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Towards a Protocol for Preference Evaluation of Cosmetic Products Using Physiological Sensors

Javier Miranda-Mellado
Equipe de Recherche des Processus
Innovatifs (ERPI-ENSGSI)
Université de Lorraine
Nancy, France
javier.miranda.m@usach.cl

Juliana Serna
Equipe de Recherche des Processus
Innovatifs (ERPI-ENSGSI)
Université de Lorraine
Nancy, France
juliana.serna-rodas@univ-lorraine.fr

Giovanny Arbelaez-Garces
Equipe de Recherche des Processus
Innovatifs (ERPI-ENSGSI)
Université de Lorraine
Nancy, France
arbelaez5@univ-lorraine.fr

Javier A. Arrieta-Escobar
Laboratoire Réactions et Génie des
Procédés (CNRS-LRGP-ENSIC)
Université de Lorraine
Nancy, France
javier-andres.arrieta-escobar@univ-lorraine.fr

Véronique SADTLER
Laboratoire Réactions et Génie des
Procédés (CNRS-LRGP-ENSIC)
Université de Lorraine
Nancy, France
veronique.sadtler@univ-lorraine.fr

Mathieu Kacha
Centre Européen de Recherche en
Économie Financière et Gestion des
Entreprises, (CERFIGE)
Université de Lorraine
Nancy, France
mathieu.kacha@univ-lorraine.fr

Abstract— The evaluation of consumer preferences is a fundamental aspect for cosmetic products development and marketing. Consumer preferences are the result of sensory, emotional, and cognitive responses to products. They have been traditionally studied with sensorial evaluation methods which are time-consuming and are based only on the explicit responses of users and trained panels. Recently, with the evolution of the technology of physiological sensors, they have emerged as possible tools to study customer preferences from their physiological and non-conscious reactions. However, there is currently no standard protocol or application guide explaining how to use them for the evaluation of customer preferences for cosmetic products. In response to the above, this article presents the main factors to propose such a protocol. We present the steps, the decisions to be made, the criteria and some application guide for the selection of the appropriate evaluation methods and statistical analysis according to the goal of the consumer preferences study. A protocol is proposed and tested for a case study: the evaluation of consumer preferences over two cosmetic creams with different textures. As conclusions, physiological sensors give complementary information to surveys about the preferences of customers, because they enable to follow in real time their physiological reactions to the product. However, not all physiological sensors are equally applicable, and individual analysis of each signal may be inconclusive. It is recommended to study sensor signals and survey results in an integrated manner, overall considering that preferences are the result of a systemic complex process (sensory, physiological, emotional, conscious).

Keywords— *preference, cosmetic products, physiological measurements, sensorial evaluation, protocol, application guide*

I. INTRODUCTION

The evaluation of consumer preferences has been a fundamental element in the development and marketing of cosmetic products, whose success deeply depends on the sensations they produce in addition to their functionality [1]. For this reason, product sensorial properties have been traditionally study through sensorial evaluation methods, such as discriminating or descriptive [2]. These methods are supported by the scientific discipline of sensory evaluation [3] and have defined protocols explaining the appropriate way to be implemented. They explain how to carry out the selection and training of evaluation panels, the selection of evaluated samples, vocabulary definition (when the method is verbal) experimentation space, experimental design, and

statistical analysis, among others. Moreover, there are standards norms that can be considered when applying a sensorial analysis [4], [5], and some of them are specific for cosmetic products [6]. Notwithstanding the above, sensory analyses in its traditional form have some disadvantages: It is usually carried out by experts in the field [7], or trained panels involving a lot of time and resources.

In addition, preferences are not only the result of a cognitive reflection, but also of a sensorial, and unconscious process. Pensé-Lhéritier describes the interaction of consumers with products as follow: “First, the consumers perceive the characteristics of the product, that is color, perfume and texture, through their sensory system. This information is then integrated so that the consumers, through this physiological process, can identify a symbolical value or feel a positive emotion” [2]. Thus, the establishment of preferences goes beyond cognitive-logical process [8] and its deep analysis requires multidisciplinary research approaches [9]. In this context, the application of neuro physiological sensors for understanding consumers’ preferences is a tool that would allow to obtain data coming from customers’ body responses in the presence of stimuli. These technologies provide complementary information that can enrich the evaluation of product sensorial properties and its effects on user preferences [10].

As an example of the above, several researchers have begun to explore neural and physiological sensors to evaluate preferences in the cosmetic sector [8], [11], [12]. These studies are still exploratory and there are not protocols or application guide explaining procedural decisions. An example of this is that the above-mentioned publications, all of which are applied in the cosmetic sector, use different sensors, experimental procedures, and experimental designs. While it is true that they evaluate different stimuli ([8] and [11] explore a visual stimulus, [12] studies an olfactory stimulus), they do not explicitly explain their different procedural decisions. As a result, their experimental procedures cannot be generalized. Moreover, the treatment of the data differs from one publication to another, which makes it difficult to compare their results. This happens because the application of neurophysiological sensors for the evaluation of consumer products (and thus of cosmetic products) is a

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field in development, and standards and protocols that enable repeatable, comparable, and reliable measurements are still to be proposed.

In view of the above, this study presents the main procedural decisions and factors to be considered to propose an evaluation protocol of cosmetic products using physiological sensors. The article is organized as follow: The second section presents a literature review on publications using physiological sensors to evaluate cosmetic products. Main procedural steps, captors, experimental design practices and data analysis techniques are identified. The third section analyzes in detail the information gathered in the literature review and presents the criteria and application guide for the preparation of a protocol to evaluate cosmetic products with physiological sensors. The fourth section presents a case study where the protocol is applied for the evaluation of two cosmetic creams with different rheological behaviors. Finally, conclusions and remarks are presented in section five.

II. LITERATURE REVIEW: USE OF PHYSIOLOGICAL SENSORS FOR THE EVALUATION OF COSMETICS PRODUCTS

According to [13], consumer neuroscience tools can be classified in three categories: behavioral, physiological and neurophysiological. Behavioral tools record a person's activities and how they perform tasks. They comprise reaction time (RT), observation and surveys. Physiological sensors measure the biological response to physical stimuli or activities. They comprise tools such as Electrocardiogram (ECG), Eye tracking (ET), Facial Expression recognition (fERS) and Galvanic Skin Response (GSR). Neurophysiological tools measure brain activity. Examples of them are Electroencephalography (EEG) and Functional Magnetic Resonance Imaging (fMRI). This study focuses on physiological sensors because they are frequently used in quantitative studies of product evaluation [14]. Behavioral sensors are mainly used for ergonomic studies, while neurophysiological sensors have not been widely explored for product testing, because their conditions of use are difficult due to their high sensitivity to any event that occurs around the person.

Publications addressing the use of common physiological sensors [13] to evaluate cosmetic products were searched in the Scopus data base. Common physiological sensors are briefly summarized in Table 1. We searched publications analyzing cosmetic products, i.e., skin care products and hair care products, in the last 10 years. The search equation is presented below:

Search equation:

("behavioral analysis" OR "skin conductance response" OR "consumer neuroscience" OR "Eye Tracker" OR "Electrocardiogram" OR "Facial expression recognition" OR "Galvanic skin response" OR "electrodermal activity") AND ("cosmetic product" OR "skin care product" OR "hair care product") AND PUBYEAR>2010

Based on the search equation, 24 publications were initially identified. After abstract reading, 6 publications were selected for a deep analysis. Other publications were screened out because they were focused on medical applications or just mentioned but did not use physiological sensors. Table 2

shows the analyzed publications, highlighting products, applied stimuli (visual, olfactory, or tactile), physiological sensors, procedural steps, statistical analysis methods and conclusions.

TABLE I. PHYSIOLOGICAL CAPTORS COMMONLY USED IN CONSUMER RESEARCH [13]

Instrument	Acronym	Physiological measurement	Applications
Electrocardiogram	ECG	Electrical activity of the heart	Study of heart rate variations
Galvanic Skin Response / Electrodermal Activity	GSR	Electrical activity of the skin	Study of dermal conductivity under stress and excitation.
EyeTracking	ET	Position and movement of the eyes	Study of visual behaviors such as gaze, fixation, pupil size, attention.
Facial Expression Recognition / Facial electromyography	fERS	Facial muscle movements	Study of facial expression and emotional reactions.

It is to highlight that the primary application of physiological information in these studies is to complement the information gathered from self-report surveys and behavioral studies. None of the analyzed publications used only physiological information to develop inferences about consumer decisions.

III. THE PROTOCOL

Figure 1 presents the procedural steps of the protocol for the evaluation of cosmetic products using sensors. Part of the protocol is based on standards for sensorial analysis, mainly from iso norm 6658:2017[17] and application guide AFNOR GAV09-027[18], the latter being specific for cosmetics. The portion of the protocol that deals with the implementation of sensors is mainly based on the articles presented in Table 2 and a recent review in neuroscience tools [13].

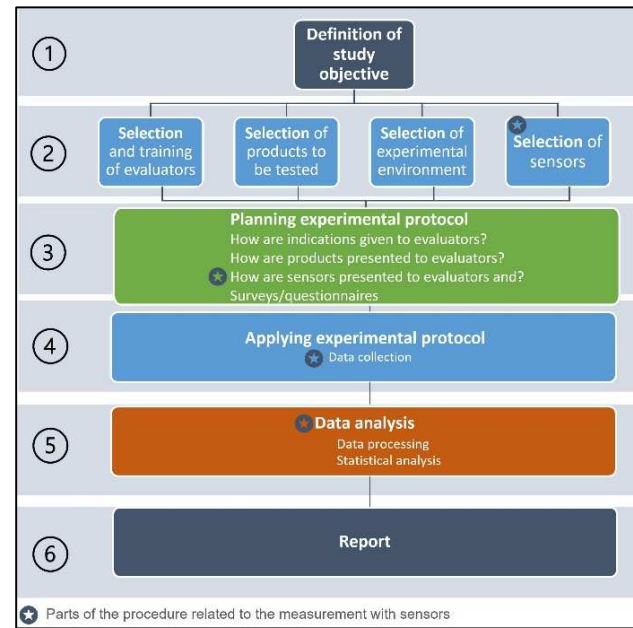


Fig. 1 Steps of the protocol

A. Step 1: Objective of the study

The first step is the clear establishment of the objective of the study. Norm ISO 6658 [17] describes 2 types of objectives:

Those related to categorization, ranking and description of the product(s): Studies can be descriptive, for example when the objective is the generation of the sensorial profile of a product or a group of products. The norm ISO 13299:2016 [19] presents in detail descriptive methods.

Those related to the comparison between products: These studies are also called discrimination tests. They are used when the objective is to compare a product with a standard or with another product. It is possible to compare two or more products, one sensorial property in two different products, multiple sensorial properties in two or multiple products. It is also possible to test the change of customer preferences with time. Resources and expected minimal precision should also be defined [19].

TABLE II. PUBLICATIONS USING PHYSIOLOGICAL SENSORS TO EXPLORE CONSUMER PREFERENCES IN RELATION TO COSMETIC PRODUCTS

Ref Year	Product	Stimuli	Evaluation/ sensor	Procedure steps	Tests	Statistical analysis	Conclusions
[11] 2021	Three facial creams	visual (images of package price, and product attributes)	ET, fERS, self-report survey	1)Product selection 2)Participants selection 3)Environment selection 4)Experimental procedure 5)Statistical analysis	a) Survey: Think aloud protocol (when trying the cream). b) Study with sensors: (only an image - visual stimulus).	1) ANOVA. 2) Post hoc. Test	Showing only the prices creates more negative emotions than seeing product information about its attributes.
[15] 2021	Cream with essential oil (and placebo)	visual, olfactory, tactile (daily use of cream for 1 month).	ECG, neuroendocrine parameters (cortisol), behavior observation, self-report survey (psychosocial stress tes),	1)Product selection. 2)Selection of participants 3)Training of participants 4)Experimental procedure 5)Statistical analysis.	a) Survey: psychometric assessment (before trying the cream) b) Study with sensors: when testing the cream in day 1. Participants used the cream for 29 days, two times each day. Measures were repeated the last day.	1) One-way ANOVA (to compare placebo and product) 2) Two-way ANOVA for repeated measures (to compare changes after 29 days)	Cosmetic creams enriched with essential oils should be considered as a stress resilience fostering strategy due to its favorable physiological, neuroendocrine and psychological effects.
[12] 2020	Shampoo and Serum with a fragrance (and control samples)	visual, olfactory, tactile (product and control sample are tested).	ECG, GSR, non-verbal behavior recording, mental test (Reaction and strength test)	1)Product selection. 2)Selection of participants 3)Selection of the environment. 4)Logistic organization, 5)Experimental procedure 6)Statistical analysis.	a) Study with sensors: (control and sample application), b) Experimental test (after product application)	GLM analysis of variance, Fisher's LSD post-hoc	Physiological responses were more useful in demonstrating the relaxing effects of the product than the simple oral or written response of the user
[14] 2020	Advertisement channels for three cosmetic products	visual	GSR, non-verbal behavior recording	1)Selection of participants 2)Advertisement and channels Selection 3)Experimental procedure 4)Modeling business rules	Selection of preferred channel for availing product	Mean probable response for rule model construction	A business rule model was constructed based on physiological and behavioral data
[16] 2016	Two high-quality serums	visual, olfactory, tactile (products are applied to the face)	Non-verbal behavior recording (facial and body movements), self-report survey, sensory analysis with trained panel	1)Product selection 2)Selection of participants 3)Selection of the environment 4)Logistic organization 5)Experimental design 6)Tests application 7)Statistical analysis	a)Recording: Application of both products in random order with a week of difference b) Survey: liking c) Analysis using The Observer(R) software	ANOVA, Cochran's Q tests, post hoc tests for behavior analysis and sensory analysis	Using behavioral analysis made it possible to discriminate two equally top-quality products in terms of the level of appreciation and feelings they elicited.

B. Step 1: Selection of the sample(s), the panel, the environment, the sensors

Sample(s): Samples may be prototypes, final products, products from the market, among others. Prototypes can be tested for design decisions while final products may be tested before market launch. For sample(s) selection, in addition of the goal of the study, the following aspects should be considered: availability of the samples, variability of the samples (it is necessary to determine whether the samples are the same, similar, or very different, in order to establish the hypothesis to be tested), form and quantity of the samples, form to provide samples to the evaluators. The priority is to avoid bias. The application guide AFNOR GAV09-027 gives

specific application guide for cosmetic product samples and about safety requirements to test them [18].

Panel: Panels can be of three types: naïve, trained, expert. Their selection depends on the objective and resources of the project. Expert evaluators give answers with lower deviation, but they required a previous training. The norm ISO 8586 [20] gives specific application guide for selection and training of evaluators. Naïve panels are made up of customers or potential customers. They give responses with larger deviations. In the latter case, more evaluators should be invited (Application guide GAV09-027 advises about the panel size for cosmetic products [18]). The use of sensors is interesting with costumers, because the sensors allow to evaluate their spontaneous responses.

Environment: According to norm ISO 6658, test spaces should be selected to be comfortable, and free from distractions and interferences. The application guide GAV09-027 advises to create spaces similar to those normally used during cosmetic application (bathrooms, cosmetic salons) [18].

Sensor(s): Table 1 presents the most common physiological sensors. Aspects to consider for their selection are ease of use, comfort during use, temporal resolution, cost, possibility of using it with other sensor(s) [13]. A key aspect is the body's response to stimuli and the sensitiveness of the measuring instrument. For example, the GSR measures the electrical activity of the skin which is a very sensitive responses of the body to a stimulus. It can assess the impact of any emotional arousal given by real physical objects, videos, images, sounds, smells, foods, and other sensory stimuli, as well as reflexive experiences and mental images [21]. On the other hand, physiological measurements of temperature, respiratory rate, and heart rate do not show drastic changes in response to stimuli, but rather a slow change under certain conditions such as long-term physical activity or an event that largely surprises the user. For this reason, these types of sensors have been used primarily in studies of long term effects of products, such as the relaxing effects of a lotion [12].

C. Step 3 and 4: Experimental procedure – planning and application

In this part all the activities to be carried out must be planned in detail. This includes the reception of the evaluators, the indications given to them, the preparation of the sensors and samples, the presentation of the samples, the order of presentation, indications of how and where to apply the samples. The experimental protocol should be planned to achieve the objectives, to avoid bias and to have the expected data for the application of a statistical analysis as planned. Samples should be named three with random numbers and the order of sample presentation should be balanced. For cosmetics, the area of application on the skin must also be indicated (application guide GAV09-027[18]). The way the samples are presented, the way they are used and the number of times they are presented depend on the type of test being performed and the expected statistical analysis. Repetitions are highly recommended to have reliable results. For example, in discrimination tests, same samples may be shown more than once in different arrangements (ISO norms 5495[22], 4120[23], 10399[24] show this in detail).

D. Step 5: Data analysis

Data treatment: This is especially important when sensors are used, because the data collected are usually large. They should be treated to reduce noise and they should be normalized to compare responses between different users. Data treatment depends on the sensor and the nature of data collected. This article focuses on data processing from the sensor GSR. In this case, data were treated as explained in [25], [21]. More details are given in the case study section.

Data analysis and comparison: Methodologies for analyzing physiological data fall into two categories [25]. They are differentiated according to the type of stimulus, whether it is instantaneous or sustained over a time interval. Instantaneous stimuli are those of short duration, but which have a rapid impact on people's emotions (e.g., fear, surprise). By their part, enduring stimuli are maintained over time, also

generating enduring emotions (e.g., well-being, satisfaction, aversion). In our case, the test of a body cream is an enduring stimulus, where the application of the cream on the skin lasted for a while. There, the experimentation time is divided according to performed activities, and data are analyzed for each interval and each user. The analysis is focused on the interval during which the cream is applied (the stimulus is presented).

E. Step 6: Results and Report

The report of results should content all information that enable the reproduction of the test. According with Norm ISO 6658:2017, the report should contain at least: objective of the study, samples information, sample preparation, sample testing, test date and time, description of test environment, data recording method, evaluators profile, statistical methods, and results, contact of responsible.

IV. APPLICATION CASE: EVALUATION OF A TWO COSMETIC CREAMS WITH DIFFERENT TEXTURES

A. Step 1: Objective of the study – application case

This study aims to explore customer preferences based on sensorial characteristics of cosmetic creams. For this, a protocol for testing cosmetics using physiological sensors is applied. Most demanded categories of cosmetics are skin care and hair care products [26], in which the skin care segment has the highest sales and annual growth. In view of the above, this research proposes to study two body creams with different textures and compare customer reactions and responses. Body creams are commonly used products, and they are easy to test.

B. Step 2: Selection of samples, panel, the environment, and the sensors – application case

This study aims to explore customer preferences based on sensorial characteristics of cosmetic creams. For this, a protocol for testing cosmetics using physiological sensors is applied. Most demanded categories of cosmetics are skin care and hair care products [26], in which the skin care segment has the highest sales and annual growth. In view of the above, this research proposes to study two body creams with different textures and compare customer reactions and responses. Body creams are commonly used products, and they are easy to test.

Samples: For this research, we select to study the texture of the creams as a differentiation factor because along with the aroma, already explored in other articles [27][12], it is an fundamental characteristic in the creation of preferences. Moreover, texture and viscosity have received much attention in research on cosmetics formulation and design [28][29][30]. In view of the above, we tested two creams of the same brand with very different textures (a very thick and a light texture cream). Both creams are white and have mild fragrances. In this way, the study of textures was prioritized. After feeling cream textures, participants were also invited to observe and smell the creams to analyze the effect of these factors.

Panel: The experiments were carried out exclusively with women who do not have any problems or allergies related to the use of body cream and who do not have sensory difficulties in perceiving the color, smell or texture of the

products. The data collection campaign involved 27 female volunteers between the ages of 20 and 60. All participants gave written consent to participate in the experiment.

Environment: The tests were conducted in two sessions at two laboratories at a university in France. Same room conditions in terms of lighting and temperature were kept.

Sensors: The test of a body cream lasts about 5 minutes, and it does not generate a strong unexpected stimulus, but it creates tactile, visual, and olfactory stimuli. Considering this, the sensors used are: GSR due to its sensitivity to all types of stimuli. ECG because it has been used in similar research [27][12]. Eye tracking to obtain information about consumers' visual behavior and interest. Some evaluators wear reading glasses, and thus they could not use the eyetracking glasses. In these cases, only information from other sensors was considered.

C. Step 3 and 4: Experimental procedure - application case

Experimental design is based on the product testing format presented in [15] and [16]. The participants evaluate two cosmetic products presented in random order in individual transparent packages, without indication of brand or price.

At the beginning of the test, participants are instructed on the use of sensors and the test procedure. Sensors (shown in Figure 2) are given to participants, and they put them in place. The GSR sensor is fixed on two fingers of the non-dominant hand. The ECG is placed on the chest so that the sensor picks up the heartbeat. Participants with non-glasses are invited to use the eye tracking glasses. Sensors are used during the entire test.

At the beginning of the test, participants are invited to smell a container of coffee to eliminate the smell of other products. Afterwards, they fill a form with their general information (age, gender, preferences) to obtain their consumer profile. The period in which the person answers this form is used to define a baseline in sensors signals for the analysis of the physiological data.

Visual, olfactory, and tactile characteristics of the product were evaluated individually for each cream. Participants were indicated to focus on each sensory feature at a time as indicated in [31]. After each sensorial evaluation subtask, participants are asked to fill out a questionnaire with their preference, as explained below:

1. Visual inspection: participants observe the product, avoiding touching or smelling it. Then, they answer the appearance evaluation questions.
2. Smell: Participants smell the cream without touching it. Then, they answer the olfactory evaluation questions.
3. Application of the cream on the fingers: participants test the product between their fingers without applying on other body part. Then, they answer the questions of the tactile evaluation.
4. Application of the cream on the skin: participants test the product on the inside of the forearm. Then they answer the evaluation questions about the sensation after application.

After the application of each cream, participants answer a second questionnaire about cream attributes, its quality and their satisfaction with each product, indicating their agreement/disagreement on a scale of 1 to 7 (A sample of the questionnaire is presented in the annex of this article).

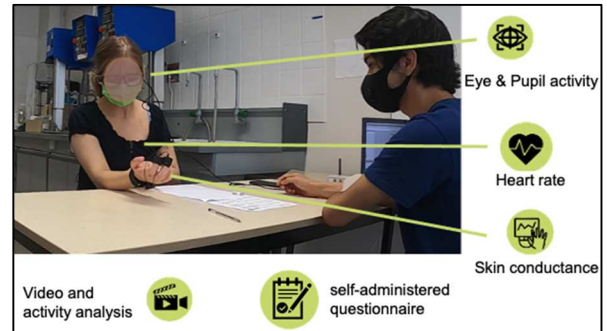


Fig. 2 Use of sensors during test

D. Data analysis - application case

Data treatment: Physiological data were recorded, filtered, and exported using Captiv software (TEA ergo, Nancy). Data were recorded at a rate of 32Hz. Each experiment was coded according to activities (instructions, first form, coffee sniffing, product test, product evaluation form) and according to the type of stimulus during the product test (visual, olfactory, finger touch, skin touch) (Figure 3).

Subsequently, data were filtered to reduce the instrumental error. For heart rate, a filter was performed based on the average heart rate of a person at rest, which is between 60 and 100 beats per minute. For the GSR, the line was smoothed to eliminate possible noise.

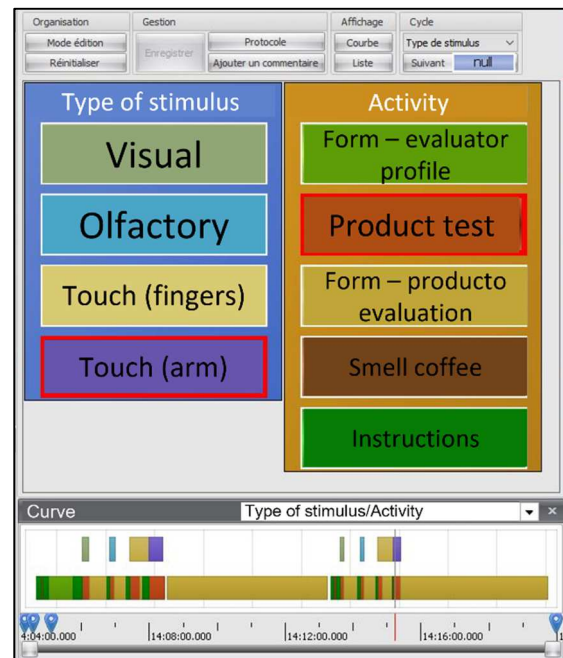


Fig. 3 Physiological data coding (Captiv)

Data analysis: For eyetracking glasses, the program CAPTIV-NEUROLAB was used. There, the videos of the vision of each person were coded in relation to what the person is looking at. For our study, only the time when the

person is looking at the creams is of interest. Thus, the fixation time of each point of interest is obtained.

For the data of ECG, the average heart rate was calculated by transforming the raw electrical signal into a BPM versus time curve using the Captiv program.

For the data of GSR, the GSR signal is divided into two components: the tonic phase and the phasic phase [25]. This is done with the program Ledalab. The continuous decomposition methodology was done as shown in [32]. The tonic phase (SCL) is the slower acting component of the signal (cumulative level, slow growth, slow decay). It shows the accumulative tendency of the signal. The phasic phase (SCR) corresponds to the rapidly changing components. It shows the instantaneous response of the body at specific times. Based on this, the comparison parameter used in this study is the total area of SCR during the presence of the stimulus. Nevertheless, as the duration of the cream test varies from person to person, it is standardized with respect to the duration of each test.

E. Results and Report – application case

Statistical results of evaluation questionnaires: To analyze the results of the responses to the questionnaires, a series of paired sample t-tests and a 2x2 mixed ANOVA test (one within-subject factor for product order and one within-subject factor for cream type) were performed. It was found that there is a significant difference in the perception of the texture of the creams (Table VI). The ANOVA shows that the results do not depend on the order in which the textures are presented.

TABLE III. T-TEST RESULTS (EVALUATION FORM)

Item	Average of responses and p-value		
	Light texture cream	Thick texture cream	P - value
Visually, I like this cream	6.07	5.11	0.00 ^a
Color in accordance with this cream	6.41	5.63	0.06
I like the texture	5.81	4.11	0.00 ^a
I like to apply this cream on my skin	5.59	4	0.03 ^a
Thick/Viscous Cream	3.19	6.22	0.00 ^a
Fatty cream	3.74	5.37	0.00 ^a
Nourishing cream	5.19	5.96	0.03 ^a
I like this cream	5.37	4.11	0.01 ^a
Quality cream	5.26	4.67	0.10
Use of the cream	5.30	4	0.01 ^a
Propensity to pay in euros	10,96	9.15	0.12

Answers with a significant difference (p-value < 0.05)

Physiological data: Two types of statistical tests were carried out: 1) a comparison of the average heart rate and the area of SCR during and after application of the two samples. 2) a correlation of physiological data with declarative responses. Additionally, 3) the data from eye tracking were qualitatively analyzed.

1. For the first statistical test, the normality of data was tested with a Shapiro Wilk test. It was found that results of the GSR, ECG data are not normal. Thus, a comparison between the results of the two creams was done using a non-parametric test, the Wilcoxon

test. Based on the results, no significant difference between the creams was found.

2. Secondly, a correlation test was performed between the data from each test phase and the preference scores corresponding to each sensory aspect (colour, smell, viscosity). The results showed that there was no correlation between the physiological data and the responses of the forms for a p-value lower than 0.01.
3. The eyetracking results showed that most users make a detailed and short observation of the cream just at the moment it is presented to them. During the test they focus on their skin when they apply the cream. Forms are the item they looked at the longest during the test, which makes sense because they must read and concentrate. No significant difference was found between the time that the evaluators observed each of the creams.

In this experiment, with the selected statistical methods, it was not possible to establish a discriminating relation using the physiological data. The difference was perceived with the data from the forms. Nevertheless, the use of sensors and the way to perform sensory testing of cosmetic products are still to be explored. Data treatment of sensors and statistical analysis of the data should be study in further detail to propose a complete and structured protocol for sensory analysis with neurophysiological sensors.

V. PERSPECTIVES AND CONCLUSIONS

This article proposes a complete protocol for sensory analysis using sensors. The protocol contains the stages of 1) study objective, 2) selection of panel, samples, experimental environment, sensors, 3) planning of the experimental protocol, 4) application of experimental protocol, 5) data analysis, 6) results and report. Key aspects to define the experimental stages are highlighted. The protocol is based on Iso norms for sensorial analysis and cosmetic sensorial analysis and on current publications in the use of neurophysiological sensors in the cosmetic sectors.

The protocol was applied in a case study comparing two cosmetic creams with different textures. Customers tested the creams on their skin and at the same time, they use three types of physiological sensors (GSR, ECG and eye tracking glasses). Physiological data and explicit information recollected through forms about their preferences were analyzed.

The results show that customers show a preference for a product according to the questionnaire responses, but this was not clearly seen in the data from single physiological parameters (e.g., GSR only, or heart rate only). Clear methods for the treatment and statistical analysis of data should be established in future research. This limitation has been pointed by other researchers [33]. Some of them have shown that the combination of sensors signals, for example in the General Additive Mixed Model (GAMM), can provide more information of the tendency of physiological reactions [34][33]. In Figure 4 we see an example of one GAMMs model (Fig. 4b) constructed for one of the participants of the study using both the signal of the heart rate and GSR (Fig 4a). The combined model shows that there are two moments during product use that generate a combined physiological

response. This type of data analysis needs to be further explored in future research.

Even though more research on the subject is required, this article shows the potential of using neurophysiological sensors for sensory product evaluation and for studying customer preferences in the cosmetic sector. The need of clear application guide and protocols for experimental planning and statistical analysis is clearly established. Neurophysiological sensors give much more information than that collected through the forms. Sensors give information in real time of what is happening in customer body after a stimulus, or a combination of stimuli is applied. They enable to follow and understand the complex process behind customer preferences generation, and to identify key product characteristics and design factors. Further work should be done for a clear data treatment and analysis to complete the protocol.

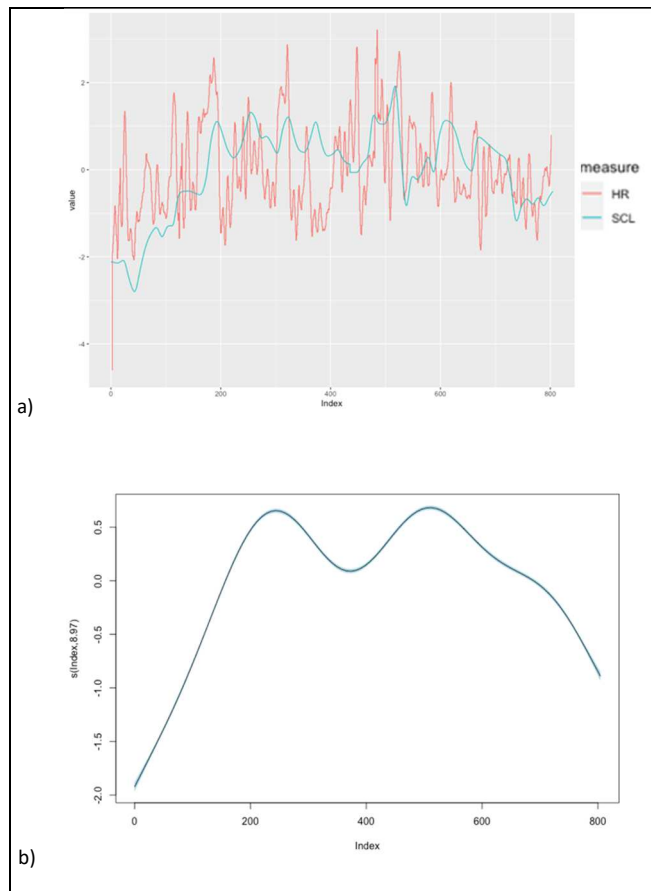


Fig. 4 Application of GAMM to the data the combined physiological data of one participant. a) red curve is the heart rate and blue curve is the SCL, b) GAMM of the signals heart rate and SCL.

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- ## ANNEX

PRODUCT EVALUATION

I. Visual inspection

II. Smelling

III. Before application

IV. After application

• • •

I like this cream	Disagree <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Strongly agree
This cream is of good quality	Disagree <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> <input type="radio"/> Strongly agree