Different Cosmetic Formulations Can Induce Distinct Neural Substrates

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INTRODUCTION

- Cosmetic products have a variety of formulations. Applying cosmetics to the skin evokes emotions related to the texture of formulations. Some formulations cause positive feelings, such as softness and moistness while others cause negative feelings of stickiness or greasiness.
- Traditionally, questionnaires and survey were used to measure the emotions evoked when applying cosmetics. However, this method cannot capture a real-time response for cosmetic formulation-related emotions and can be flawed by the respondent's incorrect remembrance.
- For this reason, researchers proposed a new method using neurophysiological data which can acquire more objective and quantifiable emotion-related data while using cosmetics.
- The purpose of this study was to compare the emotions evoked by the application of different cosmetic formulations using electroencephalography (EEG), and to automatically classify the emotions using EEG features based on machine learning technique.

METHOD

Experimental Condition

- Five subjects (4 females, 1 male) participated in the study. All subjects were healthy, and none of them had skin allergies, neurological or psychiatric disorders..
- Before the experiment, three locations of the subjects' left forearm were marked to deliver three different formulations, including two positive formulations (P1, P2) and one negative formulation (N). Each of the formulations was repeatedly applied three times in a random order.
- After applying each formulation using a pipette, a 10 sec baseline was given and then the subjects were instructed to apply the formulation for 20 sec using the right hand.

Figure 1. Experimental Paradigm

Data Analysis

- The EEG data were acquired with twenty dry electrodes attached on the scalp according to international 10-20 system. A1 electrode was placed on the left earlobe as ground and reference electrode. The P3 electrode was excluded from further analysis due to severe physiological artifacts.
- The raw EEG data were band-pass filtered between 0.5 – 55 Hz and down-sampled at 200 Hz. The filtered EEG data were epoched for an interval of -1 – 20 sec based on the onset of the hand apply period. Independent component analysis (ICA) was applied to the epoched data to remove physiological artifacts, such as electrooculography (EOG) and electromyography (EMG).
- We performed event-related spectral perturbation analysis to investigate event-related (de)synchronization (ERD/ERS) and estimated mean ERD/ERS values over the time and channel for six different frequency bands (delta: 0.5 – 4 Hz, theta: 4 – 8 Hz, alpha: 8 – 12 Hz, beta: 12 – 30 Hz, gamma: 30 – 55 Hz, all: 0.5 – 55 Hz) to confirm the distinct ERD/ERS between the different formulations.
- Classification of each formulation was performed for each frequency band using mean ERD/ERS values as features; one feature was extracted per channel. Data augmentation was performed using a 1 sec of window size with 50% overlap to increase the number of samples. Each augmented data was normalized to the range of 0 to 1 to reduce the variation between subjects.
- Support vector machine (SVM) model was used as a classifier with Fisher score for feature selection.

RESULT

- Figure 2 shows the difference of mean ERD/ERS values between positive and negative formulations for six frequency bands when applying each formulation.
- The negative formulation showed relatively stronger ERD compared to the positive formulation in general, but significant difference between formulations was not observed.

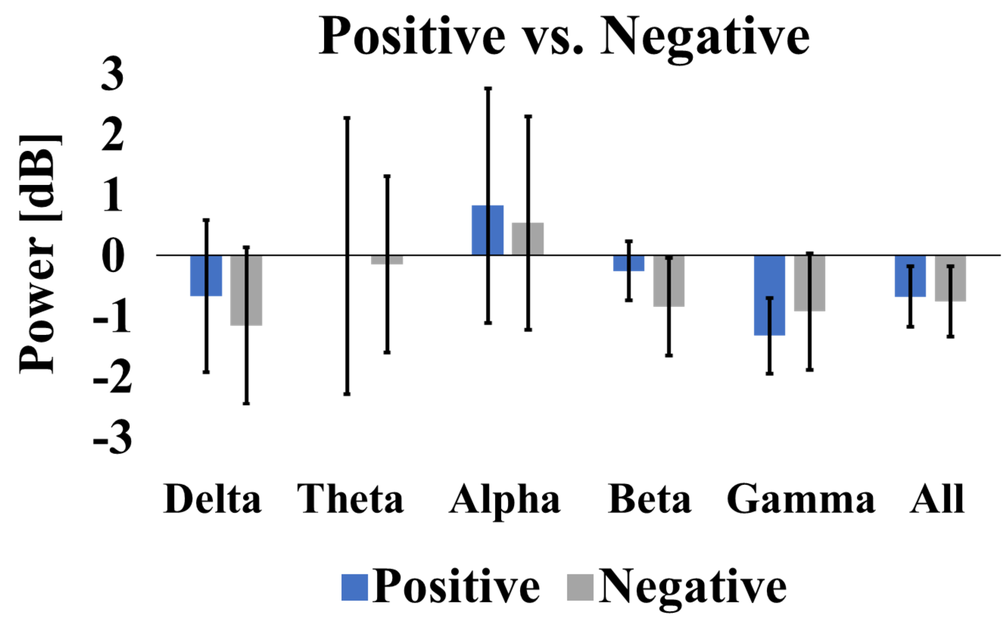

Figure 2. Grand-average ERD/ERS values of all subjects during applying the different formulations

- Figure 3 shows the average classification results with respect to the number of features. Overall, the beta band showed the highest classification accuracy, and in particular, the highest accuracy of 71.84% was observed when using six features selected by Fisher score in beta frequency band.

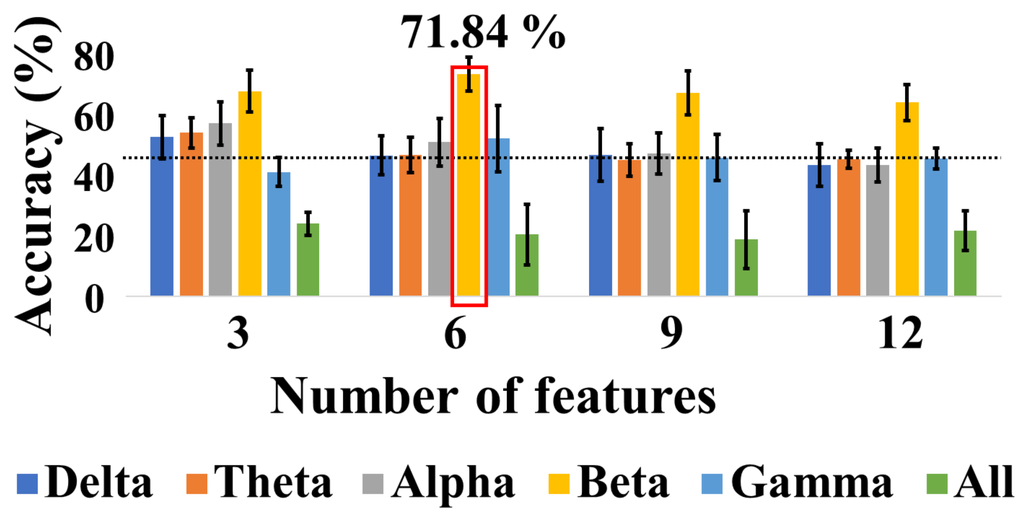

Figure 3. Average classification accuracies for six frequency bands with respect to the number of features

CONCLUSION

- In this study, we investigated the differences in EEG when different types of formulations were applied to the skin.
- As a result, the negative formulation showed relatively stronger ERD patterns as compared to the positive formulation and the highest classification accuracy of 71.84 % was shown, demonstrating the feasibility of decoding emotions induced by different formulations using EEG.
- In the future work, we attempt to acquire sufficient data in order to increase classification performance with more advanced classification algorithms such as deep learning, thereby developing an EEG-based customized cosmetics.

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