How do our brains perceive comfort during face-washing actions?
-An investigation of the reason why we continue to use cleansing foams-

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Abstract.
Cleansing foams not only to remove the excess dirt on the skin, but also provide comfort to users. Therefore, to develop a cleansing foam that is pleasant to the user, we aimed to capture the emotional response of users while using cleansing foams. We examined the effect of the froth up of the cleansing foam and the tactile feel of the foam on participants' emotions. To capture the brief and latent emotions during face-washing, we used electroencephalography as a neurophysiological indicator. In this study, we focused on three phases of the face-washing action: phase 1: frothing up; phase 2: the tactile feel of foam on the hands; and phase 3: applying the foam on the face. The results showed that the neural activity values in the Brodmann area 11 (BA11) region, which controls rewarding properties, increased as the act of washing the face progressed from phase 1 to phase 3. Comparison of the neural activity in the BA11 region by phase revealed that speed of lathering in phase 1, fineness of the lathering in phase 2, and elasticity of the lather in phase 3 increased the neural activity in the BA11 region. These results suggest that brain activity related to rewarding properties change depending on the phase of face-washing action and the characteristics of the cleansing foam. This study demonstrated the possibility of capturing emotional changes while using a face wash. These findings could be useful as design indicators for developing facial cleansers that can generate pleasant emotions in consumers.

Keywords: Cleansing foam; Electroencephalogram; reward system; questionnaire

1. Introduction.

Generally, cosmetics used by consumers on a daily basis are intended to improve skin quality and prevent skin problems. However, in addition to skin quality, cosmetics are known to have positive effects on users’ minds, such as providing a sense of well-being [1]. Thus, improving mental health is also a role of cosmetics. In other words, the development of cosmetics that have a positive effect not only on the skin but also on the mind are required to improve consumers' quality of life (QoL).

Tactile information is known to induce emotional changes in the subject. In other fields, tactile stimulation with different materials has been reported to be associated with pleasant sensations [2]. In cosmetics, tactile stimuli are generated when users pick up an object and apply it to their faces. Therefore, some kind of emotional change could occur during the use of cosmetics, but until now, there have been insufficient studies on emotions during cosmetic application. Until now, subjective sensory evaluation has often been used to measure emotions during cosmetic use [3]. However, although sensory evaluation can capture formulation characteristics, such as physical properties, it cannot capture the emotional effect of formulation characteristics on the user. Therefore, in recent years, there have been an increasing number of attempts to evaluate the psychological effects of cosmetic textures on consumers using neurophysiological methods [4].

Cosmetics are broadly classified into cleansers, skin care products, and makeup products, and the effects of texture on consumers have most frequently been investigated for skin care products. With regard to cleansers, the emphasis has been on functions such as removing makeup and dirt. Therefore, the psychological effects of their use have not been investigated extensively.

Burden on the skin due to friction is an issue with cleansers, including cleansing foams [5]. Therefore, it is generally recommended that cleansing foams should be used after sufficient foaming by the user. It has also been reported that well-lathered foam improves the cleaning power [6, 7]. For these reasons, many cleansing foams are applied to the face after the subjects froth it up with their hands. In other words, in addition to the tactile stimulation described above, even the comfort of use, such as ease of frothing up, may have a psychological effect on us. One neurophysiological way to investigate emotions is to examine brain activity. Several attempts to capture changes in emotion using functional magnetic resonance imaging and near-infrared spectroscopy have been reported as non-invasive methods for examining brain activity [8, 9]. However, there are some challenges in capturing emotional changes during the actual use of cosmetics, such as low temporal resolution. Electroencephalography (EEG) has a high temporal resolution and can capture real-time changes in emotions.

The act of washing the face consists of a series of actions: lathering the cleanser, gathering it in the hands, applying it to the face, spreading it, and rinsing it off. In this study, we focused on the tactile information provided by the foam and the process of preparing the foam and examined the effects of the actions from frothing up to applying the foam on the face on the user's emotional state. We set out to test the hypothesis that the ease of lathering and the characteristics of the lather created by the facial cleanser affect the user's affective response. By capturing the emotion caused by the process of creating foam and the characteristics of foam, we expect to apply the results to design indexes for cleansing foam that also contribute to consumers' mental health.

2. Materials and Methods.

The relationship between the characteristics of cleansing foams and emotional changes, which was the purpose of this study, was verified using the scheme shown in Fig. 1. The procedure for the preliminary experiment was previously reported [10].

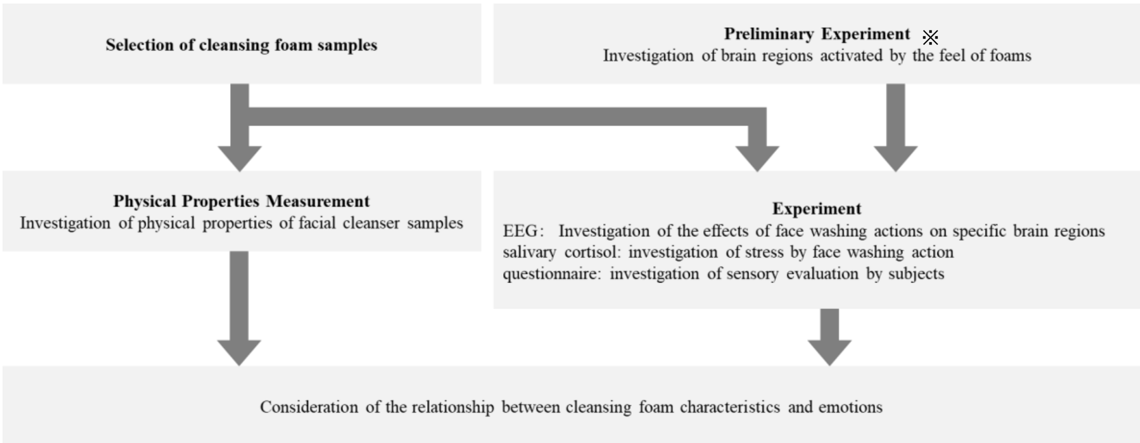


Fig. 1 Verification scheme in this study; ※: According to the previously reported method

2-1. Participants

Preliminary experiment: Twelve healthy adult women (mean age: 20.2 ± 0.7 years) with no history of orthopedic or neurological disease were included in the study. Measurements were recorded between November 11 and 13, 2020.

Experiment: Twelve healthy adult women (mean age: 21.5 ± 1.2 years) different from preliminary experiment, with no history of orthopedic or neurological disease were included in the study. Measurements were recorded between August 25 and 29, 2021. To standardize the lathering process, subjects were given a pre-specified facial cleanser, a video was shown on how to lather, and they were told to perform several practice sessions. The subjects answered the number of times they practiced and the amount of foam they could create in a preliminary questionnaire.

The preliminary experiment and experiment were approved by the ethical review committee of the FANCL Corporation (approval number F20-006). The purpose, content, and procedures of the study were explained orally and in writing, and informed consent was obtained.

2-2. Selection of cleansing foam samples

For the purpose of sample selection, 12 skilled workers performed sensory evaluations of 12 different facial cleansers. We selected samples with low ratings for lather and foam elasticity (Sample A) and samples with high ratings for lather and foam elasticity (Sample B) as test products. In addition, Sample C was created by increasing the ingredients that contribute to the foaming power of the formula in Sample B. Three types of samples, A, B, and C, were used for testing. Fragrances are known to affect the EEG and cause relaxation and arousal [11]. In this study, fragrance-free samples were selected to avoid the influence of fragrances.

To ensure an objective evaluation of the three selected samples, the samples were lathered in a uniform manner. Two grams of the cleanser was measured in a mesh-type milk frother, and 24 g of tap water was poured into it. While adjusting the milk frother to sufficiently dissolve the cleanser, the lever of the milk frother was moved up and down to foam the cleanser to the default foam volume (approximately 110 cm^3). The foam was evaluated using the following three methods:

(1) Foaming speed

The time to reach the default foam volume was recorded.

(2) Foam fineness

The foam was photographed with a digital microscope VHX-5000 (Keyence Co., Osaka, Japan) at 50x magnification, and the circular area was calculated using the automatic area measurement tool of the instrument (threshold value 30).

(3) Elasticity of the foam

The maximum value (gw) was recorded when foams were measured under the following conditions: measurement equipment: Fudoh Rheo Meter (Rheotech Co., Ltd., Tokyo, Japan); range: 200 gw; adapter: flat plate φ20 mm; sample table speed: 60 mm/min; entry width: 10 mm; chart speed: 60 mm/min; chart full-scale: 4 gw.

2-3. preliminary experimental procedure

The procedure was carried out as previously reported [10]. Subjects were given foam that had been pre-foamed by the researcher; EEG was measured in two phases (phase I: feeling the foam given to them using their hand, phase II: placing the foam on their face).

2-4. experimental procedure

Fig. 2 illustrates the experimental procedure. First, the researcher placed a sample of the face wash on the palm of the subject's hand and collected the saliva. Next, the subjects were instructed to rest for 120 sec in a sitting position with their eyes open. The subjects then began frothing up the cleansing foam on their own (phase 1). The subjects were asked in advance how much foam they would routinely produce with the cleansing foam. The researcher instructed them to finish frothing the cleansing foam with the preferred amount of foam as the goal. Phase 1 had a maximum time limit of 300 sec. Next, subjects gathered the foam in their hands for 10 sec (phase 2), placed the foam on their cheeks, and held it for 3 sec (phase 3). Subsequently, it is the same as in the preliminary study shown in Fig. 2. Finally, the saliva was collected again. A series of face-washing actions were performed using Samples A, B, and C selected in 2-2. Measures to deal with the sequential effects and sequelae of tactile stimulation were the same as in the preliminary experiment.

After the act of washing the face was completed, the subjects were asked about the ease of lathering, the fineness of the lather, and the elasticity of the lather created for each cleanser using a questionnaire. The questionnaire was given a score from 1 to 7, with higher ratings given to better ratings in 0.5-point increments.

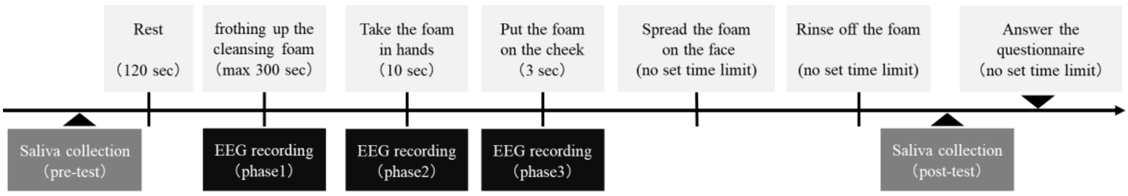


Fig. 2 experimental protocol

2-5. EEG Measurement and Analysis

We measured the EEG signals in phases 1, 2, and 3 (Fig. 2). We used active electrodes (g.tec medical engineering GmbH, Schiedlberg, Austria) and a biosignal analysis system (Livo, Tec-Gihan, Kyoto, Japan) for the tests. The measurement sites were derived from 15 sites (Fpz, Fz, Cz, Pz, Oz, F3, F4, C3, C4, P3, P4, F7, F8, T7, and T8) using both earlobes as reference electrodes according to the international 10-20 method. The band-pass filter was 1–30 Hz, and the sampling frequency was 1,000 Hz. After the EEG measurement, the brain neural activity related to hand movement and the movement of the hand touching the face were subtracted from the data regarding the application of the three facial cleansing samples. In phase 1, the time until the subject finished lathering was cut into 3-sec epochs of data, and the average data (3 sec) was used. In phase 2, 9 sec of EEG data were cut into 3-sec epochs of data, and the average data (3 sec) were used. Phase 3 used the 3-sec data as they were. The measured EEG data were subjected to fast Fourier transform analysis in standardized low-resolution brain electromagnetic tomography (sLORETA) [12] and standardized using the Talairach Daemon software embedded in the analysis program. Then, the sLORETA analysis was used to calculate the coordinates of the Montreal Neurological Institute standard brain coordinate system in the x, y, and z directions for each frequency in a brain region divided into 6,239 voxels, which were converted into a three-dimensional image. The results are presented as the current density values (μA/mm2) for each voxel. Since the purpose of this study was to detect emotional responses in the cerebral cortex using EEG, the neural activity in the beta wave band (13-20 Hz) was verified.

2-6. Salivary Cortisol Measurement

Saliva samples were collected and salivary cortisol levels were measured before and after a series of facial cleansing actions (Fig. 2). Saliva samples were collected using a SOMA Oral Fluid Collector (OFC) (SOMA Bioscience, Wallingford, UK). An OFC swab was placed on the participant’s tongue and the mouth was closed. Saliva (0.5 mL) was absorbed by the OFC, removed from the participant's mouth, and stored in 3 mL of buffer solution. Saliva samples were analyzed using a SOMA lateral flow device and a SOMA cube reader.

2-7. Statistical Analysis

In the sLORETA analysis, the predominantly neurally active regions in the beta waveband were shown in red. In addition, one-way analysis of variance (ANOVA) with Fisher's least significant difference method (Fisher's LSD) was used for the comparison by phase (three groups) of the current density values in the most neurally active regions. Two-way ANOVA with Fisher's LSD was used for comparisons by phase (three groups) and sample (three groups). Corresponding t-tests were used to compare the mean cortisol levels before and after face-washing actions, as shown in Fig. 2. The Kruskal-Wallis test was used for the sensory evaluation results, and the Steel-Duwas method was used for multiple comparisons. The statistical significance level was set at 5%.

3. Results.

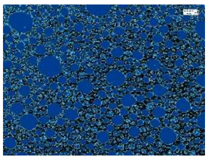
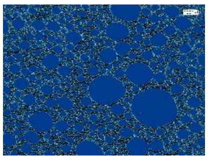
3-1. Selection of cleansing foam samples

The results of the objective evaluation of the three selected cleansing foams are presented in Table 1. First, the time to reach the default foam volume described in 2-2 was the longest for Sample A, followed by Sample B, and shortest for Sample C. This indicates that Sample C produces foam the fastest, while Sample A produces it the slowest.

The area of the bubbles was smallest for Sample A, followed by Sample B, and largest for Sample C. A smaller area occupied by bubbles indicates a finer foam texture, whereas a larger area of bubbles indicates a coarser foam texture. It is evident that the foam was finest in Sample A, followed by Sample B, and least fine in Sample C.

The hardness of the foam was the highest for Sample B, followed by Sample C, and the lowest for Sample A. In this study, a high foam hardness was considered as an elastic foam, and a low foam hardness was considered as a non-elastic foam. Therefore, it was suggested that the elasticity of the foam was highest for Sample B, followed by Sample C, and lowest for Sample A.

Table. 1 Physical properties of the foam of the selected cleansing foams

Samples	A	B	C
Time required to froth up (sec)	55	27	13
Average area of bubbles （μm^2）	1809 	2131 	3476 
Hardness of foam (gw)	2.29 ± 0.05	3.51 ± 0.12	3.17 ± 0.02
Properties of foam Foaming/Fineness/Elasticity	Slow/Fine/Non elastic	Normal/Fine/El astic	Quick/Coarse/ Elastic

3-2. Preliminary experiment：Application of pre-foamed cleansing foam

As a preliminary experiment, we examined neural activity when subjects were given foam samples that had been pre-foamed by the researcher. As shown in Fig. 3, neural activity was high in the prefrontal cortex, particularly in the Brodmann area 11 (BA11), as previously reported [10]. Table 2 shows the coordinates of the areas of high neural activity and their corresponding mental states.

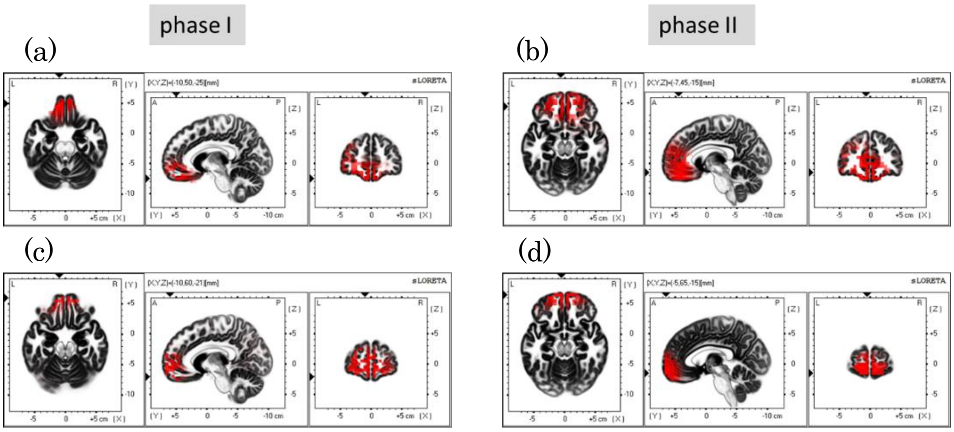


Fig. 3 Areas of neural activity in the brain: (a) phase I - Sample A; (b) phase II - Sample A; (c) phase I - Sample B; (d) phase II - Sample B

Table. 2 Coordinates with high neural activity values and corresponding mental states

area name	MNI coordinates	Mental state
BA11 Brodmann area 11	X= -5, Y= 60, Z= -10	Rewarding behavior
BA32 Brodmann area 32	X= -8, Y= 40, Z= 15	Cognitive judgment and decision making based on motivation and rewarding

3-3. Experiment：Application of foam frothed up by subjects themselves

3-3-1. EEG

The subjects were given a cleansing foam to froth up (phase 1), and after the frothing up was completed, foams were collected by hand (phase 2) and applied to the face (phase 3). First, to investigate the effect of each phase in face-washing on the neural activity values of BA11, we calculated the average of the neural activity values in the BA11 region during the use of three types of face washes in phase 1, 2, and 3. The results shown in Fig. 4 indicate that the BA11 neural activity increased significantly from phase 1 to phase 2, and from phase 2 to phase 3, indicating that BA11 neural activity increased as face-washing progressed.

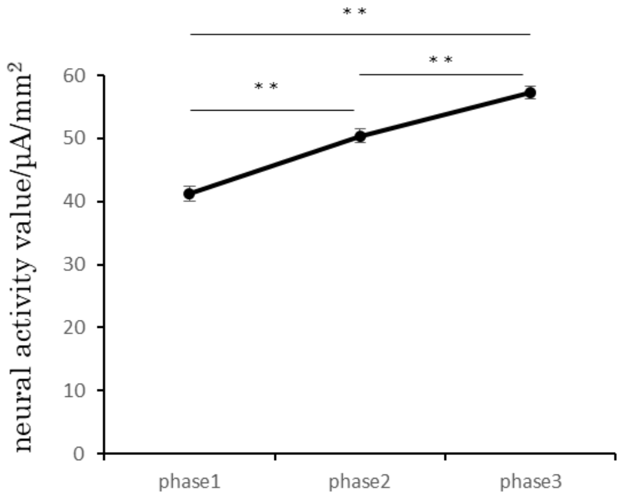


Fig. 4 Neural activity values in BA11 coordinate in each phase; **: $p<0.01$

Next, we compared the differences in the neural activity values of BA11 between samples. As shown in Fig. 5, in phase 1, Sample C had significantly higher neural activity values in the BA11 region than Sample A did.

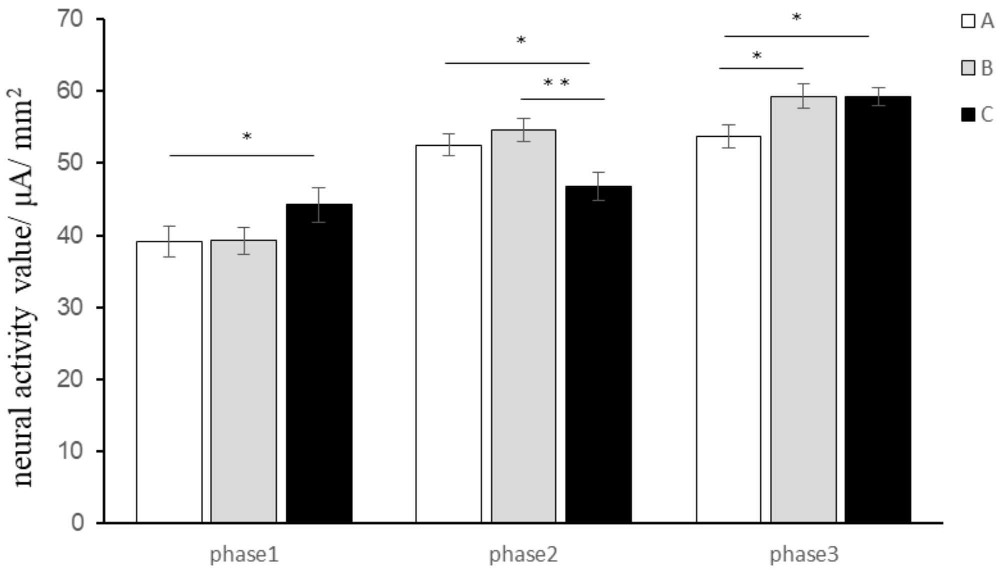


Fig. 5 Comparison of neural activity values in BA11; *: $p<0.05$, **: $p<0.01$

On the other hand, in phase 2, Samples A and B had significantly higher neural activity values for BA11 than Sample C.

In phase 3, Samples B and C had significantly higher neural activity values than Sample A did.

3-3-2. Salivary Cortisol

We compared the mean cortisol levels in saliva collected before (pre) and after (post) face-washing actions using the three cleansing foams. The results, shown in Fig. 6, showed no difference in cortisol levels before and after face-washing.

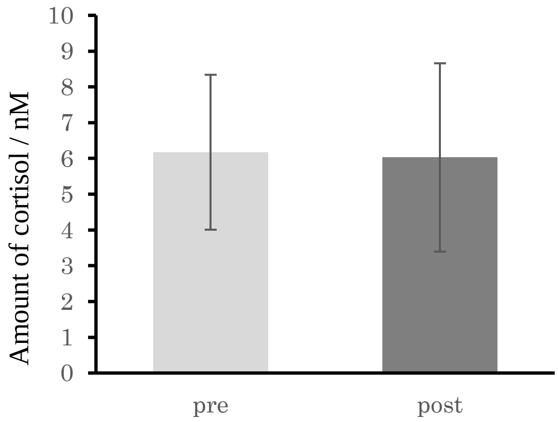


Fig. 6 Comparison of salivary cortisol levels before and after face-washing actions. “pre”: before “Rest” in Fig. 3, “post”: after “Rinse off the foam” in Fig. 3

3-3-3. Questionnaire

As shown in Fig. 7, the foaming speed scores was significantly higher for sample C than for sample A. This is consistent with the results shown in Fig. 8 for the time subjects took to foam, and Table 1 for the time to reach the default foam volume.

The fineness scores of the foams in Fig. 7 tended to be higher for Sample B than for Sample A. This was not consistent with the results for the area of the bubbles shown in Table 1, where Sample A had a smaller bubble area than Sample B.

The elasticity scores of the foam in Fig. 7 was significantly higher for Samples B and C than for Sample A. This is consistent with the foam hardness results shown in Table 1, where Samples B and C had higher hardness values than Sample A.

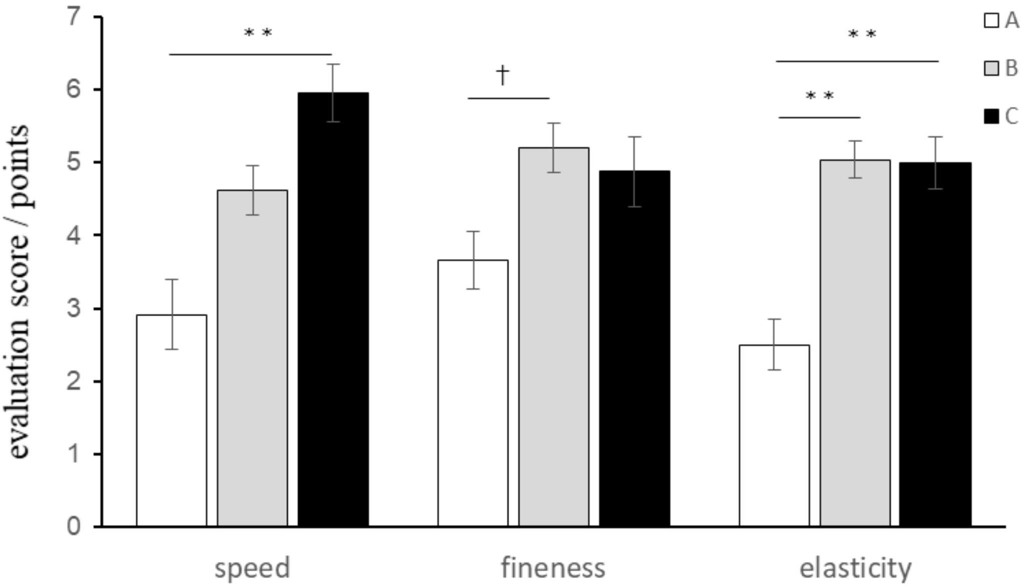


Fig. 7 Subjects' questionnaire evaluation of the created foam. Speed: evaluation of speed of foaming (left), fineness: evaluation of the fineness of the created foam (center), elasticity: evaluation of the elasticity of the created foam; †: $p < 0.1$, *: $p<0.05$, **: $p<0.01$

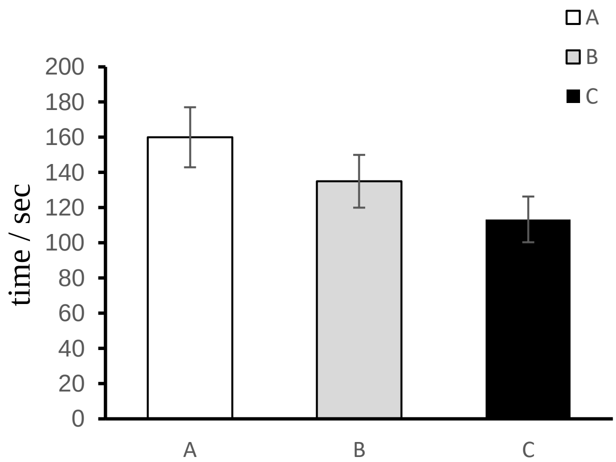


Fig. 8 Time for the subject to finish frothing up

Discussion.

This study showed that neural activity in the BA11 region increased as the face-washing action progressed. It was also shown that neural activity in the BA11 region changes when face washes with different physical properties are used. In this section, we discuss the possibility that face-washing actions may elicit pleasant emotions among the users through activation of the BA11 area. We also discuss the relationship between the neural activity of the BA11 region in each phase and the physical properties of the face washes.

To investigate the effects of foam quality on the mind and body, it was first necessary to verify whether neural activity was affected by the cleansing foam. The results of the preliminary experiment, shown in Fig. 3, indicate that neural activity in BA11 increased more predominantly than in other regions when exposed to facial cleansing foam. This indicates that the feel of the bubbles has a psychological impact. Since BA11 is known to be a region that controls "rewarding" behavior [13], and is activated by tactile stimuli accompanied by pleasant emotions [14]. It was suggested that the feel of the bubbles may provide the user with the pleasant emotion of “reward”. Next, it was necessary to ensure that the face-washing actions were not uncomfortable for the user when accompanied by frothing by the subjects themselves. In this study, the salivary cortisol level, a known stress indicator, was measured before and after the samples were used. It has been reported that the amount of cortisol in saliva decreases during relaxation [15, 16] and increases under stress conditions [17, 18]. A comparison of the mean values of all samples before and after use showed no change in the cortisol levels (Fig. 6). This indicates that face-washing is not a stressful act for users.

The results in Fig. 3 indicate that the feel of the foam affects the neural activity in the BA11 region. Therefore, we investigated the neural activity values in the BA11 region during face-washing actions, starting with lathering, in accordance with actual use. As shown in Fig. 4, the neural activity of BA11 increased in all samples as the face-washing actions progressed from phase 1 to phase 2 and from phase 2 to phase 3. It has been reported that comfortable and continuous tactile stimulation increases activity in the orbitofrontal cortex, including BA11 [19]. These indicate that face-washing actions may induce a sense of comfort in people by increasing neural activity, which reflects reward processing.

To test whether rewarding neural activity values varied with sample characteristics, we compared the neural activity of BA11 by sample. As shown in Fig. 5, in phase 1, Sample C had a higher BA11 neural activity than Sample A. The results of the subject's evaluation shown in Fig. 7 and the time required for foaming shown in Fig. 8 indicate that sample C produced foam the fastest. This suggests that the ease of use, such as the ease of frothing up, may have a pleasurable emotional effect. Based on EEG-based evaluations, previous studies in other fields have reported that stress increases as the usability of multifunctional phones worsens [20]. This suggests that usability, such as the ease or difficulty of frothing up cleansing foam, may also affect emotions. In phase 2, in contrast to phase 1, Samples

A and B had significantly higher BA11 neural activity values than Sample C. Sample A was inferior to Sample C in terms of foamability and foam elasticity. The only factor that was superior in other samples compared to that in Sample C was the fineness of the foam, as shown in Table 1. Therefore, it was suggested that the fineness of the foams may have influenced the neural activity value of BA11 in phase 2. Previous studies have shown that visual stimulation activates neural activity in the orbitofrontal cortex, which is associated with rewarding properties [21]. This suggests that the appearance of the foam may have elicited pleasant emotions in the subjects as a visual stimulus in this study. However, the results of the sensory evaluation in Fig. 7 show that Sample A had the lowest score of fineness, which did not match the results for the average area of bubbles in Table 1. This may reflect the uncertainty of the sensory evaluation, which was answered after all tasks were completed. On the other hand, the results suggest that EEG may have been able to capture emotions in real time.

In phase 3, Samples B and C had higher BA11 neural activity values than Sample A did. This could be attributed to the fact that Samples B and C had more elastic foams than Sample A, because in phase 3, unlike phase 2, visual information was blocked. Therefore, the only input signal to the face was the tactile stimulus of the foam touching it. This supports the hypothesis that the fine appearance of the foam affects emotion in phase 2, where visual information is acceptable.

We believe that the resolution of the following limitations can help improve the QoL for people who use cleansing foams. (1) The subjects in this study were young women. Since facial cleansers are used by all genders and ages, it is necessary to increase the number of subjects in future studies; (2) the types of facial cleansers used in this study were limited. This study demonstrated the possibility that user emotions may change depending on the properties of the cleanser. We believe that in the future, by using various types of facial cleansers with different properties for verification, the results can be widely applied when designing facial cleansers; (3) in this study, the verification phase was from frothing up to applying the foam on the face; however, as shown in Fig. 2, the act of washing the face includes spreading foam on the face and rinsing it off. By expanding the verification phase in the future, it may be possible to create an index for designing cleansing foams that generate pleasant emotions throughout the facial cleansing process.

Conclusion.

In this study, we examined the effects of input stimuli, such as tactile information from cleansing foam and the process of preparing the foam, on the emotions of the subjects. This study showed that emotions change during face-washing actions. It was also suggested that the ease of creating foam during the phase of frothing up, the fineness of foam during the phase of touching by hand, and the elasticity of foam during the application of foam to the face may influence rewarding neural activity. These results provide new insights into the psychological effects of tactile and visual information of foams on the user, as well as the foam-creating process.

Conflict of Interest Statement. NONE.

References.

1. Zhang L, Adique A, Sarkar P, et al (2020) The Impact of Routine Skin Care on the Quality of Life. Cosmetics 7:59.
2. Yasaka K, Mori T, Yamaguchi M, et al (2019) Representations of Microgeometric Tactile Information During Object Recog-nition. Cogn Process 20:19–30.
3. Choi, J.-Y., Kim, K.-H., Kim, M.-S (2007) Cosmetics Buying Patterns and Satisfaction among Female University Students in China, Japan and Korea. Journal of the Korean Society of Clothing and Textiles. J Korean Soc Cloth Text 31(12):1772–1783.
4. Barkat S, Thomas-Danguin T, Bensafi M, et al (2003) Odor and color of cosmetic products: correlations between subjective judgement and autonomous nervous system response. Int J Cosmet Sci 25: 273–283.
5. Koenig DW, Dvoracek B, Vongsa R (2013) In vitro prediction of in vivo skin damage associated with the wiping of dry tissue against skin. Skin Res Technol 19: e453–e458.
6. Sonoda J, Sakai T, Inomata Y (2014) Liquid Oil That Flows in Spaces of Aqueous Foam without Defoaming. J Phys Chem B 118:9438–9444.
7. Kusaka A, Sonoda J, Tajima H, et al (2018) Dynamics of Liquid Oil that Flows Inside Aqueous Wet Foam. J Phys Chem B 122:9786–9791.
8. Balconi M, Molteni E (2016) Past and future of near-infrared spectroscopy in studies of emotion and social neuroscience. J Cogn Psychol 28(2):129–146.
9. Querleux B, Gazano G, Mohen-Domenech O, et al (1999) Brain activation in response to a tactile stimulation: functional magnetic resonance imaging (FMRI) versus cognitive analysis. Int J Cosmet Sci 21(2):107–118.
10. Inoko K, et al (2021). The effect of the quality of foam on psycho-physiological index―How do you feel the moment you touch foam?―. [Conference presentation abstract]. The 16th Spring Annual Meeting of Japan Society of Kansei Engineering, Online Congress, 2021-03-07/08, Japan Society of Kansei Engineering, vol.16th 5D-

02.
11. Miguel AD, Nancy AJ, Tiffany F, et al (1998) Aromatherapy Positively Affects Mood, Eeg Patterns of Alertness and Math Computations, International Journal of Neuroscience, 96(3-4), 217-224
12. Pascual-Marqui RD (2002) Standardized Low-Resolution Brain Electromagnetic Tomography (sLORETA): Technical Details. Methods Find Exp Clin Pharmacol 24(Suppl D):5–12.
13. Rolls ET (2004) The Functions of the Orbitofrontal Cortex. Brain Cogn 55:11–29.
14. Francis S, Rolls ET, Bowtell R, et al (1999) The representation of pleasant touch in the brain and its relationship with taste and olfactory areas. Neuroreport 10(3):453–459.
15. Park BJ, Tsunetsugu Y, Kasetani T, et al (2007) Physiological Effects of Shinrin-yoku (Taking in the Atmosphere of the Forest) - Using Salivary Cortisol and Cerebral Activity as Indicators. J Physiol Anthropol 26:123–128.
16. Sakano K, Ryo K, Tamaki Y, et al (2014) Possible Benefits of Singing to the Mental and Physical Condition of the Elderly. Biopsychosocial Med 8:11.
17. Izawa S, Sugaya N, Shirotsuki K, et al (2008) Salivary Dehydroepiandrosterone Secretion in Response to Acute Psychosocial Stress and Its Correlations with Biological and Psychological Changes. Biol Psychol 79:294–298.
18. Kudielka BM, Buske-Kirschbaum A, Hellhammer DH, et al (2004) HPA Axis Responses to Laboratory Psychosocial Stress in Healthy Elderly Adults, Younger Adults, and Children: Impact of Age and Gender. Psychoneuroendocrinology 29:83–98.
19. Uta S, Chantal T, Gisela H, et al (2016), Temporal dynamics of brain activation during 40 minutes of pleasant touch, NeuroImage 139: 360-367.
20. Tsunoda T, Shimizu M, Nakagawa M, et al (2013) On the Operability Assessment of Multi-functional Emergency phones with Fractal Analyses of EEG. IEICE Tech Rep 113(222):77–82.
21. Schienle A, Schäfer A, Hermann A, et al (2009) Binge-Eating Disorder: Reward Sensitivity and Brain Activation to Images of Food. Biol Psychiatry 65(8):654–661.