Responses Analysis of Visual and Linguistic Information on Digital Signage Using fNIRS

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Abstract. When customers receive recommended information through digital signage, it is important not only to choose suitable commodities matching each customer's preferences, but also to choose suitable information media to express their features. This paper proposes a method to estimate their preferences on information media by measuring brain activity. First step in order to achieve our final goal, we disclose that there are significant differences in brain activity in case subjects receive recommended information. The result of analysis shows there are significant differences in brain activity, especially visual cortex and language area.

Keywords: fNIRS, Preference on Commodities and Information Parts, Information Recommendation.

1 Introduction

Digital signage has become popular in real shops and in web sites as advertising media for sales promotion [1]. Customers receive much information on commodities through digital signage in shopping. It is important not only to choose suitable commodities matching each customer's preferences, but also to choose suitable information media to express their features. If we can estimate his personal preference on information media, which describe some specific feature of commodities, he can provide more effective message to the customer regarding the specific commodities.

In society, only page view logs are adopted to estimate each customer's personal preference of commodities, which is insufficient to analyze the reasons of his behavior. We expect that some indices of brain activity are a key to estimate the degree of his attention to the information media as well as to the commodity. If some messages describe a specific feature of the preferred commodity, the customer pays attention to messages, otherwise does not.

Therefore, we measure the customer's response on visual and linguistic information on display by fNIRS to detect the degree of his attention.

M. Kurosu (Ed.): Human-Computer Interaction, Part V, HCII 2013, LNCS 8008, pp. 411–420, 2013.
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2 Methods of Our Research

These days, technologies of measuring brain activities have been developing, and there are some experiments that these technologies have been applying to marketing research to understand consumer's psychological state in shopping [2]. Previous studies showed that if image information was displayed to a subject, there were significant activities in his visual cortex [3]. There are some measuring systems, and in our study, we choose functional near-infrared spectroscopy (fNIRS), because fNIRS has high spatial resolution where there are significant activities in brain to same degree and lower physical restraint to a subject than other measuring systems [4].

We assume two behaviors in shopping; first behavior is that when a customer finds a commodity correspond with his preference, he pays attention to a commodity, and second behavior is that when he is received information about his preferred commodity, he pays attention to part of preferred information. Therefore in our research, we are developing a control mechanism to alter information message styles according to each customer's preference on a commodity (Fig. 1).

Our current purpose is that in case customers view some information about a commodity according to their preference, there will be significant differences in brain activities between displayed information. In this paper, we especially focus on clothes, and classify information into two categories; first category holds mainly commodity's visual messages, such as coordinates with other commodities. The other category holds mainly commodity's linguistic explanation, such as statements about its features.

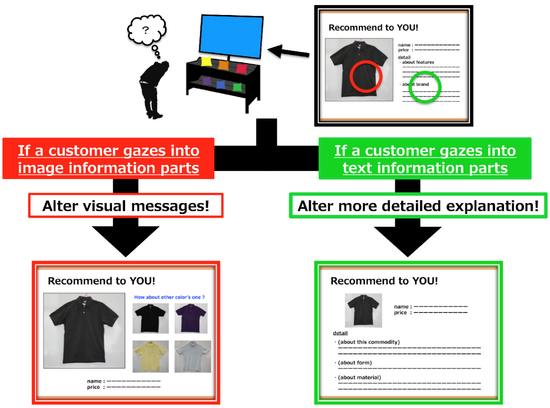

Fig. 1. Recommendation message styles of our suggestion

We assume two behaviors. (1) When a customer finds a commodity correspond with his preference, he pays attention to a commodity. (2) When he is received information about his preferred commodity, he pays attention to part of preferred information.

3 Expriment: Measuring Responses of Information on Display by Fnirs

We used the multichannel fNIRS optical topography system ETG-4000 (HITACHI Medical Cooperation) and adopted the event-related design in our experiment. In our experiments, subjects viewed recommended information about a commodity, and responded to all commodities by rating scale five degrees about preference. Our procedure we experimented is summarized in Fig. 2.

We set the fNIRS probes to cover the visual cortex and language area according to the international 10-20 systems in electroencephalography [5], and showed in Fig. 3. Especially in this study, the placement on language area was left side of the brain. In visual area, Oz was consistent with the optical electrode middle second of the lower row of 3×3, the bottom line was along a well-balanced to horizontal reference curve. In language area, T3 was consistent with the optical electrode middle second of the lower row of 3×3, and the bottom line was along a well balanced to horizontal reference curve. For spatial profiling of fNIRS data, we employed virtual registration to register the data to MNI standard brain space [7][8][9].

Profiles of ten subjects are male, 22-24 years old and right-handed. The reason of right-handed is that the significant brain is different whether they are right-handed or left-handed [6]. In experiment, we divided a task into two stages; former was subjects understood a commodity, later was they evaluated their preference. The reason was to make sure if there are significant activities in brain, that significant activities are resulted from the process whether they understood commodities or they evaluated their preference.

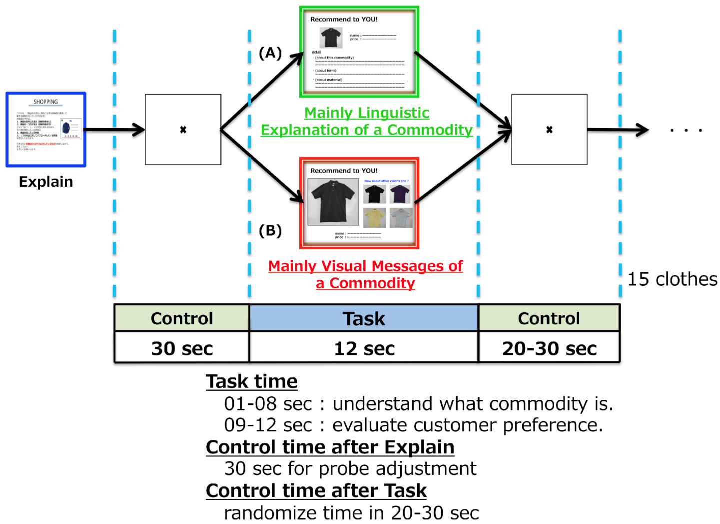

Fig. 2. The event-related design in our experiment

(A) Type of commodity's linguistic explanation, (B) Type of commodity's visual messages

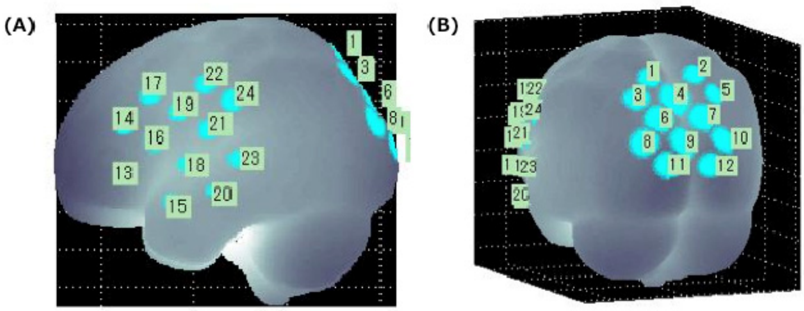

Fig. 3. The placement of our study based on international 10-20 system [7][8][9]

(1) The placement of fNIRS probes on language area, especially Broca's area, (2) The placement of fNIRS probes on visual cortex

4 Hypothesises in Our Methods and Analysis

Our hypotheses are described below. First hypothesis is that when subjects receive commodity's visual messages, oxy-Hb values in visual cortex were increasing more than those of language area. Second hypothesis is that when they receive commodity's linguistic explanation, oxy-Hb values in language area were increasing more than those of visual cortex. In this paper, we adopted oxy-Hb, because oxy-Hb is more reliable parameter than other parameters measured by fNIRS.

4.1 Method of Integral Analysis

Measurement data are revised by integral analysis, and we calculated arithmetic mean of all subject's revised data on each type of linguistic explanation and visual messages. We tested statistical analysis by t-test and described in Fig. 4.

4.2 Method of Comparing Period's Mean

Measurement data are preprocessed by the following way. First, each subject's measurement data were preprocessed with a trend revision. Second, individual timeline data for the oxy-Hb signal of each channel were preprocessed with a band pass filter using cut-off frequencies of 0.012 Hz to remove drift and 0.8 Hz to filter out heartbeat pulsations. Third, we set 3 periods in timeline: pre period was 5 sec before stimulus periods, stimulus period was 12 sec during task, and post period was 15 sec. after stimulus period. According to this, total timeline for each commodity was 32 sec. Finally, pre period was set to baseline and we calculated amount of change from baseline. After preprocessed, we obtained each period's mean from preprocessed timeline: pre period's mean was calculated from 0-5 sec, stimulus period's mean was calculated from 11-23 sec, post period's mean was calculated in 27-32 sec (Fig. 5).

Through this method, we tested statistical analysis in two cases. First case was to compare stimulus period' mean with pre/post period's mean in same recommended type, and we tested statistical analysis by non-repeated measures four-way ANOVA and Bonferroni method. The other case was to compare stimulus period's mean between visual messages' experiment and linguistic explanation's experiment, and we tested statistical analysis by non-repeated measures five-way ANOVA.

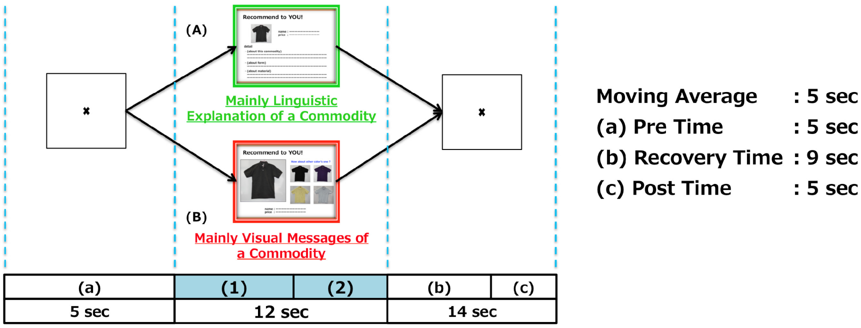

Fig. 4. Outline of integral analysis

(1) Subjects understand what commodity is. (2) Subjects evaluate their preference about a commodity. (A) Type of commodity's linguistic explanation, (B) Type of commodity's visual messages

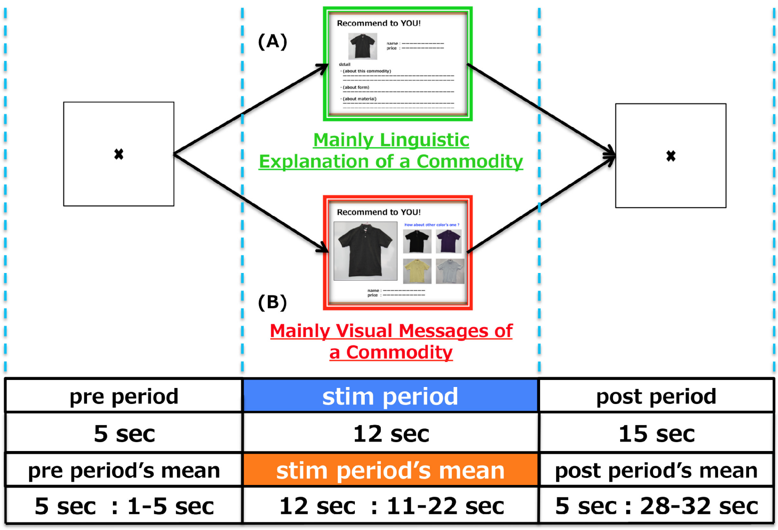

Fig. 5. Outline of calculating each period's mean for analysis

(A) Type of commodity's linguistic explanation, (B) Type of commodity's visual messages

5 Current Results

5.1 Results of Integral Analysis

We found significant differences on additional averages on total data. In case of received commodity's visual messages, when subjects evaluated their preferences degree about commodities, Δoxy-Hb values in visual cortex increased more than those of language area. Also, in case of received commodity's linguistic explanation, when subjects evaluated their preferences, Δoxy-Hb values in language area increased more than those of visual cortex (Fig. 6, 7, 8).

5.2 Results of Comparing Each Period's Mean on Same Recommended Type

According to non-repeated measures four-way ANOVA and Bonferroni method, we found some significant differences between stimulus period's mean and pre/post period's mean in each recommended types. In case of received commodity's linguistic explanation, there were some significant main effects of subjects and period-type, and some significant interactions, such as interaction between subjects and period-types. In case of received commodity's visual messages, there were some significant main effects of subjects and period-type, and some significant interactions, such as interaction between subjects and period-types.

5.3 Results of Comparing Stimulus Period's Mean between Visual Messages and Linguistic Explanations

According to non-repeated measures five-way ANOVA, we found some significant differences between visual messages' experiment and linguistic explanation's experiment and showed in Fig. 9. There were some significant main effects of subjects and recommended types in CH 4, 6, 7, 9, 14, 16, 17, 19. Also, there were some significant interactions, such as interaction between subjects and recommended types. However, there weren't significant indications about preference. We showed Δoxy-Hb mean values each recommended types in Table 1, which there were significant differences. In channels that there were significant difference, when subjects view visual message's recommendation, stimulus mean values in visual cortex were bigger than subjects view visual message's recommendation. Also, when subjects view linguistic explanation's recommendation, stimulus mean values in language area were bigger than subjects view visual message's recommendation.

Therefore, these results showed that when subjects view some information which holds mainly commodity's visual messages, visual cortex is more activated more than when subjects view some information which holds mainly commodity's linguistic explanation. Also, when subjects view some information, which holds mainly commodity's linguistic explanation, language area is more activated more than when subjects view some information, which holds mainly commodity's visual messages.

We showed anatomical labeling and spatial probability were estimated for the significantly activated channels (Table 2). For example, CH9 in visual cortex was estimated Visual Association Cortex by Brodmann Area, and CH14 in language area was estimated pars triangularis Broca's area.

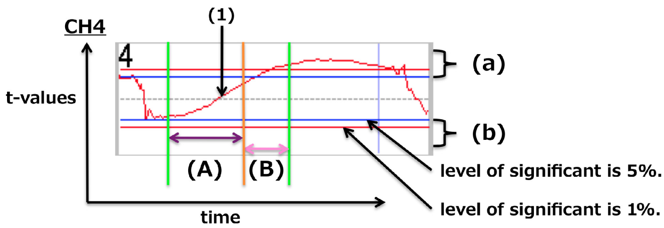

Fig. 6. How to look results of analysis

(1)T-values in t-test detecting differences of activation level by (oxy-Hb values in visual cortex) – (oxy-Hb values in language area) (A) Subjects understand what commodity is. (B) Subjects evaluate their preference about a commodity. (a) This value showed visual cortex was more activated than language area. (b) This value showed language area was more activated than visual cortex.

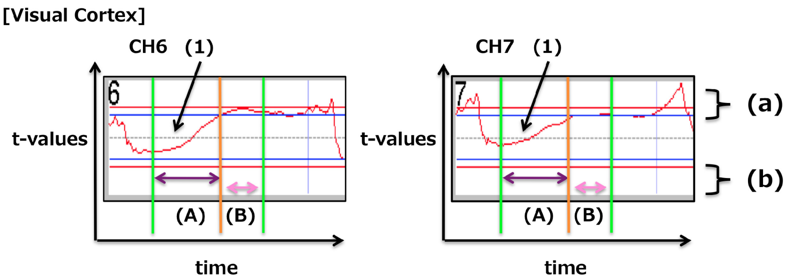

Fig. 7. Part of results in visual cortex

When subjects evaluated their preferences degrees about commodities, there were significant differences in visual cortex. (1) T-values in t-test detecting differences of activation level by (oxy-Hb values in visual cortex) – (oxy-Hb values in language area) (A) Subjects understand what commodity is. (B) Subjects evaluate their preference about a commodity. (a) This value showed visual cortex was activated more than language area. (b) This value showed language area was activated more than visual cortex.

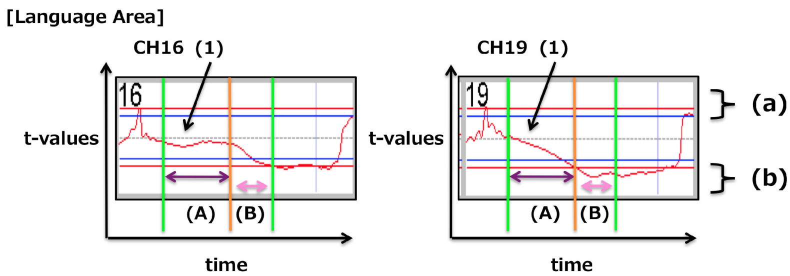

Fig. 8. Part of results in language area

When subjects evaluated their preferences, oxy-Hb values in language area were increasing more than those of language area. (1) T-values in t-test detecting differences of activation level by (oxy-Hb values in visual cortex) – (oxy-Hb values in language area) (A) Subjects understand what commodity is. (B) Subjects evaluate their preference about a commodity. (a) This value showed visual cortex was activated more than language area. (b) This value showed language area was activated more than visual cortex.

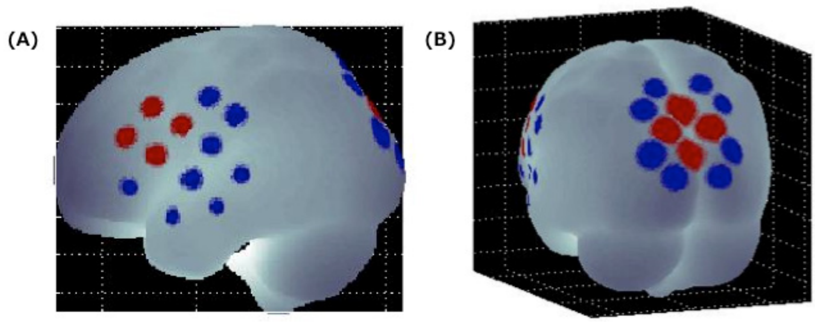

Fig. 9. The result comparing each period's mean [7][8][9]

(A) The result in language area, (B) The result in visual cortex Red circles showed there were significant differences in channels based on analysis. Blue circles showed there weren't significant differences.

Table 1. Stimulus mean values on each recommended types

In visual cortex	CH4**	CH6**	CH7**	CH9**
visual messages	**0.0393**	**0.0361**	**0.0517**	**0.0242**
linguistic explanation	-0.0093	0.0041	0.0093	-0.0139
In language area	CH14*	CH16*	CH17**	CH19***
visual messages	-0.0164	-0.0091	-0.0068	-0.0011
linguistic explanation	**0.0161**	**0.0308**	**0.0413**	**0.0507**

p-value	
***	0.001
**	0.01
*	0.05

Table 2. Spatial and functional profiles of the channels [7][8][9]

CH	Position x	Position y	Position z	SD (mm)	BrodmanArea(Chris rorden' MRIcro)	Percentage
4	-1.804	-81.46	47.522	10	7 - Somatosensory Association Cortex	0.601
					19 - V3	0.399
6	-15.122	-91.367	37.197	10	19 - V3	0.609
					18 - Visual Association Cortex (V2)	0.391
7	14.41	-91.307	36.77	10	19 - V3	0.614
					18 - Visual Association Cortex (V2)	0.386
9	-2.657	-97.748	22.707	10	18 - Visual Association Cortex (V2)	0.608
					17 - Primary Visual Cortex (V1)	0.392
14	-51.131	36.234	21.921	10	45 - pars triangularis Broca's area	1
16	-59.022	20.75	13.201	10	45 - pars triangularis Broca's area	0.415
					44 - pars opercularis, part of Broca's area	0.355
					48 - Retrosubicular area	0.119
					6 - Pre-Motor and Supplementary Motor Cortex	0.11
17	-50.422	22.797	37.424	10	44 - pars opercularis, part of Broca's area	0.759
					45 - pars triangularis Broca's area	0.175
					9 - Dorsolateral prefrontal cortex	0.066
19	-60.98	7.164	28.252	10	6 - Pre-Motor and Supplementary Motor Cortex	0.596
					44 - pars opercularis, part of Broca's area	0.195
					43 - Subcentral area	0.178
					4 - Primary Motor Cortex	0.031

6 Conclusion

Our current purpose was that in case customers view some information about a commodity according to their preference, there were significant differences in brain activities between displayed information. Especially, we focused on clothes, and classify information into two categories, which were visual messages and linguistic explanation. In experiment, subjects were experimented two types: first experiment was subjects viewed recommended information, which holds mainly commodity's visual messages. Second experiment was subjects viewed recommended information, which holds mainly commodity's linguistic explanation. According to compare each experiment's result, we aimed to achieve our current goal. Through above methods, results were when subjects view some information, which hold mainly commodity's visual messages, visual cortex is more activated than when subjects view some information, which hold mainly commodity's linguistic explanation. Also, when subjects view some information, which hold mainly commodity's linguistic explanation, language area is more activated than when subjects view some information, which hold mainly commodity's visual messages.

Through analysis on comparing same recommended types, there were not significant differences in visual cortex and language area whether subjects have preferences on commodities or not. Thus, we found when subjects view some information about commodities, their brain activities in visual cortex and language area is same activity degrees whether they have preferences on commodities or not. We observed idea in order to achieve our final goal, it is important for us to focus on preferences and demonstrate there are significant differences in brain activities.

Acknowledgement. This work was partially supported by JSPS KAKENHI grants, "Effective Modeling of Multimodal KANSEI Perception Processes and its Application to Environment Management" (No.24650110). "Robotics modeling of diversity of multiple KANSEI and situation understanding in real space" (No. 19100004) and TISE Research Grant of Chuo University, "KANSEI Robotics Environment".

References

1. Fujiwara, K.: The Cutting Edge In-Store Promotion using Digital Signage. Journal of the Japan Society of Mechanical Engineers 114(1110), 353–355 (2011)
2. Fujisawa, T., Matsui, T., Kazai, K., Furuya, S., Katayose, H.: Music in Our Brain. Information Processing Society of Japan Magazine 50(8), 764–770 (2009)
3. Taya, S., Maehara, G., Kojima, H.: Hemodynamic responses corresponding to the stimulated visual field. Technical report of The Institute of Electronics, Information and Communication Engineers. HIP 106(328), 49–52 (2006)
4. Maki, A., Sato, D., Obata, A.: Optical Topography and Brain Science. Journal of the Japan Society of Precision Engineering 74(11), 1147–1151 (2008)
5. Monden, Y., Dan, H., Nagashima, M., Dan, I., Kyutoku, Y., Okamoto, M., Yamagata, T., Momoi, M.Y., Watanabe, E.: Clinically-oriented monitoring of acute effects of methylphenidate on cerebral hemodynamics in ADHD children using fNIRS. Clinical Neurophysiology 123(6), 1147–1157 (2012), doi:10.1016/j.clinph.2011.10.006.Epub (November 15, 2011)
6. Tanaka, S.: Cerebral Lateralization. Journal of Japanese Society for Artificial Intelligence 20(4), 486–491 (2005)
7. Tsuzuki, D., Jurcak, V., Singh, A., Okamoto, M., Watanabe, E., Dan, I.: Virtual spatial registration of stand-alone fNIRS data to MNI space. Neuroimage 34(4), 1506–1518 (2007) PMID: 17207638
8. Singh, A.K., Okamoto, M., Dan, H., Jurcak, V., Dan, I.: Spatial registration of multichannel multi-subject fNIRS data to MNI space without MRI. Neuroimage 27(4), 842–851 (2005)
9. Rorden, C., Brett, M.: Stereotaxic display of brain lesions. Behavioural Neurology 12(4), 191–200 (2000)