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Neuromarketing empirical approaches and food choice: A systematic review

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ABSTRACT

Consumers' food choices are often driven by reasons of which consumers are not fully aware. 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 opinions. Indeed, traditional techniques, such as self-reports or interviews, mainly allow the measurement of conscious and rational reactions to a product or advertising. Recently, there has been a rapidly growing interest in the multidisciplinary field of “neuromarketing,” which takes advantage of neuroscientific techniques to study consumer behavior.

This discipline applies neuroscientific methods and tools that allow the measurement of consumers' emotional and spontaneous reactions in a more objective and observable way. The aim of this paper is (a) to describe neuromarketing's underlying assumptions, techniques, and the advantages of this perspective, examining the scientific literature on 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 non-invasive methods.

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

1. Introduction

To understand the increasingly complex consumer decision-making and consumption environment, modern marketing scholars have started to study drivers of consumers' purchasing decisions from a multidisciplinary perspective. The marketing discipline has changed considerably, 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 and is defined as “the study of the cerebral mechanism to understand the consumer's behavior 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 the one hand, interesting findings emerged from the study. On the other, the unsuccessful attempt to provide complete clarification enabling our understanding of decision making in consumers opened the floodgates to seeking 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 knowing or not knowing the name of brand being consumed. In particular, it suggested that a well-known brand like 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 argued that when subjects do not know which brand they are consuming, they report preferring Pepsi, and the orbitofrontal cortex on the left hemisphere is more activated when tasting Pepsi in comparison when they are tasting Coca-Cola. In contrast, when subjects do know what they are drinking, they report preferring Coca-Cola over Pepsi, and their dorsolateral prefrontal cortex is activated in a greater way together with the hippocampus in comparison to the situation where subjects drink Pepsi. From an evolutionary standpoint, the hippocampus is an old brain structure. It is located in the limbic system (in

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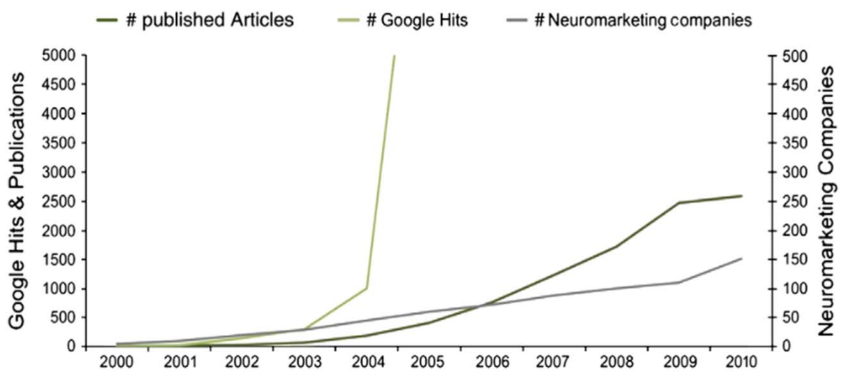

Fig. 1. Growth of research applying neuroscience to marketing over time (from Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. Journal of Consumer Psychology, 22(1), 18–36).
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the deep center of the brain) that is generally responsible for emotional and instinctual behavior. Since this study was published, new scientific articles have appeared in the literature reporting the growing interest in neuromarketing, proposing both new research directions and potential applications (Plassmann, O'Doherty, Shiv, & Rangel, 2007) in an attempt to introduce these innovative techniques to improve upon traditional studies based on self-reports and interviews.

Despite the initial skepticism (Murphy, 2008), the application of neuroscientific concepts and techniques in marketing (i.e., neuromarketing) has rapidly grown over the past few years in both academia (Plassmann, O'Doherty, & Rangel, 2010; Plassmann, Ramsøy, & Milosavljevic, 2012; 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 on neuromarketing in the past decade has led to an explosion of new insights and practical applications for the marketing domain. Plassmann et al. (2012) showed the increase of Google hits and publications about neuromarketing from 2004 forward (Fig. 1), and in a more recent article, she stated 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, Venkatraman, Huettel, & Yoon, 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 real places where people decide what to purchase, such as grocery stores or other food shops. This paper 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 tools to increase consumers' data variance into economic studies focused on food preference analysis and choice prediction. In addition, the paper offers new knowledge by presenting a unique reference point for scholars working in this field who wish to apply neuromarketing techniques in food choice experiments.

Food choice is a complex phenomenon that is not yet 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 the influence of attitudes and emotions on choices, which traditional segmentation variables, such as sociodemographics, psychometrics, and stated preferences, do not cover.

There are many stimuli not directly related to a product that can drive consumers' food choices and purchase decisions, such as brightness (Milosavljevic, Navalpakkam, Koch, & Rangel, 2011), the colors and shape of the packaging (Itti & Koch, 2001; Mannan, Kennard, & Husain, 2009), and price (Oliver, 1999; Peng & Wang, 2006; Cheng, Edwin, Lai, & Yeung, 2008). In fact, a growing number of studies have applied a neuromarketing approach to investigate how the subconscious and emotional response to those features could influence consumers' preferences.

This 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 choices in order to help advance the knowledge in this field. More specifically, this paper will first describe the link between neuroscience and consumer behavior, highlighting the key innovative elements of the neuromarketing approach. In the second part, the study will focus on the different neuroscientific techniques that are suitable for investigating food decision making and review 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 lie on a bed and stay still (not an optimal experimental context to study food choices). These techniques include eye-tracking, electroencephalography, skin conductance monitoring and automatic emotional facial expressions recognition.

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

2. Consumer behavior and neuroscience

"Consumer Neuroscience is a new burgeoning field comprising academic research at the intersection of neuroscience, psychology, economics, decision theory, and marketing" (Plassmann, Yoon, Feinberg, & Shiv, 2011). Many researchers have acknowledged that affect plays a guiding role for information processing (Clore, Schwarz, & Conway, 1994; Mellers, Schwartz, & Ritov, 1999; Schwarz & Clore, 1988, Fortunato, Giraldi, & de Oliveira, 2014, Jordão, Souza, Oliveira, and Giraldi, 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 behavioral theories, models and tested experimental designs from consumer psychology and related disciplines such as behavioral decision sciences, to develop a neurophysiologically sound theory to understand consumer behavior." The distinction between consumer neuroscience and neuromarketing should be addressed by the application: consumer neuroscience refers to academic research at the intersection of neuroscience and consumer psychology, while neuromarketing refers to "practitioner 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." Conducting an additional exploration of 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 brain areas are enrolled in the decision-making process so that they can be proficiently applied for future research. However, the ability to develop solutions that at a minimum reduce the presence of suboptimal or unnatural experimental settings will enable the design of studies more prone to detect what is occurring when a person makes a decision. There are already reviews examining 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 due to the size of the machines, to stimuli or situations that might be comparable to what is occurring in real-life situations. Although data have showed promising results about how these techniques can add useful information, enabling a broader understanding of consumer behavior, it is now possible to envisage solutions that can detect and study emotional reactions "in vivo" rather than just within the walls of a lab. This factor allows decision making processes about food to be studied in the place where decisions are actually made. For this reason, it is worthwhile to deepen the potential of neuromarketing not only as a consulting activity, as mentioned by previous studies (Plassmann et al., 2011) but also as an academic research activity. Due to the improvement of technology around portable solutions on the one hand, 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 on the other, it is possible to explore the possibility of monitoring specific biological activities within the central nervous system (e.g., brain waves activity by means of EEG) and in the peripheral nervous system, particularly regarding the branch of the autonomous nervous system (for instance, by means of skin conductance monitoring).

As described above and further in this paper in trying to show the importance of the contributions from neuroscience regarding food studies, the fMRI is the most popular brain imaging method used in consumer neuroscience and neuromarketing (Vecchiato et al., 2011). This technique returns a sequence of brain images of 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 brain activity with a time window of 10 s), they provide a very high spatial resolution that cannot be shown by any other brain imaging technique. It is well known that fMRIs can detect neuronal activation in a space of few cubic millimeters and thus detect the enrollment of brain systems such the amygdala or nucleus accumbens located in the deep brain that are strongly correlated with emotional reactions (Sheline et al., 2001) and reward (Berridge, Robinson, & Aldridge, 2009). The lack of time resolution due to the slow blood flow and the fact that subjects must lie on a bed inside a machine, however, make these techniques less suitable for studying food choices in front of the shelves of a shop. There are other brain imaging techniques available, however, that can overcome the limits provided by fMRI, such as electroencephalography (EEG) and magnetoencephalography (MEG), which can provide a time resolution in terms of milliseconds (Vecchiato et al., 2011). The 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 millimeters. The EEG detects the electrical activity of the neuronal population (a group of many neurons), more or less in a squared centimeter, while the MEG records the magnetic field generated by the neuronal population within a few cubic millimeters. In a broad sense, neuron activity is generally represented by two states: being in a rest phase or being in an action potential phase. Basically, the possibility of distinguishing between the two states can show whether the neurons are not firing (rest state) or firing (conveying an action potential, an electrical impulse along the axon of the neuron that excites other neurons or controls metabolic changes, organ functions and muscle 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 is also hampered by the fact that subjects must stay in a special laboratory (the walls are completely filled in by special materials to protect MEG signals from external interference), sitting on a chair (that is a better position than lying on a bed but is still a different condition than when people approach a shelf) and wearing a sort of helmet equipped with the "iron squids" that enable the detection of brain activation. Last but not least, the MEG technique takes advantage of liquid helium and uses special shielded structures to monitor and record the tiny brain magnetic signals generated in terms of femtotesla. This technology, aside from expert people with the skills to use the techniques properly, is expensive: a general estimation might range from 400 to 600 dollars per minute of usage. In contrast, EEG devices are relatively inexpensive, robust, and even wearable by the subject, making such techniques more interesting and better suited for evaluating marketing impacts enacted by food stimuli. Today, many companies in the field of medical equipment are also working to simplify the use of EEG equipment for specific marketing applications. This is the reason that EEG will be further exploited in the present paper. FMRI and MEG techniques will be useful to further develop consumer neuroscience research, as they have already provided useful insights enabling the implementation of neuromarketing solutions specifically for food studies. In this vision, the EEG technique seeking to monitor activity from the CNS might be coupled with other techniques. One example is skin conductance monitoring, which reveals information controlled by subcortical areas such as amygdala (Bechara et al., 2000), thus allowing the indirect measurement of deep brain areas (directly monitored by fMRI and MEG). Another example is eye-tracking, which conveys information about visual attention.

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

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

Neuromarketing techniques have gained importance over the last decade mainly due to several technological innovations and new ways of conceptualizing consumer behavior 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., grocery stores). Furthermore, in recent decades, a new way of thinking and studying the decision maker has emerged based on the acknowledgment that both rational and irrational dimensions (i.e., emotion and implicit attitudes) affect choices.

Purchase decisions are undoubtedly connected with emotional involvement with the brand. Individual decisions, however, which lead to a certain choice that determines behavior, occur rapidly and often occur routinely without complete rational control. Indeed, approximately 95% of all cognitive processes occur unconsciously, in the "black box" of the mind. In other words, not more than 5% of cognitive processes occur consciously (Zaltman, 2003).

The questions that a company must face are as follows: how much is a product able to generate emotions? How strong are the connection and the emotional involvement between consumers and products/brands? How strong is the emotion generated by the product's image and features, such as visual appearance (e.g., color or shape) or sensory attributes (e.g., odor, tactile features)?

In contrast, with merely rational consumer choice models, which study cognitive processes from a logical-mathematical perspective based on the writings of Adam Smith (Cătoiu & Teodorescu, 2004), from the 1970s 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 showed the prevalence of an emotional dimension in the perception of stimuli. Moreover, they together 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, high energy demanding process and followed by a second faster process, relevant to survival, that is connected to the most ancestral part of our brain, the thalamic area. Additionally, studies from Damasio and others (Rainville, Bao & Chrétien 2005; Damasio et al., 2000) showed the presence of cortical and subcortical processing in matter of affective states, enabling an understanding of 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 behavior and expected consequences). This key role for integral affect suggests that it is directly relevant in decision processes (Kahneman, Wakker, & Sarin, 1997; Lichtenstein & Slovic, 2006; Loewenstein & Lerner, 2003).

Neuromarketing helps to gather useful data to predict consumer behavior and allows a more adequate assessment of the effects of communication. Indeed, several studies have demonstrated the effectiveness of neuromarketing in predicting behavior compared to the traditional techniques based on subjects' declarations. For instance, Berns and Moore (2011) showed how measurements by means of fMRI of 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 of a song they listened to for the first 15 s. The interesting finding is that the subjective likability rated by means of self-reports about the song did not 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 traditional approaches. In another research article, Venkatraman et al. (2015) applied a unique protocol to evaluate responses to TV ads. The 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 were exposed to TV ads and were then asked to fill in self-reports about their level of linking, together with an Implicit Association Test to assess their memorization and emotional impact. In study 2), they enrolled 29 participants, who were exposed to TV ads while eye-tracking and psychophysiological signals (skin conductance, heart rate and respiration) were recorded; in study 3), 29 participants were exposed to the same protocol used in previous study but were monitored using an fMRI machine while watching TV ads: finally, in study 4), 29 subject were exposed to the same TV ads while a high-resolution EEG monitored their brain wave 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, the authors reported that the findings clearly demonstrate the importance of contributions provided by neurophysiological measures in addition to 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, as described further in the section related to EEG; however, only more recently have studies begun reporting on the use of EEG measures in real-life situations (Arns et al., 2007; Wascher, Heppner, & Hoffmann, 2014). Furthermore, these novel techniques can add value and objectivity to marketing studies, since these methods offer the possibility of directly measuring emotions during decisional processes and the reactions toward advertising stimuli, even if consumers are not aware of those emotions and reactions themselves (Bechara et al., 2000; Damasio, 1994; Kenning, Plassmann, & Ahlert, 2007; Posner, 2004; Smith & Gevins, 2000).

3. 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 behavior connected to survival, but it is also grounded in hedonistic impulses and psychological mechanisms. Our subconscious associates certain foods with pleasure and happiness, and certain others with fear.

Packaging, communication, and product displays play a major role in influencing consumers' emotional states and thus food purchasing choices. Today, consumers have a wide variety of alternatives within a single food category, and for this reason they require 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 will subsequently increase the chances that the product will be chosen (Arcia, Curutchet, Costell, & Tarrega, 2012).

There are numerous neuroscientific studies investigating the relationships 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, consumers can receive several kinds of information through packaging: recognition of the brand, information about an unknown product, or (dis)confirmation of expected information (Van der Laan, De Ridder, Viergever, & Smeets, 2012).

A recent eye-tracking study conducted by Ares et al. (2013a) involved 53 consumers who were asked to rate their perception of the authenticity of three different foods (mayonnaise, bread and yogurt) and express their willingness to buy each product. The 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. For 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 the 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 highlighted how visual attributes such as brightness, color, or shape can alter consumers' visual behavior while watching a shelf or a vending machine (Itti & Koch, 2001; Mannan et al., 2009).

Another interesting study was conducted by Venkatraman et al. (2015). The authors analyzed different sectors. More specifically, they analyzed 186 subjects with self-report scales, and 29 subjects with a modified version of the IAT (implicit grading and implicit memory of the spots): eye-tracker and psycho-physiological signals during commercial viewing, FMRI scans, and EEG. The data for each measurement were 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 influences product expectations and, as a consequence, affects the quality of the hedonic experiences. These experiments are

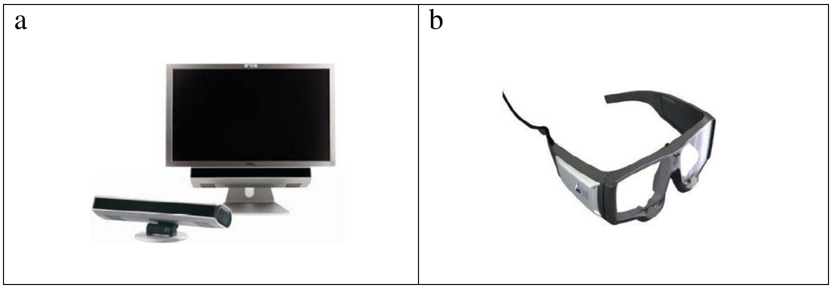

Fig. 2. a: Eye tracker remote recording systems; b: eye-tracking system.

usually conducted comparing different experimental conditions: (1) the "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) the "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; and (3) the "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 seeking to investigate the effects on consumer satisfaction of the following factors:

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

b) Geographical origin of the products (Caporale and Monteleone, 2004; Caporale, Policastro, Carlucci, & Monteleone, 2006; Stefani, Romano, & Cavicchi, 2006) or information about the brand (Di Monaco et al., 2004; Lange, Martin, Chabanet, Combris, & Issanchou, 2002);

c) Pricing information (Ares & Deliza, 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 pricing.

4. Application of neuromarketing tools in the food and beverage sector

In this section, 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 through online marketing campaigns that create unprecedented intimacies between adolescents and the brands and products that now literally surround them (Montgomery & 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 cannot be obtained through conventional marketing methods (Ariely & 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 of food and beverage 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 researchers to study food decision-making processes "in vivo," where the decisions are made (e.g., in front of shelves).

4.1. Eye-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 approximately 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, and represents the fastest valuable movement in the human body (Nielsen & Pernice, 2009; Wedel & Pieters, 2008). Visual information is collected during fixations, whereas during saccades, vision is suppressed (Pertzob, Avidan, & Zohary, 2009; Rayner, 1998). Eye movements allow people to shift the position of the highest resolution part of the retina, called the 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. It allows researchers to identify where users are looking, for instance, on a computer screen or a shelf in the supermarket. Eye movement recording is objective and provides high temporal and spatial information accuracy (Chae & Lee, 2013; Duchowski, 2003; Zurawicki, 2010).

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, which indicates the emotional valence of the stimulus (Lang, 1995; Lang, 1995; Dunning, Auriemmo, Castille, & Hajcak, 2010).

Eye-Tracker systems are available as remote systems embedded in the computer display (Fig. 1), as well as wearable and wireless system integrated into glasses (Fig. 2). The glasses make the measuring process less intrusive and allow research in real-life environments, as people can walk through a shop, stand in front of the shelves in a grocery store, or perform different daily activities like reading a magazine, using products or tasting foods.

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 & Subramaniam, 1995). Furthermore, this hypothesis claims that eye movements provide objective information about where a person's attention is directed (Hoffman & Subramaniam, 1995; Spence & Driver, 2004).

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

Today, eye-tracking methodology is widespread in consumer behavior studies, including food packaging analysis (e.g., Pieters, Warlop, & Wedel, 2002; Reutskaja, Hagel, Camerer, & Rangel, 2011; Bialkova & van Trijp, 2011; Van Herpen and Van Trijp, 2011; Graham, Orquin, & Visschers, 2012; Antunez et al., 2013; Ares et al., 2013; Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013; Gofman, Moskowitz, Fyrbjork, Moskowitz, & Mets, 2009).

It is well known that food purchase decisions are influenced by a number of factors that go beyond taste. Contemporary consumers have a wide variety of alternatives in the same product category. Therefore, consumers require additional information to make their purchase decisions. Labels, or more generally, communication implemented by the brand, are essential to attract customers' attention and 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 plays a decisive role in the perception and expectations about a product (Ares & Deliza, 2010; Mizutani et al., 2012; Moskowitz et al., 2009; Crilly, Moultrie, & Clarkson, 2004; Fenko et al., 2011; Murray & Delahunty, 2000).

Traditionally, packaging was studied based on consumers' self-report questionnaires, interviews or focus groups; however, these techniques can only measure what the consumer is aware of and willing to declare (Greenwald & Banaji, 1995; Jacoby, Stephen Lindsay, & Toth, 1992). Visual processes, in contrast, are not completely conscious. Therefore, eye-tracking research is highly suitable to obtain objective information about food packaging.

In a recent study, Vidal and colleagues (Vidal et al., 2013) asked a group of participants to rate the healthiness of yogurt labels while their eye movements were recorded. The 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 an impact on the perception of healthiness of the yogurts was the nutrition label. The only information used to evaluate the purchase intention was the product name and the nutrition label.

Van Herpen and Van Trijp (2011) conducted an eye tracking study testing consumer attention on three different nutrition labeling 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, Mawad, Giménez, and Maiche (2014) conducted a study using 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 in a greater search and analysis of nutritional information for the choice. This study highlighted the importance of the thinking approach for people's food choices, and the results are very useful to improve food packaging and thereby increase sales.

Similarly, Visschers, Hess, and Siegrist (2010) studied visual attention to the nutrition information on 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, as participants spent more time looking at the product labels of the food that they decided to buy.

Several studies have been conducted focusing on packaging features.

For example, Piqueras-Fiszman et al. (2013) conducted an eye-tracking study seeking 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 the jam jar influenced consumers' willingness to buy the product.

Koenigstorfer et al. (2013) investigated the role of nutrition information on decision making, finding that the way in which the nutrition information is presented can affect both visual attention and the tendency to make healthy choices.

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

The results showed that products with color-coded GDAs were fixated upon 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. (2015) 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 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.

Regarding packaging information position, Graham and Jeffery (2011) noted that consumers spend over 30% more time viewing a nutrition label that is positioned centrally on a package than those placed on the sides. Further, they showed that label information displayed at the bottom of the label was 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 and Loose (2013). The researchers demonstrated that the less visually salient the nutrition label, the more time passes before the subjects see it for the first time.

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

Goldberg, Probart, and Zak (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 center of the label is harder to find than information at the bottom or the top. With a similar aim, Antunez et al. (2013) studied the communicative effectiveness of three colored (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, finding that a traffic light on the label was more effective in communicating the healthiness of food than a standard label.

In conclusion, eye tracking research on food labeling confirmed the usefulness of this methodology as a viable alternative to study the visual behavior of consumers regarding packaging, particularly in the field of food packaging (Wedel & Pieters, 2008). With eye-tracking, it could be possible to explore several factors related to the packaging, enabling the revelation of the most watched information in general and how they are used differently by target users characterized by diverse cultures, ages, gender, socio-economic status, etc. Thus, with Eye-Tracking, it might be possible to improve the layout of packaging and the effectiveness of information communicated. Decision-making processes could also be analyzed and improved using eye-tracking techniques.

4.2. Electroencephalography (EEG)

Among the instruments employed in neuromarketing research, the most common techniques are functional magnetic resonance (fMRI), and the ElectroEncephaloGram (EEG). The first 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 good spatial resolution (approximately 1–2 mm). These advantages led to the wide use of the fMRI in recent years for research on decision-making processes to identify the areas involved in various choices, correlating the activation of specific cortical areas to consumers' preferences (e.g., Deppe, Schwindt, Kugel, Plassmann, & Kenning, 2005; Schaefer and Rotte, 2007).

One relevant study by Plassmann and colleagues (Plassmann et al., 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. The necessary equipment is very expensive (Ariely & Berns, 2010; Plassmann et al., 2012), and the time resolution is low (2–5 s). Moreover, the scan can be annoying for the subject, who must remain still while prostrate 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) can 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, as in food studies. The EEG measures the cortical activation of 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, Tassinary, & Berntson, 2000; Jasper, 1958), which represents the common reference system (Fig. 3).

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 and reflecting different cognitive states.

Although the spatial resolution appears modest, and the EEG is able to detect only superficial cortical activity (Zurawicki, 2010), there are several advantages to using EEG. First, the EEG signal has a high temporal resolution in sub-milliseconds (Huettel, Song, & McCarthy, 2004), which allows the accurate detection of changes in brain activity

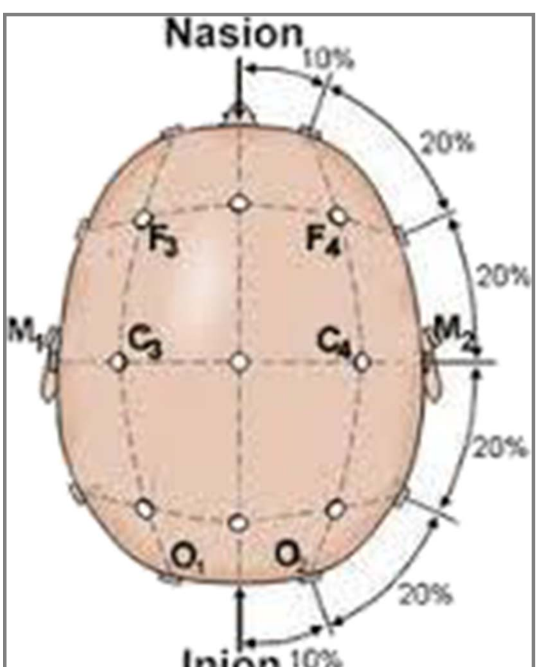

Fig. 3. Placement points of EEG sensors on human head.

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 & Berns, 2010; Plassmann et al., 2012). Indeed, neuroimaging techniques require the subject to lie still inside a noisy machine (Zurawicki, 2010).

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

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

The EEG index that is most often used in the field of neuromarketing is the cortical asymmetry in the frontal alpha band. The underlying principle is the lateralization of brain functions, particularly the selective activation of the left (right) part of the cerebral cortex in response to positive (negative) stimuli (Davidson, Schwartz, Saron, Bennett, & Goleman, 1979). Indeed, the left part of the frontal cortex is part of a circuit involved in experiencing positive emotions, which leads to a tendency to approach stimuli perceived as desirable, while the corresponding area on the right is an important component of the circuit involved in the processing of negative emotions and in defensive withdrawal from stimuli (Davidson, 2000; Davidson, 2004).

Several scholars have collected empirical evidence to support the principle of lateralization, both in adults and in children (Davidson, 1993a, 1993b; Davidson & 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, O'Hara, Uijtdehaage, Mandelkern, & Leuchter, 1998; Laufs et al., 2003; Laufs 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, Coan, & Nazarian, 2004; Davidson, 1998; Pfurtscheller, Stancak, & Neuper, 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.

Today, FAA is widely accepted as an index of approach-withdrawal tendency toward the stimulus (Berkman & Lieberman, 2010; Carver & Harmon-Jones, 2009; Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Harmon-Jones, Gable, & Peterson, 2010; Price, Peterson, & Harmon-Jones, 2012; Rutherford & Lindell, 2011), and it is broadly employed in neuromarketing research.

One of the marketing areas that benefitted 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, Matukin, and Szezurko, 2010; Ohme, Reykowska, Wiener, & Choromanska, 2009, Ohme, Reykowska, et al., 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.

In addition to advertising, the field of food decision-making and consumption has also employed the FAA index in order investigate product attractiveness, with a particular focus on different olfactory aromas.

Kline, Blackhart, Woodward, Williams, and Schwartz (2000) measured the activation of the frontal lobe while consumers had to smell different odors (pleasant: vanilla, unpleasant: valerian, neutral: plain water). Vanilla aroma, which is the most pleasant odor, induced significantly greater relative left-hemispheric activation compared to the other odors.

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

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

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 flavor 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 chewing gum containing sugar. Conversely, during the tasting of a sugar-free gum, 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, Randolph, & Burkhalter, 2012) investigated the influence of price and brand familiarity on purchasing decisions by recording cortical activity. They detected activation in the frontal lobe during the tasting of two drinks (one private-label brand and one manufacturer labeled 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 because 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 from a stimulus and it proved to be a predictor of consumers' preferences and purchasing decisions (Ravaja, Somervuori, & Salminen, 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 field of food and beverage studies.

4.3. Skin conductance and food studies

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

The skin conductance level (SCL) is determined by the activity of the skin's sweat glands, which are controlled by the Sympathetic branch (Boucsein, 1992) of the Autonomic Nervous System (ANS). The understanding of the neural bases of SCL have come from brain injury 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, Scabini & Violani 1982) and in the bilateral ventromedial prefrontal cortex, bilateral anterior cingulate gyrus, right inferior parietal lobes and amygdala (Bechara et al., 2000). SCL responses can be elicited by electrical stimulation of the amygdala, hippocampus, and anterior cingulated and frontal cortex (Mangina and Beuzeron-Mangina, 1996). The positive correlation between SCL and the ventromedial prefrontal cortex when experiencing risk and reinforcement are shown in functional imaging studies (Critchley, Elliott, Mathias, & Dolan, 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, 1994) suggests that arousal, in addition to generating feelings, might bias social behavior and decision making.

The ANS regulates involuntary and unconscious actions such as breathing, digestion, heartbeats, and internal-organ functions. 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. The sympathetic nervous system is a set of "accelerators" enabling humans (and animals) to have a "fight or flight response" that is triggered when humans perceive a threat such as a harmful event or an attack. The ANS will automatically trigger a set of physiological reactions aimed at coping with the threat either by attacking (fight) or simply escaping it (flight response). For instance, with an increased heart rate and lung ventilation, the organism will have more oxygen in the blood, and more blood will be pumped into the muscles to support the behaviors for attacking the threatening stimulus or to compensate for the energy lost by of running away.

The parasympathetic branch, on the other hand, is a set of "brakes" that stimulates the body to return to homeostasis after the "fight or flight response." Among 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 managing organism functions while the body is resting or digesting.

The "fight or flight response" increases the sweat glands' activation in order to cool the body while a person is fighting or running away. Enhanced sweat gland activity enables the body to decrease the body temperature raised by the motor actions. A decreased SCL, reflected by diminishing sweat gland activities, corresponds to an increase of body temperature. This is a central physiological function executed by sweat 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 et al., 2009; Bradley, Cuthbert, & Lang, 1996) according to the scientific framework explained by the "Fight or Flight Theory" (Porges, 2011). This can also explain other physiological changes, such as cardiorespiratory rhythms (Rainville et al., 2005; Mauri, Onorati, & Russo, 2012) or pupil dilation (Bradley, Miccoli, Escrig, & Lang, 2008; Onorati, Barbieri, Mauri, Russo, & Mainardi, 2013) correlating with different emotional states.

SCL measurement has been used in many studies in many different fields, including psychology, neuroscience, physiology, and technology.

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

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

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 that 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 is reduced, as the electric current flows much more easily through the body. This is the reason why the SCL also has different labels and nouns, such as electro-dermal activity (EDA), skin conductance (SC), which is the reverse of skin resistance (SR), or galvanic skin response (GSR).

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

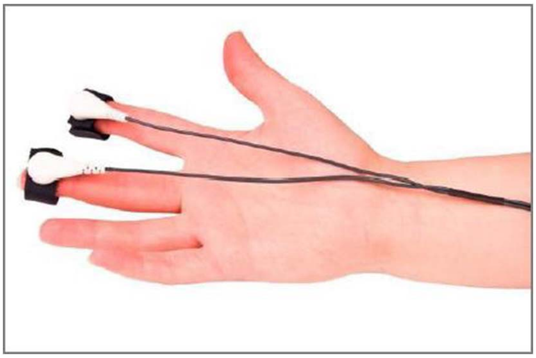

Fig. 4. SCL sensors position on finger tips.

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

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

Recently, neuro-economics (Rustichini, 2005) and Neuromarketing (Lee, Broderick, & Chamberlain, 2006) has started using SCL in order to assess emotional responses in purchasing and decision-making processes (Cipresso et al., 2015).

The measurement of SCL has been applied in different research studies in marketing in order to assess different processes in consumers' reactions. For instance, Walla, Brenner, and Koller (2011) showed how the use of skin conductance can reveal preferences for certain brands over other ones. In another study, SC was used to determine which colors were more arousing (Wilson, 1966).

The SCL has been used not only to determine whether pictures (Lang, 1995) or videos (Vecchiato et al., 2010) could be more or less 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, He, Mensink, Verhoeven, and de Graaf (2014) showed how 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 correlated with gender, type of beverage, and amount of repetitive exposure. In another study (Nederkoorn et al., 2000), SCL was shown to significantly change during the food consumption experience, while it decreased after food intake.

de Wijk, Kooijman, Verhoeven, Holthuysen, and Graaf (2012) explored the use of skin conductance in relation to 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 simply viewed the different types of food; in the second phase, the subject smelled the food types; and in the third phase, participants tasted the different food types. SCL showed a significant arc across the phases of the experimental situation (vision, smell or tasting), with lower values during vision and higher values while smelling and tasting.

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

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

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

4.4. Face reading technology

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

Today, it is possible to operate facial expression decoding automatically through software such as 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 on facial expressions. The software records users' faces through a webcam and codifies the facial muscle movements on the basis of 44 Action Units (AUs) identified by Ekman. AUs are contractions or relaxations of one or more muscles, and there are thousands of combinations that allow the identification of different emotions.

From a theoretical standpoint, emotional facial expressions are considered an evolutionary heritage that allowed the possibility of refining the "fight or flight" response within members of the same species. The Polivagal theory proposed by Porges (Porges, 1995) helps 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 (particularly regarding the vagal nerve, as the branches of the vagal nerve serve different evolutionary stress responses in mammals). According to the theory of evolution on the bases of neuroanatomical comparative studies across different species, the ANS changed along 3 different global stages. In the first stage, labeled "visceral vagus," the vagus is simply "visceral," as it does not yet have the myelin folder (the myelin folder speeds up the action potential along the axon of neurons, thus increasing the rapidity of responses provided by the nervous system — this indicates the age of the process 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). In the second stage, the "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 a response system), but it mobilizes and regulates the "fight or flight" behaviors, responding 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 prompt 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). At this point, a myelin folder is present (an indication that it is a new system from a phylogenetic standpoint), and 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 a rapid increase in the metabolic activity of autonomic processes, and 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 enroll other structures, like the connections of the ANS with the other brain systems, the hypothalamic-pituitary-surrenal way, the neuropeptides of oxytocin and vasopressin and the immune system. As the emotional facial expressions can now be decoded automatically by software, they have become a crucial source of information in food studies.

Generally, the software mechanism starts with the classification of facial reactions by estimating the probability that the face is showing one of the six basic emotions 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' reactions to different taste stimuli (Rosenstein & Oster, 1988, 1997; Steiner, 1973, 1977, 1979).

More recently, Greimel, Machtb, Krumhuberc, and Ellgringb (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 watching a video clip taken from a movie inducing joy or sadness.

The results strongly indicated that the tastes produced specific facial reactions that were not affected by participants' moods. Indeed, induced emotions modulated taste ratings, but the opposite was not true.

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

In another study (Zeinstra, Colindres, Koelen, & De Graaf, 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 at measuring their preference or their neutrality. This study was 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 s after each tasting. The analysis of the video recordings through the 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, Haindl, et al., 2014; de Wijk, Valesca, Verhoeven, Holthuysen, & de Graaf, 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 among 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 studies about food products, such as the one conducted by Horio (2003), it has been shown that food preferences can be inferred better for "disliking" or "aversion" than for "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, Sidorkina, et al. (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 tasting) measure. The results showed that the latter allows better discrimination between the different tastes that in turn had a high correlation with the hedonic preferences. Nevertheless, the inclusion of some implicit measurements over the self-report declarations about preference provides a good index of liking toward food because of the capability to hold the aversive responses.

Regarding food advertising, Lewinski, Fransen, and Tan (2014) showed that the expression of happiness was the greater indicator of advertising effectiveness and a positive predisposition toward the brand.

All these studies suggest that the application of the techniques of facial expressions analysis in the field of food and beverage is appropriate, albeit with all due caution and care.

5. 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 as follows:

- Costs. Limited costs allow increasing replicability of analyses and diffusion of methodologies. Moreover, wider samples are possible when data collection is inexpensive;
- Type of equipment needed. This influences costs related to the initial investment, replicability, and diffusion of the methodology;
- Duration of collection. Fast data collection allows larger sample sizes and lowers costs. Moreover, it could influence the reliability of data because of the tiredness of respondents;
- Width of the field of application. The possibility to extend data collection geographically allows the gathering of better information on food choice behavior for inferential analyses;
- Invasiveness of data collection. More invasive methods, although this paper discusses mainly non-invasive methods, could influence the sampling process and induce sample bias into results of the analyses;
- Naturalness of the environment. Naturalness of the environment could allow the retrieval of precise information on consumers at the moment of food purchase. A laboratory environment, on the other hand, could bias the results;
- Accuracy of the information retrieved. The ability to capture small differences in consumers' behavior could furnish important sources of variability in the analysis;
- Reliability of the information. This could influence the reliability of results with important consequences on impacts;
- Usefulness for descriptive statistics. This is the ability of the information to be used to describe individuals and/or samples with descriptive statistics and graphs;
- Usefulness for segmentation analyses. The possibility to have results that effectively allow the creation of targeted strategies for specific consumer groups could be relevant for food marketing implications;
- Usefulness for predictive analyses. Models predicting consumers' behavior are important for setting up strategies and drawing inferences.

Table 1 below compares the analyzed methodologies and self-report/questionnaire-based data collection for food preferences.

6. Discussion

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

Specifically, neuromarketing techniques enable researchers to take advantage of results from consumer neuroscience thanks to the use of fMRI, MEG or PET techniques, which allow the identification of the brain structures that are enrolled during decision making about food products. On the other hand, to reduce the impact of the presence of the recording system that fMRI, MEG and PET techniques, the methods described in the present paper should be implemented, as they allow the monitoring of the brain structure in a less invasive and less expensive way. Indeed, scholars worldwide are developing a growing number of empirical applications of neuromarketing techniques on food

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 participating to the data collection, costs related to equipment and personnel for assistance during data collection	High, related to frequent monetary compensation to respondents for participating 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 participating to the data collection, costs related to equipment and personnel for assistance during data collection	Limited related to frequent monetary compensation to respondents for participating 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, assistant for data collection. Only assistant for portable eye-trackers	EEG machine, computer/laptop, dedicated room/laboratory for data collection, assistant for data collection.	Skin conductance machine, computer/laptop, dedicated room/laboratory for data collection, assistant for data collection.	Face reading machine, computer/laptop, dedicated room/laboratory for data collection, assistant for data collection.
Duration of collection	Fast, few minutes depending on the length 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 equipment	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

issues.

Meanwhile, the industry could develop a 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 is the possibility that neuro-marketing tools will evolve to cheaper and faster applications; and second is the hope that neuromarketing will provide the industry with information that cannot be obtained through other traditional marketing methods. Such a trend could enable rapid developments of the techniques reviewed here. The ICT industry, connected with bio-engineering, could have strong incentives to work on those improvements in this regard.

At 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.

Neuro-marketing measurements, however, could be highly sensitive, potentially bringing to light hidden elements of an 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 it remains relatively unexplored to date.

In general, the neurological reaction of consumers in terms of taste, packaging, which includes labeled information and brands, communication and pricing has been studied. The analysis of the literature, however, has allowed neuromarketing techniques to be systematized, thereby identifying the main elements of focus for which they are applied. In fact, *eye tracking* is widely used to research the importance of brand and labeled information, especially related to nutritional aspects; *frontal alpha asymmetry through EEG* is mostly used in food advertisement research to evaluate the impact of specific odors during tasting, although the literature is considerably poor with regard to this approach; *skin conductance* is generally used to explore the reaction to the pleasantness of food products and predict consumers' preferences; and *face reading* is used in studies measuring disliking more than neutrality or positive preferences. Experiments in the literature focus on fruit juice, milk and other drinks, finding good correlations with hedonic preferences.

To the knowledge of the authors, there are no studies in the field of food choices applying multiple techniques within the same experiment. An interesting research development would be the use of multiple methods to explore food preferences. In other words, this would comprise the simultaneous application of:

a) EEG measures that gather information about the cortical activity (in particular, from the frontal lobes correlating with decision-making processes) reflecting approach/withdrawal behavior toward the stimulus; in other words, the hedonic quality of emotional reaction or valence;
b) Skin conductance measures, which provide information about the subcortical activity related to the level of arousal or intensity of emotional reactions;
c) Eye-tracking, which links emotional reactions to a specific element of the visual scene;
d) Automatic emotional facial expression analyses, which provide a second reference aside from internal reactions that are redundant but also useful for interpreting consumers' reactions.

The power of the combination of all these different metrics suggests the possibility of studying decision making about food products, taking into account the place where these phenomena are usually occurring: real grocery stores, in front of the shelves.

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

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