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Emotional effects induced by lip balms containing different emollients:
neuroscientific approach to studying the tactual experience

KEYWORDS: Neuroscience, lip balm, emollients, emotional purchase, consumer insights.

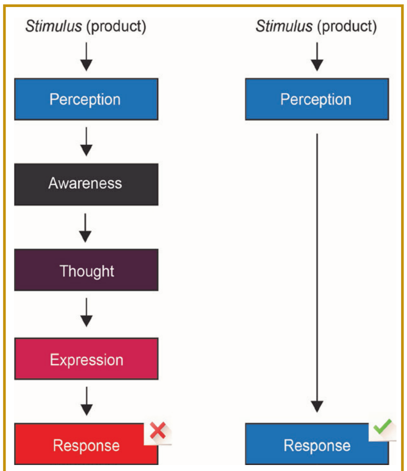
Abstract
Companies rely on traditional market research, e.g. consumer tests and focus groups, for predicting consumer compliance. Since they investigate the conscious perception of a product, their results can be one of the causes of the high failure rate (40%) of products after the launch. In recent years, experts in neurology, psychology and neuroscience have demonstrated that emotions, and the unconscious interactions between consumers and products, strongly influence the buying process and the purchase decision. The integration of emotional and neuroscientific profiling to the classical consumer research methodologies can provide additional useful information to build better products. For cosmetic products, the texture is strongly involved in customer loyalty, so the emotional effects of tactual stimulation could be one key to create successful products. By means of neuroscientific instruments and methodologies, we have demonstrated that lip balms containing the same ingredients but diverging for only one emollient are able to trigger different emotional responses during their application on the lips.

INTRODUCTION

New product failure rate is around 40% (1) despite initial successful testing with traditional market research. This might be due to the low predictivity of methodologies so far employed such as *consumer tests* and *focus groups*.
More than fifty years ago, David M. Ogilvy – the father of advertising – affirmed that "*The problem with market research is that people don't think what they feel, don't say what they think and don't do what they say*" (2). In more recent years, many academic and commercial researchers have gained a deeper knowledge of human behaviour. Most notably, Gerald Zaltman, Professor Emeritus at Harvard Business School, is spending is career declaring the need for a new way to study consumers' behaviour to prevent disastrous marketing decisions: the interaction between products and consumers is complex and the latest neurological methodologies may be really helpful (3, 4).
For centuries, Western culture and science have spurned emotions as uninteresting. During the 1990s decade, researchers discovered more truths about the brain than they have during the entire history of psychology and neurology. The neurologist Antonio Damasio demonstrated that emotions are central in human behaviour including decision-making (and purchase decision), opening the road to a new way of think about consumers' behaviour: everyday decisions are based on unarticulate-unconscious motives, and rational reasoning has a marginal role (5,-10).

Classical market research is unemotional: the consumers are asked to say what they think of a particular concept, product or brand. These tests require cognitive information processing by the consumer, leading in some cases to incorrect results. When a product activates peripheral sensorial receptors, perception occurs. A subject can express an opinion only if perception is converted into thought, and it occurs only if he or she is aware of that perception (Scheme 1, left side). In other terms, there is a formal distance between the input and the output: the relationship between the stimulus and the final opinion is not straightforward but it is multi-step, and every step is error-prone. Verbal or written opinions can be flawed by the respondent's cognitive processes activated during the interview, being the implicit memory and subject's emotions inaccessible to the interviewer that uses traditional techniques (3, 4).

Emotions and Neuroscience
One definition of emotion is "mental experiences of body states" (11) arising from the body's responses to internal or external stimuli. Thus, an emotion can be described by two phenomena: mental states and physiological variations of the body. Body responses to external stimuli are uncontrollable by consciousness and they include pupil dilation, skin sweating, variation in heart rate or respiratory rhythm, and others (12-14).
Mental states and subtle variations of body organs can be



Scheme 1. Classical market research (left side) versus neuroscientific research (right side): reliability of results.

studied by means of advanced neuroscientific methodologies and instruments. In the simplest of definitions, neuroscience is the study of the nervous system with an interdisciplinary approach combining the fields of biology, medicine, genetics, physics, chemistry, computer science and engineering. Results of neuroscientific studies are data obtained through the detection and registration of the physiological responses induced by a stimulus. There are no errorprone conscious processes between a product tested and the final response detected (Scheme 1, right side).

Neuroscience and cosmetic industry: the importance of touch in consumer loyalty

The emotional response the customer gets from applying a cosmetic product is a key factor for success. To date, cosmetic companies are trying to exploit neuroscience methodologies for studying visual stimuli such as static or video advertising, packaging and product placement in retail stores. Thus, in most of neuromarketing studies applied to the cosmetic field, touch is being slightly neglected despite texture - together with perfume - is one of the main drivers in the buying process, especially in the repurchasing of any item. The positive emotions induced by the application of a product have to be taken into consideration for understanding, deciphering and inducing customer fidelization (15, 16).

MATERIALS AND METHODS

The study has been designed to scientifically evaluate the capacity of three different lip balms to induce different emotions when applied on the lips of female subjects. We used simultaneous Electroencephalography (EEG) and Galvanic Skin Response (GSR) measurements during the whole experiment. All data was sent to a laptop computer, collected and analysed with the aid of iMotions Biometric Research Platform - an advanced software for neuroscientific studies - able to report real-time changes of the physiological variations registered by many kinds of sensors (17).

Neuroscientific measurements

Electroencephalography: overview

Electroencephalography (EEG) is a method based on the record of the electrical activity generated by the synchronized activity of thousands of neurons by using electrodes placed on the scalp. Among the brain imaging techniques EEG offers the highest time resolution allowing the analysis even at sub-second timescale. Applied first to humans in the 1920s by the German neurologist Hans Berger (18), EEG is a non-expensive, non-invasive and completely passive recording technique. The billions of neurons in the human brain have highly complex firing pattern, mixing in a rather complicated fashion. The signal is a mixture of several underlying frequencies, classified by researchers into specific frequency ranges (or frequency bands): delta band (1-4 Hz), theta band (4-8 Hz), alpha band (8-12 Hz) and gamma band (>25 Hz). Frequencies fluctuate according to the state of mind and brain area where they are generated, and their variations can be used to study brain reactions to any stimuli (19).

EEG measurements

In order to decipher stimuli-induced, mental states have been detected and registered by means of a portable wireless EEG-system, the Emotiv EPOC + wireless headset (20).The headset consists of 14 data-collecting electrodes locating at AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, AF4 following the American EEG Society standard (21). This headset does not require a moistened cap or gels to improve conduction. The sampling rate was 128 Hz, the bandwidth was 0.2-45 Hz, and the digital notch filters was at 50 Hz and 60 Hz. The embedded software of the headset converted electric signals variations (in brain location, phase and frequency) detected on the scalp into four mental states (defined and described in Scheme 2) in a dimensionless scale from 0 to 1. Details about the algorithms used to obtain the conversion of brain waves into mental states have not been published because of their proprietary nature. *Engagement* is experienced as a mixture of attention and concentration. It is characterized by increased physiological arousal and beta waves along with attenuated alpha waves; an engagement-inducing stimulus is an interesting stimulus. *Excitement* is experienced as an awareness of feeling of physiological arousal with a positive value. *Frustration* can be defined as a state of discomfort and irritation. *Meditation* is a state of calmness and relax. Each value is a measure of the likelihood that an event is occurring (probability). For example, a value of 0.7 for a mental state means that there is a 70% chance the respondent is feeling that mental states (according to the software of the headset). The algorithm for conversion has been developed by the headset supplier and is based on rigorous experimental studies on human volunteers, validated for non-medical use in many peerreviewed studies (22-24).

MENTAL STATE	DESCRIPTION
ENGAGEMENT	Mental state induced by an interesting stimulus. Opposite to boredom.
EXCITEMENT	Highest degree of pleasantness
FRUSTRATION	Negative mental state induced by an unconsciously disliked stimulus
MEDITATION	State of calmness and relax

Scheme 2. Description of the mental states registered in the study.

Galvanic skin response: overview

Galvanic skin response (GSR) is one of the most sensitive measures for emotional arousal (23), the phenomenon by which the skin temporarily becomes a better conductor of electricity. When a positive or a negative stimulus is emotionally arousing, it activates the autonomic nervous system, which triggers an increase of sweating especially in hand palms and fingers as well as foot soles. Both positive and negative stimuli can result in an increase in arousal triggering GSR. Thus, GSR measurement is not able to reveal the emotional valence but has to be integrated with other sources of data in order to paint the full picture of an emotion (24, 25) e.g. EEG measurements.

GSR measurements

The arousal has been recorded with the wireless GSR Shimmer3 Sensor (26) with a sampling rate of 102.4 Hz by the constant voltage method: once a low constant voltage (15.9 Hz) Direct Current is applied, by the measurement of the voltage differences between the two electrodes, the skin conductance was quantified (in microSiemens units). The AgAgCl electrodes (10mm diameter of active area) were attached to the palmar side of the middle phalanges of the second and the third fingers of the nondominant hand (in order to allow participants the using of the dominant hand during task performance) by means of a velcro fastener.

Environmental condition

Measurements were taken under controlled temperature (22±1°C) and humidity (45±5%).

Subjects

A panel of 20 healthy female volunteers (average age 35±10), healthy, right-handed and heavy users for lip products (lip balm, lip gloss, lip creams, lip stains daily used at least 3 times a day) was recruited. None of them suffered at the time of the experiment from chronic diseases, mental disorders, drug of alcohol abuse, depression or anxiety, dermatological or neurological diseases. Informed consent was obtained from each subject after explanation of the study. After the data has been collected, a survey has been performed.

Tested products

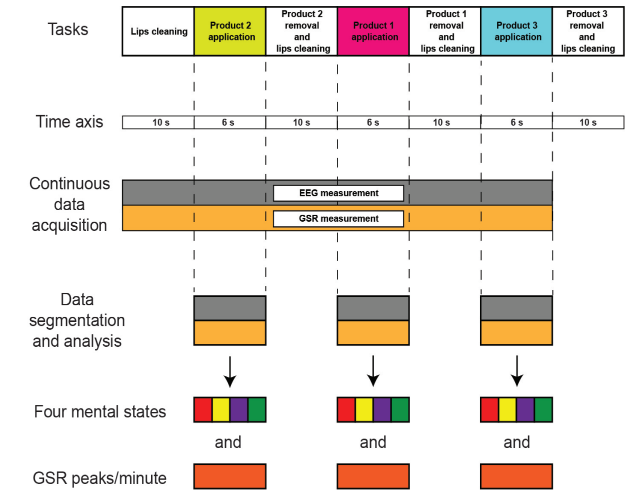
The products tested were three lip balms with the same formulation (32 ingredients) with the exclusion of one emollient: lip balm 1 contained Octyldodecyl PCA; lip balm 2, Octyldodecanol; lip balm 3, Lauryl PCA. The three emollients were added at the same concentration (Table 1). The products tested had the same appearance and the same aroma in order to infer that the final results were associated only to tactual properties of the stimulus.

Experimental design

After 30 minutes of acclimatisation period, the volunteers were asked to apply each product for 6 seconds on both lips. Randomization of the stimuli was made in order to remove the "sequence influence" as possible confounding factor. The subjects were instructed to clean their lips for 10 seconds with a neutral swipe (before the study and between the application of one lip balm and the next one). Every task was guided by instructions shown on a PC monitor put in front of the volunteer. EEG and GSR data - continuously acquired during the whole experiment - were segmented in order to analyse only the time-windows of interest (Scheme 3).

Ingredients	Range %
Ethylhexyl Palmitate	10-25 %
Caprylic/Capric Triglyceride	10-25 %
Sorbitan Isostearate	5-10 %
PEG-2 Hydrogenated Castor Oil	1-5 %
Bis-Diglyceryl Polyacyladipate-2	1-5 %
Cera Alba	1-5 %
Glyceryl Behenate	1-5 %
Polyglyceryl-3 Beeswax	1-5 %
C16-23 Alkane	1-5 %
Glycerin	1-5 %
Butyl Methoxydibenzoylmethane	1-5 %
Ethylhexyl methoxycinnamate	1-5 %
Octocrylene	1-5 %
Hydrogenated Castor Oil	1-5 %
Ozokerite	1-5 %
Aroma	1-5 %
PPG-26-Buteth-26	1-5 %
C12-15 Alkyl Benzoate	1-5 %
Butyloctyl Salicylate	0.1-1 %
PEG-40 Hydrogenated Castor Oil	0.1-1 %
Titanium Dioxide (nano)	0.1-1 %
Palmitic/stearic Triglyceride	0.1-1 %
Aqua	0.1-1 %
Glyceryl Laurate	0.1-1 %
Chamomilla Recutita Flower Extract	0.1-1 %
Aluminum Stearate	0-0.1 %
Polyhydroxystearic Acid	0-0.1 %
Tocopherol	0-0.1 %
Beta-Sitosterol	0-0.1 %
Alumina	0-0.1 %
Squalene	0-0.1 %
Octyldodecyl PCA (only in Lipbalm 1)	5-10 %
Octyldodecanol (only in Lipbalm 2)	5-10 %
Lauryl PCA (only in Lipbalm 3)	5-10 %

Table 1. Composition of the three lip balms tested.



Scheme 3. Visual representation of the experimental design.

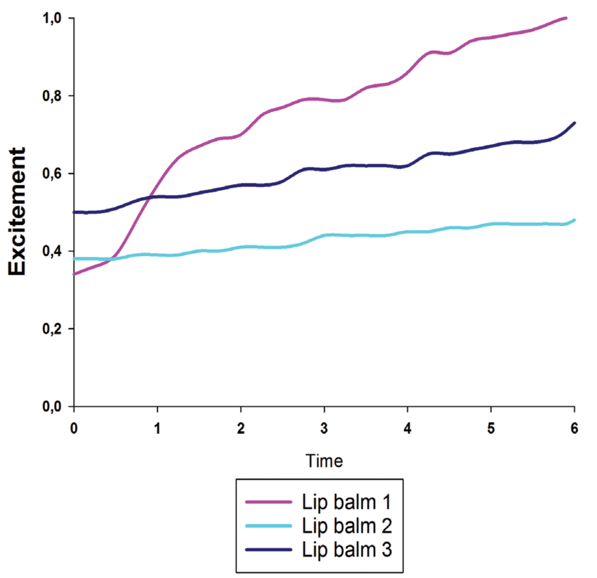
RESULTS AND DISCUSSION

Statistical tests

The nonparametric Kruskal-Wallis test, designed for unpaired data measured on a continuous scale, was applied to all cases. A Dunn's post test was performed using GraphPad Prism version 7 for intergroup analysis (Lip balm 1 vs. Lip balm 2, Lip balm 1 vs. Lip balm 3 and Lip balm 2 vs. Lip balm 3). A p-value<0.05 was considered significant.

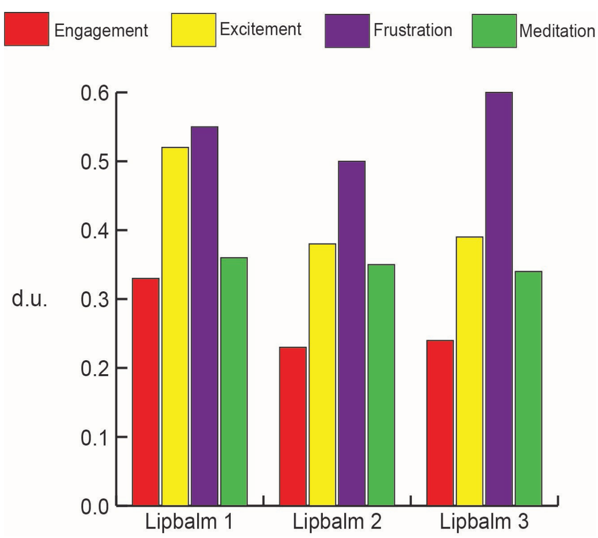
EEG metrics

Graph 1 shows the Excitement readings from one volunteer (Time vs. Excitement) during rub-out and used for statistical analysis. The rub-out time-intervals for that respondent were 10s-16s for lip balm 2 (light blue line), 26-32s for lip balm 1 (pink line), 42-48 for lip balm 3 (dark blue line). Curves have been grouped in one graph for an easy visual comparison.



Graph 1. Electroencephalographic reading (from respondent number 4): grouped curves of Time (seconds) vs. Excitement. See text for details.

Time-averaged mean was calculated for the four mental states registered during the application of each product (Graph 2). The higher value of Excitement was induced by Lip balm 1 (0.52) and the higher value of Frustration by Lip balm 3 (0.60). Engagement was higher for Lip balm 1 (0.33). Meditation was the EEG-metric characterized by the smallest variations (0.36, 0.35 and 0.34 for Lip balm 1, 2 and 3, respectively) which were not significant (p>0.05). See Table 2 for details.



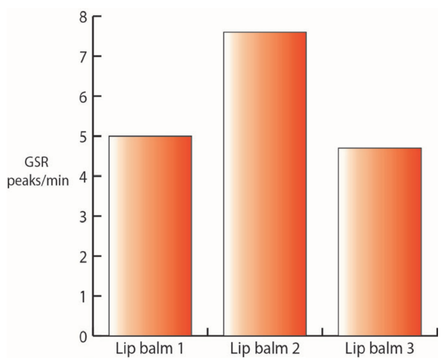
Graph 2. EEG metric: mental states associated with the three lip balms under study. (d.u.= dimensionless units).

	Lip balm 1 vs. Lip balm 2	Lip balm 1 vs. Lip balm 3	Lip balm 2 vs. Lip balm 3
Engagement	sign.	sign.	sign.
Excitement	sign.	sign.	sign.
Frustration	sign.	sign.	sign.
Meditation	no sign.	no sign.	no sign.

Table 2. Dunn's post test results. (Sign. = statistical significance, p-value < 0.05; no sign. = no statistical significance, pvalue ≥0.05).

GSR metrics

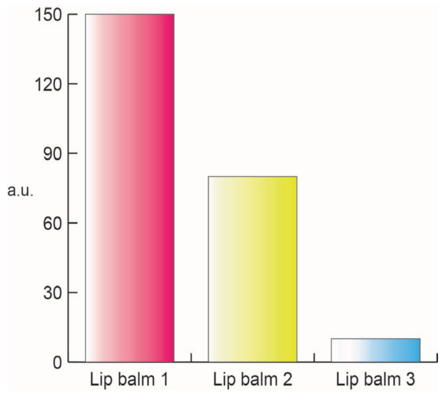
Simply analysing the amplitude (total conductance in microSiemens units) is only really useful if you like to get an overview of individual changes. The reason is due to the shape of GSR signals. The GSR signal consists of two main components: the tonic level and the phasic level. Tonic changes vary within tens of seconds to minutes and derive from subject's physiological skin hydration and dryness. They differ markedly across individuals and do not depend to any external stimulus tested. The phasic response rides on top of the tonic changes and shows significantly faster alteration. Variations of the phasic component of the GSR signal are named GSR peaks and they are sensitive to specific emotionally arousing stimuli. Thus, one of the most acknowledged methods for analysing GSR data is the - so called "peak detection method", and this is the method we have used. Briefly, the algorithm neutralises the tonic level and find how many peaks occur during a recording condition (27). Since the lip balms were applied in a discrete time window (6 seconds), we have decided to report GSR peaks in a time scale (minutes) for each respondent. Average results are shown in Graph 3. Lip balm 2 induced the highest emotional arousal (7.5 peaks/min).



Graph 3. GSR results expressed in GSR peaks/ minute units.

Index of positivity (of emotional response): IOP

An index of positivity (IOP) in arbitrary units (a.u.) was employed to combine and easily display EEG and GSR results for each product. IOP combines probability values with a physical quantity (GSR i.e. changes in the electrical properties of the skin) and it can only be expressed as arbitrary units. For IOP creation we took into consideration both GSR values and the direction of the mental states induced by the lip balms: engagement, excitement and meditation have been considered as positive mental states and frustration as negative mental state. Lip balm 3 (containing Lauryl PCA) showed the lowest IOP value (IOP=10) (see Graph 4 and Table 3).



Graph 4. Index of positivity (IOP): combination of EEG results and GSR results (a.u. = arbitrary units).

	Lip balm 1 vs. Lip balm 2	Lip balm 1 vs. Lip balm 3	Lip balm 2 vs. Lip balm 3
IOP	sign.	sign.	sign.

Table 3. Dunn's post test results. Sign.= statistical significance, p-value<0.05.

Survey
To the question "Which product do you like the most?" 70 (14 out 20) of the respondents answered "Lip balm 1", 30% (6 out 20) "Lip balm 2" and none of them selected "Lip balm 3". To the question "Which product will you never buy" 100% (20 out 20) answered "Lip balm 1".

CONCLUSIONS

With the study presented in this paper we wanted to propose a way to study the emotional effects induced by lip balms.

For our group EEG metrics alone were not sufficient to understand the emotional effect of the products for two reasons: 1) they are correlated to electrical variations of the central nervous system, and emotions trigger peripheral variations as well 2) the output of the headset used is expressed as probability. Therefore, the integration of EEG data with GSR metrics as a measure of emotional intensity was considered fundamental.
The final scoring system has been created by taking into consideration the output of the two methodologies used: cerebral response from electroencephalography and skin sweating from galvanic skin response sensors. This allowed us to merge the biometric data obtained to depict more easily the emotional effect of the tested lip balms. Lip balm 1 induced engagement and excitement with a *higher chance* (0.33 and 0.52, respectively). The higher arousal was registered for lip balm 2, which induced engagement and excitement with the *lowest chance* (0.22 and 0.38, respectively). Higher chance does not mean higher intensity but since both engagement and excitement are mental states related to positive arousal (see Materials and Methods) we have decided to use GSR values as multiplicative factor for generating the arbitrary IOP score.
The three products showed significant differences in their emotional profile. In particular, the lip balm 3 was characterized by the worst tactile emotional performance (IOP=10) among the products tested. The best emotional performance was induced by Lip balm 1 (IOP=150). The IOP scores seem to correlate to the degree of appreciation achieved by the survey: lip balm 3 was the least appreciated product and lip balm 1 was the preferred one.

Interestingly, PCA-esters emollients, Octyldodecyl PCA in Lip balm 1 and Lauryl PCA in Lip balm 3, showed highly significant differences in their unconscious effects. To date, we cannot infer the reason why such differences have been detected (and it was not the final aim of our study). We can suppose that the different chemical structure i.e. the length of the aliphatic chain of the alcoholic part of the esters which influences skin absorption may have divergent impact on peripheral receptors such as tactile receptors but also nociceptors or others. Thus, different emollients provide different emotional properties to the cosmetic in which they are incorporated, suggesting that they might activate quantitatively and qualitatively divergent pathways toward the central nervous system.

The portable neuroheadsets used by our group has been developed by the supplier by using visual stimuli, which are known to be more powerful in eliciting emotions (together with olfactory stimuli). With our study we wanted to shift the use of the instrument to the emotional analysis of the texture of a product. Inspired by the work of Jimenez' group (30) , we wanted to assess the ability of the headset to reveal differences in the mental states induced by complex products diverging for one ingredient.

Aware that emotions are highly complex and subtle phenomena, at the time of publications, our group has selected two methodologies to be integrated with GSR and EEG: facial expression analysis for studying valence and photoplethysmography (heart rate estimation) for quantifying emotional arousal.

PERSPECTIVES

The amount of information consumers are exposed to is enormous, yet our processing capacity is limited. Each second we are exposed to an estimated 11 million bits of information that reach us through all our senses, yet the conscious mind is capable of processing only around 50 bits of that information (31). In other words, conscious mind is someway impenetrable by stimuli in every-day life, but, by deciphering the nonconscious response to products, it is possible to convey the desired sensorial massage to the customer's emotional mind and build a better product.

The avenues for applying neuroscience in consumer research are countless: with a proper study design it is feasible to understand and quantify the consumer's unexpressed needs and the emotional response related to a cosmetic product. The application of neuroscience in the cosmetic field is only just beginning, and companies able to fully exploit its potential would gain extraordinary competitive advantages.

REFERENCES AND NOTES

1. Castellion G and S. K. Markham. New Product Failure Rates: Influence of Argumentum ad Populom as self-interest J Prod Innov

Manag 30(5) 976979 (2013)
2. Ogilvy David M., Confessions of an Advertising Man Ed. Atheneum, New York, USA (1963)
3. Zaltman G. How Customers Think: Essential Insights into the Mind of the Markets, Harvard Business School Press, Boston, USA (2003)
4. Zaltman G., Zaltman L. H Marketing Metaphoria: What Deep Methaphors Reveal About the Minds of Consumers Harvard Business School Press, Boston, USA (2008)
5. Lang P.J. The emotion probe: studies of motivation and attention Am Psychol 50(5), 372385 (1995)
6. Bechara A. et al. Decision neuroscience Market Lett 16(3/4) 375386 (2005)
7. Tversky A. and Kanheman D., The framing of decision and the psychology of choice Science 211,(4481) 453-458 (1981)
8. LeDoux J., The emotional brain: the misterious underpinnings of emotional life Ed. Simon and Schuster, New York, USA (1998)
9. Haynes J. D. et al., Reading ridde intentions in the human brain Curr Biol 17(4) 322328 (2007)
10. Tamietto M. and De Gelder B., Neural bases of the non-conscious perception of emotional signals Nature Rev Neuroscience 11, 697-709 (2010)
11. Damasio A. and Carvalho G. B., The Nature of feelings: evolutionary and neurobiological origins Nature Rev Neuroscience 14, 143-152 (2013)
12. Ioannides A.A., Liu L., Theofilou D., Dammers J., Burne T., Ambler T. Rose S. Real time processing of affective and cognitive stimuli in the human brain extracted from MEG signals Brain Topog, 13, 11-19 (2000).
13. Knutson B., Rick S., Wimmer G.E. Prelec D., Loewenstein G., Neural predictors of purchase, Neuron, 53, 147-156 (2007).
14. Morris J.D., Klar N.J. Shen F., Villegas J., Wright P., He G., Liu Y. Mapping multidimensional emotion in response to television commercials, Hum Brain Mapp 30(3), 789-796 (2009)
15. Barden P., Decoded: The Science Behind What We Buy, John Wiley and Sons, United Kingdom (2013)
16. Du Plessis E., The Branded mind: What neuroscience really tell us about the puzzle of the Brain and the Brand, Millwward Brown, USA (2011)
17. iMotions Biometric Research Platform 6.0, iMotions A/S, Copenhagen, Denmark, 2016
18. Jung R. and Berger H., Fünfzig Jahre EEG. Hans Bergers Entdeckung des Elektroenkephalogramms und seine ersten Befunde 1924–1931. Archiv für Psychiatrie und Nervenkrankheiten, 227, 279300 (1979)
19. Kandel et al. Principles of Neural Science McGrawHill, USA, Fifth Editions, (2012)
20. Emotive EPOC http://www.emotiv.com/epoc
21. http://www.acns.org/UserFiles/file/2GuidelinesforStandardElectrodePositionNomenclature_v1.pdf.
22. Trung D.P. and Dat T., Emotion recognition using the Emotiv Epoc device, ICONIP 12, Part V, 394-399 Springer Verlag Berlin, Heidelberg, ISBN 978-3-642-34499-2 (2012).
23. Taylor G. S. And Schmidt C., Empirical Evaluation of the Emotive BCI Headset for the Detection of Mental Actions from Proceeding of the Human Factors and Ergonomics Society Annual Meeting, Vol 56, Issue 1 (2012)
24. Duvinage et al. Performance of the Emotiv Epoc headset for P300-based applications BioMedical Engineering 12, 56, (2013)
25. Mauss I. B. and Robinson M. D. Measures of emotion : A review, Cogn Emot 23(2), 209-237 (2009)
26. The autonomic nervous system (ANS) is a general-purpose physiological system responsible for modulating peripheral functions Öhmann A., Hamm A., Hugdahl K. Cognition and the autonomic nervous system: Orienting, anticipation, and conditioning, in Handbook of psycophysyology, Vol 2, p. 533-575 edited by Cacioppo J.T., Tassinary L.G., Bernston G.G., Cambridge University Press, New York, USA (2000)
27. Benedek M., Kaernbach, C. A continuous measure of phasic electrodermal activity J. Neurosci. Methods 190, 8091 (2010)
28. http://www.shimmersensing.com
29. Benedek, M, and Kaernbach, C., Decomposition of skin conductance data by means of nonnegative deconvolution Psycophysiology 47, 647-658.
30. Jiménez, J. Sànchez D. And Sanchez A. Neuro characterization of emulsion sensory profile: use of electroencephalography (EEG) for evaluating pick-up, rub-out and after-feel, Sofw journal 142 44-53 (2016)
31. Wilson T. D. Strangers to ourselves: Discovering the adaptive unconscious, Belknap Press of Harvard University Press, Cambridge (2002).