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SKIN MEASUREMENTS: INSTRUMENTAL AND SENSORIAL STRATEGY IN THE EVALUATION OF COSMECEUTICALS AND AESTHETIC SURGERY PERFORMANCES

MERITVE KOŽNIH LASTNOSTI: TEHNI NE IN ZAZNAVNE METODE ZA VREDNOTENJE KOZMETI NIH PRIPRAVKOV TER POSEGOV V ESTETSKI KIRURGIJI

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Abstract

Background   *Nowadays, good health, beauty and fitness are perceived as qualities that are required for social acceptance and professional success. The cosmetic surgery industry is dynamic and growth levels reach record high. The technological advancements, especially in non-surgical procedures such as anti-aging techniques are developing with an astonishing speed. The demonstration of functionality with scientific measures becomes necessary and it is a right of the buyer as well as of the patient. To maintain high scientific standards in such evaluations, adequate protocols and statistical tests must be applied. In our review we describe some of the targeted skin conditions in anti-aging procedures, namely skin moisturization, elasticity, surface wrinkledness, skin thickness, evaluated with specific instruments. We are also able to follow the treatment of acne phenomenon as well as skin whitening, cellulite, stretch marks and hair loss by using special devices. Digital photography is a well established method for treatment evaluation; however the standardization of digital images is gaining importance.*

Conclusions   *Nevertheless, human perceptions enable the analysis of the sensory responses to specific stimulus in qualitative and quantitative ways. Such analysis can be as accurate and statistically significant as the instrumental analytical evaluations. We want to stress the increasing popularity of anti-aging techniques and the need for their evaluation. The family practice doctors as well as researchers in the field of anti-aging should benefit from this article.*

Key words   *skin measurements; evaluation; cosmeceuticals; aesthetic surgery; anti-aging*

Izvleček

Izhodiš a   *Zdravje, lepota, dobra telesna ohranjenost in urejenost so dandanes nujne tako za sprejem v družbo/družbeni razred kot tudi za poklicni uspeh. Kozmetična industrija je v porastu. Vedno večjo priljubljenost pridobivajo nekirurški oziroma minimalno invazivni posegi, najizraziteje v področju boja proti posledicam staranja. Z vedno novimi metodami pa se veča tudi potreba po objektivnem vrednotenju rezultatov. Dokaz/prikaz učinkovitosti določene tehnike/preparata je tako pravica kupca kot ne nazadnje tudi bolnika. Za ovrednotenje rezultatov določenega posega/preparata so potrebni posebni protokoli.*

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V našem prispevku bomo opisali metode za vrednotenje tarčnih kožnih lastnosti pri posegih v boju proti posledicam staranja kože (npr. kožna vlažnost, elastičnost, naguba-nost, površina itd.). Opisali bomo tudi postopke, ki vrednotijo uspeh pri zdravljenju aken, bledenju, celulitisu, strijah, plešavosti. Digitalna fotografija ima že dolgo časa mesto v sledenju zdravljenja. Predstavili bomo standardizacijo le-te.

Zaklju ki   *Človeški čuti, ki ne nazadnje nikoli ne odpovejo, so tako v kvantitativni in kvalitativni oceni kot tudi statistični značilnosti primerljivi z nekaterimi tehničnimi metodami. Glede na porast priljubljenosti kozmetične industrije in vedno večjega povpraševanja naj bi bil splošni zdravnik vsaj deloma seznanjen s posegi, ki so na tržišču, prav tako pa z njihovo učinkovitostjo.*

Ključne besede   *kožne lastnosti; vrednotenje rezultatov; kozmetični pripravki; estetska kirurgija; staranje*

Introduction

The concept of beauty has been continuously evolving through the history of mankind. Today, the importance of fitness and good health are increasingly perceived as qualities associated with youthfulness and beauty. The subliminal as well as overt message is that these are necessary and desirable requirements for social acceptance and professional success, often overemphasized by the media. On the other hand, people are living longer, and factors such as sedentary lifestyle and dietary excesses, associated with genetic determination, pregnancy and the aging process, contribute to alterations of the face and body that result in the loss of the individual's self-image.[1]

The cosmetic surgery industry is dynamic and growth levels reach record high; in 2006, the total UK cosmetic surgery was worth an estimated Ł 528.9 million, a rise of 47.4 % on 2005. Nowadays, the cosmetic surgery market is also being driven by the astonishing speed of technological advancements, particularly in non-surgical procedures. Recovery times are shorter and consumers can often be back at work shortly after fairly major procedures.

One of mankind's greatest problems is the lack of communication. The cornerstone of successful plastic surgery operation is the consultation. The probable and expected results should be described to the patient as accurately and completely as possible. Especially, it is of great importance to give a realistic advice to the patient who wants a minimally invasive procedure in order to cope with the process of natural and normal aging. In addition, a family medicine doctor should be aware of new evolving techniques and products as well as their evaluation. In the following, we present new methods for objective assessment of the anti-aging procedures. We think that also scientists in the field of anti-aging research may benefit from this article.

The demonstration of functionality of different methods and products is not just a mere requirement of the European Law. Indeed, it represents a key element of quality in the economic agreement between the manufacturer of the product and its buyer or we could say between the patient and the doctor. Moreover, evaluating the efficacy of any aesthetic treatment establishes clear parameters for the objective qualification and quantification of surgery performances. The need of scientific measures responds to the requests of all people involved in the demonstration of objective results in comparison to an initial picture.

The increasing development of biophysical non-invasive methods today allows to measure key physiological properties of the skin, like moisturization, barrier function, mechanical properties, micro-circulation, skin colour and even to characterize its topography. Skin maintenance, skin improvements, skin recovery can be evaluated during time, by registering all variations induced by a product application or by performing an aesthetic treatment. In order to maintain high scientific standards in such evaluations, adequate protocols and statistical test must be designed and applied.[2–4]

Frequently, efficacy assessments concerning cosmeceuticals and aesthetic surgery require the combined application of 1) a pool of instrumental methods, 2) together with the objective clinical evaluation performed by the expert physician and 3) refined sensory evaluations. The advantage of all such methods is in the lack of interference with the cutaneous site under examination.

Anti-aging techniques: a short introduction

The number of promising rejuvenation techniques is increasing and many times they are overemphasised by the media. The messages delivered by TV, newspapers, radio have a considerable impact on the people and widely (maybe too often) are regarded as truth.

Successful cosmetic results depend on critical analysis of patient selection, distinct knowledge of the specific method and their mode of action, technique and aesthetic performance.

The best way to approach facial rejuvenation in an elegant manner is to learn the anatomy of the face in detail, specially the deep midface components. Both dynamic and volumetric anatomical changes need to be thoroughly understood and addressed. Dynamic changes are modified with botulinum neurotoxin type A in glabella, forehead, crow's feet areas and peri-oral zone. Volumetric changes are another important

anatomical issue when discussing facial rejuvenation. Most often seen in the mid and lower face and neck, volumetric changes can be addressed surgically or nonsurgically, and can be related to one of two distinct diagnoses: 1) a desire for reshaping (in cases with adequate volume), where remodelling of the face is performed in order to produce a return to a more youthful, delicate visage; or 2) a desire for re-filling (in cases of soft tissue loss or inadequate volume or to fill wrinkles), for which injectable soft tissue augmentation agents such as dermal fillers or fat grafting can be used. While it is useful from academic perspective to look at dynamic versus volumetric changes, the trend currently is toward assessing the face as a whole and using combination therapy to provide each patient with the best possible outcomes.[5] Thus, using fillers in facial rejuvenation requires the insight in the specific aspects of aging as well as knowledge of the specific fillers and their injection technique.

Chemical peelings are based in the cutaneous application of chemical substances aiming at controlled skin layers destruction and a programmed renewal with therapeutic and/or cosmetic goals. Superficial peelings that reach only epidermal layer are indicated for pigmentary alteration. Medium deep peelings extending deep to the papillary dermis are chosen for patients with moderate findings of photoaging. Deep peels used to penetrate into mid-reticular dermis are indicated for severe photodamage with solar elastosis, deep wrinkles and pigmentary changes.[6]

Photodynamic therapy has become an integral part of laser and light source treatments in order to improve the clinical results of photorejuvenation. Resurfacing with CO_2 and Er:Yag ablative lasers are still popular and effective methods for treatment of lax skin, deeper rhytidies and photodamage. Furthermore, with some new systems it is possible to do fractional resurfacing and stimulation for remodelling (»smooth mode«).[7]

Radiofrequency (RF) electrical energy induces histological modification in the density and organization of dermal collagen network and in some way also changes the hypodermal fat.[8]

The »perfect« cocktail containing botox-like peptides, dimethylethanolamine or norcholine, hyaluronic acid, organic silicium, vitamines, trace elements, aminoacids, growth hormones and lipoic acid is designed to relax muscles, tense dermis, perform dermis refill, repair skin, stimulate metabolism, revitalize and protect the skin. Unfortunately, the perfect cocktail can not be contained in one vial; actually the perfect cocktail is still the cocktail the physician needs to make immediately before the treatment.[9]

There are several immune-enhancing nutritional supplements, intradermal fibroblast stimulation and fibrolifting[10] and many evolutionary methods of carboxytherapy (the micro injection of CO_2), mesotherapy (a treatment based on targeted micro-injections of medications directly to the site's pathology, introducing microscopic quantities of pharmaceutical agents into the skin) and kemiperoxy therapy (micro injections of active cocktail combined to a micro-

quantity of gas). The combination of active cocktails and carbon dioxide produces a synergy which through the hyper-oxygenating action of the gas leads to an optimization of the effects of the revitalizing and lipolytic products used.[11]

Commercially available are also new formulas for hydration of the dermis. This is a natural source of skin rejuvenation through its rehydration inspired by injection techniques from mesotherapy. This approach does not require using any active components as is usual in mesotherapy, but allows superficially damaged and dry skin to be rehydrated.[12] Simultaneously, the use of topical anti-oxidants are helpful in the control of the oxidative stress present in the skin.

Still in research trials is dermal rejuvenation and volumetric therapy utilizing autologous platelet rich plasma (A-PRP). It is a dermal injection technique that is utilized as an autologous alternative for dermal volumetric regeneration and rejuvenation versus synthetic dermal or hypodermal augmentation products.[13] Also, the reproduction of tissue from adult stem cells will make it possible to »repair« body tissue and restore organs to their natural function.

Most frequent measures and instruments

According to the popularity of anti-aging techniques it becomes obvious that the most commonly carried out evaluations concern the efficacy of anti-wrinkle treatments. Test protocols usually include skin moisturization, elasticity and surface wrinkledness measurements. To this basic group of parameters, the evaluation of more specific parameters may be added, like, for instance, skin thickness.

Skin hydration can be measured by Corneometer CM 825 (Courage & Khazaka) a device based on skin capacitance parameters. A non-invasive probe is applied to the skin for some seconds and the values of skin hydration are expressed in arbitrary corneometric units.[14] As per skin elasticity, Cutometer SEM 575, also by Courage & Khazaka, measures the vertical deformation of the skin when it is sucked into the opening of a probe, for an established time. When the air depression is annulled, the skin returns to its original position. An optical system follows continuously the deformation of the skin surface. Key parameters calculated from such measures are: maximal deformation of the skin, overall elasticity and viscoelastic ratio.[15, 16] Skin roughness measures are carried out by comparison, before and after any treatment, the surface micro-relief, as replicated by a cast of fast hardening silicone gum. Skin replicas, as shown below, are analysed by a designed image processing software (Quantilines, Monaderm) which allows a global data analysis of some relief parameters, such as the maximum and mean roughness and wrinkle anisotropy (Figure 1). For demonstrating a lifting effect, the image analysis allows to compare the micro-relief of the skin, before and after the treatment, with the help of objective numbers.[17]
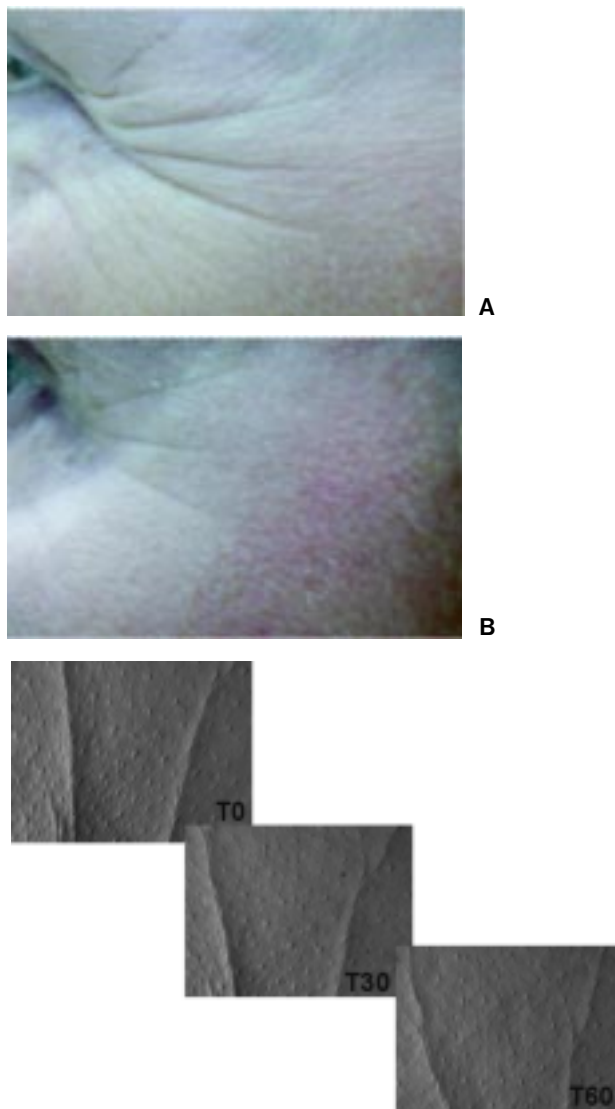
Figure 1. *Digital images taken in the periocular area before and after a 2-month treatment with an anti-wrinkles product (A). Skin replicas visualized through Quantilnes software (Monaderm). The same skin area is analysed before the treatment and after 30 days and 60 days of product application (B).*

Sl. 1. *Digitalna fotografija periokularnega področja pred zdravljenjem in dva meseca po njem s pripravki za zmanjševanje gub (A). Kožne replike ponazorjene s programom Quantilnes software (Monaderm). Vrednotenje učinka pred, 30 dni in 60 dni po zdravljenju (B).*

In case of plumping or re-densifying (or rethickening) treatments the investigation of cutaneous thickness is really necessary.[18, 19] The device used in this case is an ultrasound scanner based on a physical principle used also in the oil industry. When an ultrasound beam reaches the skin, it crosses structurally different sections. Hence, the beam is partly transmitted and partly reflected by the areas of the adjacent skin sections. Echo sounds with different amplitude are thus generated. Their intensity is assessed by a micropro-

cessor and shown on the screen as an image, which visualizes differences in density by colour artefacts. Dermascan C® Ver. 3 (Cortex Technology, Denmark) is a high-resolution B scanner emitting high-frequency ultrasound (20 MHz) that allows the observation of the tissue to a depth of 3 cm with 50 μ-axial and 350 μ-side resolution. Therefore, it is possible to measure the thickness (expressed in mm) of different skin structures (in particular, epidermis, dermis and hypo-dermis).

Today, a very popular skin treatment is peeling. In this case, it is considered useful to check its effects by measures of skin pH and trans-epidermal water loss. This is important in order to control the respect of skin barrier functionality after treatments that could be too strong or aggressive for some patients. This evaluation could help to understand the opportunity to change the applied product for the successive applications.

Skin acidity and its measure (pH) is important for skin equilibrium and the activity of its enzymes and co-factors. pH is also a marker of skin irritation and recovery. pH-meter PH900, by Courage & Khazaka, consists of a measuring probe made of 2 electrodes (measuring and control). The electrode front surface has a flat round shape, which makes it perfectly adhere to the skin. Values are expressed as all usual pH values.[20]

Skin barrier is a very sensitive shield to environmental pollutants. Many treatments can disrupt its integrity. Moreover, a right barrier is a sign of skin health. Tewameter TM210, Courage & Khazaka, measures the water vapour released by the skin surface. This evaporimeter has a probe which contains a pair of sensors. The humidity which evaporates from the skin surface passes through the cylindrical part of the probe. The humidity saturation gradient which is formed, is indirectly measured by the sensors (temperature and relative humidity) and then transformed into numeric values, expressed in grams of water/hour $\times$ m^2.[21]

Many young people suffer from acne phenomena. We could follow the time and treatment evolution of the single lesions through macro-photography. Pictures can be taken at defined time intervals to detect the number of days required for the problem to be reduced or disappear after an adequate treatment.[22, 23] In case of products specifically studied for greasy skin, one can follow an evaluation protocol including the evaluation of sebometry. The device, Sebumeter SM 810, Courage & Khazaka, has a ribbon able to absorb the sebum from the skin. A light beam is then projected towards the ribbon; reflected by a mirror onto a photocell and amplified. The greater the quantity of lipids on the ribbon, the more transparent the film will become: the numerical values are directly proportional to the transparency of the ribbon and hence to the quantity of lipids present onto it.[24]

Other popular kind of cosmetic products or treatment involves the skin whitening efficacy. For two main reasons: firstly, by aging, typical dark spots are developed on the skin surface which increase in number and intensity with growing age. However, another category of people seeking for these products

are Asians and Africans. Even young generation try to lighten their skin colour in order to be more similar to Caucasians, both with cosmetics and surgical operations. Colorimetry is the technique needed to assess the effectiveness of a whitening product. Chroma Meter CR-300 (Minolta) is a portable dual channel, reflecting colorimeter with incorporated microcomputer, liquid crystal display and Xenon light source. The measuring head surface is 8 mm in diameter. The colour rating system used to read is L* a* b*: L* parameter refers to skin luminosity. a* and b* refer to two-colours axis: a* represents

T 0   **T 90**

Figure 2. *Example of phototrichogram. A selected 1 cm² area on the scalp of the volunteer is shaved at the beginning of the test. 48 hours after shaving, a picture is taken through a specific videocamera. The same visit is performed at the end of the test. It is possible to count the anagen and telogen hair and to compare the basal situation to the one observed after the treatment.*

Sl. 2. *Primer fototrihograma. Prikaz testnega področja (1 cm²) obritega lasišča. Z uporabo posebne video kamere lahko preštejemo lase v anageni in telogeni fazi 48 ur po poskusu in ob koncu poskusa ter jih primerjamo s prvotnim stanjem.*

the red-green colour while b* the yellow-blue colour. According to the aim of the treatment, values relating to the skin redness (a* parameter) or skin brightness (L* parameter) are taken into account.[25]

Colorimetry can also be used to check the effectiveness of treatments for sensitive skin, which try to avoid the onset of skin redness due to adverse environmental conditions (cold, wind, snow...). On the other site, it can also be used to follow the lenitive effect (redness reduction) of products. Moreover, it can demonstrate the normalization of microcirculation after invasive treatments.

90 % of Caucasian women are affected by cellulite: a state of skin disequilibrium that may give rise to more severe physiological and psychological problems. For this reason, many women decide to undergo surgical operations, for trying to remove its evidences. For studying the results of cellulite-reducing treatments, both instrumental and clinical evaluations are requested. It is necessary to investigate over the blood micro flow, the skin topography, its elasticity and thickness. A visual clinical assessment is also made and rated according to a recognized scale ranking the severity of the defects.[26]

The blood micro-flow is measured by means of a computerized laser Doppler device, Periflux PF4001 (Perimed). A laser light, carried by an optic fibres probe, is partially reflected and partially absorbed by the examined tissue. When hitting the moving haematic cells, the light beam is subjected to wavelength variation (Doppler effect). The power and frequency distribution of the wavelength variations are correlated to the number and speed of flow of the haematic cells, but not to their direction. The related information are picked up by a return optic fibre, turned into an electronic signal and analyzed. The perfusion is expressed in arbitrary Perfusion Units (P. U.).[27]

Another common women problem are stretch marks. Repair efficacy can be proven by performing evaluations on elasticity and skin micro relief. In all cases
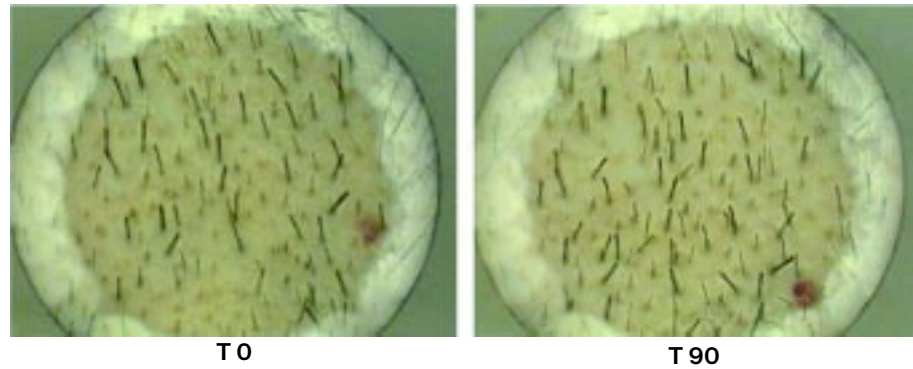
where appearance changes are important, macro-photography can be really useful. It allows both the patient and the physician to compare the images taken before and after the treatment, so they can clearly understand and immediately visualize the differences.

Ever growing men population loose their hair both in the old and young age. In order to monitor the cosmetic treatments result, scalp checks at precise intervals through 'pull test' and 'wash test' techniques or through photo-trichogram are performed (Figure 2). In the former, both the number of hair lost after washing and the resistance to traction are tested, while in the latter a small scalp area is shaved. After 48/72 hours it is analysed by videocamera, to detect the number of hair in anagen/telogen phase.[28–33]

Not only hair can be followed during their re-growth cycle: also skin cell renewal can be easily quantified by colorimetric methods. Quantifying odour changes looks more complicated: indeed, a study to detect the decrease of axillary odour can be performed by a so-called 'sniff test'. It is carried out at fixed times after the last washing/application of the product by a panel of trained judges.[34]

Digital images

Efficacy evaluations can be supported also by digital images of the treated area, taken before and after the treatment. This type of evaluation can be performed both in short-term and in long-term studies. Photographs of the areas involved in the test are analysed by means of a special system, the FotoFinder Dermoscope. A method has been developed to standardize the images, in order to allow their comparison at different study times. For instance, anti wrinkle efficacy is followed by comparing digital images of the peri-orbital area and of the whole face. The efficacy of the treatment in reducing fine lines and deep wrinkles (around eyes and mouth, on the

Figure 3. *Frontal and lateral digital images of the lips area (explanation in the text).*

Sl. 3. *Digitalni fotografiji sprednje in stranske strani področja okoli ust (za razlago glej besedilo).*

forehead), as well as the efficacy in smoothing the skin or making it brighter is easily evaluated. In surgical operations, digital images are strictly necessary; for instance, in rhinoplasty, blepharoplasty, mammaplasty, liposuction, in treatment of stretch marks and scars, laser photo-coagulation, definitive depilation by pulsed laser and hair transplantation.

In lip augmentation, frontal and lateral photographs of the lips area are taken. Images are then analysed and the following measurements are performed:

On the frontal image, after drawing a reference line at nasal base, measures regard the length of:

1. midline white lips (from the lowest central point of the upper lip to the reference line): should decrease after the treatment.

2. lateral white lips (from the uppermost lateral point of the upper lip to the reference line): should decrease after the treatment.

3. total midline red lips (from the lowest central point of the upper lip to the lowest point of the lower lip following an ideal vertical line): should increase after the treatment.

4. total lateral red lips (from the uppermost lateral point of the upper lip to the lowest point of the lower lip following an ideal vertical line): should increase after the treatment.

On the lateral image, we measure (after drawing the line tangent to the point of the nose and to the point of the chin as a reference line) the length of the upper and lower lip projection (from the most protruding point of the upper and lower lips to the reference tangent line): both should decrease after the treatment. Measuring lines are not shown in the below pictures (Figure 3).

Sensory analysis

Where all instrumental methods fail is when results are related to human perceptions. In this case, sensory analysis is the only solution. This is a scientific method which enables the analysis of the sensory responses to specific stimulus in qualitative and quantitative ways.[35, 36] Sensory techniques are classified in three key categories, which differ in several factors. Discriminative tests investigate qualitatively the overall or specific differences between two or more products. This category of tests require only partially trained panellists. Panellists are asked to detect differences without being influenced by the pleasantness or unpleasantness of the tested product. A more in depth analysis can be achieved with the responses provided by so-called descriptive tests.[37] This procedure is so accurate that can be compared to an instrumental analytical evaluation (in terms of repeatability/reproducibility of results, use of statistics, exactitude). These two techniques foresee the use of panellists which are specifically trained (and successively monitored) in the correct evaluation of intensity of perceptions, without being influenced by their pleasantness.[38, 39] Affective tests concern the hedonic aspects of the product. The panellists involved are representative of the target consumer.[40] They receive no training and are asked to express their acceptance/preference judgements. All these tests can be used to investigate specific attributes, related to the different moments of the use phases.

It is necessary to mention another type of sensory evaluation. It is the so-called expert's evaluation, which is performed by a professional (physician) who evaluates the skin feel of a cream or the key characteristics of the skin of a patient. It is a very accurate method, but it does not give reproducible results (two experts have different experiences), it is not numeric (so cannot be compared statistically) and is influenced by affection (my product/performance is always better/worse than competitor's) and by the mood of the evaluator.

In Quantitative Descriptive Analysis, the most refined sensory method, panellists (usually from 10 to 15) are selected according to their ability to discriminate differences in sensory properties. During training, they develop a common language to describe their perceptions and express appropriate attribute descriptions. They are also trained to use linear (non-numeric) scales and to use references, related to different intensity levels for each attribute. The panellists' skills are recorded and monitored for reproducibility, consistency, sensitivity and calibration. The evaluation is performed according to a detailed protocol worked out during the training phase. The perceived intensities of the selected attributes are assessed by making a mark on a linear scale. Then the marks converted into scores by

measuring their distance from the end of the line. Descriptive statistics (arithmetic mean, standard deviation) is elaborated for each attribute and a suitable statistical test is performed in order to compare the situation pre- and post-treatment.

Discriminative and descriptive tests can be used in different ways according to the project aim, for instance during the development of the product or in order to investigate the attributes concerning the intrinsic properties of the different formulas. Trained panellists are asked to detect which product leaves the skin softer or is more easily absorbed by the skin, what kind of feeling (oily, greasy, silky...) is sensed after the application, etc.

The application of sensory techniques can take place also in the field of lifting results. Digital images taken in standard conditions (same position of the subject, acclimatization to eliminate eventual redness due to emotive feelings or to physical problems like passing from supine position to erect position, environmental light, distance from the subject, picture taken in the very same area, etc.) can help. The images of several patients taken before and after the treatment (or operation) can be compared by trained panellists to evidence the presence of a difference and to quantify it according to precise scales.

In the evaluation of surgical treatments, the opinion of the subject who has just undergone the treatment is, indeed, a sensory evaluation. Unfortunately, it is not objective. People going to the physician with an aesthetic problem, usually have great expectations on the final outcome. They expect to appear much more beautiful not seeing their aesthetic disturbance anymore (or at least to see a great difference with respect to the pre-treatment situation).

How to find an objective way of quantification of results, not influenced by »Olympic« (stratospheric) expectations? No method has till now been developed. One idea could be to take pictures of the subject before the treatment, modify the images by computer programs, then give the patient a possible scale (not too much optimistic) of the results and searching his or her agreement on such hypothesis or on the range of possible hypothesis. Final results, together with the demonstration of perfectly recovered skin functionality, could be compared with agreed expectations and satisfaction could be accomplished. Difficult, but non impossible, in the age of skin measurements!

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