure 3. We set peak time duration (For 15 seconds from 20 second to 35 second) by using the waveforms. The duration of oxy-Hb for 15 seconds data was averaged and used in statistical analysis.

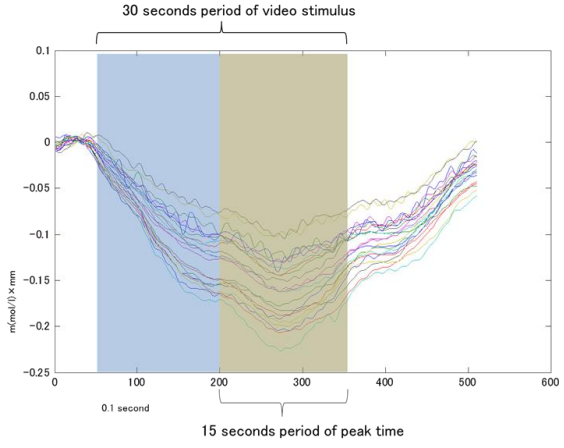

Figure 3. Average waveforms of 22 channels.

The peak time duration was determined with these waveforms. A chart represented Oxy-Hb changes at a channel. A time length of a chart was 50 seconds (5 seconds before onset of video stimulus, 30 seconds of video stimulus and 15 seconds after video stimulus).

2.4.2. Data selection for analysis

We selected oxy-Hb data to observe the differences of brain activity among the excellent, normal and poor videos certainly. First of all, their ratings of subjective evaluations for six videos were averaged each video, and the videos were ranked by the average score. Excellent, normal and poor video groups were classified in Table 2 according to the ranking. In addition, we used only oxy-Hb data, of which the subjective evaluation per person in the optical experiment fitted with the classification of group. For example, a meaning of excellent oxy-Hb date in this analysis was judged as excellent both in the classification and the subjective evaluation during optical topography experiment. Moreover, the oxy-HB data, which from the video participant had watched in the past, were removed. Consequently, the number of participants was screened from 20 to 8 in excellent, 20 to 8 in normal, 20 to 8 in poor.

2.4.3. Regions of interest (ROIs)

We determined regions of interest (ROIs) in frontal cortex. We used virtual registration method [6] to estimate channel positions on frontal cortex. We labeled the estimated locations using anatomical information based on Brodmann areas. We classified the 22 channels into 7 ROIs according to the estimated labels, and the labels, which had 60 % and more of probabilities of positions, were used (Table 1). The channels were combined based on the labeling result.

Table 1. Spatial profiles of channels of ROIs.

Seven ROIs were in the right column. Channels, which had less than 60 % probabilities of Brodmann area, were omitted.

		MNI coordinates			
Brodmann area	Ch	x	y	z	Probability
R B9 - Dorsolateral prefrontal cortex	21	13.343	50.203	45.299	1
	22	36.428	40.016	41.771	0.791
L B9- Dorsolateral prefrontal cortex	19	−34.1	39.974	42.287	0.8
	20	−11.3	50.347	45.717	1
R B45- pars triangularis Broca's area	18	47.05	41.279	26.855	0.84
L B45- pars triangularis Broca's area	14	−45.2	41.068	28.007	0.779
R B46- Dorsolateral prefrontal cortex	9	46.106	52.737	0.873	0.881
	13	37.556	58.395	18.063	0.627
L B46- Dorsolateral prefrontal cortex	5	−45.44	52.252	1.712	0.89
	10	−35.55	57.613	18.932	0.777
B10- Frontopolar area	8	26.793	67.623	7.986	0.839
	12	14.246	67.718	22.365	1
	6	−24.85	67.591	8.93	0.869
	11	−12.78	66.258	21.91	1
	7	1.344	67.547	9.01	1

2.4.4 Statistical analysis for oxy-Hb

Statistical analyses were performed using SPSS Statistical Packages (SPSS Inc., Chicago, USA). We performed one-sample and paired t-test (N =19) on ROIs to determine the aspect of Oxy-Hb changes during watching videos. In the one-sample t test, 5 seconds average oxy-Hb data from onset (baseline: zero) and peak time average of oxy-Hb data were compared. The peak time averages were calculated regardless of levels: excellent, normal and poor. After the t-test, we conducted one-way ANOVA (N=8) to investigate whether the oxy-Hb data in three levels of subjective evaluation had difference in each ROI, and then performed one-sample and paired t-test (excellent vs normal, normal vs poor, and excellent vs poor) on ROI which showed significant difference in the ANOVA. Bonferroni correction was applied for all comparisons. Flowchart of analysis process was in Figure 4.

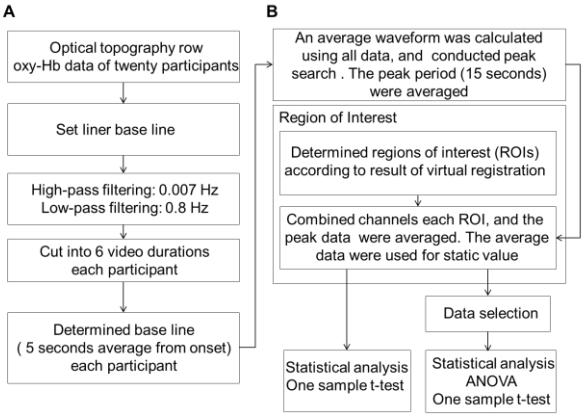

Figure 4. Flowchart of calculating statistical value.

(A) Flowchart of preprocessing of oxy-Hb data from optical topography. (B) Flowchart after the preprocessing to statistical analysis. Rectangles represent processes.

3. Result of optical topography experiment

3.1. Result of subjective evaluation in optical topography experiment

Table 2 and Figure 5 showed the result of subjective evaluation of the six videos in twenty participants in optical topography experiment. We used this classification in Table 2 for data selection process.

Table 2. Six videos: two excellent, two normal and two poor videos in optical topography experiment.

CM No.	Year	Company name	Average score	Evaluation
1	1980	FUJIFILM Corporation	4.3	Excellent
2	1974	Panasonic Corporation	3.65	Excellent
13	1977	Panasonic Corporation	2.9	Normal
15	1985	Shiseido Company, Limited	2.45	Normal
14	1969	PILOT CORPORATION	2.4	Poor
16	1980	Yamaha Motor Co., Ltd.	2.1	Poor

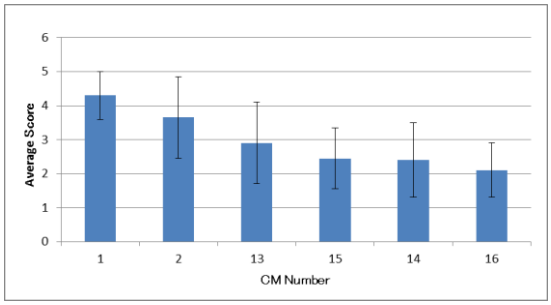

Figure 5. Average score and standard deviation of six videos.

Bar showed average score ± standard deviation. There was an obvious difference between excellent (CM No.1 and 2) and poor videos (CM No.14 and 16).

3.2. Result of Oxy-Hb change statistical analysis

Comparison between baseline and peak time on each ROI by one-sample and paired t-test

The comparisons showed significant differences in all ROIs : in the left B46 ($t_{(18)} = 4.208$, $p < 0.01$), in the B10 ($t_{(18)} = 5.268$, $p < 0.01$), left B9($t_{(18)} = 5.731$, $p < 0.01$), right B9($t_{(18)} = 5.112$, $p < 0.01$), left B45($t_{(18)} = 4.642$, $p < 0.01$), right B45 ($t_{(17)} = 4.984$, $p < 0.01$), and in the right B46($t_{(18)} = 3.585$, $p < 0.05$). Box plots of all ROIs were shown in Figure 6.

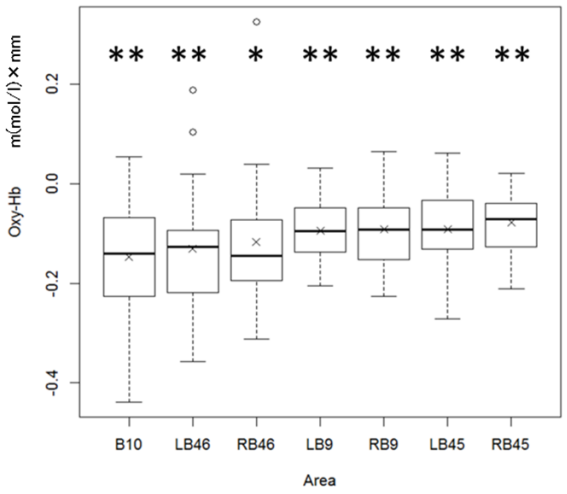

Figure 6. Box plot of seven ROIs.

A horizon line in a box indicated median. The box boundaries indicated first and third quartiles. The two horizon lines extending vertically from the box indicated maximum and minimum. A cross mark indicated average. A point showed outlier. Statistically significant difference was indicated with asterisk (* p <0.05, ** p<0.01).

Comparison among three levels: excellent, normal and poor, on each ROI by one-way ANOVA

The ANOVA indicated significance on only B46, including channel 9 and channel 13, in the right hemisphere ($F_{(2,14)}$ = 11.794, p < 0.05, partialη^2 = 0.628) among the three levels of evaluation.

Comparison among three levels: excellent, normal and poor, on Right Brodmann46 by one-sample and paired t-test

Oxy-Hb change was significant different between the normal and poor video ($t_{(7)}$ = 3.847, p < 0.05) and between the excellent and poor video ($t_{(7)}$ = 3.866, p < 0.05). The oxy-Hb concentration value of normal was less than that of poor, and the oxy-Hb concentration value of excellent was less than that of poor in Figure 7.

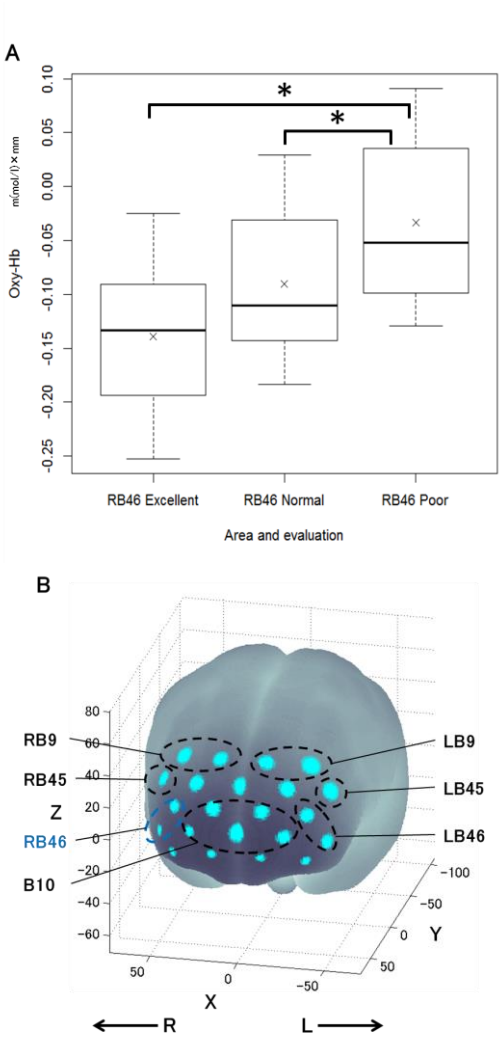

Figure 7. Box plot of Right Brodmann 46 in three levels of evaluation and the position.

(A) A horizon line in a box indicated median. The box boundaries indicated first and third quartiles. The two horizon lines extending vertically from the box indicated maximum and minimum. A cross mark indicated average. Statistically significant difference was indicated with asterisk (* p <0.05). (B) The virtual position of Brodmann46 in right hemisphere.

5. Conclusion

Results from our optical topography experiment for t-test between peak time values and baselines, the significant differences at Brodmann 9, 10, 45, and 46 on frontal cortex were detected. The oxy-Hb concentrations were decreased than baseline at all ROIs in frontal cortex. The results might indicate the video stimuli, especially TV commercial, caused decreases of oxy-Hb change in frontal cortex.

Results from ANOVA for comparison among three levels of subjective evaluation: excellent, normal and poor showed the oxy-HB concentrations were significant different in subjective evaluations at only Brodmann 46 in right hemisphere. Furthermore, comparison among the three levels by t-test at right B46 showed significant differences between normal and poor, excellent and poor. This result might indicate this Brodmann 46 area (Dorsolateral prefrontal cortex) in right hemisphere associated with evaluating impression of likability for videos.

Acknowledgments

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References

1. Astolfi L, et al. (2008) IEEE Transactions on Neural System and Rehabilitation Engineering, Vol. 16, No.6.
2. Kono T, et al. (2007) Neuroscience Research, 57: 504-512.
3. Villringer A, et al. (1993) Neuroscience, Letters, 154: 101–104.
4. Jurcak V, et al. (2007)Neuroimage, Volume 34, Issue 4: 1600–1611.
5. Chul Ye J, et al. (2008) Neuroimage, 44: 428-447.
6. Tsuzuki D, et al. (2007) Neuroimage, 34: 1506–1518.