

## Luxury Cues Facilitate the Connection Between Social Dominance and Reward Mediated by the Lateral Prefrontal Cortex

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### Synopsis

Luxury skin care products have emotional value because of their texture and accompanying product information. The influence of these factors appears to be linked. Here, we investigated the influence of information on brain activity during hand massages with skin care creams in healthy female volunteers. In the first session, participants received hand massages using two skin care creams (luxury and basic). In the second session, participants were shown information which indicated whether each cream was a luxury or basic product during the massage. In the third session, they received a hand massage as per the first session. Functional magnetic resonance imaging data were recorded during massages. Differential activity in the ventral striatum (VS), the caudate nucleus, and the dorsomedial prefrontal cortex (DMPFC) was significantly higher in the third session than in the first session. Moreover, differential activity in the right dorsolateral prefrontal cortex (DLPFC) was positively correlated with differential activity in both the VS and the DMPFC in the third session. These results suggest that the neural substrate of the effects is based on both the dopamine reward system and the self-other distinction system involved in social dominance and that the right DLPFC plays a critical role in the association between these systems.

### INTRODUCTION

Skin care products are applied to maintain a preferable physical condition (e.g., well moisturized) of the user's skin. In addition, these products concurrently provide emotional value. The fine texture of the cream provides comfort to users, stimulating their somatosensory system. Moreover, other types of satisfaction, such as a sense of superiority, can be achieved cognitively through the luxurious image of the brand. This image is provided through product information, the brand story, decorative packaging, and price, which indicates the value. Generally, users focus on information about the luxurious nature of the product when purchasing it. However, if the user associates the information related

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to the luxurious nature of the product with its texture, the texture itself may provide not only a feeling of comfort but also satisfaction linked to the knowledge that the product is a luxury. When the somatosensory signal generated by the feeling of applying the product reaches the central nervous system, it may act as a cue, like a conditioned stimulus. Cosmetic manufacturers worldwide are attempting to produce attractive skin care products based on not only their texture but also the product information that indicates, e.g., how much luxury it can offer. Understanding the neural mechanism of satisfaction based on the memorized association between the texture of a skin care product and the value provided by the product information may facilitate the production of attractive skin care products.

In this study, we have investigated the neural process of associating a product's texture with the value provided by the product information. Using functional magnetic resonance imaging (fMRI), we investigated the influence of product information on brain activity during a hand massage with a skin care cream, comparing the brain activity before and after the product information was provided to participants. Despite the importance of understanding the neural basis of the effect of skin care product application, no such fMRI study has been previously performed.

The caudate nucleus has been shown to be associated with the effective aspect of tactile processes that have a hedonic or motivational component and with the discriminative aspect of touch information processing (1,2). Activity in the ventral striatum (VS), which plays a critical role in the reward system, has been shown to correlate with the score of subjective pleasantness in an fMRI study in which participants applied a cream while being visually provided with the information of its richness (3). Regarding the effects of product information, it has been reported that observing the logo of a favorite brand of car can activate the VS (4) and the dorsomedial prefrontal cortex (DMPFC), a brain region associated with self-relevant processing (5). The value of brand image appears to be related to the cognition of social dominance because possession of goods from luxury brands represents a superior social status that distinguishes the owners from others (6). In addition, the DMPFC is also associated with information processing related to the image of "social competence," and it may be related to the cognitive values (7). The DMPFC is also a critical region for the self-other distinction system, which is strongly related to the cognition of social dominance. Accordingly, the ability of some brand logos to cause neural activation in the DMPFC is considered to be due to the memorized association between the attractive brand image and the logos (4–6). In addition to the caudate nucleus, the VS, and the DMPFC, the dorsolateral prefrontal cortex (DLPFC) represents associations between rules and expected reward outcomes (8). Generally, many of the values we have in society are based on rules. For example, the value of a product from a luxury brand is based on the rule that it represents superior social status. Thus, the DLPFC may be involved in the association between the reward and social dominance in this context.

Here, we have hypothesized that after participants were shown information revealing that a product is a luxury product, brain regions related to the reward system (the caudate nucleus and the VS) and the self-other distinction system (the DMPFC) would be significantly activated. In addition, we hypothesized that the lateral prefrontal cortex plays an important role in the association between the two systems. Thus, we recorded brain activity using fMRI during hand massages using skin care creams and compared it before and after product information was provided to participants, to investigate the influence

of the product information on brain activity. We conducted a region of interest (ROI) analysis and performed a multiple regression analysis with the DLPFC as the dependent variable and the other ROIs as the independent variables.

## MATERIALS AND METHODS

### PARTICIPANTS

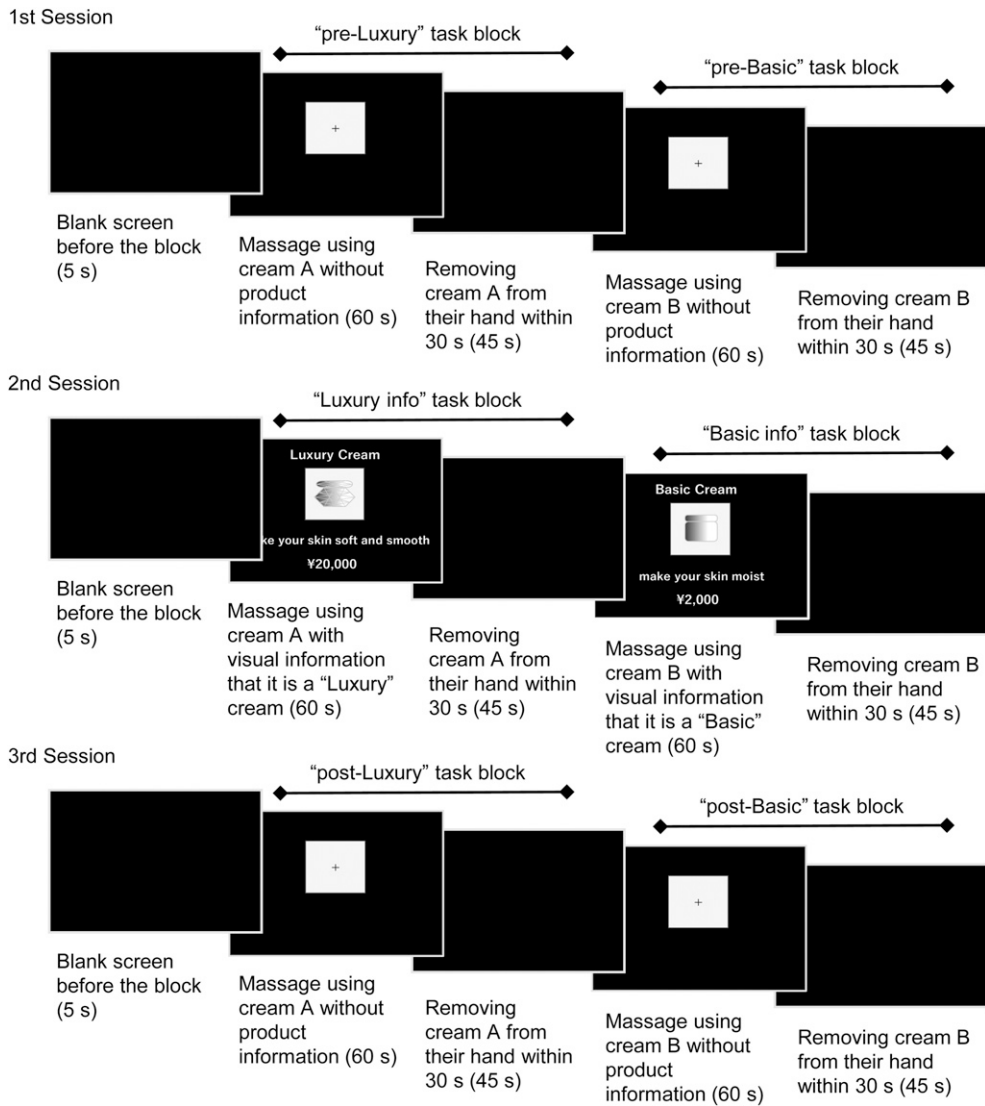
Twenty-two healthy, right-handed women (age:  $34.8 \pm 2.8$  years) participated in the study. All participants were using skin care creams with a price of more than ¥15,000 as part of their daily routine and had no history of neurological or psychiatric disorder. They provided written and oral informed consent to participate in this study. The Research Ethics Committee of Shiseido Global Innovation Center approved this study, and all methods were conducted in accordance with the approved guidelines.

### STIMULI, TRIAL PROTOCOL, AND PROCEDURE

We used two skin care creams (cream A and cream B) with noticeably different textures, so that participants could discriminate the textures of the two creams by the way they felt on the back of their hand; cream A was formulated to be softer, smoother, and lighter to touch than cream B. Both were water in oil type creams. Creams A and B were applied in the “Luxury” and “Basic” conditions, respectively.

Data for six task blocks were recorded across three sessions: the precream application session (first session, “pre-Luxury” task block and “pre-Basic” task block); the simultaneous cream and information session (second session, “Luxury info” task block and “Basic info” task block); and the postcream application session (third session, “post-Luxury” task block and “post-Basic” task block). A black screen was shown for 45 s after each task block to indicate a reset, and for 5 s before the first task block. In the second session, information on each cream was provided. The information consisted of a word representing the cream (“Luxury cream” or “Basic cream”), a photo of the creams’ case (a glass or plastic container) in a gray square, a statement of the intended effect of the cream (“make your skin soft and smooth” or “make your skin moist”), and price (¥20,000 or ¥2,000) written on a black background. For the first and third sessions, a gray square on a black background was shown as a visual control. Visual stimuli were projected onto a display mounted in goggles attached to the participant’s head (Figure 1).

Participants were massaged on the back of their left hand using the skin care creams. The amount of the cream that was applied was 0.2 g. A member of the experimental staff who is a beauty specialist (M.S.) massaged the back of the hands of the participants using her right fingers and palm. She applied the cream on the skin and moved her hand in a circle slowly and softly. During the last part of the massage, she placed her hand on the skin and pressed lightly in circular motion. The speed of movement was approximately 2.5 s per cycle. The massage procedure was the same in all blocks. During the reset block, the experimental staff removed the cream from the back of participants’ hands using a warm wet towel.



**Figure 1.** The three sessions of the study. In the second session, participants were given the product information visually during the massage. In the first and third sessions, participants were given the same view without the product information.

FMRI DATA ANALYSIS

Scanning was conducted using a 3.0T MRI system (Achieva Series Quasar Dual 3.0T; Philips Medical Systems, Best, Netherlands). Blood Oxygenation Level Dependent T2-weighted MR signals were measured with a gradient echo-planar imaging (EPI) sequence [repetition time (TR) = 2,500 ms, echo time (TE) = 35 ms, flip angle (FA) = 90°, field of view (FOV) = 230 × 230 mm<sup>2</sup>, scan matrix = 128 × 128, total scan time = 635 s, dynamic scans = 245 volumes, slice thickness = 5 mm, and 24 slices per volume]. Image processing was conducted with Statistical Parametric Mapping software (SPM12, Wellcome

Department of Imaging Neuroscience, London, UK; <http://www.fil.ion.ucl.ac.uk/spm/software/spm12>). T1-weighted anatomical images were acquired using the following parameters: 150 slices, thickness, 1.0 mm, TE = 2.0 ms, TR = 23 ms, FOV =  $240 \times 240$  mm<sup>2</sup>, FA = 30°, and matrix size =  $240 \times 240$ . EPIs were spatially realigned, co-registered (T1 to EPI), and normalized to the Montreal Neurological Institute template. Normalized images were smoothed using an 8-mm full-width half-maximum Gaussian kernel. The data were temporally convolved with hemodynamic response function and high pass filtered with a cutoff period of 128 s.

We searched the local maximum points within the nearest 5 mm from the coordinates of the left caudate nucleus (−12 2 23) (1), the right caudate nucleus (10 14 18) (9), the VS (10 4 −2) (10), and the DMPFC (−3 47 49) (11). We then selected spherical regions within a 5-mm radius centered at these points as the ROIs and investigated significant activation at  $p < 0.05$  [family-wise error corrected, small volume correction], in the contrast of the third session (post-Luxury vs. post-Basic) versus the first session (pre-Luxury vs. pre-Basic), and in the contrast of Luxury versus Basic both in the third session (post-Luxury vs. post-Basic) and first session (pre-Luxury vs. pre-Basic). Moreover, we conducted a multiple comparison analysis based on the Holm method ( $p < 0.05$ ) (12). Furthermore, we set the DLPFC (33 15 45) (8) as the ROI and conducted a multiple regression analysis with the eigenvariate value for the DLPFC as the dependent variable and those of the other ROIs as the independent variables ( $p < 0.05$ ). The multiple regression analysis was conducted for each contrast of the first (pre-Luxury vs. pre-Basic) and third (post-Luxury vs. post-Basic) sessions. Moreover, we analyzed the residuals by performing the Shapiro–Wilk (S-W) test of normality ( $p < 0.05$ ) and calculated the Durbin–Watson (D-W) statistic for the null hypothesis of no autocorrelation.

## RESULTS

### INFLUENCE OF THE LUXURY CUE ON BRAIN ACTIVITY

In session 1, where we compared luxury and basic creams before showing product information, the ROI analyses did not show significant activation in any region. However, the ROI analyses in session 3 showed significant activation in four regions compared with session 1, which indicates the effect of the product information. These areas were the left caudate nucleus ( $p = 0.032$ ), the right caudate nucleus ( $p = 0.006$ ), the VS ( $p = 0.022$ ), and the DMPFC ( $p = 0.004$ ) (Table 1 and Figures 2 and 3). Each Euclidean distance was 1.00, 0.00, 0.00, and 3.32 mm, respectively. In addition, the ROI analyses in session 3, where we compared creams of different quality after showing the product information, also revealed significant activation in the right caudate nucleus ( $p = 0.006$ ) and the DMPFC ( $p = 0.015$ ) (Table 1 and Figures 2 and 3).

### REGIONS WHICH SHOWED SIGNIFICANT CORRELATIONS WITH THE DLPFC

Activity in the right DLPFC was positively correlated with activity in the DMPFC ( $t = 3.327$ ,  $p = 0.004$ ) and the VS ( $t = 2.239$ ,  $p = 0.037$ ) (adjusted  $R^2 = 0.437$ ; S-W statistic = 0.917,  $p = 0.066$ ; D-W statistic = 1.826) in the third session (post-Luxury vs. post-Basic), whereas there was no significant correlation in the first session (pre-Luxury vs. pre-Basic) (Figure 4).

Table I  
Activation of the Brain Regions

Brain region	First		Third		Third versus First	
	<i>p</i>	Beta	<i>p</i>	Beta	<i>p</i>	Beta
Left caudate nucleus	0.032	-0.783 ± 0.104	0.560	1.31 ± 0.162	0.116	1.95 ± 0.150
Right caudate nucleus	0.006	-2.13 ± 0.124	0.642	2.90 ± 0.104	0.006	3.66 ± 0.154
VS	0.022	-2.13 ± 0.0908	0.668	0.998 ± 0.118	0.185	2.23 ± 0.139
DMPFC	0.004	-1.17 ± 0.302	0.672	3.17 ± 0.327	0.015	2.98 ± 0.467

First: pre-Luxury versus pre-Basic; third: post-Luxury versus post-Basic; third versus first: (post-Luxury vs. post-Basic) versus (pre-Luxury vs. pre-Basic).

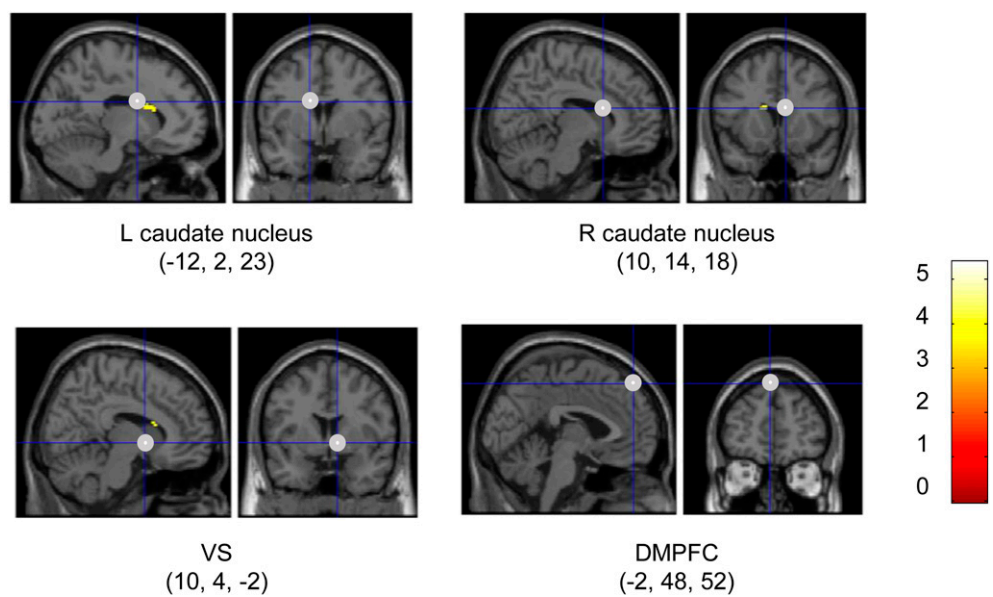
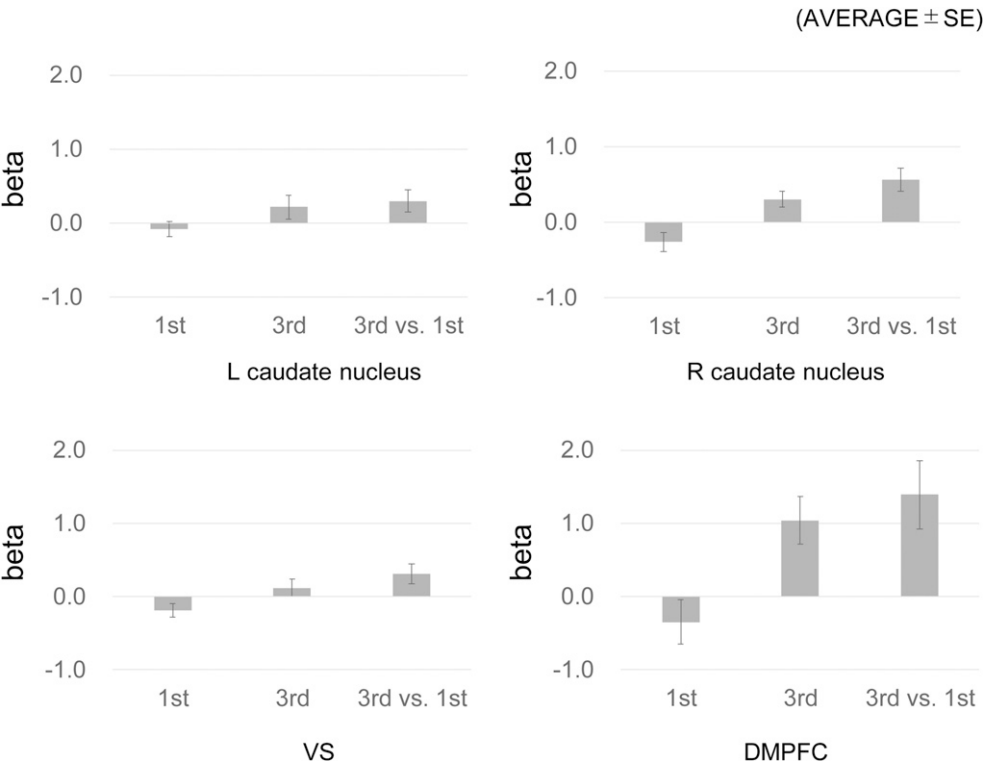


Figure 2. The location of the ROI. The differential activity in the VS, caudate nucleus, and DMPFC was significantly higher in the third session than in the first session. L: left, R: right.

DISCUSSION

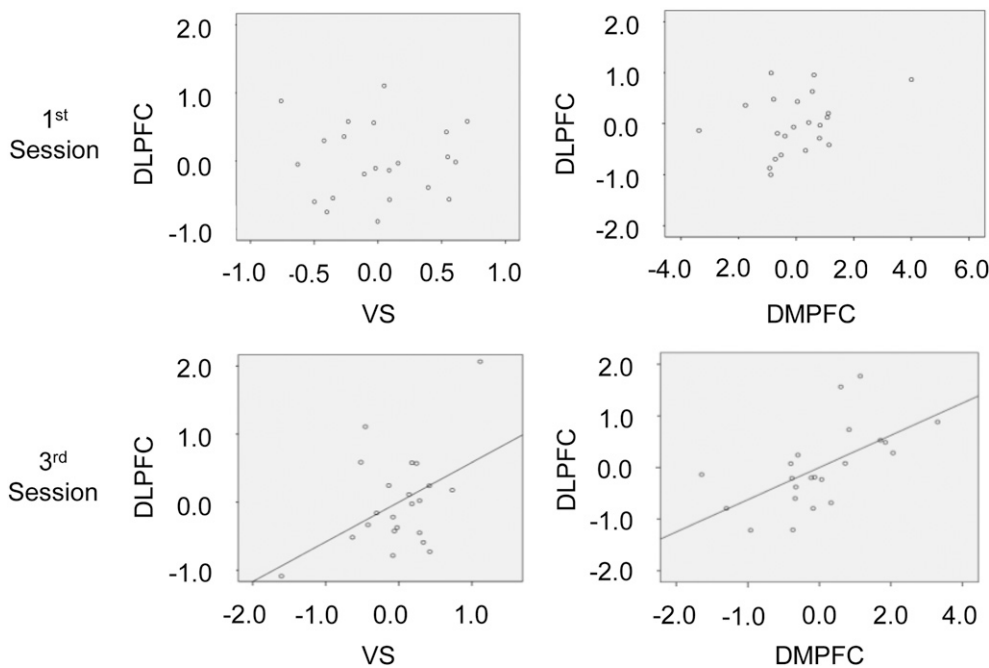
In the present study, we found significant changes in brain activity with the same tactile stimuli before and after providing participants with the product information. This change could have been dependent on the memory of the visual information that was shown in the second session. The caudate nucleus and the VS were significantly activated after receiving visual information in the Luxury condition compared with the Basic condition. Activation of the caudate nucleus is associated with rewards of touch (1) and social evaluation (9). In addition, it is related to the affective aspect and also the discriminative aspect of touch (2). The significant activity in the caudate nucleus was observed only in the post-Luxury versus post-Basic, but not in the pre-Luxury versus pre-Basic. Therefore, in the first session, the difference in the texture alone may not be associated with reward. Only after learning the association between the texture and the value based on the luxury





**Figure 3.** Averaged beta values for Luxury versus Basic creams in each brain region. In the first session, there were no significant differences in any brain region. The activities of each region in Luxury compared with Basic were significantly higher in the third session compared with the first session. First: pre-Luxury versus pre-Basic; third: post-Luxury versus post-Basic; third versus first: third (post-Luxury vs. post-Basic) versus first (pre-Luxury vs. pre-Basic).

cue of cream A were participants able to more clearly discriminate it from cream B. Activity in the VS has been reported to be linked to pleasant feelings associated with contact with skin care cream (3). In addition, the VS plays a critical role in the processing of reward outcome and expectation. It is involved in many kinds of reward such as money, pleasant feelings associated with contact with skin care cream (3), and satisfaction based on social comparison (13). Accordingly, the luxury cue provided by the product information might associate the texture of cream A with its emotional and social value. We also observed that the DMPFC was significantly activated after participants visually received product information. It has been reported that the DMPFC is related to the psychological function of comparing oneself with others (11). Furthermore, the activity of the middle frontal gyrus cluster, which overlaps with an area of the DMPFC, has been shown to be influenced by social feedback such as smiling or anger (9). Moreover, the DMPFC plays an important role in the evaluation of brand images, which may be related to its involvement in the cognition of social dominance because possessing goods from luxury brands can represent a superior social status that distinguishes the owner from others (6). Accordingly, the activation we observed that the DMPFC is likely to be strongly linked to the cognition of social dominance. In an fMRI study into decision-making which is driven by the expected reward value, it has been shown that the DLPFC plays a direct role



**Figure 4.** Correlations between the DLPFC, the VS, and the DMPFC in the first and third sessions. The correlations between the DLPFC and VS, and the DLPFC and the DMPFC became statistically significant after perceiving product information.

in the motivational processes which represent associations between rules and expected reward outcomes (8). Here, the activity in the DLPFC was correlated with the activity in both the DMPFC and the VS, suggesting that this region serves as an integrative hub linking rule (luxury represents social dominance) and reward (social dominance is rewarding). Our findings provide further implications for the value of cosmetic products in consumers' lives. First, skin care products with information indicating that they are luxury items may provide satisfaction to consumers in the context of social dominance. Second, the social dominance-related effect of the product information can be triggered by touching the product even when the information is not present if it has been presented previously. The cosmetics industry contributes to enhancing the quality of life in our society through the psychophysiological effects which are offered by the products such as soothing feel caused by the texture of skin care creams (13) or modification of appearance which considerably improves self-confidence (14). From the results of this experiment, we may be able to consider the potential of information regarding the luxury offered by the product to improve consumer satisfaction.

LIMITATIONS

In this study, we observed the effects of providing information about two kinds of skin care creams. It would have been better to use a range of skin care products such as skin lotion, skin milk, and serum, to assess if these results are applicable to skin care products



in general. It may also be important to exchange the creams (cream A and cream B) used for the two conditions. In this study, we focused on assessing changes in the neural response before and after providing the product information. However, if the change was caused by the learning process, the strength of the connection between the specific tactile stimuli of the creams and the information might change depending on whether the texture is a better or worse match with the image of the luxury brand.

There is also a limitation by using fMRI. Indeed, the creams were applied to the skin on the hand rather than the face which is more common for consumers. It is because the head of participants must be fixed and covered by an RF-coil during the fMRI scanning. Moreover, the participants were recruited based on the condition that they used creams with a price of more than ¥15,000 as part of their daily routine. However, luxury concept is influenced by many other factors such as marriage, children, and socioeconomic status. Therefore, further neuroimaging studies are needed to clarify the influences of these factors.

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