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"Neuroscience & Machine Learning - Artificial Intelligence at the service of a revolution in the evaluation of the consumer experience"

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1. Introduction

In an era defined by personalization and emotional experience, consumer experience has emerged as a decisive factor in the success of beauty and wellness products. Traditional evaluation methods—surveys, interviews, and focus groups—often rely heavily on subjective data and can be limited in scope, cultural adaptability, and real-time applicability. As global consumer bases diversify, there is an increasing need for tools that deliver objective, scalable, and emotionally intelligent insights across countries, cultures and product usage contexts.

Deciphering consumer insights is a delicate task, as we know the limits of declarative methods and our difficulty in explicitly verbalizing our emotions and the origin of our choices. Emotions are complex to measure, which requires deciphering multimodal manifestations [1]:

- Experiencing: neurophysiological responses (brain activity, cardiac activity, electrodermal activity)

- Expressing: behavioral responses (voice emotion, facial expression, eyetracking, gesture, inspiration)

- Evaluating: verbal responses (semantic speech analysis, scales, questionnaires…)

Each measure gives valuable but partial information. Evaluating and understanding the consumer experience requires combining all measures through a multimodal evaluation, with the ultimate goal of assessing the emotional impact of products and services.

This paper introduces a pioneering software-as-a-service (SaaS) platform designed to revolutionize the way beauty and wellness brands evaluate consumer experiences. By merging the fields of neuroscience, artificial intelligence, and digital innovation, this platform not only enhances data collection but fundamentally redefines how we interpret consumer emotional engagement and satisfaction.

2. Materials and Methods

2.1 Solution Architecture

The SaaS platform is composed of five core modules which can be implemented separately according to customer needs, or all together in order to carry out end-to-end studies (Fig. 1).

- **Automated Study Management**

A unique and ergonomic 360° solution to centralize all study actions and manage international studies in a simple and efficient way.
End-to-end automation of panel recruitment, communication, data capture, and reporting through a centralized dashboard.
In a few clicks, the study set-up is carried out according to the study protocol, inclusion criteria and scientific objectives. In an automated way, a recruitment campaign is launched and qualifies the panelists who meet the criteria. They are automatically accompanied to sign their consent, and access their panelist space in a 100% digital and automated way.

- **Conversational AI Avatar**

Capable of conducting interviews in 27 languages, the avatar uses natural language processing and real-time emotional recognition to engage participants in a natural and unbiased dialogue.
The conversational avatar allows both a unique, fluid and engaging panelist experience in the real context of product use, but above all to guarantee an unbiased collection of quality data. By asking questions in a neutral and identical way in all countries, the avatar guarantees control of the drivers and ensures that the emotions detected in an ecological environment are indeed provoked by the product experience monitored in real time.

- **AI-Multimodal Emotion Measurement**

Captures explicit responses (spontaneous speech, scales, questionnaires, i.e., evaluating component) and implicit signals (facial expressions, voice modulation, posture, gesture, respiration, and heart rate, i.e., expressing component) via standard device cameras and microphones. The recording of these hybrid data is carried out in real time during the discovery and application of the cosmetic product, under real use conditions -in a store, in real-life, at-home...).

- **Biocaptors data processing**

The platform also integrates automated signal collection and analysis (EEG, ECG, GSR, i.e., experiencing component).

- **Digital Product Interaction Interface**

Participants access the platform by scanning a QR code on the product packaging, triggering a digital AI-guided interview accessible via smartphone, tablet, or computer.
Client access the dashboard to visualize individual data (audio & video recording of panelists with real-time measurement of each metric) and consolidated data (hybrid group metrics) in a rigorous and transparent way.

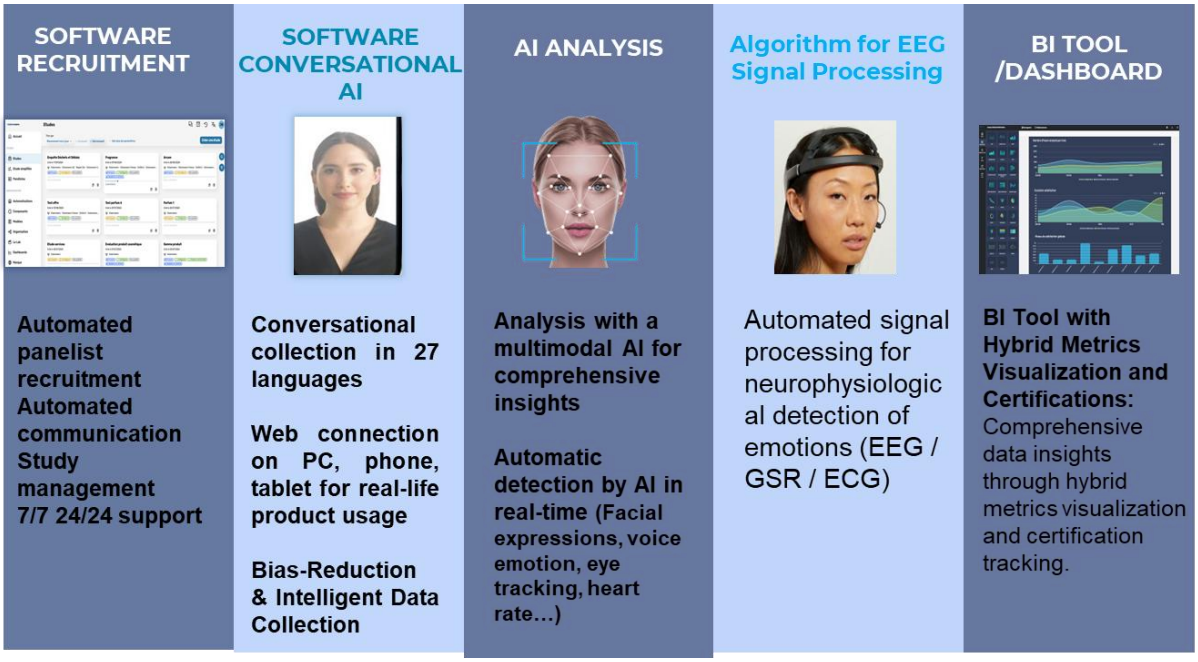

Figure 1. Solution Architecture. SaaS platform composed of 5 core modules, available in white label and integration via API on client tools.

2.2 Data Analysis

To holistically evaluate the panelists' reactions to the cosmetic product, the solution relies on multimodal analysis combining several dimensions in real-time analysis:

- Experiencing: analysis of neurophysiological responses combining cerebral activity (EEG), cardiac activity (ECG) and skin conductance (GSR)
- Expressing: analysis of behavioral responses combining semantics, facial expressions, voice analysis, gesture, and physiological measures such as heart rate and breathing.
- Evaluating: analysis of verbal responses and choices on scale and questionnaires

This method extracts rich and varied data, revealing not only the conscious emotions of the panelists but also their unconscious emotional and physiological reactions.

Here’s how each modality is integrated into the analysis process:

Electroencephalography (EEG)

Objective: Understand the emotional impact with a direct real-time central measure of brain activity [2]

Individual calibration: using images (12 images from affective standardized image set) to individually determine the neural correlates associated with valence and arousal axis.

Signal pre-processing: filtering 4-44Hz, artifact removal (ICA), epoch segmentation [-1000 / + 3000ms], Baseline |-1000 / 0 ms]. Electrods referenced to Cz and grounded to Fz. Analysis [0 / + 2000ms]

Signal processing: Electrodes of interest frontotemporal areas - Fast Fourier Transform (FFT) for time-frequency analysis defined as theta band (4-8 Hz), alpha band (8-13 Hz), beta band (13-30 Hz), and gamma band (36-44 Hz). Linear regression to individually determine and quantify valence and arousal.

Data interpretation: Normalized data with min max transformation for Valence and Arousal [3].

Electrocardiogram (ECG)

Objective: Understand the emotional impact with a peripherical measure of cardiac activity [4]

Heart rate variability (HRV): heartbeat detection, R peak detection, inter-beat interval measures, standard deviation of RR interval, ratio LF/HF (low frequency power / high frequency power). Measured during the entire product presentation.

Data interpretation: Normalized data with min max transformation.

Galvanic Skin Response (GSR)

Objective: Understand the emotional impact with a peripherical measure of skin conductance [5]

Arousal detection: response peaks detection, rise time detection, creation of time slice. Based on latency min and max parameters [500 - 3000ms] and a minimum amplitude threshold (0,05µS).

Data interpretation: Number of arousal when smelling the fragrance. Intensity of the emotional responses (high above 2/3 of max amplitude - medium from 1/3 to 2/3 of max amplitude - low emotion below 1/3 of max amplitude)

Semantic and Sentiment Analysis (Conversational AI)

Objective: Understand the emotional valence and opinions expressed through the words used by the panelists during exchanges with the AI avatar [6, 7].
The conversational AI uses natural language processing (NLP) techniques to analyze the word choice, key phrases, and speech structure of panelists as they describe their feelings about the cosmetic product or experience. The AI identifies terms that reveal preferences, dissatisfactions, or relevant decision criteria. For instance, words like "comfortable," "pleasant," or "boring" are categorized to evaluate the perceived strengths and weaknesses of the product.
Then, the analysis relies on text sentiment to evaluate the polarity of the sentiments expressed by the panelists in their responses: positive, neutral, or negative. Each verbal response is analyzed to measure the general attitude toward evaluated aspects of the product.
Finally, by analyzing emotional keywords used in conversations (e.g., "enthusiasm," "frustration," "disappointment"), the AI can deduce which explicit emotions predominate when panelists experience or apply the product.

Voice Analysis (Tone and Pitch)
Objective: Analyze the panelists' vocal characteristics to detect unconscious emotional cues such as enthusiasm, frustration, or indifference [8, 9].
The conversational AI analyzes the tone of the panelists' voices (positive, neutral, negative) and their speech rhythm (speeding up or slowing down) to infer emotional reactions. Advanced vocal analysis tools measure voice modulations (intensity, pitch variation) to identify mood or sentiment changes throughout the conversation.

Gesture Analysis (Body Tracking)
Body tracking monitors panelists' posture and gestures (crossing arms, leaning forward, etc.) to deduce their engagement or disengagement during the cosmetic experience [10].

Facial expressions (Face Tracking)
Cameras can detect facial micro-expressions (subtle smiles, frowns) that reveal instant emotional reactions to specific criteria of the product. This helps measure immediate, often unconscious, emotional reactions to specific elements like texture, ease of application. Measures are based on Facial Coding System Analysis [11].

Physiological Measurements (Heart Rate and Breathing)
A specific machine-learning algorithm was trained to track the panelists' heart rate variations with the camera [12]. Respiratory rate is also measured to detect emotional changes [13].

Multimodal Data Integration
Data are combined from all sources (voice, eye movements, gestures, heart rate, breathing) to obtain a comprehensive and objective view of the panelists' reactions. The data collected from voice, gestures, and physiological measurements are combined to identify correlations between verbal and physical responses.

The results are aggregated and analyzed using statistical and machine learning tools to provide both qualitative insights and quantifiable metrics of emotional engagement and satisfaction.

Results Visualization:
Visual dashboards are generated to represent hybrid measures combining the different modalities. This helps us understand where the impactful areas of the sleeping mask are—those that trigger the strongest emotional reactions while where the paint points need improvements.

3. Results

This innovative SaaS solution has been developed to offer a global groundbreaking, multimodal objective evaluation of products and services by combining validated neuroscience data with artificial intelligence.

The solution's benefits are multifaceted:

1. Deliver a unique and immersive consumer experience worldwide: Enhance brand image through personalized interviews conducted in 27 languages by an AI-powered conversational avatar ensuring a reproducible and unbiased data collection (96% of satisfaction of panelists using the solution).
2. Monitor real-life product usage: Provide a fully digital experience allowing consumers to scan a QR code on the product and share their real-time impressions within the context of actual use simply on a smartphone, computer, or tablet.
3. Improve productivity, efficiency, and cost-effectiveness (60% reduction in study time and costs): Assist with an automated global SaaS solution that manages every step (automated panelist recruitment, personalized consumer communication, real-time insight collection and analysis, scientific rigorous reporting). Merge qualitative / quantitative studies and conduct international studies directly in participants' homes with a single, ubiquitous tool.
4. Measure the emotional impact of products: Leverage simple video data capture and real-time multimodal measurements that combine explicit feedback (oral responses, questionnaires, scales) with implicit metrics (real-time emotional measurements such as voice tone, facial expressions, posture, gestures, eye tracking, respiration, and heart rate) to reveal more than 70 emotions (from primary and secondary emotions of Plutchik wheel to complex unprecedented sentiment).
5. Obtain augmented insights through a validated mathematical model of emotional data: Benefit from a proprietary mathematical model based on 5-years research to ensure the objective identification of the real-time emotions through multimodal evaluation with rigorous data statistics validation and innovative scientific-based machine learning algorithms.
6. Identify avenues for improvement: Use a predictive impact AI-tool to forecast potential product enhancements to maximize emotional impact. The emotional modeling engine successfully identified key product attributes (texture, scent, packaging aesthetics) that correlated strongly with positive emotional responses. These insights guided reformulation and redesign strategies, which, when implemented, showed improved consumer response in follow-up tests.

The solution offers a holistic, AI-powered, neuroscience-driven platform that:

- Ubiquity and centralized solution: Supports product development, marketing, quality assurance, and consumer engagement.
- Augmented multi-modal studies: Bridges the gap between brand expectations and real consumer emotions across geographies.

- Ecologic real usage testing: Operates seamlessly through a digital-first interface using smartphones, computers, or tablets.

The solution's applications are multiple (Fig.2):

- Study: Product testing & validation

Objective: Provides objective, neuroscience-backed insights to guide product formulation and positioning.

- Consumer experience: In-Market monitoring

Objective: Enables brands to adapt quickly to consumer feedback across different markets and cultures.

- Quality / Vigilance: Consumer support

Objective: Enhances consumer satisfaction and product safety by resolving issues promptly and consistently.

- Benchmark: Strategic insights

Objective: Helps refine or reformulate products for stronger market positioning and emotional connection with users with competitive analysis and R&D optimization based on emotions.

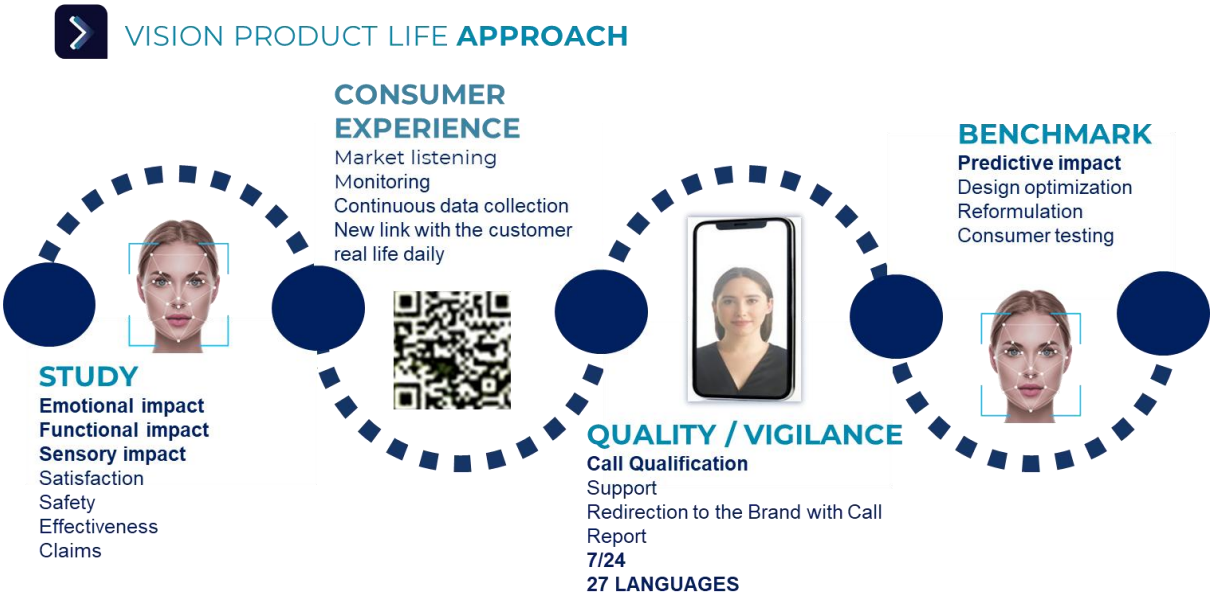

Figure 2. Solution Application. Proprietary AI-innovation is based on both data collection and analysis, making multiple and tailor-made applications possible.

4. Discussion

This new approach transcends the limits of conventional consumer research methods. The integration of neuroscience principles into AI-powered tools allows for a more holistic understanding of the user's interaction with beauty and wellness products. Importantly, it captures subconscious emotional responses often missed in standard evaluations. By combining multimodal measures (experiencing, expressing & evaluating component of emotion), this solution studies emotions in real time in a rigorous, powerful and completely new way.

Key advantages include:

- Scalability and Cultural Sensitivity: With multilingual capabilities and context-based design, the solution operates seamlessly across geographies.
- Objectivity and Reproducibility: Multimodal, real-time data minimizes bias, increasing the reliability of insights.
- Actionable Insights: The proprietary emotional model translates complex data into clear, strategic guidance for product development, marketing, and customer experience teams.

This solution represents a significant step forward in embedding emotional intelligence into the product evaluation process, ultimately promoting better alignment between consumer needs and product design.

5. Conclusion

By combining artificial intelligence, validated neuroscience methods, and real-world usability, this SaaS platform presents a transformative approach to understanding and enhancing the consumer experience in the beauty and wellness industries. It allows companies to not only gather data but to deeply understand the emotional journey of their users, thus fostering more authentic connections and more impactful innovations.

As the market evolves toward experience-driven value, such tools will become indispensable in designing the next generation of beauty and wellness solutions grounded in well-being and emotional resonance.

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