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Brain's Role in Beauty: The Connection Between Stress, Inflammation, Emotional Well-Being

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1. Introduction

The key to healthy aging may reside in the mind. Increasing evidence from recent research shows that chronic stress influences the body through interconnected pathways involving inflammation and emotional and mental health. [1][2].

The stress-inflammation-mind axis: Stressors, whether physiological, environmental, or psychological, trigger a feedback loop in which the hypothalamic-pituitary-adrenal (HPA) axis releases glucocorticoids (GCs) that promote the expression of pro-inflammatory factors. These factors, in turn, stimulate the HPA axis and communicate with the brain, inducing structural and functional changes that affect neurotransmission, neuroendocrine activity, and emotional regulation, ultimately impacting psychological well-being.[3] This axis is bidirectional, as negative emotions act as stressors, and consequently, brain activity—including thoughts and feelings—contributes to stress and inflammation, and vice versa.

These insights provide a new perspective for promoting longevity and healthy aging. There is a growing body of research focusing on accessible, straightforward strategies aimed at modulating this stress-inflammation-mind axis. These predominantly involve lifestyle [4][5] choices such as:

- Healthy diet: For example, the Mediterranean diet, avoiding inflammatory and processed foods (refined carbohydrates, trans fats); even small dietary changes can lead to significant improvements.[6]
- Regular physical activity: in short periods throughout the day (15 minutes of moderate to vigorous intensity) or by dedicating specific times each week; the key is to start moving more.[7]
- Elimination of toxic habits: Quitting smoking and reducing alcohol consumption.[8][9]
- Stress and emotional management: Employing tools like meditation, breathwork, mindfulness, journaling to identify and challenge negative thoughts, and maintaining a calm reflective state.[10]

- Adequate sleep: 7-9 hours, with routines that promote quality rest (limiting screen time before bed, exercise, relaxation techniques).[11]

A holistic approach combining even small, consistent changes can yield substantial benefits. Implementing two or three lifestyle modifications can reduce disease risk by approximately 37%, and up to 60% when covering four or more domains.[12]

Despite the extensive evidence on lifestyle's impact on health, adoption remains challenging because awareness alone often does not sustain behavior change.[13] To address this, it is essential to leverage additional motivational systems—such as reward mechanisms—that reinforce positive behaviors. A compelling example of this influence has been demonstrated in studies examining warning labels on tobacco products. Traditionally, such labels have focused on conveying serious health risks; however, these messages often fail to significantly impact smokers' behavior. Conversely, exposure to aesthetic images—such as photographs depicting dental staining caused by smoking—has shown to be more memorable, with 75% of smokers recalling these images and perceiving them as more effective deterrents.[14] Motivation driven by the desire to maintain a positive appearance appears to be more potent than health-related motivations, given its greater tangibility and immediacy.

Hypothesis: The premise of this study is that aesthetic and beauty rituals may serve as strong motivational tools to promote positive lifestyle changes, thereby impacting health, longevity, and overall well-being. At the intersection of beauty and emotional health, cosmetics can act as tools for personal empowerment.

This research aims to evaluate how a biohacking beauty routine can facilitate lifestyle modifications that counteract damage caused by the stress-inflammation-brain axis. Two *in vivo* clinical trials monitored key markers associated with optimal health. To evaluate the impact of the intervention, various markers related to physical and mental health—particularly those associated with the stress-inflammation-mind axis—were monitored.

- Physiological markers included cortisol, the primary glucocorticoid (GC) marker of stress, which plays a central role in regulating biological, metabolic, and immune processes.[15] Interleukin-8 (IL-8/CXCL8), a broad-spectrum pro-inflammatory cytokine stimulated by oxidative and psychosocial stressors, was also assessed given its role in psychoneuroimmunological pathways and its prolonged activity.[16][17]. Glycated proteins, such as hemoglobin A1c and other advanced glycation end-products (AGE), served as key biomarkers of long-term glycemic stress. Elevated levels of these proteins are strongly associated with chronic stress and impaired glucose metabolism.[18] Additionally, 8-hydroxy-2'-deoxyguanosine (8-OHdG), a marker of accumulated oxidative DNA damage, was measured to identify cellular exposure to toxins, aging processes, and environmental insults—thus serving as an indicator of the organism's exposure to harmful conditions.[19]
- Psychological assessments included measures of physical self-perception—evaluating satisfaction with facial and body appearance—and self-esteem, both closely linked.[20] Self-esteem, one of the components of subjective well-being, is part of the self-concept and refers to the subjective evaluation of oneself.[21] High self-esteem is associated with happiness, confidence, and a positive and optimistic attitude towards life.[22] Psychological well-being was defined through a multidimensional six-factor model that encompasses autonomy, personal growth, environmental mastery, purpose in life, positive relationships with others, and self-acceptance. Within this framework, self-concept—comprising an

individual's perception of themselves and their self-image, and associated with stability and mental resilience—plays a particularly significant role.[23]

- Neuromarkers include brain measures such as frontal alpha asymmetry (8–12Hz), which indicates the difference in brain activity between the left and right frontal regions; the Frontal Asymmetry (FA) index reflects differences in power between electrodes placed over each hemisphere, mapping superficial brain activity.[24][25][26] An emotional map is also generated, based on scores related to disgust and joy, as well as emotional responses categorized as “exciting and happy,” “calm and serene,” “distressed and tense,” and “lethargic and sad.” [27] Heat maps of eye fixation are used to establish associations with sensations experienced during exposure to visual stimuli.[28]

2. Materials and Methods

Participants: Healthy women aged 40–64, without significant health issues or ongoing pharmacological/hormonal treatments, not pregnant or breastfeeding. Cosmetic products supplied by the study sponsor were used for ritual practices.

2.1. Mid-term evaluation of the lifestyle biohacking intervention.

A clinical study involving 20 participants divided into a control group and a biohacking intervention group. Baseline measurements were taken, and outcomes compared after 30 days. Inclusion criteria: BMI <30, without any significant foreseeable changes in their lives during the study. The control group maintained their usual lifestyle; the biohacking group underwent a two-phase intervention to implement healthy routines:

- Phase 1: Educational immersion retreat: A 4-day program at a hotel & spa along the Mediterranean shoreline, focusing on aligning mind and body through expert guidance on healthy eating (Mediterranean diet), physical activity (walking, strength training, aerobic exercises), toxin elimination, sleep hygiene, stress and emotion regulation (breathwork, meditation, yoga, sound therapy). It also involved therapeutic spa treatments (balneotherapy, thermal contrasts, facial and body massages) and the conscious application of cosmetics with a positive mental discourse. Participants were encouraged to practice self-acceptance, focusing on the present moment and sensations such as smell, texture, and other sensory experiences.
- Phase 2: Daily rituals: Over 26 days, participants used supplied cosmetic products with mindful application, integrating selected lifestyle commitments. Participants kept diaries to monitor progress and obstacles.

Parameters analyzed. Weight and BMI: Omron BF511 Family Body Composition Monitor. Blood plasma biomarkers: Reagents used included water (Braun), PBS (Gibco), human IL-8 ELISA kit (Abcam), OxiSelect Advanced Glycation End Product (AGE) assay kit (Bionova), and TCA (Sigma). Blood samples were collected at baseline (time 0, before treatment) and after 30 days. Samples were centrifuged at 1,000 g for 10 minutes to extract plasma. Levels of 8-OHdG and cortisol: Blood plasma proteins were precipitated by adding 10% TCA and incubating for a minimum of 2 hours at 4°C. The samples were then centrifuged at 10,000 g for 15 minutes, and the supernatant was used to quantify cortisol and 8-OHdG levels via HPLC-MS. Levels of IL-8: Plasma IL-8 concentrations were determined using a human-specific ELISA kit. Glycated proteins concentration: it was quantified using a specific AGE assay kit. Psychological markers: Physical self-perception was assessed with a scale based on the Body

Self-Esteem Scale (EAC) [29], selecting items related to body attractiveness and emotional aspects. Participants self-rated their satisfaction with each item on a Likert scale from 1 (very dissatisfied) to 10 (very satisfied). Self-esteem was evaluated with the Rosenberg scale, consisting of 10 items scored from 1 (strongly agree) to 4 (strongly disagree).[30] Psychological well-being was measured using the Ryff Scale, comprising 39 items answered on a Likert-type scale from 1 (strongly disagree) to 6 (strongly agree).[31] The subscales included Self-Acceptance, Positive Relationships, Autonomy, Environmental Mastery, Purpose in Life and Personal Growth. Sleep parameters: Participants wore various smartwatches (Samsung Active, Amazfit, Apple Watch, Fitbit, Garmin, Gtouch, Redmi Watch 2, TOZO-S2, Xiaomi Smart Band 8). Sleep data—hours of sleep, duration of deep sleep, and light sleep—were recorded. Participants also rated their sleep quality upon waking using a sleep score ranging from 0 to 10.

2.2. Immediate assessment of the cerebral (neurological and emotional) effects of a conscious cosmetic routine.

The parameters were evaluated before, during, and after a single application of the ritual, in which participants were instructed in the following steps: 1) "Discover your word"—a phase of connecting with inner emotions—where volunteers selected one word from ten options[32]; 2) conscious alternate breathing, inhaling and exhaling alternately through each nostril for 5 cycles; and 3) application of the product using a self-massage routine designed to invite sensations and foster a connection between the body and mind.[33]

Parameters analyzed. Neuromarkers: The EEG device (actiCHamp, Brain Products GmbH, Germany) was used, and subjects wore the helmet throughout the entire process—baseline (before application), during product application, and post-application (for approximately 5 minutes. Brain frontal alpha asymmetry (8–12 Hz). The Frontal Asymmetry (FA) index, as well as Theta (4–7 Hz) and Alpha (8–12 Hz) power bands, were used to map surface cortical activity. Emotional mapping was performed using a combined biosensor system with the advanced facial and eye tracking system (AFETS®), powered by IMOTIONS®, which enabled multiple evaluations, including eye movement tracking (Tobii TX2 and HTC VIVE Pro Eye headsets, Stockholm, Sweden) and galvanic skin response (GSR) measurement (Shimmer SH3+, Dublin, Ireland). Participants were instructed to follow the ritual and reflect on their feelings while being filmed and recorded; facial expressions were analyzed during this period. Additionally, two sets of images served as visual stimuli for eye-tracking evaluation. Each set consisted of four images—one directly related to the expected mental attributes (such as nature and mindfulness, positive self-human interaction), and three randomly chosen from a library of concept images. Participants were asked to focus on the image that most evoked sensations related to the application, and heat maps of eye fixation were generated to analyze visual focus and emotional responses.

Statistical analysis. Plasma Blood Biomarkers: Data were analyzed using paired t-tests. Statistical significance was set at $p < 0.05$ with a 95% confidence level. Psychological biomarkers: Data were tested for normality using the Shapiro-Wilk method. Variables with a positive normality test result (parametric variables) were analyzed with paired t-tests. Variables with a non-normal distribution (nonparametric variables) were analyzed using the paired Wilcoxon signed-rank test. Emotional assessment: Statistical comparisons were performed using the Wilcoxon signed-rank test (a nonparametric test) and the General Linear Model (GLM). The significance level was set at 95%. Significance levels are indicated as $*p < 0.05$, $**p < 0.01$, and $***p < 0.001$. Values marked as *ns* indicate non-significant results, and *na* indicates not applicable.

3. Results

3.1. Mid-term evaluation of the lifestyle biohacking intervention.

Throughout the study, there were no significant differences in weight and BMI between the control and treatment groups. Similarly, levels of 8-OHdH (<0.1) and sleep markers remained stable until the end of the study. Sleep markers included a total of approximately 7 hours, with 3.5–4 hours of light sleep and 2.5–3 hours of deep sleep, with a rest quality rating of 7 out of 10. The results obtained for the analyzed parameters are shown in Table 1.

Table 1. Mean differences in parameters measured entre el día 0 y 30.

Parameter	Treatment mean \pm SEM (%)	Control mean \pm SEM (%)	Treatment vs. control differences
Cortisol	-43.5 \pm 18.4*	Not affected	na
IL-8	+233 \pm 68**	+1021 \pm 156***	na
AGE-BSA	Not affected	+36.5 \pm 15.2*	na
Physical self-perception ¹	19.2 \pm 2.8***	7.6 \pm 1.1*	11.6 *
Self-esteem	11.4 \pm 2.2 (p0,055)	2.3 \pm 3.2 ns	9.1 ns
Psychological well-being:			
Self-acceptance	10.4 \pm 2.2**	4.1 \pm 2.2	6.3 ns
Autonomy	10.5 \pm 4.3*	9.5 \pm 3.1*	1.0 ns
Mastery of environment	7.0 \pm 3.7 ns	4.0 \pm 2.6 ns	3.0 ns
Life purpose	4.3 \pm 2.7 ns	9.4 \pm 3.7 ns	-5.1*
Positive relationships	8.0 \pm 4.6 ns	6.5 \pm 3.7 ns	1.5 **
Personal growth	-4.3 \pm 3.8 ***	- 0.7 \pm 2.7 ns	-3.6***

¹ The most relevant improvements were observed in items related to feeling more attractive, sexy, sensual, and erotic.

3.2. Immediate assessment of the cerebral (neurological & emotional) effects of a conscious cosmetic routine.

GSR & Facial Expression Analysis. Results are shown in Table 2.

Table 2. Valence percentage, GSR values and emotional states of the subjects throughout the ritual.

	After card reading	During Product application	After product application
Valence %	2,728	8,978	- 7,290
GSR value	7,239	25,630	-33,181
Emotional state	Happy	Excited	Calm

Heat Maps Eye tracking. Results are shown in Table 3.

Table 3. Percentage of time spent fixating on the target image compared to the alternative images.

Evocation of sensations	Target image (%)	Alternative images (%)
Meditation & Nature	63.3*	9,63/9,77/ 2,57
Positive self-interactions, relaxation and joy.	43.3 ns ²	20.78/19.17/ 11.70

² Although not statistically significant, the alternative random images were not significantly different, and in all cases, fixation times remained below 50% of the target image.

Frontal alpha asymmetry. Results are shown in Table 4. A pleasant product induces a positive score—indicating that alpha waves in the left hemisphere are less activated than in the right—particularly during the application phase, which can be associated with an excited emotional state during this period.

Table 4. The emergence of motivational aspects during the ritual phases, expressed as positive values relative to baseline, with positive values indicating a tendency toward liking.

Respiration	Card reading	Application	Think phase
+0.011182	-0.0695	+0.063909	-0.0045

Mapping of the superficial brain. An increased activation was observed in both the frontal area and the rest of the brain for alpha and theta and alpha waves (see Figure 1). During product application and the subsequent thinking phase, there was increased activation in the frontal area, particularly in theta waves.

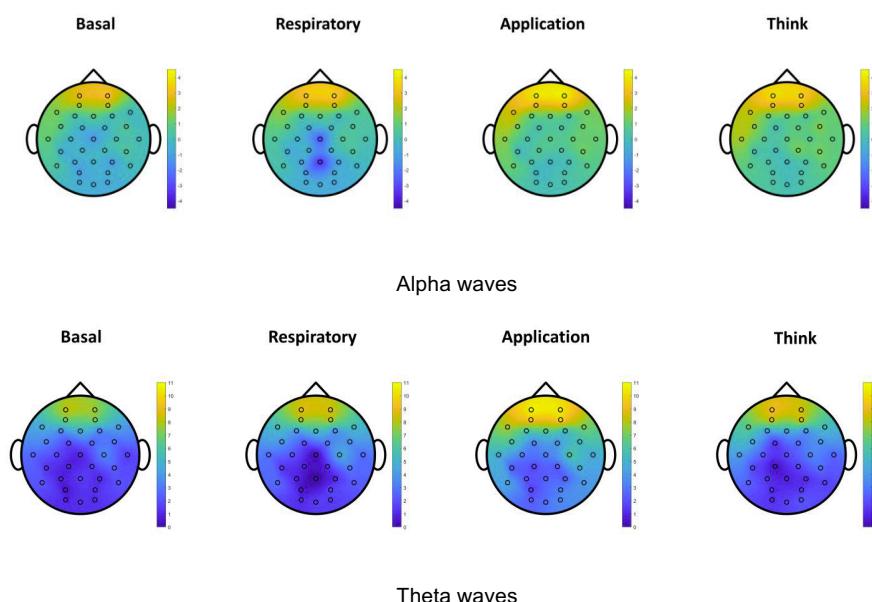


Figure 1. Distribution of theta (scale 0-11) and alpha (scale 0-4) waves across the brain.

Discussion

The biohacking study demonstrated that an intervention rooted in education and training, involving the daily practice of a conscious cosmetic ritual as a motivational tool for promoting positive change, effectively integrated healthy modifications into participants' daily routines. These improvements were observed across psychological, biological, and mental markers. The findings are particularly noteworthy, as they were obtained from healthy volunteers with a good baseline level of physical and mental well-being.

In the control group, there was a 36.5% increase in glycated proteins, and a highly unexpected 1021% increase in IL-8 levels, which could not be explained, as this group did not alter their lifestyles, and cortisol and 8-OHdG levels remained stable. Conversely, in the *biohacking* group, IL-8 levels also increased but to a much lesser extent, representing an 85% protective effect. Regarding glycation, protection was 100% against the increase observed in the control

group, and cortisol levels were significantly reduced by 43.5%, suggesting that the intervention enhanced stress and emotional regulation, which could partly explain the observed protective effect. This aligns with IL-8's role as a psychoneuroimmunological mediator, with its reduction likely attributed to emotional regulation.¹⁷ Given its capacity to remain active over prolonged periods, IL-8 is particularly relevant and its sustained activation can potentiate tissue damage.

Psychologically, the volunteers' baseline scores on the assessed scales ranged from mid- to high-range (64–77%). In the *biohacking* group, a significant improvement was observed in self-perception relative to baseline and control (+253%). Although no statistically significant change was observed in self-esteem—likely due to initially high scores—a trend toward improvement was noted, surpassing the control group. Regarding psychological well-being, the *biohacking* group showed significant gains compared to baseline in the dimension of self-acceptance (+10.4%), consistent with the improvements observed in self-perception and the tendency toward increased self-esteem, which are aligned with a conscious process of self-connection promoted by the intervention. These results are especially relevant for a population group within an age range that includes menopausal phases, characterized by an accelerated manifestation of aging signs, which pose challenges to self-confidence.^[34] Other dimensions of psychological well-being, including environmental mastery, purpose in life, and positive relationships, did not exhibit statistically significant changes relative to baseline, which aligns with the fact that these domains were not specifically addressed within the scope of the intervention. Interestingly, in the *biohacking* group, the parameter of personal growth showed a significant reduction compared to baseline and the control group. A deeper analysis revealed that this decrease was most prominent in responses to items such as "I don't want to try new ways of doing things; my life is fine as it is" and "When I think about it, I haven't improved much as a person over the years," suggesting a more profound reflection on areas for improvement and the potential for personal growth within this group.

Throughout the application ritual, emotional states transitioned from positive affective conditions such as happiness to heightened arousal and, subsequently, to a state of calmness, indicating an enhancement in perceived well-being. Eye-tracking metrics revealed that both stimulus sets effectively elicited strong associations with sensations related to nature and mindfulness practices, as well as with indicators of self-care, including positive self-interactions, relaxation, and joy. Brain wave maps indicated increased activation of alpha and theta waves both in the frontal area and across other regions, corroborating the induction of a relaxation and meditation state (theta) and of calm, creativity, and concentration (alpha), especially during and following product application. These changes can be correlated with a more excited and aroused state during the application phase, and a more meditative and relaxed behavior during the thinking phase. Product application induced a positive frontal alpha asymmetry during the respiratory and application phases, which correlates with an emotionally pleasant experience. This pattern aligns with increased neural activity associated with relaxation and overall well-being. Conversely, during the card reading and reflection phases, the engagement of cognitive and intellectual processes explains the observed negative asymmetry values.

The observed correlation between product application and activation of positive emotional responses reinforces its potential to become a self-care ritual that transcends mere aesthetics. It is demonstrated at the cerebral level that the product and its application can activate brain states associated with Mental Beauty.³³ The sense of touch and smell, mediated by the skin and olfactory pathways, serve as direct communication channels to the brain and, consequently, influence emotional and physical well-being. Applying cosmetic products through mindful massages and positive messaging activates positive responses in the brain.

Additionally, if the ritual includes conscious breathing and emotional connection, it enhances the beneficial influence on overall well-being.

5. Conclusion

This study emphasizes the importance of integrating emotional well-being with skin care within a holistic concept of beauty. The results demonstrate that mindful self-care practices, combined with emotional regulation and sensory rituals, have the potential to transform the perception and experience of cosmetics—promoting not only improvements in external appearance but also the strengthening of emotional and psychological health. The application of products through mindful massage techniques, coupled with positive messages, induces neurophysiological responses associated with relaxation and well-being, as well as activating brain states linked to *Mental Beauty*. These rituals, which create pleasurable experiences, act as vehicles for lifestyle improvement and thus establish optimal conditions for healthy aging and longevity. By caring for appearance, this approach influences both physiology and mental health, addressing the interconnected axes of the inflammation-stress-mind system to support healthy aging.

The evolution of the concept of beauty from superficial standards to a tool for personal empowerment and emotional well-being reinforces the idea that conscious, meaningful self-care practices serve as vehicles for comprehensive transformation. Cosmetics are thus positioned not only as enhancers of external aesthetics but also as facilitators of self-esteem and emotional resilience, enriching life experiences and fostering greater self-awareness.

Finally, this research underscores the vital relationship between emotional health and physical beauty, paving the way for innovative strategies in modern cosmetics. Future research should aim to expand these findings to larger and more diverse populations, including men, individuals from different cultural backgrounds, and groups with increased vulnerability. Additionally, it is essential to investigate the long-term effects; evaluating these interventions over extended periods will be critical to establishing their efficacy as holistic strategies for promoting longevity. This includes the development and optimization of intervention protocols to maximize their sustained benefits across diverse populations.

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