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Analysis of How Impressions are Fixed After One Week of Listening to Music Using Subjective Evaluation and Brain Activity Measurement

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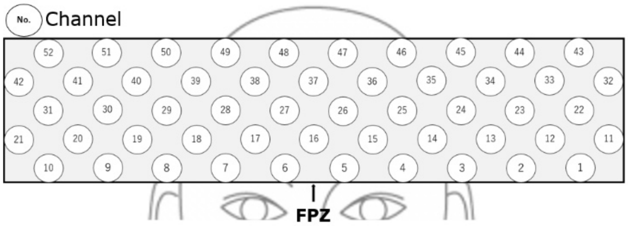
ABSTRACT

Repeating information is a common technique in advertising to increase consumer interest; however, how brain activity is affected is not well understood. In this study, we investigated the relationship between the repetition effect of music and brain activity. The subjects listened to music every day for a week and, on the first and last days of the week, they were asked to make subjective ratings of their likes and dislikes, and their brain functions were measured. There was a significant increase in impression evaluation from the first to the last day of the subjective evaluation. Analyses of the cerebral blood flow data indicated that prefrontal cortex activity increased when dealing with negative impressions. In particular, Dorsolateral prefrontal cortex (DLPFC) activity may be closely related to impression judgment. The results also suggested the possibility of estimating future impressions after repeated listening from brain activity at the time of first listening to music.

Keywords: First impression, Prefrontal cortex, Optical topography

INTRODUCTION

In recent years, "neuromarketing" has been attracting attention as a way to examine the relationship between brain activity and various psychological effects in marketing. Some research has been conducted on the "mere exposure effect" using brain measurements (Harmon-Jones and Allen, 2001; Green at al., 2012). In advertising and marketing, this "mere exposure effect" is the basis for the repeated presentation of information, which is said to increase the interest and sensitivity of consumers. According to a survey by Japan's CM Research Institute, AGC's corporate commercial ranked third in the liking of commercials by brand in the first quarter of January 2020 (Nikkei, 2020). It was an unusually high score for a commercial from a B2B company, a materials manufacturer, to be in third place. The monitors said



Brodmann Area	Region	Channel Number
BA09	DLPFC	46,47,48,49
BA46	DLPFC	3,8,14,18,25,28
BA10	FrP	4,7,15,16,17,26,27
BA44	Broca	34,40
BA45	Broca	13,19,24,29
BA21	MTG	1,10
BA38	Tmp	2
BA43	Subcentral	33

Figure 1: Measurement Ch. and classification of the Broadman area.

that "the phrases stay in my ears" and "the music gets stuck in my head." Furthermore, the top factor for liking the commercial was "music/sound." The repetition of music also appears to create a positive impression of the advertisement based on these findings. In these cases, it is common to attempt to maximize the effect by presenting information repeatedly over a long period. There is, however, little neuroscience research on multiple presentations of stimuli across days.

We investigated how impressions are fixed in individuals when stimuli are presented across multiple days, using subjective evaluations and brain activity. Subjects listened to music every day for a week, and on the first and last days they were asked to make evaluations of their likes and dislikes, and brain functions were measured.

In this study, we focused on preference as one of the components of impressions. In a study of TV commercial preference and prefrontal cortex activity, Mitsui et al. (2013) found that the concentration of oxygenated hemoglobin (Oxy-Hb) in the cerebral bloodstream of the right hemisphere decreased after viewing a video with a good first impression. Endo et al., (2020) investigated changes in impression evaluation and brain activity during two repeated viewings of a TV commercial. The results revealed that brain activity differed depending on the number of views, even though the subjective ratings were the same. They also summarized the results of previous studies, suggesting that the dorsolateral prefrontal cortex (DLPFC) activity may decrease when first impressions are good.

MATERIALS AND METHODS

We used optical topography (ETG-4000, Hitachi, Ltd.) to measure brain function. This is based on functional near-infrared spectroscopy (fNIRS), and measures the changes in the concentration of oxy-Hb and deoxy-Hb (deoxygenated hemoglobin) in cerebral blood flow as a time-series data volume. In the human brain, the amount of oxy-Hb in a specific active area increases with time. By measuring the increase and decrease in the oxy-Hb level, we can understand how the subject responds to stimuli (Maki et al., 2008).

The device was worn over the subject's prefrontal cortex. Figure 1 shows the serial numbers of the 52 channels (Ch.). The area between Ch. 5 and Ch. 6 is located at Fpz, as specified in the International 10-20 Method, which is the standard for electrode placement in EEG. By mounting the device, it is possible to measure the oxy-Hb concentration in the region indicated in the Table in the figure with an accuracy of more than 80%. The accuracy was derived using the virtual registration method (Tsuzuki et al., 2007).

Ten healthy right-handed subjects in their twenties (8 males, 2 females, mean age 22.6 years), who consented to the regulations of the Ethics Committee of Chuo University when measuring brain activity, were tested. To control the experimental conditions, a total of nine musical stimuli, which the participants had never heard before, were created, using the automatic music creation tool "SOUNDRAW." Pink noise, which is white noise with 1/f fluctuations, was also used as a comparison stimulus. We measured brain function on the first day of listening to music stimuli. The subjects listened to the music stimuli once a day for five days at home. We then conducted the same brain function measurement experiment again six days after the first day. After presenting the music stimuli, we conducted a questionnaire survey. The subjects were asked to rate each stimulus on a 7-point scale (-3 to +3) for "liking the music stimulus." The music stimuli were presented in a random order for each subject. The tasks were presented in the following order for each music stimulus: (1) Resting image (10sec) (2) Pink noise (30sec) (3) Resting image (10sec) (4) Music stimulus (30sec) (5) Questionnaire evaluation (10sec)

Brain activity was analyzed using the POTATo (Platform for Optical Topography Analysis Tools) analysis software for fNIRS. The data processed by POTATo were subjected to a t-test at a significance level of 5% for each Ch. using the analysis software R, and Ch. were considered statistically significant. The null hypothesis of the t-test was that the mean of the differences between the data of the musical stimuli was zero, taking the mean of oxy-Hb.

RESULTS

Subjective Assessment of Music

In this experiment, the data obtained on the first day of the experiment is called "First" and the data obtained on the last day of the experiment is called "Last." Figure 2 shows the bubble chart of the evaluation values of "First" and "Last" obtained using the 7-scale method.

A t-test was conducted to determine if there was a significant difference between the impression ratings of "First" and "Last." The results show that the p-value is 0.00026, the mean value of "First" is 0.62, and the mean value of "Last" is 1.18, which means that the impression rating has increased significantly. Furthermore, this integer data were normalized, and its value was used as the Z-score.

Comparison of Brain Activity by Amount of Change

To exclude those whose impressions did not change much, oxy-Hb data were excluded when the change in Z-score was between −0.5 and 0.5. The remaining data were subjected to t-tests for each Ch. The four combinations of t-tests are presented in Table 1 below.

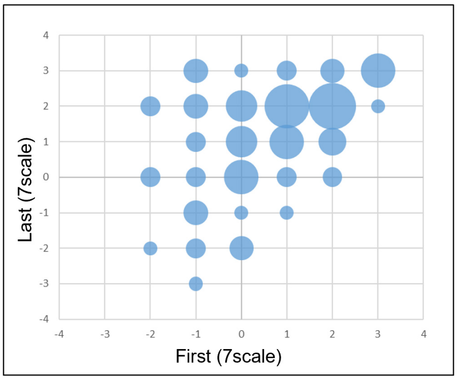


Figure 2: Bubble charts of impression ratings.

Table 1. How to combine t-tests by amount of change.

	Amount of change ＋ : First	Amount of change － : Last
Amount of change ＋ : Last	1	4
Amount of change － : First	3	2

Table 2. Results of the t-tests for combinations 1-4 by amount of change.

	Last > First	Last < First
① ＋, "Last" : "First"	49	11,14,25,32,34,35, 36,40,44,45,46,47, 48,49,50,51
② －, "Last" : "First"	1,8,10,18,29,40, 41,42,50,51	
	＋ > －	**＋ < －**
③ First, "＋" : "－"	1,2,3,4,5,7,8,11,14, 18,24,25,28,34,35, 39,40,44,45,47,48, 49,50,51	
④ Last, "＋" : "－"		12,18,40,51

Ch. that became significant from the results of the t-tests for combinations 1-4 are shown in Tables 2 and 3, respectively.

The results of combination 1 showed that the brain activity of "First" was larger when the amount of change was positive, especially in the right hemisphere. The results for combination 3 showed that brain activity was higher when the amount of change after the "First" was positive. Furthermore, significant differences were observed in the DLPFC (BA46) and c-DLPFC (BA09).

Table 3. How to combine t-tests by the first impression and amount of change.

	A First	B Last
A Last	1	4
B First	3	2

Table 4. Results of the t-tests for combinations 1-4 by the first impression and amount of change.

	Last > First	Last < First
① **A**, "Last" : "First"	49	1,2,7,8,10,18,24, 29,30,40,41,49
② **B**, "Last" : "First"	1,15,25,26,34,36,44, 45,46,47,48,49,50	
	A > B	**A < B**
③ First, **"A" : "B"**	1,2,3,5,8,10,11,13,22, 24,25,26,32,33,34,36, 38,39,40,44,47,48,49, 50	
④ Last, **"A" : "B"**		40

Comparison of Brain Activity According to the First Impression and Amount of Change

The following classification was made according to positive and negative first impressions: Negative "first" impressions and positive changes, and B positive "first" impressions and negative changes. In other words, "A" means that the first impression is low, and the subsequent impression is good. Subsequently, "B" means that the first impression is high, and the subsequent impression is low. To exclude values near 0, we excluded oxy-Hb data when the change in Z-score was between −0.3 and 0.3. The t-test combinations are shown in Table 3.

In combinations 1-4, Ch. that became significant from the results of the t-test are listed in Table 4.

The results of combination 1 show that for a low rating at the beginning and a higher rating afterward, there were more active areas in the "First" than in the "Last." Conversely, in combination 2, when the rating was high at the beginning and then decreased, there were more active areas in the "Last" than in the "First." For combination 3, when the rating was low and increased later, brain activity was generally higher during the "First" session. In contrast, for combination 4, no significant differences were found in most of the Ch.

DISCUSSION

The results show the possibility of estimating future impressions from brain activity after repeated listening to music for the first time. In the comparison of "First" brain activity (Table 2), there was a significant difference in the classification based on the amount of change in symmetrical Ch. In contrast, in the comparison of "First" brain activity in the classification of how the first impression and subsequent impressions change (Table 4), the significant Ch. was not symmetrical and was biased toward the left hemisphere. The difference between the two classification methods was whether the first impression depended on the classification. This suggests that it is possible to infer how future impressions will change, based on the brain activity of the first impression.

Furthermore, the prefrontal cortex was activated more during the processing of negative evaluations in the overall results. In particular, the DLPFC was activated when judging the impressions. When the amount of change was positive, the brain activity of "First" was higher than that of "Last" in the comparison between "First" and "Last" (Table 2). In contrast, when the amount of change was negative (Table 2), the brain activity of "Last" was larger than that of "First." Therefore, it can be considered that the brain is more active when impression evaluation is low. There was a significant difference in the activity of the c-DLPFC (BA09), suggesting that it may be involved in the processing of negative impressions. The comparison between "First" and "Last" in "A" (Table 4) shows that overall brain activity in "First" is higher than that in "Last." In contrast, in the comparison of "B" (Table 4), the brain activity of "Last" was higher than that of "First," especially in c-DLPFC. "A" is where the first impression is bad and subsequent impression good, and "B" is where the first impression is good and subsequent impression bad. This finding suggests that the prefrontal cortex is involved in the processing of bad impressions, as in the previous case. These results indicate that DLPFC activity is high when the impression is bad, which is consistent with the results of previous studies (Mitsui et al., 2013; Endo et al., 2020). Therefore, we should focus on DLPFC activity to estimate the impression of favorability from brain activity.

CONCLUSION

We had the subjects listen to music every day for a week and measured their subjective evaluation of the music and brain activity on the first and last days. Analysis of blood flow data showed that the prefrontal cortex was more active during the processing of negative impressions. In particular, the DLPFC may be deeply involved in the judgment of impressions. It was suggested that the brain activity of first impressions can be used to estimate how impressions will change in the future. We consider these results to be discoveries from the perspective of neuromarketing.

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REFERENCES

Anders C. Green, Klaus B. Bærentsen, Hans Stødkilde-Jørgensen, Andreas Roepstorff, Peter Vuust. (2012): Listen, Learn, Like! Dorsolateral Prefrontal Cortex Involved in the Mere Exposure Effect in Music, Neurology Research International, Volume 2012, 846270 https://doi.org/10.1155/2012/846270

Anna Endo, Naoki Takahashi, Takashi Sakamoto, Toshikazu Kato. (2020): Analyses of Impression Changes and Frontal Lobe Activity While Viewing Videos, Lecture Notes in Computer Science, pp. 129–141, https://doi.org/10.1007/978-3-030-50353-6_10

Atsushi Maki, Hiroki Sato, Akiko Obata. (2008): Optical Topography and Brain Science, Journal of the Japan Society for Precision Engineering, Volume 74, No. 11, 1147–1151, https://doi.org/10.2493/jjspe.74.1147

Daisuke Tsuzuki, Valer Jurcak, Archana K. Singh, Masako Okamoto, Eiju Watanabe, Ippeita Dan. (2007): Virtual Spatial Registration of Stand-Alone fNIRS Data to MNI Space, Neuroimage, Volume 34, No. 4, pp. 1506-1518, https://doi.org/10.1016/j.neuroimage.2006.10.043

Eddie Harmon-Jones, John J.B. Allen. (2001): The Role of Affect in the Mere Exposure Effect: Evidence from Psychophysiological and Individual Differences Approaches, Personality and Social Psychology Bulletin, Volume 27, No. 7, pp. 889–898, https://doi.org/10.1177/0146167201277011

Nikkei Style (2020): Issei Takahashi's "Nandashi AGC" commercial sensitivity soars, https://style.nikkei.com/article/DGXMZO54922680Y0A120C2000000?channel=DF010320183446&n_cid=LMNST011, (Last search date: January 20 2022)

Shinsuke Mitsui, Atsushi Maki, Toshikazu Kato. (2013): Relationship Analysis Between Subjective Evaluation and NIRS-Based Index on Video Content, Lecture Notes in Computer Science, pp. 459–466, https://doi.org/10.1007/978-3-642-39454-6_49