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Holistic emotional impact assessment of cosmetic product: combining physical measurement of AI facial expression recognition and EEG and psychological evaluation of mood questionnaire

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1. Introduction

In contemporary hyperconnected societies, chronic stress exposure has precipitated a paradigm shift in dermatological science, with mounting evidence revealing the bidirectional communication between psychological states and cutaneous health through the brain-skin axis [1]. Epidemiological data indicates that 62% of urban populations experience stress-related dermatological conditions, from transient erythema to chronic inflammation (Global Skin Health Index, 2022), driving demand for skincare solutions that address both physiological and emotional well-being. This psychodermatological imperative is further underscored by mechanistic studies demonstrating cortisol-mediated degradation of extracellular matrix proteins and stress-induced epidermal barrier dysfunction [2]. Concurrently, the global market for mood-enhancing skincare is projected to reach $8.36 billion by 2027 [3], reflecting consumers' growing prioritization of products delivering dual dermatological and psychological benefits.

Traditional skincare paradigms focusing on mechanical cleansing and barrier repair [4] are being supplanted by neurocosmetic innovations targeting emotional modulation. Clinical validation of these interventions has gained momentum, with controlled trials demonstrating significant stress reduction through aromatherapy-enhanced regimens. However, existing evaluation frameworks often lack ecological validity, failing to capture the multidimensional nature of emotional responses across acute, subacute, and chronic timescales [5]. This gap is particularly critical given emerging insights into the skin's role as both a stress transducer and emotional interface, where millisecond-scale neuroaesthetic responses interact with month-long neuroplastic adaptations [6].

As the public's understanding of emotional skincare continues to deepen, the verification and testing of the emotional improvement effects of skincare products have also increasingly drawn attention. Against the backdrop of the current and continuous rise in consumers' attention to emotional skincare. To archive this aim, this study introduces a multimodal assessment framework integrating neurophysiological, behavioral, and psychometric

measures. Building on consumer neuroscience principles, we employ 16-channel EEG to quantify emotion change during product fragrance exposure, synchronized with Facial Action Coding System (FACS)-based micro expression analysis to quantify valence during cream self massage and apply emotional assessments through whole treatment. In addition, relevant psychological scales regarding the impact of the facial cream on emotional improvement during the 28-day home using test period by consumers will be retrieved, so as to comprehensively and deeply analyze the impact of the facial cream on emotions in different scenarios.

2. Materials and Methods

Panel recruitment

For CLT test (Real-time mood monitoring), 31 healthy female participants aged between 25 and 45 years (with a mean age of 37.7 years) were carefully selected. For HUT test (Long-term mood monitoring), 34 healthy female participants with average age of 46.3 years old were included, and their ages ranged from 34 to 54 years old. This study was conducted in accordance with the principles of the Declaration of Helsinki, and written informed consent was obtained from all participants.

Testing procedure

- CLT - Central Location Test (Real-time mood monitoring)

To comprehensively evaluate the effects of the skincare product, the field test was precisely divided into two consecutive and independent phases.

Phase 1: Olfactory Stimulation and EEG Monitoring

In this phase, participants were guided to sniff a facial cream (with essential oil). To capture the immediate neural responses triggered by the cream's scent, electroencephalogram (EEG) recordings of the participants' brain activities were meticulously taken both before and after the olfactory encounter. This process was strictly carried out in accordance with standardized procedures to ensure the accuracy and reliability of the EEG data, providing an objective basis for analyzing the impact of the cream's scent on the nervous system.

Phase 2: Facial Application and Facial Expression Analysis

After completing the olfactory test, participants were required to apply the cream evenly on their faces and massage it in by themselves. Before and after the massage, researchers used advanced facial expression analysis technology to comprehensively record the participants' facial expression changes. Through in - depth analysis of these facial expression data, it was possible to intuitively understand the participants' emotional fluctuations and experiences during the process of using the cream.

Scale Assessment

To quantitatively evaluate the participants' stress and relaxation levels at each stage, Chinese Perceived Stress Scale (CPSS - 14), Stress Visual Analog Scale (VAS) and a Brief Mood Introspection Scale (BMIS-Negative relaxed) were selected for this study. Before and after each test stage, researchers instructed the participants to carefully fill out these scales to obtain data on their psychological states at different time points. Specifically, psychological scale questionnaires are filled out before and after the electroencephalogram (EEG) tests and before and after the facial - recognition tests with the application of face creams.

- HUT -Home - use Test (Long-term mood monitoring)

To gain a deeper understanding of the long - lasting effects of the product, a comprehensive well - being questionnaire (emotional questions referring to the POMS and PANAS scales) was distributed to the participants after they had continuously used the product for 28 days. This questionnaire delves into multiple aspects, including pleasantness, comfort, happiness, relaxation, and vitality etc. Its primary purpose is to collect participants ' subjective evaluations and holistic experiences of the product's effectiveness.

Self - assessment sessions are scheduled for participants. They need to evaluate themselves right after product application/massage (D0 Timm). Followed self-assessments are carried out on the Day 1 (D1, at least 16 hours after the initial use), and on Day 14 (D14) and Day 28 (D28) at least 24 hours after the final product use. Responses are given on a 5 - point Likert scale, ranging from "Completely Disagree" to "Completely Agree".

3. Results

3.1 Data results of the emotional impact in the sniffing cream's scent test

Table 1. Statistical table of power values of EEG bands before and after sniffing cream's scent

Statistics	Variance analysis N=31 δ,θ,α and β power values (power unit: dB)							
	δ bands		θ bands		α bands		β bands	
	Before	After	Before	After	Before	After	Before	After
Mean±SD	9.01±2.49	9.57±3.23	2.26±1.55	2.21±1.65	4.26±3.73	3.93±3.89	-0.57±2.23	-0.70±2.17
The P-value of the normality test	0.79	0.37	0.05	0.08	0.19	0.32	0.78	0.71
P-value of the difference test (vs. Before)	/	0.08	/	0.60	/	0.80	/	0.21
Change rate	/	6.22%	/	-2.21%	/	-7.74%	/	-22.8%
Variance analysis (vs. Before)	/	Significant differences	/	No significant differences	/	No significant differences	/	No significant differences

Parameter description	δ and θ are the brainwaves of subconscious activity, α are related to the active mental state of cognitive activity and emotional state β the mental state of being in a relaxed state of mind and a conscious mind. [7-10] δ, θ, and α waves were more dominant in the relaxed state, so the decibel values of δ, θ, and α increased, and the β decibel values decreased, indicating that the relaxed state was improved.

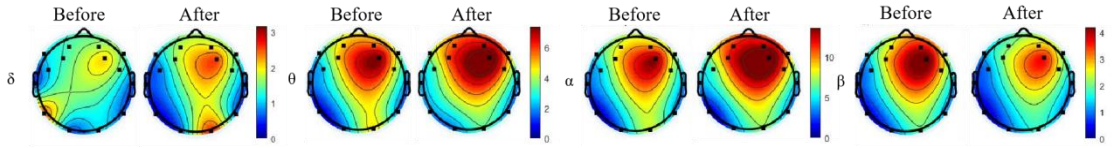

Figure 1. Topographic map of the EEG bands before and after the sniffing cream sample.

Note: In the EEG band tomography, the redder the color, the greater the energy of the brain region of this frequency band, and the bluer the color, the smaller the energy of the brain region of this frequency band

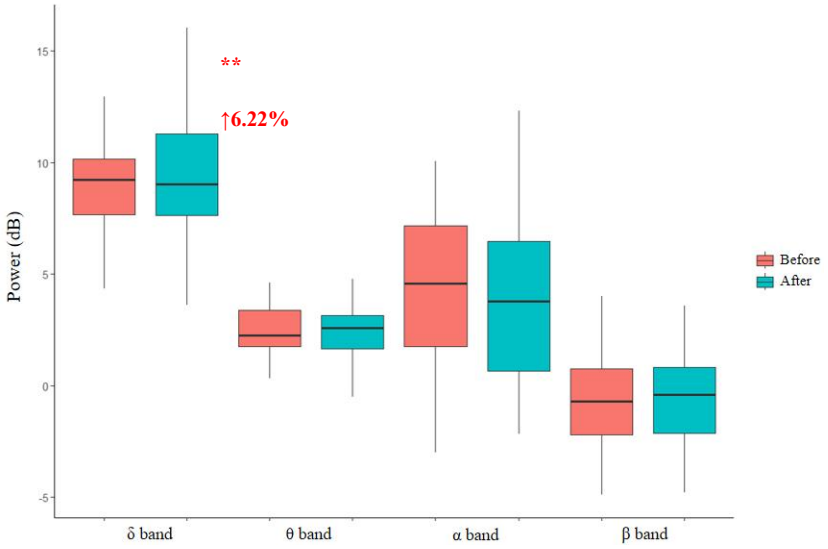

Figure 2. Box diagram of brain wave bands before and after sniffing cream sample.

*Notes: 1. The red value is the rate of change compared to the baseline [before smelling] power value, ↑ indicates an increase in the rate of change; 2.** indicates a very significant difference compared with [before smelling], P<0.05*

Table 2. Statistical table of psychological and emotional scale (comparison before and after the sniff cream's scent)

Emotion Scale	Variance analysis N=31		
	Time point	Results	Parameter

	Before	After	Change rate	Variance analysis (vs. Before)	
BMIS-Negative/Relaxation	7.84±0.32	6.77±0.27	-13.65%	Significant differences	Value reduction indicates an increase in relaxation
CPSS-14 Stress Perception	25.19±1.36	21.42±1.48	-14.97%	Significant differences	Value reduction indicates a decrease in the perceived stress emotion
Stress VAS score	3.42±1.63	2.03±1.20	-40.64%	Significant differences	Value reduction indicates a decrease in stress levels

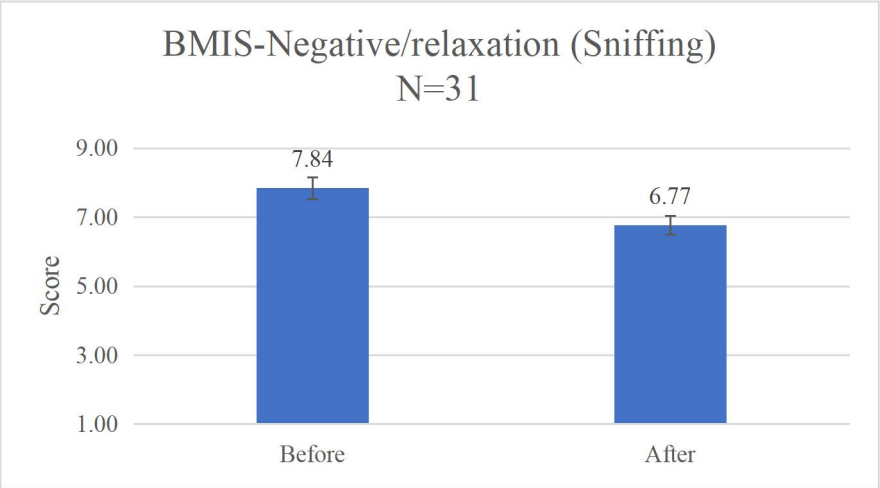

Figure 3. BMIS - negative/relaxation histogram before and after sniffing cream sample.

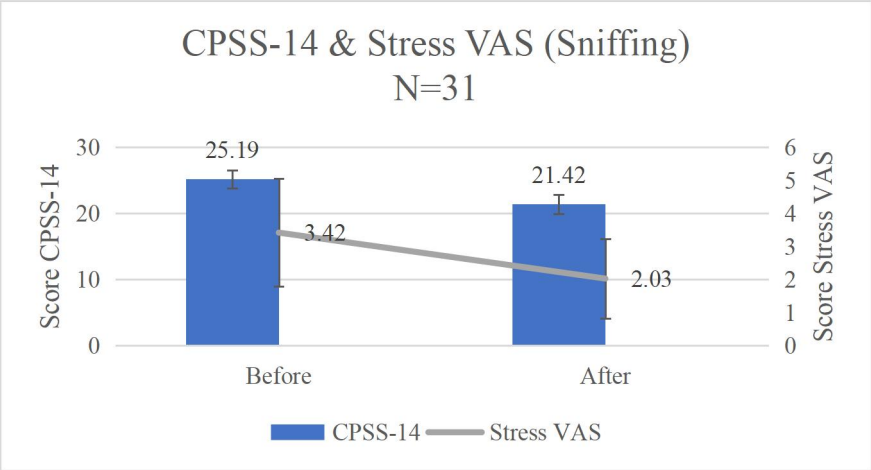

Figure 4. CPSS-14 and stress VAS score data before and after sniffing cream sample.

3.2 Data results on the emotional impact of cream from the self-massage test

Table 3. Statistical table of psychological and emotional scale (comparison before and after self-massage cream test)

Emotion Scale	Variance analysis N=31				
	Time point		Results		Parameter description
	Before	After	Change rate	Variance analysis (vs. Before)	
BMIS-Negative/Relaxation	7.84±0.32	6.81±0.23	-13.14%	Significant differences	Value reduction indicates an increase in relaxation
CPSS-14 Stress Perception	25.19±1.36	20.87±1.72	-17.15%	Significant differences	Value reduction indicates a decrease in the perceived stress emotion
Stress VAS score	3.42±1.63	1.94±1.67	-43.27%	Significant differences	Value reduction indicates a decrease in stress levels

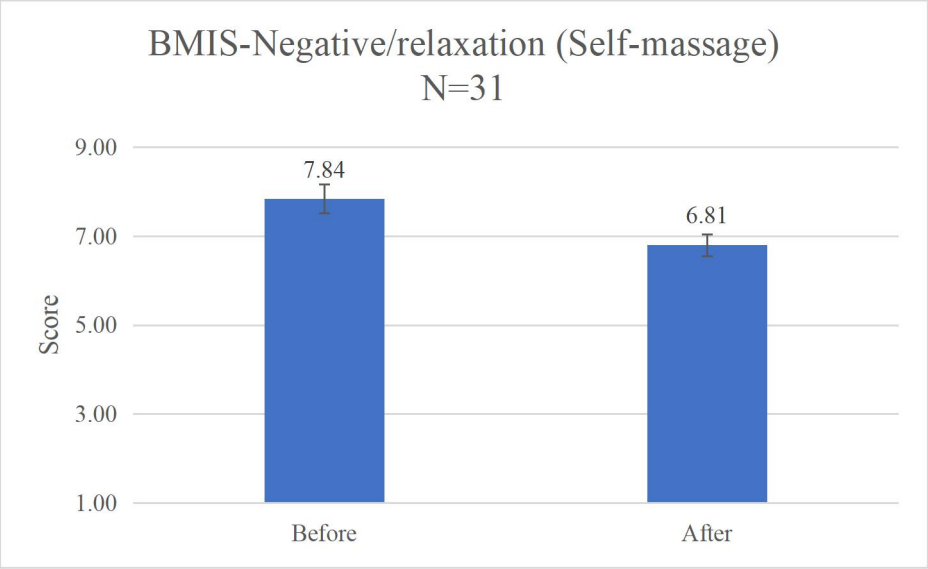

Figure 5. BMIS - negative/relaxation histogram before and after self-massage cream.

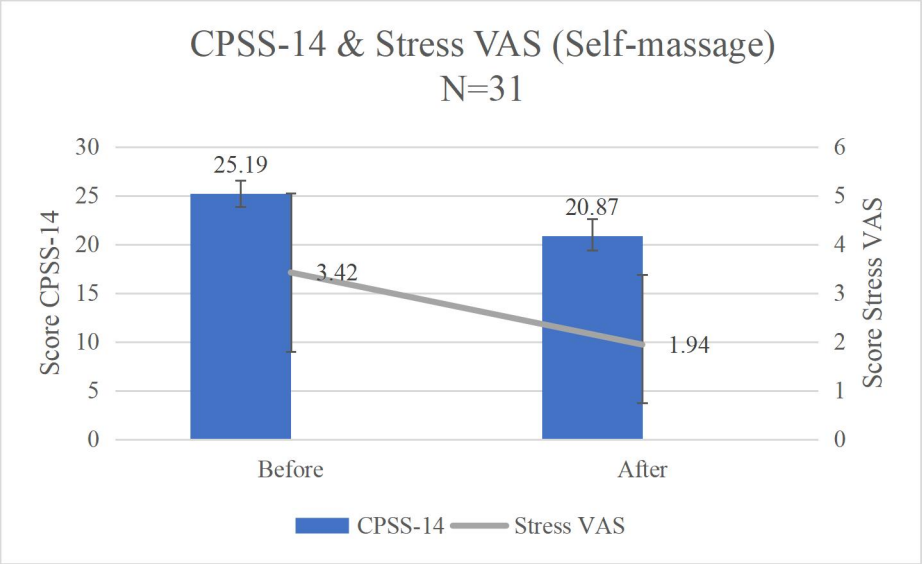

Figure 6. CPSS-14 and stress VAS scores before and after self-massage cream.

Table 4. AI facial recognition statistics (comparison before and after self-massage cream)

Evaluation points	Variance analysis N=31				
	Time point		Results		Parameter description
	Before	After	Change rate	Variance analysis (vs. Before)	
Happiness	0.0789±0.1329	0.1130±0.0582	43.16%	Significant differences	An increase in the value indicates heightened happiness
Arouse	-0.2972±0.2658	-0.3639±0.2581	-22.42%	Significant differences	An decrease in the value indicates heightened calmness
Valence	-0.1381±0.2456	-0.0847±0.1792	38.66%	Significant differences	An increase in the value indicates elevated positive emotions and reduced negative ones

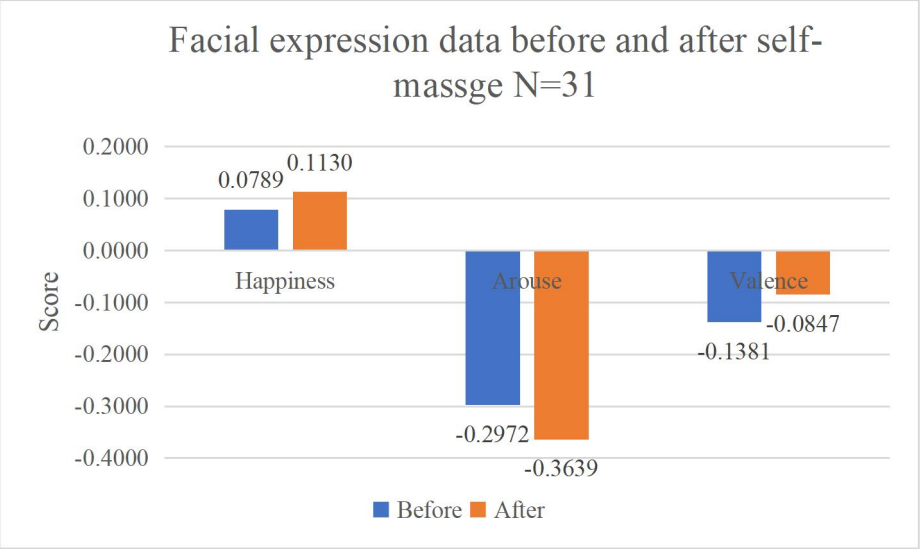

Figure 7. Histogram of AI facial expression recognition data before and after self-massage cream.

Note: Valence refers to the degree of pleasantness, ranging from unpleasant to pleasant, the higher the effective value, the higher the degree of pleasantness; Arousal is an indicator of physiological activation, ranging from calm to excited, i.e., the lower the arousal value, the higher the calmness. [11]

3.3 Long-term mood monitoring results: well-being questionnaire results

- Under normal daily use scenarios, they applied the test product (Cream) to their entire faces continuously for 28 days. After 28 days of use, the following results were obtained through the subjects' self - evaluation questionnaires:
- All subjects reported that the cream brought feelings of pleasure, comfort, happiness, relaxation, and vitality after use.
- Consumers' self - assessments showed that after 28 days of use, the sense of comfort and pleasure increased by more than 34%, and the sense of happiness increased by 37.9%.
- 100% of the subjects agreed that the cream gave the impression of being "natural", "comfortable", "gentle", "non - irritating", "elegant", "warm", and "nourishing".

The scores derived from the well - being questionnaire were analyzed using ANOVA (Analysis of Variance) tests. The results are shown in Table 5.

Table 5. Well-being Score Test result (N=34)

Well-being Score	Initial value	D1 vs. Initial value	D14 vs. Initial value	D14 vs. D1	D28 vs. Initial value	D28 vs. D1	D28 vs. D14
		change	change	change	change	change	change
Pleasure	3.62	0.32*	0.85*	0.53*	1.29*	0.97*	0.44*
Comfort	3.65	0.29*	0.85*	0.56*	1.26*	0.97*	0.41*

Happiness	3.56	0.35*	0.88*	0.53*	1.35*	1.00*	0.47*
Relaxation	3.71	0.23*	0.82*	0.59*	1.23*	1.00*	0.41*
Vitality	3.59	0.35*	0.94*	0.59*	1.32*	0.97*	0.38*

**indicates* $P<0.05$

4. Discussion

This study aimed to comprehensively evaluate the emotional improvement effects of a skincare product through a multimodal assessment framework, integrating neurophysiological, behavioral, and psychometric measures. The findings have yielded several significant insights.

In terms of the olfactory stimulation and EEG monitoring phase, although the power values of most EEG bands (θ, α, β) showed no significant differences after sniffing the cream, the change in the δ band indicated a potential improvement in the relaxed state. Additionally, the psychological and emotional scale results demonstrated significant reductions in stress - related scores (BMIS - Negative/Relaxation, CPSS - 14 Stress Perception, Stress VAS score), suggesting that the cream's scent had a positive impact on reducing stress and enhancing relaxation.

During the self - massage test, both the psychological and emotional scale analysis and the AI facial recognition statistics showed remarkable results. The stress - related scores decreased significantly, and positive emotional indicators such as happiness and valence increased, while the arouse value decreased, indicating a heightened sense of calmness. This indicates that the process of applying and massaging the cream on the face effectively enhanced positive emotions and reduced negative ones.

The home - use test results further confirmed the long - term positive effects of the product. After 28 days of continuous use, all subjects reported experiencing pleasure, comfort, happiness, relaxation, and vitality. Self - assessments showed significant increases in the senses of comfort, pleasure, and happiness. Moreover, 100% of the subjects agreed on the positive attributes of the cream, such as being "natural", "comfortable", etc.

The ANOVA analysis of the well - being questionnaire scores also revealed significant increases in pleasure, comfort, happiness, relaxation, and vitality scores over time, especially when compared to the initial values at different time points (D1, D14, D28).

5. Conclusion

In conclusion, this multimodal assessment framework has provided comprehensive evidence that the skincare product under study not only has a positive impact on the physiological aspects of the skin but also significantly enhances the emotional well - being of users. It successfully addresses the current consumer demand for products that offer both dermatological and psychological benefits. Future research could further explore the underlying mechanisms of these emotional effects and continue to optimize skincare products to better meet the needs of consumers in the context of the brain - skin axis.

6. Reference

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