Advances in neuroscience and marketing: analyzing tool possibilities and research opportunities

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Abstract

Purpose – This study aims to illuminate the contribution of neurophysiological techniques in the field of marketing and consumer decision-making and to highlight avenues and research questions that marketing researchers can take advantage of from neuroscience and psychology to inform marketing phenomena.

Methodology – The authors first reviewed the roots and definition of consumer neuroscience. Then, the authors outlined the main characteristics of the most commonly used neurophysiological tools (namely, skin conductance, facial electromyography, electrocardiogram, eye-tracking, electroencephalography, functional magnetic resonance imaging, functional near-infrared spectroscopy, magnetoencephalography and transcranial magnetic stimulation) with a special emphasis on their advantages and weaknesses. Finally, the authors propose the development of research lines that could be implemented by marketing researchers with an appropriate application and understanding of tools and theories of neuroscience and psychology.

Findings – The authors propose research questions to be addressed within four thematic areas: opportunities in product decisions (predicting product purchasing decisions, consumer responses to branding efforts and packaging), pricing, communication and retailing scenarios. The authors also incorporate insights into the complementarity of neurophysiological tools to traditional ones and situations in which these tools are useful for enhancing marketing theory. The authors finally shed light on the moral–ethical criticisms of this new branch of marketing.

Value – To the best of the authors' knowledge, this research constitutes the first study in identifying the research opportunities that marketing researchers could take advantage from neuroimaging and physiological tools to inform marketing theory and practice.

Keywords Neuromarketing, Neurophysiological tools, Marketing research, Research opportunities, Ethical concerns

Paper type Research paper

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Avances en neurociencia y marketing: Analizando las posibilidades de las herramientas y las oportunidades de investigación

Resumen

Propósito – Esta investigación tiene como objetivo esclarecer la contribución de las técnicas neurofisiológicas en el campo del marketing y la toma de decisiones de los consumidores y destacar las vías y preguntas de investigación que los investigadores de marketing pueden aprovechar de la neurociencia y la psicología para informar sobre los fenómenos del marketing.

Planteamiento – En primer lugar, revisamos el origen y la definición de la neurociencia del consumidor. A continuación, esbozamos las principales características de las herramientas neurofisiológicas más utilizadas (a saber, la conductancia, la electromiografía facial, el electrocardiograma, el seguimiento ocular, la electroencefalografía, la resonancia magnética funcional, la espectroscopia funcional en el infrarrojo cercano, la magnetoencefalografía y la estimulación magnética transcraneal), haciendo especial hincapié en sus ventajas y debilidades. Finalmente, se propone el desarrollo de líneas de investigación que podrían ser implementadas por los investigadores de marketing con una adecuada aplicación y comprensión de las herramientas y teorías de la neurociencia y la psicología.

Resultados – Proponemos preguntas de investigación para ser abordadas dentro de cuatro áreas temáticas: oportunidades en las decisiones de producto (predicción de las decisiones de compra de productos, respuestas de los consumidores a los esfuerzos de marca y envasado), precios, comunicación y distribución. También incorporamos ideas sobre la complementariedad de las herramientas neurofisiológicas con las tradicionales y las situaciones en las que estas herramientas son útiles para mejorar la teoría del marketing. Por último, arrojamos luz sobre las críticas ético-morales a esta nueva rama del marketing.

Palabras clave – Neuromarketing; herramientas neurofisiológicas; investigación en marketing; oportunidades de investigación; preocupaciones éticas

Tipo de articulo – Trabajo de investigación

神经科学和营销方面的进展。分析工具的可能性和研究机会

摘要

目的 – 本研究旨在阐明神经生理学技术在营销和消费者决策领域的贡献，并强调营销研究人员可以从神经科学和心理学中利用的途径和研究问题，以告知营销现象。

方法 – 我们首先回顾了消费者神经科学的根基和定义。然后，我们概述了最常用的神经生理学工具（即皮肤电导率、面部肌电图、心电图、眼球追踪、脑电图、功能性磁共振成像、功能性近红外光谱、脑磁图和经颅磁刺激）的主要特点，特别强调了它们的优势和劣势。最后，我们提出了研究路线的发展，这些路线可以由营销研究人员通过适当的应用和理解神经科学和心理学的工具和理论来实施。

研究结果 – 我们提出了四个主题领域的研究问题：产品决策中的机会（预测产品购买决策、消费者对品牌推广工作的反应和包装）、定价、沟通和零售场景。我们还纳入了对神经生理学工具与传统工具的互补性的见解，以及这些工具对加强营销理论有用的情况。最后，我们对这个新的营销分支的道德伦理批评进行了说明。

纸张类型 – 研究论文

1. Introduction

Academically speaking, some authors conceive that Professor Smidts (2002) was the first scholar to use the concept of neuromarketing in his inaugural conference series, Research in Management, titled "Looking into the brain: on the potential of neuromarketing." Thereafter, scholars such as McClure *et al.* (2004) published the first marketing-related research using neuroimaging in journals such as *Neuron*, aiming to assess the neurophysiological origin of consumer decision-making in marketing environments.

Since then, there have been key academic milestones that corroborate the rise of neuromarketing as an emerging discipline (Casado-Aranda, 2021):

- In 2002, the Nobel Prize in Economics was given to the psychologist Daniel Kahneman for integrating knowledge from psychology and economics;

- the Association for Neuropsychoeconomics and its related *Journal of Neuroscience, Psychology and Economics* were founded in 2005;
- in 2011, the Neuromarketing Science and Business Association (NMSBA) was developed, which explains the main ethical and moral principles of the scientific practice in this field;
- Kanheman (2011) published the book entitled "Think Fast, Think Slow," which describes how cognitive neuroscience could serve to enhance economics and human behavior theories;
- notable growth in the amount of firms dedicated to consumer neuroscience – in 2017, the NMSBA enlisted a total of 123 companies worldwide;
- an increased number of Special Issues in high-impact marketing-related journals, such as *Journal of Consumer Behavior* (2008), *Journal of Consumer Psychology* (2012), *Journal of Marketing Research* (2015) and *Psychology and Marketing* (2021); and
- an outstanding increase in the number of empirical and theoretical-based studies in consumer neuroscience, which have grown exponentially from three articles in 2006 to a total of 203 in 2019 (Sánchez-Fernández *et al.*, 2021).

Despite these advances, the Marketing Science Institute (MSI, 2020) stated that the application of neuroimaging and psychophysiological theories and techniques to the understanding of consumer decisions is still growing, and empirical and theoretical developments should provide answers to specific unsolved questions: "What advances exist in using neuroscience and biomarkers to understand customers?" "When should insights from neuro supplement or replace traditional approaches?" and "What are the ethical implications of such research compared to other methods?" Put differently, there is an urgent need to illuminate the increased contribution of neurophysiological techniques in the field of marketing and consumer decision-making while highlighting opportunities that marketing researchers can take advantage of from neuroscience and psychology to inform marketing phenomena. Note that there is a slight but crucial difference between the concepts of neuromarketing and consumer neuroscience, despite these have been interchangeably used. Neuromarketing is a fashionable concept more related to the practical and industry application of theory and knowledge obtained from consumer neuroscience (Hubert and Kenning, 2008).

The current research precisely aims to answer the MSI's questions and become a guide for marketing researchers interested in neuromarketing and consumer neuroscience to learn about the origin and definition of this discipline, its main tools, and the use that can be made of neurophysiological techniques to advance marketing research. As such, we first review the roots and definition of consumer neuroscience. We then outline the main characteristics of the most commonly used neurophysiological tools in the field of marketing, with a special emphasis on their advantages and weaknesses. Later on, we propose the development of research questions that could be addressed by marketing researchers with an appropriate application and understanding of tools and theories of neuroscience and psychology. Finally, we take a close look at some recommendations and ethical and methodological challenges that marketing scholars should consider when implementing prospective consumer neuroscience research.

2. From psychophysiology and neuroscience to neuroeconomics and consumer neuroscience

Traditional market research has largely made use of tools such as focus groups, interviews, secondary sources or surveys to deepen, explain, predict and discover relationships between

consumption-related variables, whose measurement attempts to be objective (Harris *et al.*, 2018). Thus, marketing scholars have traditionally used theoretical models and self-reported techniques to evaluate constructs such as advertising effectiveness or recall, product likeability or preference, risk, trust, attitudes, intentions or even consumer behavior, given a product, price, communication or distribution strategy (Manippa *et al.*, 2022; Petty and Cacioppo, 1986). More recent studies have even explored the use of nudge/choice architecture tools in marketing, "which refer to strategic changes in the environment (such as product location) able to guide consumer's behavior in a predictable way, without forbidding any options or significantly changing their economic incentives" (Manippa *et al.*, 2022). Despite the enormous advantages in terms of speed, statistical significance and cost, marketing researchers soon emphasized that there is an emotional component in consumer decisions that slightly escapes from measurement by traditional methods, which are subject to biases such as social desirability, subjectivity bias or language issues (Martinez-Fiestas *et al.*, 2015).

This need to complement traditional methods soon coupled with the advent of the so-called behavioral economics in the late 1970s, when psychologists such as Kahneman and Tversky corroborated that we all develop heuristic (i.e. unconscious and primarily affective shortcuts) and non-opportunistic actions that cannot be measured solely for the classical rational models or self-report tools (Tversky and Kahneman, 1986). These behavioral economists demonstrated that the underlying mechanisms and ideas revealed by psychophysiology could enhance and deepen human and consumer behavior theories. **Psychophysiology** analyzes the physiological basis (e.g. autonomic body responses) of psychological mechanisms (such as trust or risk) or, more in general, the interrelationships between mind and body. Since the 1980s, these biometric methodologies have expanded exponentially among consumer behavior researchers, who use such techniques as an unbiased and reliable measure of consumers' affective and automatic reactions to marketing stimuli (Solnais *et al.*, 2013).

Neuroscience, that is, the scientific study of the mental activities derived from coordinating and integrating incoming sensory messages and outgoing motor messages, began to acquire importance in the study of human behavior in the 1990s. Particularly, the development of the cognitive and affective neuroscience literature has recently cleared up the neural mechanisms by which mental processes of interest for human decision-making occur in the brain. The application of neuroimaging tools (such as functional magnetic resonance imaging (fMRI)) has opened a route for neuroscience theories that can enrich the understanding of human decisions. For example, a great deal of research has also evaluated the neural correlates (i.e. brain activity that corresponds to, and is necessary for, producing a particular experience) of intentions, and has concluded that brain areas related to motivation and self-relevance (such as lateral prefrontal cortex) are associated with intentional efforts (Kranzler *et al.*, 2018).

The theories and tools of cognitive and affective neuroscience were first used in the social sciences by economists, with the aim to better understand and predict economic decision-making. This was the birth of **neuroeconomics** (Camerer *et al.*, 2005). While the standard economic literature forecasts behavioral responses by means of theory-based constructs (namely, preferences or utility), cognitive neuroscience is based on the physiological responses that affect economic decision-making (Hubert and Kenning, 2008). Along this line, some authors have been interested in understanding the theoretical foundations of the dual process theory, an economic perspective that suggests that human cognition can be seen as the result of a "higher" controlled mental process (called System 2) and a "lower" heuristic one (called System 1) (Camerer *et al.*, 2005). Kuhnen and Knutson (2005) validated the prospect theory (Kahneman and Tversky, 1972), as they showed that economic rewards and losses activate different brain regions.

Consumer behavior and marketing scholars were the next social science academics to use cognitive and affective neuroscience theories and tools to inform marketing. This resulted in the birth of **consumer neuroscience**, which uses neurophysiological tools to understand events of crucial importance to marketing theory, such as predictable and unpredictable purchases, rewards, trust, willingness to pay (WTP), self-relevance, self-interest, memory or emotional engagement (Hubert and Kenning, 2008; Sánchez-Fernández *et al.*, 2021). Section 4 of the current research develops the most remarkable and outstanding research questions and domains that could greatly benefit from the application of neurophysiological tools and theories.

3. Neurophysiological tools: pros and cons

In addition to self-report responses, the literature on human behavior has largely confirmed that it is also necessary to capture the visceral, somatic and neural responses that occur in an individual organism during exposure to a given stimulus (Casado-Aranda, 2021). Specifically, research on human decision-making (Pulvermüller *et al.*, 2001) has classified these neurophysiological responses according to the nervous system that generates them: peripheral and central. The **peripheral nervous system** (PNS) is responsible to link the neural physiology to the organs, limbs and skin. The **central nervous system** (CNS) consists of two parts: the brain, which is the center of our thoughts, interpreter of our outside context and the origin of the control of body movement; and the spinal cord, the communication pathway between the brain and the body.

Precisely, neurophysiological methods enable the assessment of consumer responses derived from their PNS and CNS, while they interact with several tasks, namely, marketing stimuli or decision-making. We now develop an evaluation of the main neurophysiological tools according to whether they measure responses derived from the PNS (physiological tools) or the CNS (brain imaging tools).

3.1 Physiological tools

3.1.1 Skin conductance. Skin conductance responses (also called galvanic responses or impedance levels) refer to the ability of the skin to conduct electricity derived from an external application of direct current of constant voltage. The activity of eccrine sweat glands is responsible for modifications in skin conductance, which are the reflex of the secretion of sweat from these glands. Because sweat constitutes an electrolyte solution, the presence of more sweat in skin pores increases skin conductivity. The sympathetic branch of the autonomic nervous system is responsible for eccrine sweating, so skin conductance indicates the **intensity, arousal or emotional arousal** of the sympathetic autonomic nervous system. The electrodes needed to measure skin conductance are placed on the distal (first) phalanges of the index and middle finger (Figure 1(a)). The total cost per hour of a galvanic response session is between €25 and €100/h.

Recent research in the field of consumer behavior has evaluated electrical skin activity responses in responsible consumption or environmental settings (Martinez-Fiestas *et al.*, 2015), radio or television effectiveness or tourism destination communication campaigns (Li *et al.*, 2018).

3.1.2 Facial electromyography. Facial electromyography (EMG) records the electrical signals associated with the subtle movements of facial muscles and is able to detect facial muscle contractions in response to affective information, even though such activity is not obviously perceived (Li *et al.*, 2018). Research in the field of psychophysiology has shown that facial EMG is an established index of hedonic valence (Martinez-Fiestas *et al.*, 2015). More specifically, the response of three facial muscles is used (Figure 1(b)):

(1) Increased activity on the superciliary **corrugator** muscle, which causes the frown to furrow, is associated with negative emotions.

(2) Increased activity of another muscle, the **zygomaticus** major, which is associated with positive emotions during viewing and listening to pleasant and positive images and sounds.

(3) Increased activity in the **orbicularis**, which has been associated with positive emotions and high arousal during viewing affective images and media.

Given the enormous usefulness of EMG in identifying experienced affective valence, studies in the branch of consumer behavior have used such a tool to evaluate the emotional content of political and environmental (Martinez-Fiestas *et al.*, 2015) messages, or the effectiveness of tourism advertising (Li *et al.*, 2018). The total cost per hour of a galvanic response session is between €30 and €1,000/h.

3.1.3 Electrocardiogram. Heart rate variability consists of the physiological event of variation in the time interval among heartbeats (Lang *et al.*, 1998). This heart variability is related to the activations of the sympathetic (responsible for energy mobilization) and parasympathetic (responsible for energy conservation) systems of the PNS. Its recording is developed through electrocardiography, which measures the number of heart contractions per minute (see Figure 1(c)). Research in the field of psychology concludes that the heart rate provides two psychological significances (Lang, 1998):

(1) On the one hand, studies agree that cardiac changes are due to a **motivational/ emotional** type of adaptation to fight or resting state circumstances (Bradley *et al.*, 2005). For example, fear, stress or physical exercise implies a higher heart rate.

(2) Second, cardiac changes are due to cognitive functions of an **attentional, perceptual or mental processing** type (Bradley *et al.*, 2005). This fact implies that when we experience an attentional process, we are oriented toward that stimulus because we need to process it, a fact that translates into a greater deceleration of the cardiac response.

Literature in the branch of consumer behavior has used heart rate to assess psychological processes related to attention and motivation/emotion in marketing settings. More specifically, research has used heart rate measurements in the fields of online (Guixeres

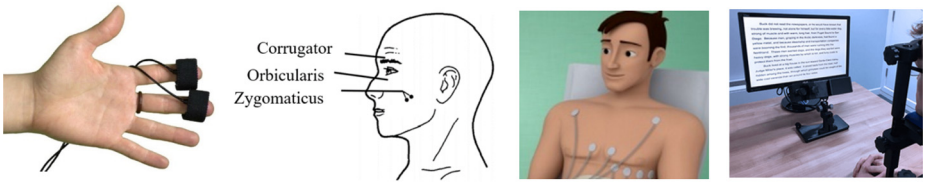


Figure 1.
Display of the main physiological tools

Notes: (a) Skin conductance: location of the electrodes on the index and middle fingers; (b) Facial electromyography: locations of the main muscles of interest for the measurement of EMG activity; (c) Sample of recording of the electrical signal as the heart progresses; (d) Traditional infrared corneal reflection eye-tracking

et al., 2017) or environmental (Martinez-Fiestas *et al.*, 2015) advertising. Electrocardiogram (EKG) sessions usually cost between €15 and €100/h.

3.1.4 Eye-tracking. The eye-tracking methodology provides observable evidence of how individuals attend to audiovisual information over time. Whether reading or searching for an object, eye movements consist of two alternating events, namely, *fixations*, when the eyes keep still during 200–300 ms, and *saccades*, when the eyes quickly move by means of "jumps" (Casado-Aranda, 2021). Information processing takes place during fixations, when a specific area of the visual field is projected onto the fovea. In marketing research, eye-tracking data usually cover four major issues, namely, *when*, *how often*, for *how long* and *what* consumers look at. Eye-tracking researchers have used three main measures derived from pupil measurement (Manippa *et al.*, 2017):

(1) Time to first fixation, referring to the time it takes a consumer to look at a specific area of interest.

(2) Number of fixations, which is related to the number of times a consumer looks at a specific area of interest. It is a measure related to the interest or relevance triggered by a stimulus.

(3) Pupil size or pupil dimensions (in millimeters) upon exposure to a marketing stimulus, which is positively related to higher cognitive load and with emotional arousal during image viewing (Bradley *et al.*, 2005).

Eye-tracking sessions usually cost between €10 and €100/h (Figure 1(d)).

Most marketing research has largely used eye-tracking to measure attention derived from two types of processes: top-down and bottom-up control. First, the individual influences attention, developing *top-down* control to select crucial information and purposely to pay attention to some parts of the information. Scholars have particularly analyzed the attentional processes toward marketing stimuli considering consumers' objectives (Pieters *et al.*, 2010). Moreover, the features of a specific stimulus itself are able to capture attention regardless of the individual, thus applying stimulus-driven or *bottom-up* control over attention. In this regard, marketing academics have analyzed attention toward specific media features of advertising design, such as animation (Casado-Aranda *et al.*, 2018a, 2018b).

3.2 Brain imaging tools

3.2.1 Functional magnetic resonance imaging. This is a non-invasive tool that records modifications in the brain's blood oxygenation-dependent level (called the fMRI BOLD signal) derived from metabolic changes in the blood flow triggered by neural activity. Specifically, scholars use the MRI scanner that records contrasts between the activity levels of deep brain structures, which are involved, according to the traditional cognitive and neuroscience literature, with particular mental functions difficult to access through psychological tools, such as fear, guilt, cognitive overload, self-relevance or intentional efforts. This technique makes it possible to localize, represent and visualize such activations while participants undergo marketing-related tasks (Solnais *et al.*, 2013).

fMRI experiments require participants to horizontally rest in the fMRI scanner while it processes the stimuli of interest. Inside the MRI scanner room, and once lying on the horizontal couch, the participant has a mirror reflecting a screen located behind the MRI scanner directly in front of his or her eyes. The screen precisely exposes the stimuli sent from the investigator's computer, displayed through a projector. Once inside the scanner,

participants engage in experimental tasks and make decisions through two push-button controls (see Figure 2).

The great strength of fMRI lies in its high spatial resolution, which allows the determination of neural activity from 3 in 3 mm^3. fMRI recordings, on the contrary, could be subject to artifacts, namely, head movement or breathing. fMRI scanners, nevertheless, have a low temporal resolution, which means that they are not able to measure significant changes over short periods of time, such as millions of milliseconds (Dimoka, 2010). fMRI scholars pay €200–€800/h.

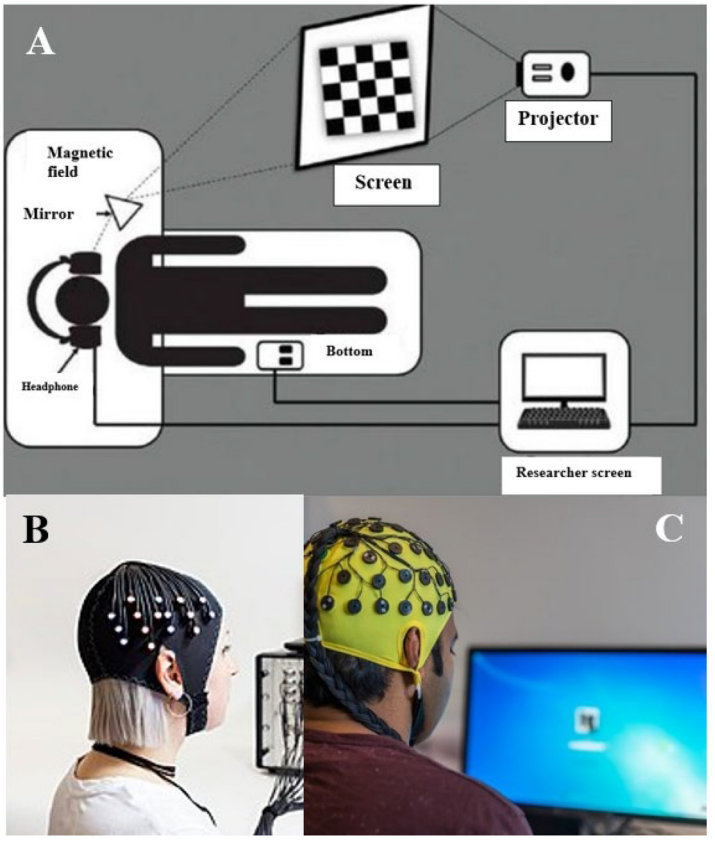
Specifically, in consumer neuroscience, fMRI has been used to determine brain differences in the perception of PayPal or debit card (Casado-Aranda *et al.*, 2018) or to explore the neural manifestations of creative and attractive packaging (Reimann *et al.*, 2010).

3.2.2 Electroencephalography. Electroencephalography (EEG) constitutes a tool that records modifications in neural electrical activity in the cerebral cortex. Specifically, it records the frequency of brain electrical currents and changes in their voltage. In particular, it makes use of electrodes placed on the scalp, which function as individual channels and are then amplified to facilitate statistical analysis. To obtain statistically valid results, typically, researchers use EEG acquisition systems with 128 electrodes in 10-20 or 10-5 international systems, which refer to the percentage of distance – 5, 10 or 20 – at which the electrodes should be placed on the frontal, occipital, right and left side of the skull (Oostenveld and Praamstra, 2001).

Among the characteristics that justify the usefulness of EEG are a high spatial resolution (from <10 to >500 ms); low cost – compared to fMRI, the cost of each participant round is between €50 and €1,000/h; and a high level of compatibility with other psychological techniques, namely, 32% of experiments combine EEG with eye-tracking, heart rate, facial EMG and galvanic response (Sánchez-Fernández *et al.*, 2021). Despite these advantages, their application has not achieved high levels of acceptance because of two main drawbacks: low spatial resolution (1–3 cm^3) and inability to pick up the activity of internal structures of brain regions of enormous interest for human decision-making, such as the amygdala (Figure 2).

According to the study by Sánchez-Fernández *et al.* (2021), EEG is the second most widely used neuroimaging tool in the field of marketing research, after fMRI, with 30% of studies using this method. Its application has recently focused on evaluating attentional and memory and emotional processes (Astolfi *et al.*, 2008) related to exposure to marketing stimuli.

3.2.3 Functional near-infrared spectroscopy. Functional near-infrared spectroscopy (fNIRS) constitutes a recently developed optical imaging tool that "measures changes in hemoglobin (Hb) flux within the brain through Hb absorption spectra in the near-infrared range" (Sánchez-Fernández *et al.*, 2021). "The spatial resolution and penetration depth of fNIRS images are up to 2 cm, making it suitable for monitoring brain areas located in the prefrontal cortex, a brain region that is central to human preferences" (Sánchez-Fernández *et al.*, 2021) (Figure 2). Similarly, mobile fNIRS extends near-infrared light through the scalp and measures optical density fluctuations derived from metabolic modifications within the brain. Studies have even corroborated that the fNIRS signal correlates with the fMRI BOLD signal (Sánchez-Fernández *et al.*, 2021). This tool even has some advantages when compared to fMRI, as it allows to measure the neural activity of the participants in environments more naturalistic and closer to real purchasing processes, in which the participant moves. Yet, as in the case of EEG, its low spatial resolution does not allow measurement of activations in inner brain areas, such as the hippocampus.



Notes: (a) fMRI experimental environment; (b) application of EEG electrodes, by means of a cap, to an experimental participant; (c) application of fNIRS

Figure 2.
(a) fMRI experimental environment; (b) application of EEG electrodes, by means of a cap, to an experimental participant; (c) application of fNIRS

Consumer neuroscience studies have recently used fNIRS for the evaluation of health communication campaigns (Cuesta *et al.*, 2020) and real purchasing decisions (Çakir *et al.*, 2018). Scholars are also prone to using fNIRS as the cost of each participant rounds between €20 and €500/h. Thus far, only 4% of consumer behavior studies reverted to fNIRS to inform on marketing processes.

3.2.4 Secondary brain imaging techniques. Although secondarily, there is also research in the marketing field that has used three additional neuroimaging techniques, namely magnetoencephalography (MEG) and brain stimulation techniques – such as the transcranial direct current stimulation (tDCS) and the transcranial magnetic stimulation (TMS). First, the rationale behind the MEG is pretty much the same as EEG but it records activation within the neural magnetic field. MEG has also good temporal resolution and even a greater spatial localization than EEG, which allows a better recording of deeper brain structures (Harris *et al.*, 2018). The main application of MEG in the marketing field has focused on identifying striate cortical activation related to recall and affective reactions

toward audiovisual advertising (Harris *et al.*, 2018). Second, tDCS constitutes a non-invasive brain stimulation technique, which uses direct electrical currents to stimulate specific parts of the brain. Thirdly, TMS makes use of a modifiable magnetic field aiming to provoke electric current within a particular brain network by means of electromagnetic induction. Much of the research using these neurostimulation tools has been used in the field of consumer food decision-making (Manippa *et al.*, 2017).

3.3 Pros and cons

One of the main reasons why social science researchers turn to neurophysiological tools is because they are able to capture processes that are **difficult** for the experimental participant **to manipulate**. Skin sweating, heart rate or hemodynamic responses are not subject to individual biases such as social desirability or subjectivity. Second, neurophysiological methods are able to capture the **hidden unconscious mechanisms** of the CNS and PNS that are beyond the reach of traditional market research techniques, such as self-report, interview or secondary data. They are particularly useful for capturing responses to **sensitive information** that is hard or unwilling to be expressed with self-reports (e.g. sexual orientation), complex mechanisms of great interest during the evaluation of marketing-related stimuli (e.g. cognitive overload) or low-order emotions key in consumer decision-making (e.g. risk or trust). Third, consumer behavior researchers show great interest in understanding the effects of product stimuli (brand, package, label), price, communication (visuals, text, etc.) and distribution (Web or physical shopping environment) at the time (and not after) they are exposed to participants. Traditional techniques have always relied on recall or imagination after executing the stimuli of interest. In contrast, neurophysiological tools allow for a **continuous, moment-to-moment measurement** during task exposure, thus allowing for a temporary match between the viewed stimuli and the psychological reaction. Therefore, neurophysiology techniques provide an additional data perspective to self-reporting tools and can corroborate, or refute them. In any case, their use is beneficial insofar as it means **not relying solely on a single type of measure**.

In spite of the great advantages of neurophysiological techniques in the understanding of consumer behavior, they nonetheless manifest some drawbacks, which are described now. First, **cost** is one of the main disadvantages of neurophysiological tools, which can range, as previously explained, from €10/h for eye-tracking to €800/h for fMRI. In addition, given the *a priori* intrusive nature of these tools, the recruitment of participants is more complex and requires financial compensation (between €20 and €50 per experimental subject). Consequently, accessibility to tools and participants is reduced compared to surveys or interviews. The experimental environment of neurophysiological techniques results, secondly, in an **artificial context**, relatively remote from real life, that may restrict the external validity of findings. Although some tools that facilitate movement in more naturalistic contexts, such as fNIRS or eye-tracking, are increasing their presence in the social scientific community, additional manipulation, control and artifact removal of the signal must be implemented for the results to be acceptable and reproducible. Furthermore, the data resulting from neurophysiological methods require an **intensive analysis process**, including motion correction (fNIRS, fMRI or eye-tracking), preparation for accurate measurements (electrode placements in EMG or EKG), manual data extraction and huge volumes of image data that require interdisciplinary teams and knowledge to be successfully analyzed. Currently, the **content validity** of such measures is also under debate, as it is questioned whether neurophysiological tools actually measure the marketing-related constructs they claim to capture. That is, the measurement of a marketing-related construct such as trust may not only be affected by confounding factors (such as signal

artifacts) but also because brain regions are involved not only with one mental process (such as trust) but with several ones (the so-called inference problem) (Poldrack, 2006). Finally, the application of neuroscience to the fields of economics and consumer behavior has raised **controversy and ethical concerns** in governments and consumer institutions because of the use of a great amount of sensitive data associated with defenseless society sectors. Table 1 summarizes the pros and cons of the above-mentioned consumer neuroscience tools.

4. Building the future of consumer neuroscience: opportunities for marketing research

This section develops the opportunities that marketing scholars can take advantage of from cognitive and affective neuroscience to improve product, pricing, communication and retailing models and decisions. These opportunities are summarized in "Research avenues that marketing scholars could address by using consumer neuroscience."

4.1 Opportunities in product decisions

4.1.1 Predicting product purchasing decisions. First, neurophysiological tools can contribute to the understanding of the neurological basis of consumer purchase decisions. Although the consumer behavior literature has traditionally elucidated that variables such as perceived value, preference, product quality, trust, intention toward product purchase and satisfaction may lead to product purchase and repurchase, the nature of purchasing itself is not fully understood. Some seminal works such as that of Knutson *et al.* (2007) used fMRI for the first time and confirmed that purchase decisions are preceded by brain circuits related to anticipatory positive affect and emotion, such as the medial prefrontal cortex (MPFC). These results can serve as a guide for the design and test of products and services that include features that trigger activations in these brain areas.

Second, neurophysiological methods can inform about the nature, dimensionality and causal relationships between product purchase drivers. For example, although some research using fMRI or EEG has already elucidated the neural nature and dimensionality of trust or preferences (Dimoka, 2010), more research is needed to explore if constructs such as trust, perceived value or loyalty could be considered as different based on distinct activations in affective or cognitive-related brain networks. These studies should pay special attention to identifying the neural correlates of consumer involvement, a powerful precursor of purchase intentions and behaviors (Casado-Aranda *et al.*, 2018), whose neural affective or cognitive nature has not yet been elucidated. In addition, because these

Pros	Cons
- Difficult to manipulate - Unbiased and reliable measure of consumers' affective and automatic reactions - Capture of hidden mechanisms of the central and peripheral nervous systems - Recording of responses to sensitive information, complex mechanisms and low-order emotions - Continuous, moment-to-moment measurement during task exposure - Additional data perspective to self-reporting tools	- High cost (from €10 to €800/h) - Artificial context, despite some improvements, e.g., fNIRS or mobile eye-tracking, are being made - Intensive analysis process: motion correction, preparation for accurate measurements, manual data extraction and huge volumes of image data to analyze - Content validity under debate - Controversy and ethical concerns - Misuse by the part of neuromarketing industry

Table 1.
Summary of the main advantages and disadvantages of neuropsychological techniques

methodologies allow a real-time data collection and a dynamic time series analysis, they could measure the flow of a single or several marketing-related constructs synchronously, thus enabling to ascertain the temporal order of diverse constructs or their dimensions. Along this latter line, marketing scholars have largely used adaptations of the theory of planned behavior (Ajzen, 1991) as a model to explain product purchases and have considered that social norms, subjective norms and perceived control are antecedents of attitudes, these latter preceding purchase intentions and behaviors. "Because emotional processes often precede cognitive ones, neurophysiological tools could illuminate the temporal dynamics of these constructs" (Dimoka, 2010) based on their cognitive or affective neural correlates.

4.1.2 Consumer responses to branding efforts. Brands constitute one of the most remarkable cues in the product purchase decision process, and traditional marketing research has attempted to understand whether and how brand positioning efforts affect brand personality, brand experience, brand preference and, more broadly, purchase intentions. Consumer neuroscience is already taking the first steps in elucidating how branding efforts modulate neural representations toward favorite brands. The seminal Coke–Pepsi fMRI study by McClure *et al.* (2004) explained for the first time that brand preferences toward Coke are based on brand recognition (because of stronger brain activations of the dorsolateral prefrontal cortex, which is associated with cognitive information processing) and not taste preferences (as both brands elicited pleasure-related brain areas).

Neuroimaging methods can also be used to better discern differences in the neural processing of prestigious/luxury brands (e.g. Porsche) and pragmatic/functional brands (e.g. Renault). The results of the study by Schaefer and Rotte (2007) showed that while brands that evoke social dominance (i.e. Porsche) activate brain areas associated with self-relevance, functional brands increase activations in cognitive control. These findings could help test whether a company's brand positioning is coherent with its value proposition (e.g. more emotional or functional) considering the type of brain responses (namely, self-relevance or cognitive control/reasoning) they evoke. Future research could even analyze the extent to which diverse consumers' personality traits (e.g. extraversion or openness) are associated with these activations during brand exposure, as this could constitute an efficient segmentation strategy building upon neural responses. Brain imaging techniques could also help identify the underexplored dimensions of constructs such as brand experience (namely, sensorial, emotional, intellectual, behavioral and social experiences) or brand loyalty (customer commitment and brand repurchase intention), as well as the temporal order of brand-related constructs.

Given the powerful ability of physiological tools to track emotional intensity (e.g. skin conductance), visual attention (e.g. eye-tracking) or valence (e.g. EMG), they could directly measure the extent to which different proposals of logos (e.g. colors, shapes and texts), slogans or brand names increase skin sweating levels, number of fixations, pupil size and activations of facial muscles, and thus infer their relative effectiveness.

4.1.3 Packaging. Physiological tools are especially useful for helping product designers to create attractive packages based on the psychological reactions to package cues. For example, eye-tracking measures could advise package designers on the position in which they should place labels, information of interest (e.g. nutrition or country of origin), graphs or brand logos based on where, when and for how long the user looks at different package locations. Facial EMG could also be useful to detect negative emotions triggered by the evaluation of diverse package designs. Furthermore, because the cognitive neuroscience literature has already cleared up the neural correlates of esthetics – namely, brain areas

linked to positive value and reward, such as ventral striatum (Reimann *et al.*, 2010) – designers could use such brain areas to test diverse design prototypes. In addition, consumer neuroscience studies could be practical as a direct usability criterion by associating package usability measures (such as technical, functional or informative quality) with neurophysiological metrics. Such physiological investigations could make use of prior packages with diverse levels of usability on specific dimensions (such as functional) to explore how functional differences are represented as neurophysiological distinctions.

Brain imaging techniques could be of great utility for identifying cognitive and affective processes responsible for mediating the valuation bias toward contextual package cues, such as labeling. Particularly, the traditional consumer behavior literature has confirmed that fair trade labels (vs conventional), organic product labels, nutritional traffic lights or country of origin labels convey inherently rewarding or negative properties, such as feeling good/bad about oneself for buying a national product, doing something good/bad or buying healthy food (Asioli *et al.*, 2017). However, little is known about the mechanisms that determine consumer choices based on these labels. Neurophysiological tools are recently revealing, for example, that neural mechanisms related to self-relevance and positive value are responsible for the higher preference toward home products, and risk-related brain regions responsible for the avoidance of foreign products (Casado-Aranda *et al.*, 2021). These neural mechanisms can be used to test the effectiveness of other product labels, such as denominations of origin and certificates from health institutions, that support the product or certificates from external institutions (such as TripAdvisor).

4.2 Opportunities in price decisions

The consumer behavior literature has largely shown that higher prices are associated with higher perceived performance quality, *ceteris paribus* (Bowbrick, 1980). Yet the mechanisms through which the price affects product choices and purchases have been understudied until strides in neurophysiological tools. In seminal fMRI research, Plassmann *et al.* (2008) showed that increasing the price of a wine conveys greater perceived flavor pleasantness and, importantly, greater activity in the medial orbitofrontal cortex (mOBFC), a brain area responsible for encoding experienced pleasantness and positive value. Consumer neuroscience studies have also revealed the neural basis of the WTP computation, namely, OBFC, in which consumers trade-off the maximum amount of resources that they intend to sacrifice in exchange for the product or service they acquire (Plassmann *et al.*, 2008). Neurophysiological tools also make it possible to assess the psychological determinants of consumers' avoidance of excessive prices. Knutson *et al.* (2007), for example, revealed that overpriced products greatly activate the insula, a brain area encoding anticipated loss and negative arousal. Knowing the neural correlates of value computation and the psychological processes associated with high prices could shed light on the implementation of pricing strategies according to the psychological perceived value of products of the company's market segment. These brain regions can also help in price testing for different brands or product lines of companies.

Brain imaging techniques could also be useful to clear up the psychological mechanisms of value computation of price on different consumer profiles, which could steer managers to improve market segmentation. The study by Medina *et al.* (2020), for example, revealed that the price labeling triggered stronger activity in brain networks linked to reward, valuation and choice in non-prosocial vs prosocial consumers, thus helping understand why buyer profiles avoiding sustainable habits place greater weight on price. Neurophysiological studies could also shed light on the importance of the price label, when compared to other package cues, such as product description. The study by Bruce *et al.* (2014), for instance, revealed that as more information is added onto the package (e.g. price, technology used or country of origin), greater brain activations

occur in the dorsolateral prefrontal cortex, a brain network linked to uncertainty and working memory load. Eye-tracking measures could also be interesting for assessing the relative visual attention directed to several product cues, including brand/product name, product imagery or price.

4.3 Opportunities in communication decisions

Of all the variables involved in marketing research, communication is the one where neurophysiological tools can make the greatest contribution. The main reason is precisely because these methods allow a continuous measurement of reactions as the message is presented, as opposed to self-reported responses, which are collected after message exposure. Because the cognitive and affective neuroscience literature has largely evidenced the neural correlates of persuasion, attention, perception, memory or self-relevance, consumer neuroscience scholars could integrate such knowledge within classic theories of persuasion, such as the limited capacity model of motivated mediated message processing (LC4MP; Lang, 2006) or the elaboration likelihood model (ELM; Petty and Cacioppo, 1986).

In particular, traditional communication models such as the ELM suggest that personally relevant information can lead to a central processing route, meaning that it may be valued more thoroughly by the person, which could be more persuasive and, hence, make behavior change more likely (Petty and Cacioppo, 1986). Thus, as the brain imaging literature has cleared up the neural bases of the two main mental processes associated with persuasion, namely, self-relevance and value (e.g. MPFC), communication scholars could use neuroimaging tools to test to what extent specific media features included in the ad (e.g. tailored vs untailored frames) trigger activations in such brain areas, as they would infer higher persuasiveness. The LC4MP model considers that messages that are able to facilitate an optimal allocation of cognitive resources in the audience will increase memory encoding, will be better retrieved and recalled, and will likely be more persuasive (Kranzler *et al.*, 2018). Because we do know from the cognitive neuroscience literature the neural correlates of information encoding, retrieval and recognition (Kranzler *et al.*, 2018), it is possible to test ad persuasiveness considering the encoding of such brain activations when exposed to several media features. Another research line of this regard could use neural activity as a predictor variable to forecast later consumer behavioral outcomes (e.g. nutritional lifestyles or click-through rates). For example, consumer neuroscience research concludes that brain networks involved with reward, self-relevance, value and mentalizing are powerful predictors of intentions toward the advertised products (Casado-Aranda *et al.*, 2018a).

Physiological tools could also be highly powerful for detecting message audiovisual elements that attract the greatest attention (e.g. eye-tracking), generate too much consumer stress or avoidance (e.g. increases of heart rate, EKG) or are perceived as pleasant and positive (e.g. activity in the zygomatic muscle, EMG). This approach would enrich the design of persuasive communication campaigns or even reveal some emotional constructs (e.g. fear and anger) beyond the subjective self-reported responses.

4.4 Opportunities in retailing decisions

Consumer neuroscience techniques have enormous potential to enhance the understanding of purchase decision-making processes in the online channel, given the emotional, quick and often unconscious nature in which we make online decisions (Dimoka, 2010). Neurophysiological tools can first be useful for enhancing our understanding of the dimensionality and nature of constructs associated with the adoption and use of consumer devices, websites or platforms, such as mobile phones, laptops or website layouts. For example, studies such as that of Dimoka (2010) or Casado-Aranda *et al.* (2018a, 2018b) have revealed the neural correlates of constructs and dimensions pertaining at the technology acceptance model (namely, perceived usefulness, trust, privacy and ease of use), but yet more research is needed to clarify the neural bases of the

emotional ones, such as anxiety, enjoyment, playfulness or innovativeness, which are indeed key for forecasting consumer purchase and usage. Knowing the psychological origin of these mental processes could be key to testing the effectiveness of media systems, devices or website elements.

Neurophysiological tools could also inform about the attention, emotional intensity, valence or stress levels triggered by the firm's website design and its elements. For example, eye-tracking measures could be used to evaluate which website elements attract the greatest number of fixations and duration, and then include them in an attractive position on the website. We can also learn about the consumer search and browse process within the website and even compare attentional or emotional patterns in novice and expert website users with the aim of exploring differences that might help beginners enhance their web interaction (Dimoka, 2010). New neurophysiological techniques, such as fNIRS or mobile eye-trackers, are making great strides in measuring consumer mental processes of interest in real purchasing environments.

5. Discussion

To our knowledge, this study may constitute one of the first investigations that, after evaluating the definition, advantages, disadvantages and potential of neuropsychology techniques, it clarifies how marketing academics can make use of consumer neuroscience tools to advance the knowledge of marketing phenomena. Previous research has clarified some of the characteristics of consumer neuroscience tools (Harris *et al.*, 2018), developed empirical and systematic reviews of the literature in this branch (Solnais *et al.*, 2013 or Sánchez-Fernández *et al.*, 2021) or advised on the methodological environment advisable with the use of these tools (Lee *et al.*, 2018). Closer to this research, the study by Dimoka (2010) specified how information system research could benefit from the use of these tools. Surprisingly, however, no research has cleared up what are the routes or main lines of research that the field of marketing could develop through the use of neuropsychology tools. Next, we offer some insights into the added value of neurophysiological methods and tools to consumer behavior and marketing research, as well as some recommendations for accurately implementing consumer neuroscience research.

First, we believe it is of utmost importance to make clear that the purpose of this research was not to claim that consumer neuroscience is a panacea. By no means should neurophysiological tools replace traditional self-reports, focus groups or interviews; instead, they may constitute complementary, precise and highly objective techniques that provide a new perspective and type of data on the same fact, i.e. consumer reactions to marketing stimuli. Consumer neuroscience scholars are urged to use several typologies of information (namely, self-report, physiological, neural, etc.) aiming to triangulate data (which, at times, may be contradictory) and have a complete picture of the same consumer response, which helps develop and enhance consumer behavior theories. We propose here some of the most promising topics to be addressed with these new tools.

Second, consumer neuroscience techniques are not useful for answering every marketing research question, but only those that are difficult to test or measure using self-reported data, and there is a rationale behind this that justifies it. Moreover, as seen previously, not all tools are useful for answering the same research question. For example, while eye-tracking reports on visual attention, facial EMG on emotional valence, fNIRS on decision-making in more superficial brain areas and fMRI on deeper neurocognitive and affective processes, such as fear, reward, risk or intention. For marketing researchers to adequately invest effort and money in such tools, they should develop interdisciplinary teams that include psychologists, physiologists, neuroscientists and statisticians. Only the background and knowledge acquired by a neuroscientist or psychologist researcher would help to develop a correct experimental design, including control of confounding variables, proper manipulation of treatments, selection of participants, and

- Opportunities in product decisions
  - *Predict product purchase decisions*
    - Which are the neural bases of consumer purchase decisions (namely, ecological, nutritional, impulsive vs planned, online vs physical. . .)?
    - Could product purchase drivers, such as trust, perceived value, satisfaction or loyalty, be considered as different based on distinct activations in affective or cognitive-related brain networks?
    - To what extent neuropsychological tools could infer the temporal order of diverse purchase-related constructs or their dimensions?
    - What are the neural correlates of consumer involvement?
  - *Consumer responses to branding efforts*
    - Through which psychological mechanisms could branding efforts modulate neural representations toward favorite brands?
    - Considering the neural cognitive or affective mental states they elicit, what are the dimensions of brand experience and brand loyalty?
    - How could diverse consumers' personality traits (e.g. extraversion, conscientiousness, impulsivity or openness) modulate brain activations during brand exposure?
    - What is the relative effectiveness of logos (e.g. colors, shapes and texts), slogans or brand names based on the physiological responses they trigger?
  - *Packaging*
    - Which is the best package location to insert labels, information of interest (e.g. nutrition or country of origin) or brand logos, based on the neurocognitive or affective responses they elicit?
    - Could the neural correlates of esthetics be used to test diverse design prototypes?
    - How diverse package usability measures (namely functional, technical or informative) are differently perceived based on neuropsychological metrics?
    - What are the cognitive and affective processes responsible for mediating the valuation bias toward contextual package cues, such as labeling (country of origin, fair trade, etc.)?
- Opportunities in price decisions
  - Through what neural mechanisms does price affect product choice and purchase?
  - What is the neural basis that explains our willingness to pay a higher price for a product?
  - What psychological mechanisms do we use to compare value and price?
  - How important is the price tag, as opposed to other product signals?
- Opportunities in communication decisions
  - To what extent specific media features included in the ad (e.g. ad duration, tone, gain/loss or future/past frames) trigger activations in brain areas related to persuasion, value and reward?
  - Could brain activations related to encoding, retrieval and remember when exposed to several media features be used as predictors of persuasion or prospect consumer behavior?
  - Which are the levels of attention, consumer stress or avoidance, or even pleasant psychological states triggered by message audiovisual elements (e.g. brand image-ad match up, colors, etc.)?

(*continued*)

Table 2.
Research avenues that marketing scholars could address by using consumer neuroscience

- Opportunities in retailing
  - Based on the neural cognitive or affective mental states they elicit, what is the dimensionality and nature of constructs associated with the adoption and use of consumer devices, websites or platforms, such as mobile phones, laptops or website layouts?
  - What are the neural bases of the emotional constructs of the TAM model, such as anxiety, enjoyment, playfulness or innovativeness? Which of them forecasts better consumer purchase?
  - Which are the levels of attention, emotional intensity, valence or stress triggered by the firm's website design and its elements
  - Do novice and expert website users show distinct attentional and emotional patterns when browsing?
  - Can we establish causal links between antecedents of online purchase intentions, such as website trust, security, awareness and satisfaction?

Table 2.

subsequent collection and analysis of neurophysiology data. If there are errors in any of these phases, the results or interpretations will lack experimental validity and robustness.

In addition, one of the main limitations for marketing researchers' access to these neuroscience tools is precisely the difficulty in interpreting the data and its terminology. On the one hand, the interpretation of the construct measured by some neurophysiological measures, such as time to first fixation or blink frequency in the case of eye-tracking, is still under debate. In addition, fMRI research often falls into what is known as the reverse inference problem, that is, inferring that participants are experiencing a specific mental state (e.g. trust) by observing brain activity traditionally associated with the construct, e.g. trust. In other words, "a specific neurophysiological measure could be associated with several theoretical constructs" (Dimoka, 2010). As brain areas have usually diverse functions, important statistical and experimental manipulation constraints should be developed to establish relative conclusions.

Finally, like any other research involving consumers, consumer neuroscience studies are subject to a thorough ethical and moral screening by expert committees to confirm that the research follows international principles of conduct. First, consumer neuroscience research must follow the code of conduct of the Declaration of Helsinki, which includes, among others, general principles, risks, costs and benefits, research methods or informed consent of the participant. In addition, codes of conduct stipulated for experimental research with psychophysiological techniques in the field of economics and marketing in particular must be complied. These guidelines have been developed by the World Medical Association and the Neuromarketing Science and Business Association (NMSBA), which include basic principles, integrity, credibility, transparency, rights and privacy of participants as experimental subjects. Despite these principles constituting a common practice, governmental, consumer and mass media institutions have developed continuing ethical objections related to relevant harms (such as immediate pernicious incidence on individual consumers or society broadly considered) and violation of positive rights to autonomy, privacy and dignity, as well as negative rights not to be deceived. Industry neuromarketing, however, motivated by the development of a competitive advantage and obtaining short- or medium-term profits, can indeed misuse neuropsychological tools. For example, the potential industry's incentive to use poor methods (namely, insufficient sample sizes, hire undertrained personnel or lack of stringent thresholds), the lack of a peer-review to prevent overstatement of the results or the opacity in the publication of their results, could encourage inappropriate use and interpretation of results derived from neuropsychological measurements.

All in all, this research is intended as a guide for future researchers in consumer neuroscience. We tried to make it clear that neurophysiological techniques could complement the existing portfolio of empirical and lab-based marketing approaches, methods and data, with the aim of shedding light on advances and enhancements of marketing and consumer behavior theories.

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