Food Research International
Manuscript Draft

Manuscript Number: FOODRES-D-17-01316R1

Title: Neuromarketing Empirical Approaches And Food Choice: A Systematic Review

Article Type: SI: Virtual reality

Keywords: Neuromarketing; food decision making; neuroscientific techniques; consumer behaviour

Manuscript Region of Origin: ITALY

Abstract: Consumers' food choices are often driven by reasons that consumers are not fully aware of. Decision-making about food is influenced by a complex set of emotions, feelings, attitudes, and values that are impossible to assess simply by asking consumers their opinion. Indeed, traditional techniques such as self-reports or interviews allow to measure mainly conscious and rational reactions toward a product or advertising. In the last decades, there is a rapidly growing interest in the multidisciplinary field of the so called "neuromarketing", which takes advantage of neuroscientific techniques to study consumer behaviour.
This discipline applies neuroscientific methods and tools that allow to measure consumers' emotional and spontaneous reactions in a more objective and observable way. The aim of this paper is (a) to describe neuromarketing underlying assumptions, techniques, advantages of this perspective, examining the scientific literature about the use of neuromarketing in food studies, and (b) to suggest best practices to apply this novel approach in the food marketing domain, with a specific focus on not invasive methods.
Finally, although the perception of nutritional elements has been already explored, nevertheless health content of labels, the presence of additives, the evaluation of the information conveyed by food packaging are other possible elements of interest in future food neuromarketing research.

***Detailed Response to Reviewers**

Comments to referees

The review was conducted by following the precious suggestions of referees. Despite the minor revisions, a more careful explanation of the added value of the paper has been included. “This paper focuses on the evolution of the integration of neuroscience and food marketing by presenting an integrated cross-analysis of literature on food preferences and neuromarketing techniques. On the basis of the extensive review of theoretical and empirical studies in this field, we propose food choice and neuro-marketing as an integrated tool to increase consumers’ data variance into economic studies focussed on food preference analysis and choice prediction. In addition, the paper offers new knowledge by presenting a unique reference point for all the scholars working in this field that want to analyze the literature evolution about neuromarketing techniques in food choice experiments”.

Moreover, a deeper analysis of literature regarding the non-invasive neuromarketing tools has been included in order to better introduce the scientific ground of each technique.

A deeper discussion on the comparison between self report questionnaire and neuromarketing techiques has been included in the section of the concluding remarks.

- food choice and neuromarketing is increasingly integrated disciplines;
- food literature referring to neuromarketing through the empirical techniques;
- no studies in the field of food choices applying jointly more techniques;
- health information, additives and functionality as elements for further research;

NEUROMARKETING EMPIRICAL APPROACHES AND FOOD CHOICE: A SYSTEMATIC REVIEW

1.Abstract

Consumers' food choices are often driven by reasons that consumers are not fully aware of. Decision-making about food is influenced by a complex set of emotions, feelings, attitudes, and values that are impossible to assess simply by asking consumers their opinion. Indeed, traditional techniques such as self-reports or interviews allow to measure mainly conscious and rational reactions toward a product or advertising. In the last decades, there is a rapidly growing interest in the multidisciplinary field of the so called "neuromarketing", which takes advantage of neuroscientific techniques to study consumer behaviour.

This discipline applies neuroscientific methods and tools that allow to measure consumers' emotional and spontaneous reactions in a more objective and observable way. The aim of this paper is (a) to describe neuromarketing underlying assumptions, techniques, advantages of this perspective, examining the scientific literature about the use of neuromarketing in food studies, and (b) to suggest best practices to apply this novel approach in the food marketing domain, with a specific focus on not invasive methods.

Finally, although the perception of nutritional elements has been already explored, nevertheless health content of labels, the presence of additives, the evaluation of the information conveyed by food packaging are other possible elements of interest in future food neuromarketing research.

Keywords**: Neuromarketing; food decision making; neuroscientific techniques; consumer behaviour.**

2.Introduction

In order to understand the increasingly complex consumer decision-making and consumption environment, modern marketing scholars started to study drivers of consumers' purchasing decisions from a multidisciplinary perspective. The marketing discipline has considerably changed, adapting to the multidimensional view of consumers' preferences, by extending and enriching concepts, theories, and methodologies derived from disciplines such as psychology, sociology, anthropology, and, more recently, neuroscience. For instance, concepts such as emotions, prejudices, and values are becoming increasingly important as intrinsic factors to understand consumers' choices.

The term neuromarketing was initially introduced by a Dutch organizational theorist and marketing professor, Ale Smidts, in 2002, defining it as "the study of the cerebral mechanism to understand the consumer's behaviour in order to improve the marketing strategies" (Boricean, 2009).

One year later, in 2003, scientists took advantage of fMRI brain imaging techniques to study and understand consumers' preferences about common beverage products such as Coca-Cola and Pepsi (McClure et al., 2004). On one hand, interesting findings emerged from the study. On the other, the unsuccessful attempt to provide a complete clarification enabling to understand decision making in consumers, opened the way to the seeking of in-depth answers about this new research field. In the study, researchers asked to a group of American subjects to drink either Coca Cola or Pepsi while their brains were monitored by an fMRI machine. The study did show how some areas of subjects' brain may be differently activated according to the knowing or not about the name of brand they are consuming. In particular, it suggested that a well known brand as Coca-Cola can elicit an area of the prefrontal lobes, considered the place of executive function which manages attention, mediates short-term memory and cover an important role in decision making and planning (McClure et al., 2004). The study claims that when subjects do not know which brand they are consuming, they do report to prefer Pepsi, and the orbitofrontal cortex on the left hemisphere is more activated when tasting Pepsi in comparison to the situation where they are tasting Coca-Cola. On the opposite, when they know what they are drinking, subjects do report to prefer Coca-Cola over Pepsi, and their dorsolateral prefrontal cortex is activated in a greater way together with hippocampus in comparison to the situation where subjects drink Pepsi. The hippocampus is an old brain structure from an evolutionary standpoint. It is located in the limbic system (in the deep center of the brain) that is generally responsible of emotional and instinctual behavior. Since this study, new scientific articles appeared in the literature reporting the growing interest in neuromarketing, proposing both research directions and potential applications (Plassman et al., 2008), in the attempt to introduce these innovative techniques aside the traditional ones based on self-reports and interviews.

Despite the initial scepticism (Murphy et al., 2008), the application of neuroscientific concepts and techniques in marketing (i.e. neuromarketing) has rapidly grown over the past few years in both academics (Plassmann et al., 2012; Plassmann et al. 2010; Smidts et al., 2014; Yoon et al. 2012) and practice (e.g. Nielsen, GFK, Millward Brown) since the first study from McClure and his research team (2004).

This growing attention to neuromarketing in the past decade lead to an explosion of new insights and practical applications for the marketing domain. Plassmann (2012) showed the increasing of Google hits and publications about neuromarketing from 2004 (Figure 1), and in a more recent article she states that the adoption of a neuroscience-based approach "holds the promise of setting the stage for conceptual developments offering potentially evolutionary insights about consumers" (Plassmann, 2015). The present paper reviews the empirical approaches of neuromarketing with a specific focus on food analyses and non-invasive methods, considering the latter as ideal solutions in the field of food studies, as they are often carried out in the real places where people decides what to purchase, like for instance supermarkets or other food shops. This paper in fact, presents an integrated cross-analysis of literature on food preferences and neuromarketing techniques. On the basis of the extensive review of theoretical and empirical studies in this field, we propose food choice and neuro-marketing as increasingly integrated tool to increase consumers' data variance into economic studies focussed on food preference analysis and choice prediction. In addition, the paper offers new knowledge by presenting a unique reference point for all the scholars working in this field that want to apply neuromarketing techniques in food choice experiments.

>>>FIGURE ONE HERE<<<

Food choice is a very complex phenomenon, still not well understood. The study of food decision making could greatly benefit from neuromarketing techniques to investigate the processes involved in food decision making such as attitude and emotion influence on choices, which traditional segmentation variables, such as socio-demographics, psychometrics, and stated preferences do not cover.

There are many stimuli not directly related to the product that can drive consumers' food choices and purchase decisions, such as brightness (Milosavljevic et al., 2011), colours and shape of the packaging (Itti and Koch, 2001; Mannan et al., 2009), and price (Oliver, 1997; Peng and Wang, 2006; Cheng et al., 2008). In fact, a growing number of studies applied neuromarketing approach to investigate how the

subconscious and the emotional response to those features could influence consumers' preferences.

The present paper represents a first attempt to present the state of the art of the empirical approaches and techniques in neuromarketing research that can be effectively applied for studying consumers' food choice and that can help to advance the knowledge in this field. More specifically, this paper will first describe the link between neuroscience and consumer behaviour, highlighting the key elements of innovation of the neuromarketing approach. In the second part, we will focus on the different neuroscientific techniques that are suitable to investigate food decision-making, explaining them and reviewing the main studies available in scientific literature, with a specific focus on food studies carried out by means of less invasive methods in comparison to fMRI and PET techniques that require to ask participants to lay on a bed and stay still (not really the optimal experimental context to study food choices), such as: eye-tracking, electroencephalography, skin conductance monitoring and automatic emotional facial expressions recognition.

In the final part, main conclusions are drawn focusing on the current state of the art.

3.Consumers' behaviour and neuroscience

"Consumer Neuroscience is a new burgeoning field comprising academic research at the intersection of neuroscience, psychology, economics, decision theory, and marketing.'' (Plassmann et al., 2011). Many researchers have acknowledged that affect plays a guiding role for information processing (Clore et al., 1994; Mellers et al., 1999; Schwarz and Clore, 1988, Fortunato et al., 2014, Jordao et al., 2017). According to the same author (Plassmann et al, 2012), consumer neuroscience has the goal "to adapt methods and theories from neuroscience, in combination with behavioural theories, models and tested experimental designs from consumer psychology and related disciplines such as behavioural decision sciences, to develop a neurophysiologically sound theory to understand consumer behaviour". The distinction between consumer neuroscience and neuromarketing should be addressed to the application: consumer neuroscience refers to academic research at the intersection of neuroscience with consumer psychology, while neuromarketing refers to "pratictioner and commercial interest in neurophysiological tools such as eye-

tracking, skin conductance, electroencephalography (EEG) and functional magnetic resonance imaging (fMRI "to conduct company-specific market research". Making an additional exploration about food studies, in the opinion of the authors of the present paper it is strategic to respect the "ecological validity" of food related decision-making processes. For this reason, fMRI studies have been useful to understand which are the brain areas enrolled in decision-making process, and they can be proficiently applied for future research. However, the ability to develop solutions reducing at the minimum the presence about suboptimal or unnatural experimental settings will enable to carry on studies more prone to detect what is happening when the person is taking a decision. There are already reviews about the adequate use of different brain imaging techniques such as fMRI or MEG (Vecchiato et al., 2011), however such techniques imply that subjects should be exposed, in the experimental lab as the machines are quite big, to stimuli or situations that might be comparable to what is happening in real life situations. Althought data showed promising results about how these techniques can add useful information enabling to widen the understanding of consumer behaviour, it is now possible to envisage solutions that enable to detect and study emotional reactions "in vivo" rather than just within lab's walls. This factor can allow to study decision making processes about food in the place where decisions are actually taken. For this reason it is worthy to deepen the potential of neuromarketing not only as a consulting activity as mentioned by previous studies (Plassman et al., 2011), but also as an academic research activity. Due to the improvement of technology about portable solutions on one side, and thanks to the knowledge that is now available about which brain systems are more prone to be enrolled and reveal preferences and effective reactions, it is possible to explore the possibility to monitor specific biological activity within the central nervous system (e.g. brain waves activity by means of EEG), and in the peripheral nervous system, in particular regarding the branch of the autonomous nervous system (for instance, by means of the skin conductance monitoring)

As described above and further in this paper, the fMRI is the most popular brain imaging method adopted in consumer neuroscience and neuromarketing. This technique returns a sequence of brain images about the neuronal activity represented by the consumption of oxygen brought by the cerebral blood flow (Vecchiato et al., 2011). Even if the images are almost static (on average, each image represents the brain activity with a time window of 10 seconds), they provide a very high spatial

resolution that cannot be shown by any other brain imaging technique. It is well known that they can detect neuronal activation in a space of few cubic millimetres, and thus detect the enrolment of brain systems such amygdale or nucleus accumbens located in the deep brain and strongly correlated with emotional reactions (citations) and reward (citation). However, the lack of time resolution due to the slow blood flowing and the fact that subjects have to lay on a bed inside the tube of the machine make these technique less suitable for studying food choices in front of the shelves of a shop. There are other brain imaging techniques enabling to overcome the limits provided by fMRI, such as electroencephalography (EEG) and magnetoencefalography (MEG), which can provide a time resolution in terms of milliseconds (Vecchiato et al., 2011), although they EEG measures the cortical activity on the surface of the brain through the scalp, while the MEG can map the entire brain with a spatial precision of few cubic millimetres. The EEG detects the electrical activity of neuronal population (a group of many neurons), more or less in a squared centimetre, while the MEG records the magnetic field generated by neuronal population within few cubic millimetres. In a broad sense, the activity of neurons is generally represented by two states: being in a rest phase or during an action potential phase. Basically, the possibility to distinguish between the two states can inform if the neurons are not firing (rest state) either they are firing (conveying an action potential, an electrical impulse along the axon of the neuron that enables to excites other neurons or controlling metabolic changes, organ functions and muscles activation). The more neurons are enrolled in specific brain functions, the greater the number of action potentials (even several action potentials within a second). The number of action potentials provided by several or many neurons in the same area impacts both the electrical activity and the magnetic field detected respectively by EEG and MEG. However, MEG has again the problem that subjects have to stay in a very special laboratory (the walls are completely fill in of special materials to protect MEG signals from external interferences), sitting on a chair (that is a better position in comparison to laying on a bed, but still it is a different condition in comparison to when people is approaching a shelf) and wearing a sort of helmet equipped with the “iron squids” that enable to detect brain activation. Last but not least, the MEG technique takes advantage of liquid helium and uses special shielded structures aimed to monitor and record the tiny brain magnetic signals generated in terms of femtotesla. This technology, aside expert people with the skills to use properly the techniques, is very

expensive, a very general estimation might range from 400 up to 600 dollars per minute of usage. On the contrary, EEG devices are relatively inexpensive, robust, moreover even wearable by the subject, making such technique more interesting and adequate for evaluating marketing impacts played by food stimuli. Nowadays, many companies in the field of medical equipments are also trying to to simplify the use of EEG equipments for specific application in marketing. This is the reason why in the present paper EEG will be further exploited. FMRI and MEG techniques will be useful to further develop consumer neuroscience research, as they already provided useful insights enabling the implementation of neuromarketing solutions specific for food studies. In this vision, the EEG technique aimed to monitor activity from the CNS, might be coupled with other techniques. Such as, on one side, skin conductance monitoring, that reveals information controlled by subcortical areas such as amygdale (Bechara et al., 1995 and 1999), thus allowing to have an indirect measures of deep brain areas (directly monitored by fMRI and MEG). Or such as, on the other side, eye-tracking, that enables to convey information about visual attention.

Neuromarketing uses neuroscientific tools to analyse biological signals and biomedical images to evaluate physiological responses to communicative stimuli. It is considered a cutting-edge approach to analyse decision-making processes in which irrational, intuitive, heuristic, and affective processes play a key role (Bargh, 1997; Bechara, Damasio, and Damasio, 2000; Dijksterhuijs, 2004; Hassin et al., 2005; Kihlstrom, 1999; Ohme, 2009; Sayegh et al., 2004).

Neuromarketing provides a number of research techniques that can directly measure those aspects now considered crucial in the process of consumption such as attention, emotional response and memory, in terms of information storage.

Neuromarketing techniques gained importance over the last decade, mainly due several technological innovations and the new way to conceptualize consumer behaviour and decision making. Indeed, the now wide availability of advanced technologies allows detailed analysis of neurological and psycho-physiological parameters, both in the laboratory and in real life settings (e.g. supermarket). Furthermore, in recent decades emerged a new way of thinking and studying the decision maker, based on the acknowledgment that both the rational and the irrational dimensions (i.e. emotion and implicit attitudes) affect choices.

Purchase decisions are undoubtedly connected with emotional involvement with the brand. However, individual decisions, leading to a certain choice that determines behaviour, happen fast and often occur routinely without a complete rational control. Indeed, approximately ninety-five per cent of all cognitive processes take place unconsciously, in the "black box" of the mind. In other words, not more than five percent of cognitive processes happen consciously (Zaltman, 2003).

The questions that a company has to face are: how much is a product able to generate emotions? How strong are the connection and the emotional involvement between consumers and products/brand? How strong is the emotion generated by the product image and features, such as visual appearance (e.g. colour or shape), or sensorial attributes (e.g. odour, tactile features).

In contrast with a merely rationalistic of consumer choice models, which study cognitive processes from a logical-mathematical perspective based on the writings of Adam Smidth (Cătoiu, and Teodorescu, 2004), from the seventies onwards a new method to conceptualize decision making has been proposed, making a profound paradigm shift in the way scholars study consumers. This new approach originates from the pioneering work of Simon (1959), Petty and Cacioppo (1986), and Kahneman and Tversky (1979). These studies show the prevalence of an emotional dimension in the perception of stimuli. Moreover, they demonstrated that cognitive processes and emotional processes are not mutually exclusive, but instead should be considered as two distinct and interacting mental functions, mediated by quite distinct, but interacting brain systems.

This idea has been further demonstrated by LeDoux (1998), who highlighted that the cognitive system is characterized by the activation of the cortical zone, starting with a slow and high energy demanding process, followed by a second faster process, relevant to survival, connected to the most ancestral part of our brain, the thalamic area. Also the studies from Damasio (Rainville et al., 2005; Damasio et al., 2000) showed the presence of cortical and subcortical processing in matter of affective states, enabling to understand why decision making processes can be affected by the interplay of the two systems.

Expected emotion is associated with directly preceding factors, a basic determinant of which is integral affect (other mediating factors are decision behaviour and expected consequences). This key role for integral affect suggests that it is directly

relevant in decision processes (Kahneman et al., 1997; Lichtenstein and Slovic, 2006; Loewenstein and Lerner, 2003).

Neuromarketing helps to gather useful data to predict consumer behaviour and allows a more adequate assessment of the effects of communication. Indeed, several studies have demonstrated the effectiveness of neuromarketing in predicting behaviour compared to the traditional techniques based on subjects' declarations. For instance, Berns and Moore (2011) showed how the measurements by means of fMRI about the orbitofrontal cortex and ventral striatum successfully correlate with songs from largely unknown artists that earned the greatest popularity in terms of sales. In the same study, subjects were asked to rate their level of liking about the song listened for the first 15 seconds. The interesting finding is that the subjective likability rated by means of self-reports about the song was not able to positively correlate with its level of success in terms of sales (likability: $R=0.110$, $p=0.313$; familiarity: $R=0.106$, $p=0.330$). Thus, neuromarketing is emerging as a valid method complementing the traditional approach. In another research article (Venkatraman et al., 2014), applying a unique protocol to evaluate responses to TV ads, authors recorded many measures about advertising effectiveness across six methods: traditional self-reports, implicit measures, eye-tracking, biometrics, electroencephalography, and fMRI. In study 1), 189 subjects are exposed to TV ads and then they are asked to fill in self-reports about their level of linking, together with an Implicit Association Test to assess their memorization and their emotional impact. In study 2) they enrol 29 participants, who are exposed to TV ads while eye-tracking and psychophysiological signals (skin conductance, heart rate and respiration) are recorded; in study 3), 29 participants were exposed to same protocol used in previous study, this time an fMRI machine was monitoring their brain activities while watching TV ads: finally, in study 4), 29 subject were exposed to same TV ads while high resolution EEG was monitoring their brain waves activities. "These measures have been shown to reliably tap into higher-level constructs commonly used in advertising research: attention, affect, memory, and desirability. Using time- series data on sales and gross rating points, the authors attempt to relate individual-level response to television ads in the lab to the ads' aggregate, market-level elasticities". The authors show how fMRI outputs explain the most variance in advertising elasticities in comparison to traditional measures. In particular (once again), "activity in the ventral striatum is the strongest predictor of real-world, market-level response to advertising". In conclusion, authors report that

findings clearly demonstrate the importance of contributes provided by neurophysiological measures aside traditional ones, not only from fMRI but also from EEG. There are many examples showing how EEG measures can be applied to study food choices, less in real life situations, that is Furthermore, it can add value and objectivity to marketing studies, since this method offers the possibility to directly measure emotions during decisional processes and the reactions toward advertising stimuli, even if consumers are not aware of those emotions and reactions (Bechara et al., 2000; Damasio, 1994; Kenning et al., 2007; Posner, 2004; Smith, & Gevins, 2000).

4.Neuromarketing of taste: the role of information and contextual elements

Consumer decisions during food purchases are influenced by a number of variables that go beyond the sensory food attributes (e.g. taste, smell). Eating is part of a basic and primitive behaviour connected to survival, but it is also grounded on hedonistic impulses and psychological mechanisms. Our subconscious associates certain food with pleasure and happiness, but in other cases with fear.

Packaging, communication, and product displays play a major role in influencing consumers' emotional states, and thus food purchasing choices. Nowadays, consumers have a wide variety of alternatives within a single food category and for this reason they need to have additional information in order to make a choice. Therefore, labels and other information generated by brands or advertising are essential to increase the level of attention for a product, which subsequently will increase the chances that the product will be chosen (Arcia et al. 2012).

There are numerous neuroscientific studies investigating the relationship among communication, perception, and satisfaction experienced by consumers. Most of these are focused on packaging, since it plays a decisive role in the process of development of perceptions. In fact, through the packaging consumers can receive several kind of information: recognition of the brand, information about an unknown product, (dis)confirmation of expected information (Van der Laan et al., 2012).

A recent eye-tracking study conducted by Ares et al. (2013a) involved 53 consumers who were asked to rate their perception of authenticity of three different foods (mayonnaise, bread and yogurt) and express their willingness to buy for each product. Results showed that the three most observed areas in order to judge the authenticity of a product were primarily the brand, followed by the list of ingredients,

and the nutritional information. As for the willingness to buy, the areas that participants focused on were, in order of importance, the ingredients, the nutritional information, and the brand name.

Another study by Milosavljevic et al. (2011) showed that salient features such as brightness and vividness of the product packages are able to influence purchase decisions. Indeed, these visual features led the participants to choose certain food products, even when they preferred the taste of other products. These results were confirmed by other studies that applied eye tracking methodology, which have highlighted how visual attributes such as brightness, colour, or shape are able to alter consumers' visual behaviour while watching a shelf or a vending machine (Itti and Koch, 2001; Mannan et. al., 2009).

Another interesting work is made from by Venkatraman et al. (2015). The authors analyzed different sectors. More specifically they analysed 186 subjects with self-report scales, and a modified version of the IAT (implicit grading and implicit memory of the spots), 29 participants: eye-tracker and psycho-physiological signals during commercial viewing, FMRI scan, EEG. The data for each measurement has been included in a prediction model of "advertising elasticity" (percentage change in sales due to 1% change in the degree of advertising effectiveness used). They demonstrate that neurophysiological methods explain "advertising elasticity" better than traditional measures alone. They also emphasize the effectiveness of the integration of the two approaches, highlighting the correlation between the measurements found within the laboratory and the concrete findings on the market.

Many other studies have attempted to investigate how product information influence product expectations, and, as a consequence, affect the quality of the hedonic experiences. These experiments were usually conducted comparing different experimental conditions: (1) "blind" condition, in which the consumers are not exposed to any information about the product, so they simply taste the food and evaluate it solely on the basis of sensory characteristics; (2) "visual" condition, where the participants do not taste the product, but assess the level of satisfaction on the basis of written and/or visual information; (3) "complete information" condition, in which the participant evaluates the product after tasting and seeing it.

This approach has been used in several studies in the scientific literature, aimed to investigate the effects on consumer satisfaction of the following aspects:

a) Information regarding the nutritional and health properties of products (Saba et al., 2010);

b) Geographical origin of the products (Caporale and Monteleone, 2001; Caporale et al., 2006; Stefani et al., 2006); information about the brand (Di Monaco et al., 2004; Lange et al., 2002);

c) Pricing information (Ares et al., 2010).

All these studies have shown that the quality of the product can be influenced by the expectations arising from information provided through the packaging or through the pricing.

5.Application of Neuromarketing tools in the food and beverage sector

In this part we will discuss several neuromarketing technologies that have been useful in studying food and beverage marketing. The advertising industry, in many instances led by food and beverage marketers, is purposefully exploiting the special relationship that teenagers have with new media, with online marketing campaigns that create unprecedented intimacies between adolescents and the brands and products that now literally surround them (Montgomery and Chester, 2009).

The application of neuroimaging methods to product marketing — neuromarketing — has recently gained considerable popularity. We propose that there are two main reasons for this trend. First, the possibility that neuroimaging will become cheaper and faster than other marketing methods; and second, the hope that neuroimaging will provide marketers with information that is not obtainable through conventional marketing methods (Ariely and Berns, 2010).

We will provide an overview of the successful methodologies, describing studies that applied those techniques, and explaining how they can be used to extend our knowledge on food and beverages marketing and communication. The tools that we will discuss are (a) Eye-Tracker, (b) EEG, (c) GSR, and (4) FR. The combination and simultaneous application of these techniques might allow to study food decision-making process "in vivo", where the decisions are taken (as for instance in front of shelves):

5.1Eye-tracking

An Eye-Tracker is a device used to determine point-of-regard, measuring eye movements and visual attention.

Eye movements comprise fixations and saccades (Velásquez, 2013). The first are moments during which the eye remains relatively still on an object for about 200–300 ms which allows people to visualize all details of the object. Saccades are the eye movements between two fixations, lasting from 40 to 50 ms, which represents the fastest valuable movement in the human body (Wedel and Pieters, 2008; Nielsen and

Pernice, 2009). Visual information is collected during fixations, whereas during saccades vision is suppressed (Rayner, 1998; Pertzob et al., 2009). Eye movements allow people to shift the position of the highest resolution part of the retina, called fovea, to that part of the visual stimulus that a person wants to process in detail.

Eye-Tracker technology measures the eye movements (fixations and saccades) in relation to the position of the head, determining precisely where the users' attention is directed to. It allows researchers to identify where users are looking at, for instance on a computer screen or a shelf in the supermarket. Eye movements recording is objective and provides high temporal and spatial information accuracy (Chae and Lee, 2013; Zurawicki, 2010; Duchowski, 2003).

Furthermore, it is possible to detect pupil dilation which is an index of interest for the stimulus (Hess, 1975; Seeber, & Kerzel, 2011), and number of blinks, that indicates the emotional valence of the stimulus (Lang, 1995; Lang et al., 1998; Dunning et al., 2010).

Eye-Tracker systems are available as remote systems embedded in the computer display (figure1), as well as wearable and wireless system integrated in glasses (figure 2). The glasses make the measuring process less intrusive and allow research in real life environment, as people can walk in a shop, stand in front of the shelve in a supermarket or in a restaurant or performing different daily activities as reading a magazine, using products or tasting foods.

.

>>>FIGURE TWO HERE<<<

The Eye-Tracking methodology is based on the "eye-mind" hypothesis, which asserts that what individuals are looking at reflects the cognitive processes taking place in their minds (Hoffman, 1998; Hoffman and Subramaniam, 1995). Furthermore, this hypothesis claims that eye movements provide objective information about where a person's attention is directed to (Hoffman and Subramaniam, 1995; Spence and Driver, 2004).

According to Russo (1978), eye movements can be considered good behavioural indices to measure visual attention because they are closely related to higher-order cognitive processes. Since last century, marketing scholars and practitioners have been using eye-tracker technology to study consumers' visual behaviour for decades.

Nowadays eye-tracking methodology is widespread in consumer behaviour studies, including food packaging analysis (e.g. Pieters et al., 2002; Reutskaja et al., 2011; Bialkova van Trijp, 2011; van Herpen and van Trijp, 2011; Graham et al. 2012; Antúnez et al., 2013; Ares et al., 2013; Piqueras-Fiszman et al., 2013; Gofman et al., 2009; Marchini et al. 2016).

It is well known that food purchase decisions are influenced by a number of factors that go beyond taste. Today consumers have a wide variety of alternatives in the same product category. Therefore, consumers need additional information to make their purchases decisions. Basically labels or, more generally, communication implemented by the brand, are essential to attract customers' attention and to provide information that can guide their choices (Arcia et al., 2012).

Another area of application of eye-tracker technology is the study of the influence of marketing communication on the perception of taste, and consequently on consumer satisfaction. Most of these studies are focused on packaging, because it has a decisive role in the perception and expectations about a product (Ares and Deliza, 2010; Mizutani et. al, 2012; Moskowitz et al., 2009; Crilly et al., 2004; Fenko et al., 2010; Murray and Delahunty, 2000)..

Traditionally, packaging was studied based on consumers self-reports questionnaires, interviews or focus group. However, these techniques allow to measure only what the consumer is aware of and willing to declare (Jacoby et al. 1992; Greenwald and Banaji, 1995). Visual processes, instead, are not completely conscious. Therefore, eye-tracking research is very suitable to obtain objective information about food packaging.

In a recent study, Vidal and colleagues (Vidal et al., 2013) asked to a group of participants to rate the healthiness of yogurt labels while their eye movements were recorded. Results showed that the only attribute that affected perceived healthiness was fat content. A similar study, conducted by Orquin and Scholderer (2011) using five different yogurts, revealed that the only feature that had in impact on the perception of healthiness of the yogurts was the nutrition label. The only information used to evaluate the purchase intention, were the product name and the nutrition label.

Van Herpen and Van Trijp (2011) conducted an eye tracking study aimed to test consumer attention on three different nutrition labelling schemes, while consumers faced different goals. In particular, during a healthy choice task, they demonstrated that traffic-light labels and logos are very effective in fostering healthy decisions.

Ares et al. (2014), conducted a study with the eye-tracking technology to evaluate the influence of rational and intuitive thinking style on consumer choices when evaluating yogurt labels.

They found that people who rely most on rational thinking engaged on a greater search and analysis of nutritional information for the choice. This study highlighted the importance of thinking approach on people food choices and the results are very useful to improve the food packaging to increase the sales.

Similarly, Visschers et al. (2010), studied visual attention on nutrition information of food packages, comparing consumers with either a health motivation or a taste motivation. Participants motivated by a healthy lifestyle focused more attention on nutritional information in comparison to the taste motivation group, who spent more time on other information.

Furthermore, Graham and Jeffery (2012) found that participants looked longer at labels of food products such as pizza, soup, and yogurt in comparison with vegetables, fruit, snacks and desserts. Moreover, researchers demonstrated that eye fixations and food decisions are related, since participants spent more time watching product labels of the food that they decided to buy.

Several studies have been conducted focusing on packaging features.

For example, Piquera-Fiszman et al. (2013) conducted an eye-tracking study aimed to determine how different packaging attributes for a specific jam brand draw attention. This study demonstrated that the pictures on packaging label and the shape of jam jar influenced consumers' willingness to buy the product.

Koenigstorfer et al., 2014, investigated the role of nutrition information on decision-making, founding that the way in which the nutrition information are presented can affect both visual attention and the tendency to make healthy choices.

Bialkova et al., 2014, have integrated eye tracker technology to investigate the role of visual attention on product nutrition labels on subsequent choice. They also studied how the colour (black and white vs. coloured GDA label) of this information influences the visual attention.

Results showed that products with color-coded GDAs were fixated longer than products with monochrome GDAs. Moreover, participants' choices were affected by the attention-getting property of the label (irrespective of brand and flavor effects). These results suggest that attention mediates the effect of nutrition labels on choice.

The study of Rebollar et al. (2014) clearly identified two different basic viewing patterns on packaging. The authors gave 127 volunteers the same chocolate snack, but they handed out three packages differing in layout. The information on all the three packages was exactly the same, but displayed in different areas of the packaging itself. The experimenters identified a visual scanning pattern of the packaging with a sequence based on the importance of the design elements and a tendency to start the viewing from the top left area, related to the western reading system. When the most important design elements were displayed in the top left part of the packaging, the effect was amplified and the path of visualization of the users was predictable.

About packaging information position, Graham and Jefferey (2011) noted that consumers spend over 30% more time viewing a nutrition label which is positioned central on a package than those placed on the sides. Further, they showed that label information displayed at the bottom of the label were viewed more than information placed at the top.

Another study showed that salient features such as brightness of the packaging are able to influence food purchase decisions, even when consumers preferred the taste of other alternative products (Milosavljevic *et al*., 2011).

The importance of saliency was also explored by Orquin et al. (2012). The researchers demonstrated that the less visual salient is the nutrition label, the more time passes before the subjects see it for the first time.

The authors argue that increase the saliency of nutrition information is a strategy to make subjects look at them immediately.

Goldberg et al. (1999) evaluated the ability of food nutrition labels to stimulate a rapid and accurate visual search for nutrition information, finding that information written in the centre of the label are harder to find that the ones at the bottom or the top. With a similar aim, Antunez et al. (2013), studied the communicative effectiveness of three coloured (red, orange, green) indicators regarding the salt content of different types of bread, to capture visual attention and convey the correct information. They concluded that this traffic light system focalized participants' attention, but it was not able to correctly communicate the amount of salt in the bread. Similarly, a study from Jones and Richardson (2007) examined the effectiveness of two types of nutrition labels, founding that a traffic light on the label was more effective in communicate the healthiness of food than a standard label.

In conclusion, eye tracking research on food labelling confirmed the usefulness of this methodology as a viable alternative to study the visual behaviour of consumers on the packaging, in particular in the field of food packaging (Wedel and Pieters, 2008). With eye-tracking could be possible explore several aspects related to the packaging. Exploring which are the most important information in general and how they are used differently by different target. With Eye-Tracking is possible to improve the layout of packaging and the effectiveness of information communication. The decision making could be analysed and improved too.

5.2 Electroencephalography (EEG)

Among the instruments employed in neuromarketing research, the most common techniques are the functional magnetic resonance (fMRI), and the ElectroEncephaloGram (EEG). The first one measures the metabolic activity in the brain through the observation of the hemodynamic response (BOLD signal, Detre, & Floyd, 2000) correlated to neuronal activity.

The fMRI has a good spatial resolution (about 1-2 millimeters), These advantages led to a wide use of the fMRI in the past years in research about decision making process to identify the areas involved in the choices, correlating the activation of specific cortical areas to consumers' preferences (e.g. Deppe et al., 2005; Schaefer, & Routes, 2007a).

One relevant study by Plassmann and colleagues (Plassmann, O'Doherty, Shiv, & Rangel, 2007), demonstrated the impact of the price on the product evaluation. With an fMRI scan during wine tasting, the authors found an increased activation of the orbitofrontal cortex when the same wine was presented with a higher price compared to the original.

The fMRI has some limitations. Indeed, the equipment is very expensive (Ariely, & Berns, 2010; Plassmann et al., 2012) and the time resolution is low (2-5 seconds). Moreover, the scan can be annoying for the subject, who must remain still lying down in a noisy machine (Zurawicki, 2010), and data processing requires complex analyses (Kenning et al. 2007; Plassmann et al., 2012; Savoy, 2005). Last but not least, The knowledge already collected by previous studies conducted with fMRI and other similar technologies (such as PET and MEG) are allowing to take advantage of more portable solutions such as electroencephalography (Vecchiato et al., 2011) in

experimental situations where it is important to rely on less invasive solutions like food studies. The EEG measures the cortical activation consumers, through the detection of cortical electrical activity by means of an ElectroEncephaloGram (EEG) with electrodes placed along the surface of the scalp according to the International System (SI) 10-20 (Cacioppo et al., 2000; Jasper, 1958), which represents the common reference system (Figure 3).

<<<FIGURE THREE HERE>>>

The EEG-signal measures the activity of brain areas revealing the state of cortical activation of the subject. The signal is composed of five brain waves each characterized by different frequencies and amplitudes, reflecting different cognitive states.

Although the spatial resolution appears modest and the EEG is able to detect only the superficial cortical activity (Zurawicki, 2010), there are several advantages in using EEG. First, the EEG signal has a high temporal resolution in sub-millisecond, (Huettel et al., 2004), which allows to accurately detect changes in brain activity due to rapid changes of stimuli. Moreover, the EEG setup is less expensive and less intrusive compared to other neuroscientific brain techniques such as fMRI which have a greater spatial resolution (Ariely and Berns, 2010; Plassmann et al., 2012). Indeed, neuroimaging techniques require the subject to lay still inside a noisy machine (Zurawicki, 2010).

Further, EEG has fewer constraints regarding experimental design and the signal can be registered through portable technologies employable even outside the laboratory.

The EEG was used in studies on marketing stimuli to measure different aspects consumers' responses, such their involvement (Swartz, 1998), their processing of television commercials (Rotshild et al., 1986), and to predict if advertisements will be remembered (Rothschild and Hyun, 1990).

The EEG index that is most often used in the field of neuromarketing is the cortical asymmetry in frontal alpha band. The underlying principle is the lateralization of brain functions, and particularly the selective activation of the left(right) part of the cerebral cortex in response to positive (negative) stimuli (Davidson et al., 1979).

Indeed, the left part of the frontal cortex is part of a circuit involved in the experience of positive emotions, which lead to a tendency of approach toward stimuli perceived as desirable, while the corresponding area on the right is an important component of the circuit involved in the processing of negative emotion and in defensive withdrawal toward stimuli (Davidson, 2000; Davidson, 2004).

Several scholars collected empirical evidence to support the principle of lateralization, both in adults and in children (Davidson, 1993a; 1993b; Davidson and Rickman, 1999; Fox, 1991).

The evaluation of the relative activation of left frontal hemisphere compared to the right one is based on the power of the alpha waves (8-13 Hz), inversely related to cortical activation (Cook et al., 1998; Laufs, Kleinschmidt, et al., 2003; Laufs, Krakow, et al., 2003). In other words, if the power of alpha waves is higher in the right side of the frontal cortex than in the left side, cortical activation is lower in the right part.

A decrease in the alpha power ("alpha inhibition") in a particular brain region indicates a greater cortical activation (Allen et al., 2004; Davidson, 1998; Pfurtscheller et al., 1996). The asymmetry in the alpha band (FAA, frontal Alpha Asymmetry) is computed as the difference between the power in the frequency band in the left and right frontal hemispheres respectively. Thus a positive value of the FAA index is interpreted as a greater activation of left than right hemisphere.

Nowadays FAA is widely accepted as an index of approach-withdrawal tendency toward the stimulus (Berkman and Lieberman, 2010; Carver and Harmon-Jones, 2009; Davidson et al., 1990; Harmon-Jones et al., 2010; Price et al., 2012; Rutherford and Lindell, 2011) and it is broadly employed in neuromarketing research.

One of the marketing areas that benefited the most from the application of FAA is advertising. For instance, Vecchiato et al., (2010; 2011), found a correlation between FAA while watching TV commercials and evaluations expressed by the participants.

Ohme and colleagues (Ohme et al., 2010; Ohme, Reykowska, Wiener, Choromanska, 2009 and 2010) used FAA as an indicator of the tendency to approach the product while watching different versions of the same TV advertisement, identifying the most emotional scenes.

Next to advertising, also the field of food decision-making and consumption, has employed the FAA index in order investigate products attractiveness, especially focusing on different olfactory aromas.

Kline et al. (2000) measured the activation of the frontal lobe while consumers had to smell different odours (pleasant: vanilla, unpleasant: valerian, neutral: plain water). Vanilla aroma, which is the most pleasant odour, induced significantly greater relative left-hemispheric activation compared to the other three odours.

Similar results were found by Sanders et al., 2002, who found a greater relative left-frontal activity for lavender versus baseline, but not for rosemary.

Emotions elicited during tasting can also be monitored via EEG. However, in the literature studies using the asymmetry index to characterize food consumption experience are scares

For instance, Park and colleagues (Park et al., 2011) detected electrical activity during the tasting of different foods and found that patterns of recorded cortical activation were dissimilar for different emotions elicited by the taste (positive, negative, neutral). Moreover, the patterns were analogous to those elicited by thinking of the taste of those three 'tastes.

Yagyu et al. (1998) found a significant difference between the prefrontal left and right activation due to the flavour of the food tasted by the participants.

In particular, the authors compared the effect of two kind of chewing gum (i.e. with or without sugar) on the perception of pleasure and cerebral activation of the subjects.

They found a shift of alpha waves to the right anterior area resulting in a positive FAA index (approach tendency) during the tasting of the sugar-containing chewing gum. Conversely, during the tasting of a sugar-free one, there was a shift of the alpha waves to the left, reflected by a negative FAA that indicates withdrawal motivation. These results were consistent with the self-reported evaluation filled out by the subjects.

Brown and colleagues (Brown et al., 2012) investigated the influence of price and brand familiarity on purchasing decisions through the recording of cortical activity. They detected activation in the frontal lobe during the tasting of two drinks (one private-label brand and one manufacturer label brand) and computed the frontal asymmetry in the alpha band.

The results showed a greater activation of the left frontal lobe, which reflected a greater liking for branded industrial products than for private labels, probably due to the fact that they are more familiar with the fist kind of product ("mere-exposure effect", Zajonc, 1968).

In summary, the frontal asymmetry index is an effective indicator of the tendency of individuals to approach or avoidance withdraw a stimulus and it proved to predictor of preferences and purchasing decisions of consumers (Ravaja et al., 2013). Nevertheless, FAA is still not often used to assess consumer reactions during the tasting of food.

For these reasons an interesting future direction for research is the deepening of the knowledge about food experience through the application of this index within the food and beverage studies.

5.3 Skin conductance and food studies

The skin conductance (SC) detection is one of the oldest psychophysiological measurements, firstly explored in the 19th century (Schwartz and Andasik, 2003). SC has been recently applied in neuromarketing research and there is a growing interest in this technique due to increased availability of affordable portable SC devices enabling SC research outside the laboratory for instance in a store.

The skin conductance level (SCL) is determined by the activity of the sweating glands of the skin, which are controlled by the Sympathetic branch (Boucsein, 1992) of the Autonomic Nervous System (ANS). The understanding about the neural bases of SCL have come from brain injuries studies, electrical stimulation and functional imaging. Impaired SCL is shown in subjects with brain lesions in the right hemisphere (Oscar-Berman and Gade, 1979; Zoccolotti et al., 1982) and in the bilateral ventromedial prefrontal cortex, bilateral anterior cingulate gyrus, right inferior parietal lobes (Tranel and Damasio, 1995) and amygdala (Bechara et al., 1995 and 1999). SCL responses can be elicited by electrical stimulation of amygdala, hippocampus, anterior cingulated and frontal cortex (Mangina and Beuzeron-Mangina, 1996). Positive correlation about SCL and ventromedial prefrontal cortex experiencing risk and reinforcement are shown in functional imaging studies (Critchley et al., 2000). The importance of SCL as a robust indicator of arousal includes effects on emotion and cognition. James (1984) proposed that the autonomic activity is the main factor to explain the origin of emotions, as the subjective "feelings" are simply an interpretation about the perception of visceral responses. Damasio's "somatic marker hypothesis" (Damasio et al. 1991; Damasio, 1994)

suggests that arousal, in addition to generating feelings, might bias social behaviour and decision making.

The ANS regulates involuntary and unconscious actions such as breathing, digestion, heartbeats, and internal-organ functions (Blakeslee and Blakeslee, 2008). The ANS operates by means of Sympathetic and Parasympathetic nervous system activity. The first activates the organs (heart, sweating glands, lungs, viscera, etc.), while the second deactivates them. Sympathetic nervous system is a set of "accelerators" enabling humans (and animals) to have a "fight or flight response", that takes place when humans perceive a threat such as a harmful event or an attack. The ANS will automatically trigger a set of physiological reactions aimed to cope with the treat either by attacking (fight) or simply by escaping from it (flight response). For instance, increased heart beats and lung ventilation, the organism will have more oxygen in the blood and more blood will be pumped into the muscles to support the behaviours for attacking the threatening stimulus or to compensate the energy lost by of running away.

The parasympathetic branch, on the other hand, is a set of "brakes" that stimulate the body to return to homeostasis after the "fight or flight response". Amongst other reactions, it decreases the heartbeat and lung rhythm, for this reason it is also called the "rest and digest system", as its main activities are related to manage the organism functions while it is resting or digesting.

The "fight or flight response" increases the sweating glands activation in order to cool the body while a person is fighting or running away. Enhanced sweating glands activity enables the body to decrease the body temperature raised by the motor actions. A decreased SCL, reflected by diminishing the sweating glands activities, corresponds to an increase of body temperature. This is a central physiological function executed by sweating glands for survival. This is why SCL changes during relaxation versus a stressful event (Lang, 1995; Mauri et al., 2010), as well as during different emotional states (Sequeira, 2009; Bradley et al., 1996) as illustrated by the "Fight or Flight Theory" (Porges, 2001).

The SCL measurement has been used in ample of studies in many different fields such as psychology, neuroscience, physiology, and technology.

The SCL is measured by a sensor, generally by two electrodes in the form of patch placed on the palm of one hand or by two small velcro rings (figure 4) placed on the index and middle finger.

Sweat is composed out of a salty water solution enabling electric current to flow through.

The two electrodes work as two poles of an electric charge. The sensor elicits a very small electric current (that cannot be perceived by human subjects) from one of the two electrodes, which is captured by the other one. The body is a sort of "resistance": if the skin is dry, the "resistance" increases as the electric current flows less easily through the body. On the opposite side, when the skin sweats, the resistance reduces as the electric current flows much easier through the body. This is the reason why the SCL has also different labels and nouns, such as electro-dermal activity (EDA), skin conductance (SC) that is the reversal of skin resistance (SR), or such as galvanic skin response (GSR).

Figure 4 shows a picture of the SCL two-sensors placed on a human hand.

>>>FIGURE FOUR HERE<<<

The unit to express SCL is micro-Siemens or micro-Ohms. In a broad sense, the increase of SCL corresponds to a higher conductivity of the skin related to a higher presence of sweat in the skin, that is determined by an augmentation of sweating gland activity controlled by the sympathetic branch of the ANS. In this perspective, the SCL is an indicator of arousal (Ravaja, 2004; Bolls et al., 2001; Lang, 1995), as it is usually suggested to measure levels of arousal rather than emotion valence (Bradley et al, 1996; Critchley et al., 2000).

In the field of consumer behaviour there are some studies showing how SC can be helpful in understanding consumer reactions.

Recently, Neuro-economics (Rustichini, 2005) and Neuromarketing (Lee et al., 2006) are using SCL in order to assess emotional responses in purchase and decision-making processes.

The measurement of SCL has been applied in different research studies in marketing in order to assess different process in consumers' reactions. For instance, Walla et al. (2011) showed how the use of skin conductance can reveal the preference of certain brands over other ones. In another study SC was to determine which colours are more arousing (Wilson, 1966).

The SCL has been used not only to determine whether pictures (Lang et al., 1995) or videos (Vecchiato et al., 2010) could be less or more arousing, but also in food

research. In this field, there are a few studies exploring how SC can convey information about consumers' reactions. For instance, de Wijk et al. (2014) showed how the skin conductance can be efficiently applied to explore the effects of repetitive exposure to one trial of food consumption (breakfast drinks). In the study, SCL was positively correlating with gender, type of beverage, and amount of repetitive exposure. In another study (Nederkoorn, 2000), SCL has been shown to significantly change during the food consumption experience, while it reduced after food intake.

de Wijk and colleagues (2012) explored the use of skin conductance in relation with pleasant and unpleasant food types. For each participant three pleasant food types and three unpleasant ones were selected and then used in the experimental setting, while different psychophysiological measures were monitored. The experimental protocol was divided into 3 phases. In the first phase subjects were just watching the different types of food; in the second phase the subject smelled the food types; and the third phase participants tasted the different food types. SCL showed a significant across the phases of the experimental situation (vision, smell or tasting), with lower values during vision, and higher values while smelling and tasting.

Wijk and colleagues concluded that the psychophysiological techniques were able to provide information about food preferences that traditional techniques based on food sample rated by means of explicit self-reports could not detect.

More recently, Danner (2014) tested different juice drinks using classic self-reports scales, skin conductance, and facial expressions. Results showed positive correlations between facial expressions and SCL on one side, and between ANS responses and self-reports on the other side. In particular, the SCL of certain juices correlated positively with the intensity of facial expressions.

Overall the scientific literature presents different evidences about how the use of psychophysiological measurements such as SCL might be useful to study the ANS responses integrated with traditional and cognitive self-reports, and how consumer psychology can benefit from the contribute of neuromarketing methods and suggestions.

5.4Face reading technology

Facial expressions are reliable indicators of the emotional state (Russell, 1994), as specific facial expression have been identified for six basic emotions (Ekmann & Friesen, 1971).

Nowadays, it is possible to operate facial expression decoding automatically through a software (Face Reader). This tool is based on the FACS (Facial Action Coding System), a manual for the facial expression coding, released by Paul Ekmann (Ekmann & Friesen, 1971), the world pioneer and expert in scientific research about facial expressions. The software records users' faces through a webcam and codifies the facial muscles movements on the basis of the 44 Action Unit (AU) identified by Ekman. AUs are contraction or relaxation of one or more muscles and there are thousands of combinations that allow to identify different emotions.

From a theoretical standpoint, emotional facial expressions are considered as an evolutionary heritage that allowed the possibility to refine the "fight or flight" response within the members of the same species. The Polivagal theory proposed by Porges (Porges, 1995; and 2000) enables to explain the behavioral social responses of humans (where emotional facial expressions play a crucial role) in terms of the psychophysiological evolution of the autonomous nervous system (in particular about the vagal nerve, as the branches of the vagal nerve serve different evolutoinay stress response in mammals). According to the theory of evolution on the bases of neuroanatomical comparative studies across different species, the ANS is changed along 3 different global stages. In the first stage, labeled "visceral vagus", the vagus is just "visceral", as it does not have the myelin folder yet (myelin folder speeds up the action potential along the axon of neurons, thus increasing the rapidity of responses provided by the nervous system - that is an indication how it is quite antique from a fologenetic point of view), it supports and regulates the digestion processes, it responds to threats by means of suppressing the metabolic activity of autonomic processes, and it immobilizes the organism in terms of behavior (e.g., in rats, feigning death). The second stage, named as "sympathetic vagus", the vagus nerve develops the "sympathetic response": it still does not have the myelin folder (revealing once again how it is still quite antique as response system), however it mobilizes and regulates the "fight or flight" behaviors; it responds to threats by means of increasing the metabolic activity of autonomic processes; it is a sort of "new response" in comparison the first one as it activates the organism for a pronpt reaction and simultaneously decreases the visceral response. The third stage is called "the myelin

valgus": in this stage, the vagus nerve develops a faster "sympathetic response", and links to cranial nerves for social behavior responses (emotional facial expressions included); it now does have a myelin folder (an indication that is a new system from a philogenetic standpoint), it elicits and regulates the "fight or flight" behaviors by means of cardio-respiratory quick changes on one side and facial expression and vocalization on the other side; it responds to threats by means of quick increasing the metabolic activity of autonomic processes; it is the most recent response, as it activates the organism in a more articulated way (in comparison to the second stage) and simultaneously deactivates the "visceral response". The parallel changes along the 3 steps enrolled other structures, like the connections of the ANS with the other brain systems, the hypothalamic-pituitary-surrenalway, the neuropeptides of ossitocin and vasopressin and the immunitarysystem. As the emotional facial expressions can now be decoded automatically by sfotwares, they become a very important source of information in food studies.

Generally, the software mechanism starts with the classification of the facial reactions by estimating the probability that the face is showing one of the six basic emotion categorized by Ekman in a specific moment (with a 0 to 1 scale) and by indicating the value of the response, (positive or negative) based on the specific emotion conveyed by the face.

Facial expressions are a good source of information in the study of taste-elicited affect in humans. For instance, they have been used to study newborns' reaction to different tastes stimuli (Steiner 1973, 1977, 1979; Rosenstein and Oster, 1988, 1997).

More recently, Greimel et al. (2006) applied FACS techniques in food experience. In this study, the researchers exposed participants to different tastes. Then, following a baseline period, participants were presented with the same taste after the watching of a video clip taken from a movie inducing joy or sadness.

The results strongly indicated that the tastes produced specific facial reactions, not affected by participants' mood. Indeed, induced emotions modulated taste ratings, but not facial reactions to tastes.

The results of Weiland *et al.* (2010) confirmed the existence of specific taste-elicited facial reactions.

In another research (Zeinstra et al., 2009) it was shown that facial reactions are suitable to measure the "disliking" (or "aversion" reaction) of tasting stimuli, but they are not yet so effective to measure their preference or their neutrality. This study has

been conducted on a sample of six participants whose age ranged between 5 and 13 years. Each participant tasted seven food stimuli in random order: apple juice, sauerkraut juice, beet juice, milk, asparagus juice, a sweet drink, and a bitter one. After each tasting, participants expressed their liking rating on a self-report scale. At the same time a camera recorded their facial reactions during and for the first 6 seconds after each tasting. Video recordings' analysis through FACS technique significantly correlated with the self-report results only regarding the "aversive stimuli", but no significant correlation was found for the "preferred stimuli".

More recent studies replicated the methodology of Zeinstra and his group by using facial automatic decoding software (Danner et al., 2014; de Wijk et al., 2012) instead of the FACS technique. Consistent with previous research, these studies have shown that from one side the "happiness" (or the "positive valence") was not able to discriminate the "pleasant" or the neutral tastes, while from the other side the "unpleasant" tastes aroused an emotional facial reaction significant enough to be observed by the software in terms of "negative valence".

In other researches about food products, as the one conducted by Horio (2003), it has been shown that food preferences can be inferred better for the "disliking" or "aversion" than for the "liking" reactions. This could be explained as an effect of the social context, because the subject is with the researcher and other people and this may inhibit the expression of happiness (de Wijk et al., 2012).

Danner and colleagues (2014) used a research approach that involved both implicit (based on the spontaneous facial expression) and explicit (asking participants to show an intentional facial expression, immediately after the taste) measure. Results showed that the latter allows a better discrimination between the different tastes that in turn had a high correlation with the hedonic preferences. Nevertheless, also the inclusion of some implicit measurements, over the self-report declarations about preference, allows to obtain a good index of liking towards food because of the capability to hold the aversive responses.

As regards the advertisings of food products, Lewinski et al. (2014) showed that happiness expression was the greater indicator of the advertising effectiveness and of the positive predisposition towards the brand.

All these researches lead to consider the application of the techniques of facial expressions analysis in the field of food and beverage to be appropriate, albeit with all due caution and care.

6. Traditional self-report survey vs. neuromarketing approach for data collection

The review of the neuromarketing methodologies for food choice experiments furnish a great opportunity to produce a detailed comparison of the techniques. The elements of discussion are:

- Costs. Limited costs allow increasing replicability of analyses and diffusion of methodology. Moreover, wider samples are possible when data collection is unexpensive;
- Type of equipment needed. It influences costs related to the initial investiment, replicability, and diffusion of the methodology;
- Duration of collection. Fast data collection allows increasing sample size and reducing costs. Moreover, it could influence the reliability of data because of tiredness of respondents;
- Width of the field of application. The possibility to extend data collection geographically allows having better information on food choice behaviour for inferential analyses;
- Invasiveness of data collection. More invasive methods, olthough the paper discusses mainly non-invasive methods, could influence the sampling process and producing sample bias into results of the analyses;
- Naturalness of the environment. Naturalness of the environment could allow retrieving exact information on consumers at the moment of food purchase. Laboratory environment, on the other hand could bias the results;
- Accuracy of the information retrieved. The ability to capture small differences in consumers' behaviour could furnish important source of variability in the analysis;
- Reliability of the information. Could influence the reliability of results with important consequences on impacts;
- Usefulness for descriptive statistics. Ability of the information to be used for describing individuals and/or samples with descriptive statistics of graphs;
- Usefulness for segmentation analyses. The possibility to have results that effectively allow setting up targeted strategies for specific consumers groups could be relevant for food marketing implications;
- Usefulness for predictive analyses. Models predicting consumers' behaviour are important for setting up strategies and making inference.

In order to compare the analysed methodologies and the self reporting/questionnaire based data collection on food preferences, Table 1 has been constructed and used at this purpose.

Table 1 – Comparison of traditional vs. neuromarketing methodologies.

methodology	Self report preferences data	Eye-tracking	EEG	Skin conductance	Face reading
data cost	low especially for internet based surveys compared to face-to-face interviews, which need specialized personnel	minimal, related to frequent monetary compensation to respondents for partecipating to the data collection, costs related to equipment and personnel for assistance during data collection	high, related to frequent monetary compensation to respondents for partecipating to the data collection, costs related to laboratory, equipment and personnel for assistance during data collection	limited related to frequent monetary compensation to respondents for partecipating to the data collection, costs related to equipment and personnel for assistance during data collection	limited related to frequent monetary compensation to respondents for partecipating to the data collection, costs related to equipment and personnel for assistance during data collection
equipment needed	from no equipment needed to computers (for computer assisted interviews), minimum equipment for market simulation experiments	eye-tracker, computer/laptop, dedicated room/laboratory for data collection, assitant for data collection. Only assistant for portable eye-trackers	EEG machine, computer/laptop, dedicated room/laboratory for data collection, assitant for data collection.	skin conductance machine, computer/laptop, dedicated room/laboratory for data collection, assitant for data collection.	facereading machine, computer/laptop, dedicated room/laboratory for data collection, assitant for data collection.
duration of collection	fast, few minutes depending on the lenght of questionnaire	a defined interval of few minutes	a defined interval of few minutes to hours	a defined interval of few minutes to hours	a defined interval of few minutes
width field of application	no limits, surveys can be conducted in vast geographical areas	limited because consumers should go to the room of the experiment, unlimited for portable equipments	limited because consumers should go to the room of the experiment	limited because consumers should go to the room of the experiment	limited because consumers should go to the room of the experiment
invasiveness of data collection	not invasive	limited to wearing eye tracking glasses	limited to wearing EGG sensors/helmet	limited to wearing sensors	not invasive

naturalness of environment	natural	natural except for data collection into laboratories	not natural, laboratory environment	not natural, laboratory environment	not natural, laboratory environment
accuracy of information retrieved	questions can explore minimum depth information in order to avoid disattention or question skipping behaviors	high level of detail of the information	high level of detail of the information	high level of detail of the information	high level of detail of the information
reliability of information	undefined and unmeasurable. depending on the approach of the respondents	high reliability for eye tracking during real life experiences	highly reliable unless revealing information into an unnatural environment	highly reliable unless revealing information into an unnatural environment	highly reliable
usefulness for descriptive statistics	yes	need numerical coding of images or identification of variables for analysis (time spent on specific areas/images) before running statistics	yes	yes	yes
usefulness for segmentation analyses	yes, especially if related to socio-demographics and consumption habits	need numerical coding of images or identification of variables for analysis (time spent on specific areas/images) before running statistics	yes, although consumers cannot be identified a-priori by using EGG information	yes, although consumers cannot be identified a-priori by using EGG information	yes, although consumers cannot be identified a-priori by using face reader information

usefulness for predictive analyses	yes	need numerical coding of images or identification of variables for analysis (time spent on specific areas/images) before running statistics	yes	yes	yes

7. Discussion

On the basis of the extensive literature review, we propose food choice and neuro-marketing as increasingly integrated tool to increase consumers' data variance into economic studies focussed on preference analysis and prediction. The present paper, by gathering together the food studies using neuromarketing techniques through the examination of non-invasive techniques, offers new knowledge by presenting a methodological reference point for all the scholars working in this field.

Specifically, with neuromarketing techniques that enable, on one side, to take advantage of results from consumer neuroscience thanks to the use of fMRI, MEG or PET techniques, that allowed to identify the brain structures that are enrolled during decision making about food products. On the other side, to reduce the impact of the presence of the recording system that fMRI, MEG and PET techniques imply, as the methods described deeply in the present paper should allow to monitor the brain structure in a less invasive and less expensive way. Indeed, worldwide scholars are developing a growing number of empirical applications of neuromarketing techniques on food issues.

Meanwhile, industry could develop deeper interest in the application of those techniques to validate and improve product developments. We propose two main elements of evolution for this empirical discipline. First, the possibility that neuro-marketing tools will evolve to cheaper and faster applications; and second, the hope that neuromarketing will provide industry with information that is not obtainable through other traditional marketing methods. Such a trend could enable fast developments of the techniques here reviewed. ICT industry, connected with bio-

engineering could, at this regard, has strong incentives to work on those improvements.

At the present, although neuromarketing is unlikely to be cheaper than other tools in the near future, there is growing evidence that it may provide hidden information about the consumer experience. The most promising application of neuroimaging methods to marketing may come before a product is even released — when it is just an idea being developed.

However, neuro-marketing measurements could be highly sensitive. Thus, they could bring to light hidden elements of the experiment or secondary reactions of the consumers' experience.

Food choice is an extremely complex topic, involving both rational judgment and a more irrational substrate: hedonistic impulses, psychological mechanisms (including eating disorders), lifestyle and subconscious states related to happiness or arousal connected to food. This complexity makes the field of food choice and consumption a highly interesting application to study consumers and further develop neuromarketing techniques and tools, although to the present not much explored.

In general, the neurological reaction of consumers in term of taste, packaging, which includes labelled information and brand, communication and pricing is studied. However, the analysis of the literature has allowed to systematize the neuromarketing techniques and identify the main elements of focus for which they are applied. In fact, *eye tracking* is widely used to research on the importance of brand and labelled information, especially those related to nutritional aspects; *frontal alpha asymmetry though EEG* is mostly used in food advertisement research to evaluating the impact of specific odours during tasting, although literature is considerably poor at regard of this approach; *skin conductance* is used to explore mostly the reaction to pleasantness of food products and predict consumers' preferences; *face reader* is used in researches measuring disliking more than neutrality or positive preferences. Experiments in literature focus on fruit juice, milk and other drinks, finding good correlation with hedonic preferences.

To the knowledge of the authors, there are no studies in the field of food choices applying jointly more techniques within the same experiment. An interesting research development would be the use of multiple methods to explore food preferences. Summarizing, the simoultaneous application of:

a) EEG measures that allows to have information about the cortical activity (in particular from the frontal lobes correlating with decision making processes) reflecting approach / withdraw behaviour toward the stimulus, in other words, the hedonic quality of emotional reaction or valence;

b) Skin conductance measures, that allows to have information about the subcortical activity related to the level of arousal or intensity of emotional reactions;

c) The eye-tracking, that links the emotional reactions to a specific element of the visual scene;

d) The automatic emotional facial expression analyses, enabling to have a second reference aside the internal reactions, redundant but also useful for interpreting consumers' reactions.

The power of the combination of all these different metrics open the way to the possibility to study decision making about food products taking into account the place where these phenomena are usually happening, as for instance in real shops or in front of a shelf.

As a conclusion to the explorative work, although the perception of nutritional elements has been already explored, health content of labels, the presence of additives, the evaluation of the information on the functionality are other possible element of interest in future food neuromarketing research.

References

Allen, J.J.B., Coan, J.A., & Nazarian, M. (2004). Issues and assumptions on the road from raw signals to metrics of frontal EEG asymmetry in emotion. Biological Psychology, 67, 183-218

Antunez, L., Vidal, L., Sapolinski, A., Gimenez, A., Maiche, A., & Ares, G. (2013). How do design features influence consumer attention when looking for nutritional information on food labels? Results from an eye-tracking study on pan bread labels. International Journal of Food Sciences and Nutrition, 64(5), 515-512

Arcia, P., Curutchet, A., Costell, E., & Tarrega, A. (2012). Influence of expectations created by label on consumers acceptance of Uruguayan low-fat cheeses. Journal of Sensory Studies, 27, 344–351

Ares, G., Gimenez, A., Bruzzone, F., Vidal, L., Antúnez, L., & Maiche, A. (2013). Consumer visual processing of food labels: Results from an eye-tracking study. Journal of Sensory Studies, 28, 138-153

Ares, G., Mawad, F., Giménez, A., Maiche, A., (2014), Influence of rational and intuitive thinking styles on food choice: Preliminary evidence from an eye-tracking study with yogurt labels, Food Quality and Preference, 31, 28-37

Ares, Gastón, and Rosires Deliza (2010), "Studying the influence of package shape and colour on consumer expectations of milk desserts using word association and conjoint analysis." *Food Quality and Preference* 21.8: 930-937.

Ares, Gastón, et al. (2010), "Comparison of two sensory profiling techniques based on consumer perception." *Food Quality and Preference* 21.4: 417-426. (a)

Ares, Gastón, et al. (2013), "Consumer visual processing of food labels: results from an eye-tracking study." *Journal of Sensory Studies* 28.2: 138-153.

Ariely, Dan, and Gregory S. Berns. "Neuromarketing: the hope and hype of neuroimaging in business." *Nature Reviews Neuroscience* 11.4 (2010): 284-292

Bargh, John A. (1997), *The Automaticity of Everyday Life*. In R.S. Wyer, Jr. (Ed.), The Automaticity of Everyday Life: Advances in Social Cognition, Vol. 10 (pp. 1-61). Mahwah, NJ: Erlbaum.

Bechara, Antoine. Hanna Damasio, and Antionio R. Damasio (2000), "Emotion, Decision Making and the Orbitofrontal Cortex." Cerebral Cortex 10.3, 295-307

Berkman, E.T., & Lieberman, M.D. (2010). Appoaching the bad and avoiding the good: Lateral prefrontal cortical asymmetry distinguishes between action and valence. Journal of Cognitive Neuroscience, 22, 1970-1979

Berns, Gregory S., and Sara E. Moore (2011). "A neural predictor of cultural popularity". *Journal of Consumer Psychology* 22.1: 154–160

Bialkova, S., & van Trijp, H.C. (2011). An efficient methodology for assessing attention to and effect of nutrition information displayed front-of-pack. Food Quality and Preference, 22(6), 592-601

Bolls, P.D., A. Lang, & Potter, R.F. (2001). The effect of message valence and listener arousal on attention, memory, and facial muscular responses to radio advertisements. Communication Research, 28(5), 627-651

Boricean V, editor. Brief history of neuromarketing. ICEA - FAA; 14 - 15th, November 2009; Bucharest. p. 119

Boucsein, W. (1992). Electrodermal activity. New York: Plenum

Bradley, M.M., Cuthbert, B.N., Lang, P.J. (1996). Picture media and emotion: Effects of a sustained affective context. Psychophysiology, 33: , 662-670

Brown, C., Randolph, A., Burkhalter, J. (2012). The Story of Taste: Using EEGs and Self-Reports to Understand Consumer Choice. The Kennesaw Journal of Undergraduate Research, 2(1). Article 5

Cacioppo, J.T., Tassinary, L.G., & Berntson, G.G. (2000). Handbook of psychophysiology, 2nd edition. New York: Cambridge University Press

Caporale, Gabriella, Sonia Policastro, Angela Carlucci, and Erminio Monteleone (2006). "Consumer expectations for sensory properties in virgin olive oils." *Food Quality and Preference* 17.1: 116-125.

Carver, C.S., & Harmon-Jones, E. (2009). Anger is an approach-related affect: Evidence and implications. Psychological Bulletin, 135, 183-204

Cătoiu, Iacob, and Nicolae Teodorescu (2004). *Consumer behaviour*. Bucharest: Uranus Editions.

Chae, S.W., & Lee, K.C. (2013). Exploring the effect of the human brand on consumers' decision quality in online shopping: An eye-tracking approach. Online Information Review, 37, 83-100

Cheng, T. C. Edwin, Lawrence C. Lai, and Andy C. Yeung (2008). "The Driving Forces of Customer Loyalty: A Study of Internet Service Providersin Hong Kong". *International Journal of E-Business Research* 4.4: 26-42

Clore, G.L.,Schwarz,N.,Conway,M.1994.Affective causes and consequences of social information processing,Handbook of social cognition.Vol.1 pp. 323– 417.

Cook, I. A., O'Hara, R., Uijtdehaage, S. H., Mandelkern, M., & Leuchter, A. F. (1998). Assessing the accuracy of topographic EEG mapping for determining local brain function. *Electroencephalography and clinical neurophysiology*, *107*(6), 408-414.Crilly, N., Moultrie, J., & Clarkson, P.J. (2004). Seeing things: consumer response to the visual domain in product design. Design studies, 25, 547-577

Crilly, Nathan, James Moultrie, and P. John Clarkson. "Seeing things: consumer response to the visual domain in product design." *Design studies* 25.6 (2004): 547-577.

Critchley, H.D., Elliott, R., Mathias, C.J., & Dolan, R.J. (2000). Neural activity relating to generation and representation of galvanic skin responses: a functional magnetic resonance imaging study. The Journal of Neuroscience, 20(8):), 3033-3040

Damasio, Antonio (1994). *Descartes' Error. Emotion, Reason and the Human Brain*. New York: Putnam's Sons. Trad. it. *L'errore di Cartesio. Emozione, Ragione e Cervello Umano*. Milano: Adelphi.

Danner, L., Haindl, S., Joechl, M., Duerrschmid, K. (2014). Facial expressions and autonomous nervous system responses elicited by tasting different juices. Food Research International, 64, 81-90

Danner, L., Sidorkina, L., Joechl, M., Duerrschmid, K. (2014). Make a face! Implicit and explicit measurement of facial expressions elicited by orange juices using face reading technology. Food Quality and Preference, 32, 167-172.

Davidson, R.J. (1993a). Cerebral asymmetry and emotion: Conceptual and methodological conundrums. Cognition and Emotion, 7, 115-138

Davidson, R.J. (1993b). The neuropsychology of emotion and affective style. In M. Lewis, & J.M. Haviland (Eds), Handbook of emotions (pp. 143-154). New York: Guilford Press

Davidson, R.J. (1998). Anterior electrophysiological asymmetries, emotion, and depression: Conceptual and methodological conundrums. Psychophysiology, 35, 607-614

Davidson, R.J. (2000). Affective style, psychopathology, and resilience: brain mechanisms and plasticity. American Psychologist, 55, 1196-1214

Davidson, R.J. (2004). What does the prefrontal cortex ‘‘do’’ in affect: perspectives on frontal EEG asymmetry research. Biological Psychology, 67(1-2), 219-233

Davidson, R.J., & Rickman,. M. (1999). Behavioral inhibition and the emotional circuitry of the brain: Stability and plasticity during the early childhood years. In L.A. Schmidt & J. Schulkin (Eds.), Extreme fear, shyness, and social phobia: Origins, biological mechanisms and clinical outcomes (pp. 67-87). New York: Oxford University Press

Davidson, R.J., Ekman, P., Saron, C.D., Senulis, J.A., & Friesen, W.V. (1990). Approach-withdrawal and cerebral asymmetry: emotional expression and brain physiology I. Journal of Personal and Social Psychology, 58, 330-341

Davidson, R.J., Schwartz, G.E., Saron, C., Bennett, J., & Goleman, D.J. (1979). Frontal versus parietal EEG asymmetry during positive and negative affect. Psychophysiology, 16, 202-203

de Wijk, R.A., He, W., Mensink, M.G.J., Verhoeven, R.H.G., de Graaf, C. (2014). ANS Responses and Facial Expressions Differentiate between the Taste of Commercial Breakfast Drinks. PLoS ONE 9(4): e93823

de Wijk, R.A., Valesca, K., Verhoeven, R.H.G., Holthuysen, N.T.E., de Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. Food Quality and Preference, 26: 196-203

Deppe, M., Schwindt, W., Kugel, H., Plassmann, H., & Kenning, P. (2005). Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision making. Journal of Neuroimaging, 15, 171-182

Detre, J.A., & Floyd, T.F. (2000). Functional MRI and its applications to the clinical neurosciences. Neuroscientist, 7, 64-79

Di Monaco, Rossella, et al. (2004). "The effect of expectations generated by brand name on the acceptability of dried semolina pasta." *Food Quality and Preference* 15.5: 429-437

Dijksterhuijs, Ap. (2004). "Think Different: The Merits of Unconscious Thought in Preference Development and Decision Making." *Journal of Personality and Social Psychology* 87.5: 586-598

Duchowski, A.T. (2003). Eye tracking methodology: Theory and practice. New York, NY: Springer

Dunning, Jonathan P., Anthony Auriemmo, Claude Castille and Greg Hajcak (2010). "In the face of anger: Startle modulation to graded facial expressions." *Psychophysiology* 47: 874-878

Ekmann, P. & Friesen, W. V. (1971). Constancts Across the Cultures in the Face and Emotion. Journal of Personality and Social Psychology, 17(2), 124-129.

Fenko, A., Schifferstein, H.N.J., & Hekkert, P. (2011) Noisy products: Does appearance matter? International Journal of Design, 5(3), 77-87

Fortunato, V. C. R., Giraldi, J. D. M. E., & de Oliveira, J. H. C. (2014). A review of studies on neuromarketing: Practical results, techniques, contributions and limitations. Journal of Management Research, 6(2), 201.

Fiszman, B.P., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars. Food Quality and Preference, 28, 328-338

Fox, N.A. (1991). If it's not left, it's right: Electroencephalograph asymmetry and the development of emotion. American Psychologist, 46, 863-872

Gofman, A., Moskowitz, H.R., Fyrbjork, J., Moskowitz, D., & Mets, T. (2009). Extending Rule Developing Experimentation to Perception of Food Packages with Eye Tracking. The Open Food Science Journal, 3, 66-78

Goldberg, J.H., Probart, C.K., & Zak, R.E. (1999). Visual search of food nutrition labels. Human Factors, 41, 425-437

Graham, D.J., & Jeffery, R.W. (2011). Location, location, location: eye tracking evidence that consumers preferentially view prominently positioned nutrition information. Journal of American Dietetic Association, 111, 1704-1711

Graham, D.J., & Jeffery, R.W. (2012). Predictors of nutrition label viewing during food purchase decision making: an eye tracking investigation. Public Health Nutrition, 15, 189-197

Graham, D.J., Orquin, J.L., & Visschers, V.H.M. (2012). Eye tracking and nutrition label use: A review of the literature and recommendations for label enhancement. Food Policy, 37, 378-382

Greenwald, Aanthony G., and Mahzarin R. Banaji (1995). "Implicit Social Cognition: Attitudes, Self-Esteem, and Stereotypes." *Psychological Review* 102: 4-27

Greimel E.; Machtb M.; Krumhuberc E.; Ellgringb H. (2006). Facial and affective reactions to tastes and their modulation by sadness and joy. Physiology & Behavior; Vol. 89, Issue 2; p. 261–269.

Harmon-Jones, E., Gable, P.A., & Peterson, C.K. (2010). The role of asymmetric frontal cortical activity in emotion-related phenomena: A review and update. Biological Psychology, 84, 451-462

Hassin, R.R., Uleman, J.S., & Bargh, J.A. (2005). *The New Unconscious*. New York: Oxford University Press.

Hess, Eckhard H. (1975). *The tell-tale eye.* New York: Van Nostrand.

Hoffman, J., & Subramaniam, B. (1995). The role of visual attention in saccadic eye movements. Perception & Psychophysics, 57, 787-795

Hoffman, J.E. (1998). Visual Attention and Eye Movements, in Pashler H, Attention, ed., University College London Press, London

Horio, T. (2003). "EMG activities of facial and chewing muscles of human adults in response to taste stimuli." *Perceptual and Motor Skills* 97.1: 289-298.

Huettel, S.A., Song, A.W., & McCarthy, G. (2004). Functional magnetic resonance imaging. Boston: Sinauer Associates

Itti, Laurent, and Christof Koch (2001). "Computational modelling of visual attention". *Nature reviews neuroscience* 2.3: 194-203.

Jacoby, Larry L., D. Stephen Lindsay, and Jeffrey P. Toth (1992). "Unconscious influences revealed: Attention, awareness, and control." *American psychologist* 47.6: 802.

Jasper, H.H. (1958). The ten-twenty electrode system of the International Federation. Electroencephalography and Clinical Neurophysiology, 10(2), 370-375

Jones, G., & Richardson, M., (2007). An objective examination of consumer perception of nutrition information based on healthiness ratings and eye movements. Public Health Nutrition, 10, 238-244

Jordão, I. L. D. S., Souza, M. T. D., Oliveira, J. H. C. D., & Giraldi, J. D. M. E. (2017). Neuromarketing applied to consumer behaviour: an integrative literature review between 2010 and 2015. International Journal of Business Forecasting and Marketing Intelligence, 3(3), 270-288.

Kahneman, D.,Wakker,P.P.,Sarin,R.,1997.BacktoBentham?explorationsofexperiencedutility.Q.J. Econ.112(2),375–406, http://dx.doi.org/10.1162/ 003355397555235.

Kahneman, Daniel, and Amos Tversky (1979). "Prospect theory: An analysis of decision under risk." *Econometrica: Journal of the Econometric Society* : 263-291.

Kenning, Peter, Hilke Plassmann, and Dieter Ahlert (2007). "Applications of Functional Magnetic Resonance Imaging for Market Research." *Qualitative Market Research* 10.2: 135-152

Kihlstrom, J.F. (1999). *Conscious Versus Unconscious Cognition*. In R.J. Sternberg (Ed.), *The Nature of Cognition* (pp. 173-203). Cambridge: MIT Press.

Kline, J.P., Blackhart, G.C., Woodward, K.M., Williams, S.R., & Schwartz, G.E.R. (2000). Anterior electroencephalographic asym- metry changes in elderly women in response to a pleasant and an un- pleasant odor. Biological Psychology, 52, 241-250

Koenigstorfer, J., Wasowicz-Kirylo, G., Stysko-Kunkowska, M., Groeppel-Klein, A. (2013). Behavioural effects of directive cues on front of package nutrition information: the combination matters! Public Health Nutrition, 2013, 1-7

Lang, P.J. (1980). Behavioral treatment and bio-behavioral assessment: Computer applications. In B. Sidowski, J.H. Johnson, & T. A. Williams (Eds.), Technology in mental health care delivery systems (pp.119-137). Norwood, NJ:Ablex.

Lang, P.J. (1995)., The emotion probe. Studies of motivation and attention, The American Psychologist, 50(5), 372-85 1995

Lange, C., Martin, C., Chabanet, C., Combris, P. and Issanchou, S. (2002). Impact of the Information Provided to Consumers on Their Willingness to pay for Champagne: comparison with hedonic scores. Food Quality and Preference, 13(7). 597-608

Laufs, H., Kleinschmidt, A., Beyerle, A., Eger, E., Salek-Haddadi, A., Preibisch, C., & Krakow, K. (2003). EEG-correlated fMRI of human alpha activity. Neuroimage, 19, 1463-1476

Laufs, H., Krakow, K., Sterzer, P., Eger, E., Beyerle, A., Salek-Haddadi, A., & Kleinschmidt, A. (2003). Electroencephalographic signatures of attentional and cognitive default modes in spontaneous brain activity fluctuations at rest. In Proceedings of the National Academy of Sciences of the United Statesof America, 100, 11053-11058

LeDoux, Joseph (1998). "Fear and the brain: where have we been, and where are we going?." *Biological psychiatry* 44.12: 1229-1238

Lee, N., Broderick, A.J., & Chamberlain, L. (2006). What is ‘neuromarketing’? A discussion and agenda for future research. International Journal of Psychophysiology, 63, 199-204

Lewinski, P.; Fransen, M. L.; Tan, Ed S. H. (2014). Predicting Advertising Effectiveness by Facial Expressions in Response to Amusing Persuasive Stimuli. Journal of Neuroscience, Psychology, & Economics.Vol. 7 Issue 1, p1-14 .

Lichtenstein, S., Slovic, P., 2006. In: The construction of preferenceCambridge University Press, New York.

Loewenstein, G., Lerner, J.S., 2003. The Role of Affect in Decision Making. In: Davidson, R.J., Scherer, K.R., Goldsmith, H.H. (Eds.), Handbook of Affective Sciences, Oxford University Press.

Mannan, Sabira K., Christopher Kennard, and Masud Husain (2009). "The role of visual salience in directing eye movements in visual object agnosia". Current Biology 19.6: 247-248

Marchini Andrea, Francesco Diotallevi , Chiara Paffarini , Antonio Stasi , Antonio Baselice , (2015) "Visualization and purchase: An analysis of the Italian olive oil grocery shelves through an in-situ visual marketing approach", Qualitative Market Research: An International Journal, Vol. 18 Iss: 3, pp.346 - 361

Mauri, M., V. Magagnin, V., P. Cipresso, P. , L. Mainardi, L., Brown, E.N., S. Cerutti, S. Villamira, M. and R. Barbieri, R. (2010). Psychophysiological signals associated with affective states, 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society.

Mellers, B., Schwartz, A. ,Ritov, I., 1999. Emotion-basedchoice. Journal of Experimental Psychology Gen.128(3), 332–345.

McClure, S. M., Li, J., Tomlin, D., Cypert, K. S., Montague, L. M., & Montague, P. R. (2004). Neural correlates of behavioral preference for culturally familiar drinks. *Neuron*, *44*(2), 379–387. https://doi.org/10.1016/j.neuron.2004.09.019

Milosavljevic, M., Navalpakkam, V., Koch, C., & Rangel, A. (2011). Relative visual saliency differences induce sizable bias in consumer choice. Working Paper: California Institute of Technology

Mizutani, Nanami, Ippeita Dan, Yasushi Kyutoku, Daisuke Tsuzuki, Lester Clowney, Yuko Kusakabe, Masako Okamoto, and Toshimasa Yamanaka (2012). "Package images modulate flavors in memory: Incidental learning of fruit juice." *Food Quality and Preference* 24: 92–98

Montague, P. Read, and Gregory S. Berns (2002). "Neural economics and the biological substrates of valuation." *Neuron* 36.2: 265-284

Montgomery, K. C., & Chester, J. (2009). Interactive food and beverage marketing: targeting adolescents in the digital age. Journal of Adolescent Health, 45(3), S18-S29.

Mormann, Milica Milosavljevic and Koch, Christof and Rangel, Antonio (2011). Consumers Can Make Decisions in as Little as a Third of a Second (August 1, 2011). Judgment and Decision Making, Vol. 6, No. 6: 520-530

Murphy, Emily R. (2008). "Neuroethics of neuromarketing." *Journal of Consumer Behaviour*, 7: 293–302

Murray, J.M., & Delahunty, C.M. (2000). Mapping consumer preference for the sensory and packaging attributes of Cheddar cheese. Food Quality and Preference, 11(5), 419-435

Nederkoorn, C., Smulders, F.T.Y., & Jansen, A. (2000). Cephalic phase responses, craving and food intake in normal subjects. Appetite, 35, 45-55

Nielsen, J., & Pernice, K. (2009). Eyetracking web usability. In Berkeley. CA: New Riders

Nixon, H.K. (1924). Attention and interest in advertising. Archives of Psychology, 72, 5-67

Ohme, R., Matukin, M., & Szezurko, T. (2010). Neurophysiology uncovers secrets of TV commercials. Der markt, 49, 133-14

Ohme, R., Reykowska, D., Wiener, D., & Choromanska, A. (2009). Analysis of Neurophysiological Reactions to Advertising Stimuli by Means of EEG and Galvanic Skin Response Measures. Journal of Neuroscience, Psychology, and Economics, 2(1), 21-31

Ohme, R., Reykowska, D., Wiener, D., & Choromańska, A. (2010). Application of frontal EEG asymmetry to advertising research: Sony Bravia case. Journal of Economic Psychology, 31, 785-793

Oliver, Richard L. (1999). "Whence consumer loyalty?" *Journal of Marketing* 63: 33-44.

Orquin, J., Scholderer, J. (2011), Attention to health cues on product packages. Journal of Eye Tracking, Visual Cognition and Emotion, 1(1), 59-63

Park, K.S., Choi, H., Lee, K.J., Lee, J.Y., Ann, K.O. and Kim, E.J. (2011). Emotion recognition based on the asymmetric left and right activation. International Journal of Medicine and Medical Sciences, 3(6). 201-209

Peng, Leong, Y., and Qing Wang (2006). "Impact of Relationship Marketing Tactics (RMTs) on Switchers and Stayers in a Competitive Service Industry." Journal of Marketing Management: 25-59

Pertzob, Y., Avidan, G., Zohary, E. (2009). Accumulation of visual information across multiple fixations. Journal Of Vision, 9, 1-12

Petty, Richard E., and John T. Cacioppo (1986). *The elaboration likelihood model of persuasion*. Springer New York.

Pfurtscheller, G., Stancak, A. Jr., Neuper, C. (1996). Event-related Synchronization (ERS) in the Alpha Band - An Electrophysiological Correlate of Cortical Idling: A Review. International Journal of Psychophysiology, 24, 39-46

Pieters, R., Warlop, L., & Wedel, M. (2002). Breaking Through the Clutter: Benefits of Advertisement Originality and Familiarity for Brand Attention and Memory. Management Science, 48, 765-781

Piqueras-Fiszman, B., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars. Food Quality and Preference, 28, 328-338

Plassmann, H., O'Doherty, J., Shiv, B., & Rangel, A. (2007). Marketing actions can modulate neural representations of experienced pleasantness. In Proceedings of the National Academy of Sciences, 105(3), 1050-1054

Plassmann, H., Yoon, C., Feinberg, F. M., & Shiv, B. (2011). Consumer neuroscience. *Wiley international encyclopedia of marketing*.

Plassmann, Hilke, John P. O'Doherty, and Antonio Rangel (2010). "Appetitive and aversive goal values are encoded in the medial orbitofrontal cortex at the time of decision making." *The Journal of Neuroscience 30*: 10799-10808

Plassmann, Hilke, Thomas Z. Ramsøy, and Milica Milosavljevic (2012). "Branding the brain: A critical review and outlook." *Journal of Consumer Psychology 22*.1: 18-36

Plassmann, Hilke, Vinod Venkatraman, Scott Huettel, and Carolyn Yoon (2015). "Consumer Neuroscience: Applications, Challenges, and Possible Solutions." *Journal of Marketing Research* 52.4: 427-435

Porges, S. (2011). The polyvagal theory: Neurophysiologial foundations of emotions, attachment, communication, and self-regulation. New York: W. W. Norton & Company

Posner, Michael I (2004). "Orienting of Attention." *Quarterly Journal of Experimental Psychology 32* 3-25

Price, T.F., Peterson, C.K., & Harmon-Jones, E. (2012). The emotive neuroscience of embodiment. Motivation and Emotion, 36, 27-37

Ravaja, N. (2004). Contributions of psychophysiology to media research: Review and recommendations. Media Psychology, 6(2), 193-235

Ravaja, N., Somervuori, O. and Salminen, M. (2013). Predicting purchase decision: The role of hemispheric asymmetry over the frontal cortex. Journal of Neuroscience, Psychology, and Economics, 6(1), 1-13

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. Psychological Bulletin, 124(3), 372-422

Rebollar, R., Lidòn, I.,, Valleio, F.J.M. (2015). The identification of viewing patterns of chocolate snack packages using eye-tracking techniques. Food Quality and Preference, 39, 251-258

Reutskaja, E., Hagel, R., Camerer, C.F., & Rangel, A. (2011). Search dynamics in consumer choice under time pressure: an Eye Tracking study. The American Economic Review, 101, 900-926

Rosenstein, Diana, and Harriet Oster (1988). "Differential facial responses to four basic tastes in newborns." Child Dev 59:1555-1568.

Rosenstein, Diana, and Harriet Oster (1997). *Differential facial responses to four basic tastes in newborns.* In: Ekman P., Rosenberg E.L. (Eds), *What the face reveals: basic and applied studies of spontaneous expression using the Facial Action Coding System (FACS)*. Oxford: Oxford University Press: 302-330.

Rothschild, M., & Hyun, Y.J. (1990). Predicting memory for components of TV commercials from EEG. Journal of Consumer Research, 4, 472-478

Rothschild, M., Thorson, E., Reeves, B., Hirsch, J., & Goldstein, R. (1986). EEG activity and the processing of television commercials. Communication Research, 2, 182-220

Russell, James A. (1994). "Is there universal recognition of emotion from facial expressions? A review of the cross-cultural studies." *Psychological Bulletin* 115.1: 102-141

Russo, J.E. (1978). Eye fixations can save the world: A critical evaluation and a comparison between eye fixations and other information processing methodologies. Advances in Consumer Research, 5, 561-570

Rustichini, A. (2005). Neuroeconomics: Past and Future. Games and Economic Behavior, 52, 201-212

Rutherford, H.J.V., & Lindell, A.K. (2011). Thriving and surviving: Approach and avoidance motivation and lateralization. Emotion Review, 3, 333-343

Saba, Anna, et al. (2010). "Country-wise differences in perception of health-related messages in cereal-based food products." *Food Quality and Preference* 21.4: 385-393.

Sanders, C., Diego, M., Fernandez, M., Field, T., Hernandez-Reif, M. & Roca, A. (2002). EEG asymmetry responses to lavender and rosemary aromas in adults and infants. International Journal of Neuroscience, 112, 1305-1320

Savoy, R.L. (2005). Experimental design in brain activation MRI: Cautionary tales. Brain Research Bulletin, 67, 361-367

Sayegh, L., Anthony, W.P., & Perrewé, P.L. (2004). "Managerial Decision-Making Under Crisis: The Role of Emotion in an Intuitive Decision Process." Human Resource Management Review 14.2: 179-199

Schaefer, M., & Rotte, M. (2007a). Favorite brands as cultural objects modulate reward circuit. Neuroreport, 18(2), 141-145

Schwarz,N.,Clore,G.L.,1988.HowdoIfeelaboutit?Theinformativefunctionofaffectivestates.Affect,Cognit.Soc.Behav.,44–62.

Schwartz, M. S., & Andrasik, F. (2003). Biofeedback: A Practitioner's Guide. NY: Guilford press, New York

Seeber Kilian G., and Dirk Kerzel (2011). "Cognitive load in simultaneous interpreting: Model meets data." *Special issue of the International Journal of Bilingualism* 16.2: 228-242

Sequeira, H., Hot, P., Silvert, L., et al. (2009). Electrical autonomic correlates of emotion. International Journal of Psychophysiology, 71, 50-56

Simon, Herbert A. (1959). "Theories of decision-making in economics and behavioral science." *The American economic review* 49.3: 253-283.

Smidts, Ale, Ming Hsu, Alan G. Sanfey, Maarten A.S. Boksem, Richard B. Ebstein, Scott A. Huettel, et al. (2014). "Advancing Consumer Neuroscience." *Marketing Letters* 25: 257-67.

Smith, Michael E., and Alan Gevins (2000). "Attention and Brain Activity While Watching Television: Components of Viewer Engagement." *Media Psychology 6*: 285-305

Spence, C., & Driver, J. (2004). Crossmodal space and crossmodal attention. Oxford: Oxford University Press

Stefani, Gianluca, Donato Romano, and Alessio Cavicchi (2006). "Consumer expectations, liking and willingness to pay for specialty foods: Do sensory characteristics tell the whole story?." *Food Quality and Preference* 17.1: 53-62

Steiner, Jacob E. (1973). The gusto-facial response observation on normal and anencephalic newborn infants. In: Bosma J.F. (Ed), The fourth symposium on oral sensation and perception. Washington (DC): US Government Printing Office: 254-278

Steiner, Jacob E. (1977). Facial expressions of the neonate infant indicating the hedonics of food-related chemical stimuli. In: Weiffenbach J.M. (Ed.), Taste and development—the genesis of sweet preference. Bethesda (MD): National Institutes of Health: 173-189.

Steiner, Jacob E. (1979). "Human facial expressions in response to taste and smell stimulation." Adv Child Dev Behav 13:257-295

Van der Laan, L. N., De Ridder, D. T., Viergever, M. A., & Smeets, P. A. (2012). Appearance matters: neural correlates of food choice and packaging aesthetics. *PloS one*, *7*(7),.

Van Herpen, E., & Van Trijp, H.C.M. (2011). Front of pack nutrition labels. Their effect on attention and choices when consumers have varying goals and time constraints. Appetite, 57, 148-160

Vecchiato, G., Astolfi, L., De Vico Fallani, F., Cincotti, F., Mattia, D., Salinari, S., Soranzo, R., & Babiloni, F. (2010). Changes in brain activity during the observation of TV commercials by using EEG, GSR and HR measurements. Brain Topography, 23(2), 165-179

Vecchiato, G., Toppi, J., Astolfi, L., De Vico Fallani, F., Cincotti, F., Mattia, D., Bez, F., & Babiloni, F. (2011) Spectral EEG frontal asymmetries correlate with the experienced pleasantness of TV commercial advertisements. Medical & Biological Engineering & Computing, 49, 579-58

Velásquez, J.D. (2013). Combining eye-tracking technologies with web usage mining for identifying Website Keyobjects. Engineering Applications of Artificial Intelligence, 26, 1469-1478.

Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., Winer, R. S. (2015). Predicting advertising success beyond traditional measures: New

insights from neurophysiological methods and market response modeling. Journal of Marketing Research, 52(4), 436-452.

Vidal, L., Antunez, L., Sapolinski, A., Gimenez, A., Maiche, A., & Ares, G. (2013). Can Eye-Tracking Techniques Overcome a Limitation of Conjoint Analysis? Case Study on Healthfulness Perception of Yogurt Labels, Journal of Sensory Studies, 28, 370-380

Visschers, V.H., Hess, R., & Siegrist, M. (2010), Health motivation and product design determine consumers' visual attention to nutrition information on food products. Public health nutrition, 13(07), 1099-106

Walla, P., Brenner, G., Koller, M. (2011). Objective Measures of Emotion Related to Brand Attitude: A New Way to Quantify Emotion-Related Aspects Relevant to Marketing. PLoS ONE 6(11): e26782. doi:10.1371/journal.pone.0026782

Wedel, M., & Pieters, R. (2008). Visual marketing: from attention to action. New York, Erlbaum

Wijk, R. A., Kooijman, V., Verhoeven, R. H. G., Holthuysen, N. T. E., Graaf, C. (2012). Autonomic nervous system responses on and facial expressions to the sight, smell, and taste of liked and disliked foods. Food Quality and Preference, 26(2), 196-203.

Wilson, G.D. (1966). Arousal properties of red versus green. Perceptual and Motor Skills, 23, 947-949

Yagyu, T., Kondakor, I., Kochi, K., Koening, T., Lehmann, D.;, Kinoshita, T., Hirota, T., Yagyu, T. (1998). Smell and taste of chewing gum affect frequency domain EEG source localizations. International Journal of Neuroscience, 93(3-4):205-16

Yoon, Carolyn, Richard Gonzalez, Antoine Bechara, Gregory S. Berns, Alain A. Dagher, Laurette Dubé, et al. (2012). "Decision Neuroscience and Consumer Decision Making." Marketing Letters, 23.2: 473-85

Zajonc, R.B. (1968). Attitudinal effects of mere exposure. Journal of Personality and Social Psychology, 9(2), 1-27

Zaltman, Gerald (2003). *How customers think: Essential insights into the mind of the market*. Harvard Business Press.

Zeinstra, G.G., Colindres, D., Koelen, M.A., De Graaf, C. (2009) Facial expressions in school-aged children are a good indicator of “dislikes”, but not of “likes”. Food Quality and Preference; Vol. 20, Issue 8; p. 620–624.

Zurawicki, L. (2010). Neuromarketing Exploring the Brain of the Consumer. New York: Springer

Figure

Figure 1- Growth of research applying neuroscience to marketing over time, (from Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. *Journal of Consumer Psychology*, *22*(1), 18-36)[1].

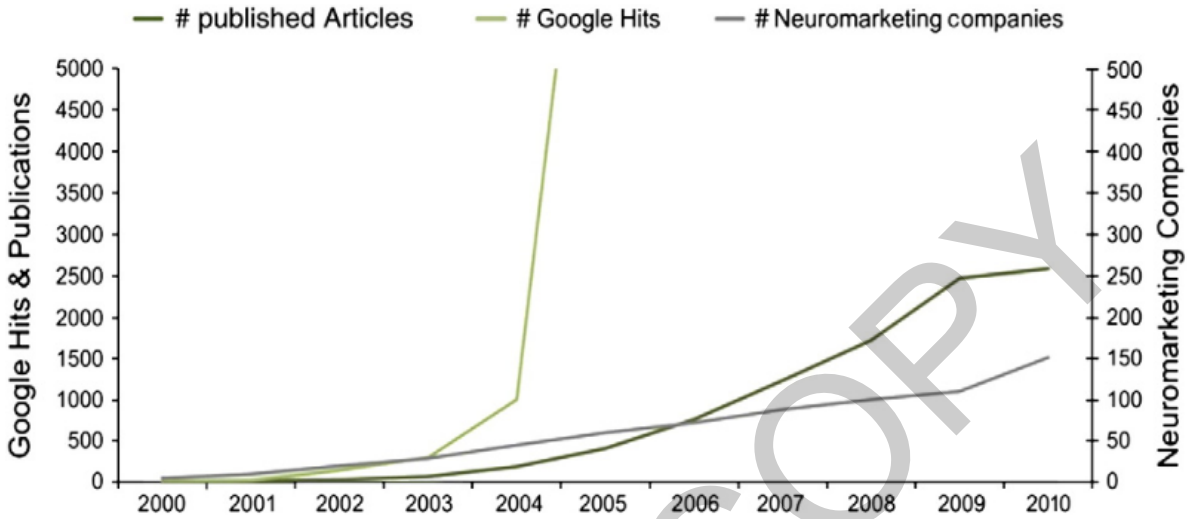


Fig. 2 – a**:** Eye Tracker remote recording systems; b: Eye-tracking system

2a	2b
	

[1] Reproduction licence no. 3958710289114

Fig. 3 – Placement points of EEG sensors on human head

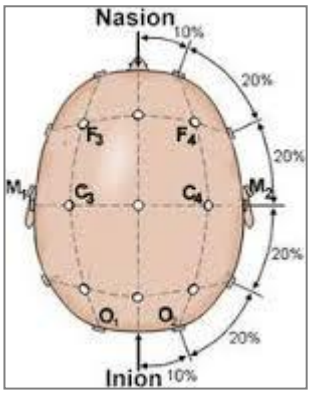
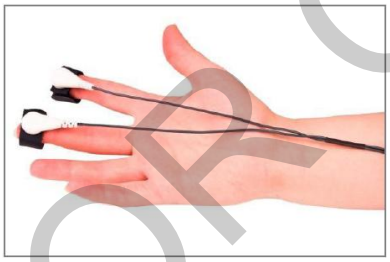


Fig. 4 – SCL sensors position on finger tips



acknowledgement

Click here to download Supplementary material for online publication only: aknowledgements.docx

*Graphical Abstract

Click here to download high resolution image