The Strides of Consumer Neuroscience: Identifying the Brain Mechanisms Underlying the Processing of Advertising and E-Commerce

Luis Alberto Casado Aranda

Tesis doctoral dirigida por Dr. Juan Sánchez Fernández

Departamento Comercialización e Investigación de Mercados

UNIVERSIDAD DE GRANADA

TESIS DOCTORAL

THE STRIDES OF CONSUMER NEUROSCIENCE:

Identifying the Brain Mechanisms Underlying the Processing of Advertising and E-commerce

Nombre del doctorando: Luis Alberto Casado Aranda

Nombre del director de tesis: Juan Sánchez Fernández

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Por ti y para ti, MAMÁ

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The Strides of Consumer Neuroscience: Identifying the Brain Mechanisms Underlying the Processing of Advertising and E-commerce

Luis Alberto Casado Aranda, lcasado@ugr.es

Universidad de Granada

RESUMEN

Propuesta/objetivos: Existe un interés creciente por la adopción de técnicas neurocientíficas en la evaluación y comprensión del comportamiento del consumidor, que ha dado lugar a un nuevo campo de investigación conocido como neurociencia del consumidor. Esta tesis doctoral ofrece una perspectiva del estado actual de la investigación en esta disciplina, al tiempo que agrupa seis estudios empíricos que esclarecen el origen neurológico de las evaluaciones de los consumidores ante estímulos procedentes de campos de la publicidad y comercio electrónico (e-commerce).

Diseño/Metodología/Enfoque: El análisis bibliométrico exhaustivo unido a la revisión sistemática de estudios en neurociencia del consumidor implementados en esta tesis doctoral realzan la necesidad de recurrir a una técnica neurocientífica, la resonancia magnética funcional (fMRI), para evaluar los mecanismos cerebrales que determinan las reacciones de los consumidores ante elementos propios de dos de los dominios de mayor interés para el campo de la neurociencia del consumidor: publicidad y e-commerce. Bajo estas consideraciones, uno de los estudios incluidos en esta tesis ofrece evidencia de la base neurológica de la percepción del consumidor ante distintitas combinaciones de producto y voz incluidas en publicidad. La misma metodología se aplicó en dos estudios para explorar los efectos neurológicos provocados por enfoques de pérdida/ganancia y futuro/pasado, así como voces masculinas/femeninas y jóvenes/adultas, en la evaluación de publicidad medioambiental. Los restantes tres estudios incluidos en esta tesis emplearon fMRI con el objetivo de revelar los mecanismos cerebrales desencadenados por medios de pago online (Paypal o tarjeta de débito), señales de seguridad (sellos de confianza, sistemas de rating o políticas de empresa) y diversas facetas del riesgo online (financiera, de privacidad y de resultados).

Hallazgos: Los resultados derivados de esta tesis doctoral avanzan que: i) combinaciones congruentes de producto y voz insertas en publicidad estimulan áreas cerebrales implicadas con un incremento de la atención endógena, mientras que las incongruentes desencadenan un procesamiento relacionado con el conflicto y el error, ii) mensajes ecológicos que enfatizan las consecuencias positivas derivadas de actuar de forma responsable, así como aquellos narrados por una voz masculina joven, confieren gran valor subconsciente y mayores aspiraciones por obtener beneficios sociales; iii) Paypal induce activaciones en áreas cerebrales involucradas con el afecto, la recompensa y la seguridad, evidenciando así que se concibe como un sistema de pago online más seguro que las tarjetas de débito; iv) el riesgo financiero provoca menores niveles de aversión subconsciente y efectos negativos en el consumidor, en comparación con los riesgos de privacidad y de resultados, y v) los sellos de seguridad constituyen la señal online más confiable al estimular recompensa y expectativas positivas en los consumidores.

Originalidad/valor: Esta tesis contribuye de forma pionera a dilucidar los dominios, subdominios, técnicas y variables de marketing mix de mayor interés para la neurociencia del consumidor. Más importante, se trata del primer trabajo de investigación que utiliza fMRI para identificar el origen neurológico de las actitudes e intenciones del consumidor ante elementos no explorados hasta la fecha de los campos de la publicidad y comercio electrónico.

Palabras clave: neurociencia del consumidor, neuromarketing, fMRI, publicidad, e-commerce, enfoque, seña de seguridad, sistema de pago online, riesgo, recompensa, valor, subconsciente.

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Luis Alberto Casado Aranda, lcasado@ugr.es

Universidad de Granada

SUMMARY

Proposal/Objectives: There is a growing interest in adopting neuroscientific tools to measure and elucidate consumer behavior resulting in a new field known as consumer neuroscience. The current doctoral thesis offers an overview of the state of research in this field and groups six studies that shed light on the neurological origin of consumers evaluations toward elements inserted in advertising and e-commerce environments.

Design/Methodology/Approach: The comprehensive bibliometric analysis and empirical review of the research on consumer neuroscience of the current study clearly indicates the need of resorting to fMRI, a neuroscientific tool, to assess the underlying brain mechanisms activated in subjects in reaction to elements of two of the more important domains of interest to consumer neuroscience: advertising and e-commerce. Accordingly, three fMRI studies unveil evidence of the neural bases of consumer perception when subject to advertisements with different product-voice combinations. Similar techniques were applied to experiments of gain/loss and future/past frames, as well as male/female voices and young/old voices in environmental advertising. Three other fMRI analyses included in this dissertation aim to reveal consumer brain mechanisms triggered by e-payments (Paypal or debit card), assurance signals (seals of approval, rating systems and assurance statements) and different online risk facets (financial, privacy and performance).

Findings: The findings highlighted by this dissertation are that i) congruent product-voice combinations in advertising elicit brain areas linked to an increase in endogenous attention, whereas their incongruent counterparts trigger conflicts and error monitoring in consumer processing, ii) green messages emphasizing future positive consequences of environmentally responsible actions, as well as those narrated by a young male voice, confer the greatest subconscious values and aspirations of social benefits, iii) Paypal induces activations in brain areas involved with affection, reward and security evidencing that it is conceived as a more secure e-payment system than that of debit cards, iv) Financial risk conveys the lowest subconscious aversion and negative values in low-involvement online purchase environments compared to privacy and performance risks, and v) Seals of approval are the most trustworthy assurance signals as they elicit the highest level of activation of brain areas linked to values of reward and expectation.

Originality/Value: The relevance of this thesis from the academic point of view is that it contributes as no other recent research to elucidate the most remarkable domains, subdomains, techniques, and marketing-mix variables of consumer neuroscience. Most importantly, this thesis is among the first resorting to fMRI to identify the neurological origin of consumer attitudes and intentions in the realm of unexplored media elements linked to two marketing domains of high interest to consumer neuroscience, namely advertising and web layouts.

Keywords: consumer neuroscience, neuromarketing, fMRI, advertising, e-commerce, frame, assurance signal, e-payment, risk, reward, value.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

This chapter offers the reader clear and concise insight into the origin, evolution and current landscape of the field of consumer neuroscience. This chapter therefore first identifies the potential that neuropsychological tools have in explaining human decision making. Then the chapter turns to focusing on the application of neuroscientific tools to the field of consumer behavior, a discipline known as consumer neuroscience. After outlining the origin and evolution of this young discipline, the chapter raises the research problem as well as the objectives laid out for the development of this doctoral dissertation. Finally, the chapter summarizes the dissertation's structure and organization.

1.1. Human decision making: from classical models to neuroeconomics

Human beings make more than 35,000 decisions every day. They decide when to start saving money, when to choose who to spend time with, when to purchase an iPhone instead of a cheaper BQ or when to shop on an online website and which seems to be the most secure. Decision making involves, therefore, the selection of a course of action from among two or more possible alternatives in order to arrive at a solution for a given problem.

Economists traditionally conceptualized human beings as rational, self-interested, guided by unemotional maximizers when it comes to making daily decisions. Renowned classical economists, such as Bernoulli (1954) and Schoemaker (1982), defended the Expected Utility Theory stating that when comparing alternative courses of action, humans rationally choose the option that has the greatest expected utility that is accompanied by the largest expected profit.

Although the concept of expected utility has played an important role in human behavior research, criticisms have been raised concerning its application to the framework of choice in business, economics and marketing. Psychologists interested in judgment and decision making were the first to put into question axioms of the classical rational theory in the late 1980s. In a series of remarkable experiments, psychologists such as Kahneman and Tversky -who called themselves *behavioral economists*- hypothesized that humans reveal heuristic (i.e. irrational shortcuts), non-opportunistic, reciprocal behaviors and other "paradoxes" that cannot be explained by the traditional rational model (Tversky & Kahneman, 1986). These authors proved that ideas, processes and mechanisms from psychology could improve and extend more objectively the models of human behavior. Rather than ignoring non-rational behavior, concepts like bounded rationality, bounded willpower or bounded self-interest arose leading specialist to acknowledge that human behavior is frequently influenced by emotions and subconscious processes. This led to the birth of *behavioral economics*, a discipline that seeks to formally codify human limits and explore the empirical implications by resorting to mathematical theory, experimental data, and psychological paradigms.

With the emergence of non-invasive human brain imaging techniques such as functional magnetic resonance imaging (fMRI), it was only a matter of time before economists, psychologists and neuroscientists set out to determine if there were a biological foundation of economic theories of choice. A new field emerged at the beginning of the 21st century, referred to as *neuroeconomics*, precisely from within experimental economics because behavioral economists often proposed theories that could be thought of as algorithms as to how information was processed, and the choices that resulted from information-processing (Camerer, Loewenstein, & Prelec, 2005; Camerer, Loewenstein, & Prelec, 2004; Hampton, Bossaerts, & O'Doherty, 2006). A natural step in testing these theories was to simultaneously gather information on the details of both information processing and associated choices. If information processing could be hypothesized in terms of neural activity, then the automatic measurements could serve to test theories as simultaneous restrictions on what information is processed, how that processing works in the brain, and the resulting choices (Bossaerts & Murawski, 2015). Based on the advances of neuroscience (which refers to the study of the biological mechanisms and neural processes that underlie mental activity, including the perception of external stimuli, memory and emotions) (Albright, Kandel, & Posner, 2000), neuroeconomics aims to determine the processes that connect feelings and actions by revealing the neurobiological mechanisms by which decisions are made (Kenning & Plassmann, 2005).

From its inception, research in neuroeconomics has dramatically increased from a single study published in 2002 to a total of 503 in 2018[1].

[1] This idea is based on neuroeconomics studies published in between 2002 and 2018, and downloaded from the Web of Science database on July 10, 2018. The query was limited to the term "neuroeconomics" AND all areas of research AND English as a language AND article as type of document.

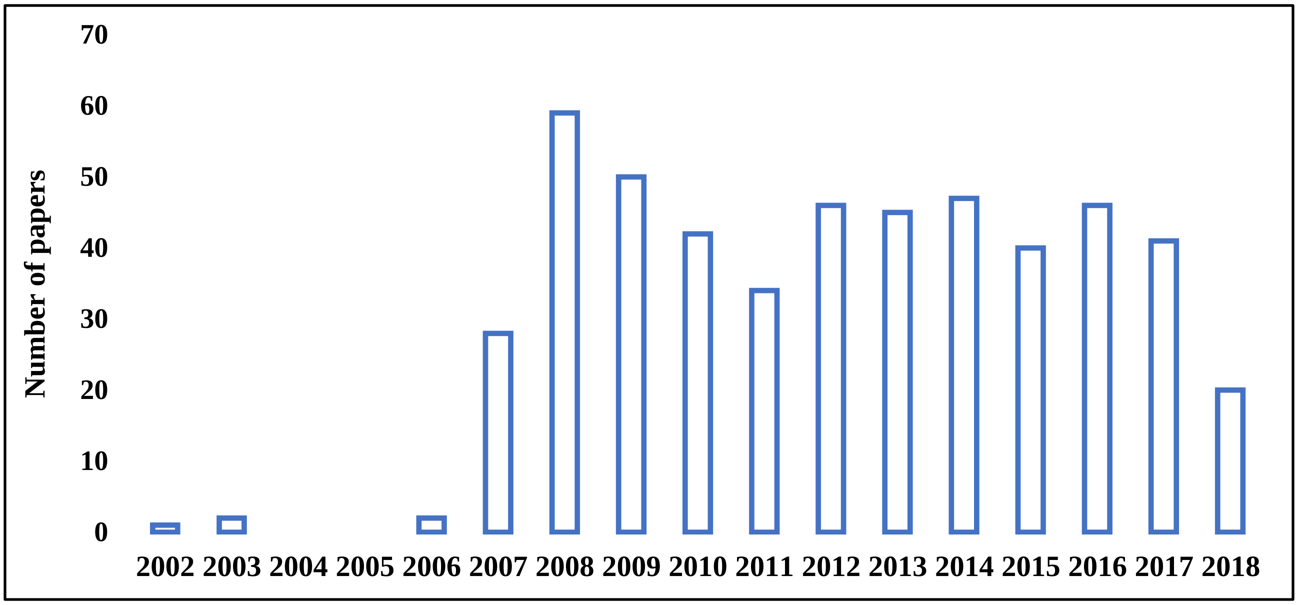

Figure 1. Number of papers in the ISIWoS service (y-axis) focusing on neuroeconomics from 2002 to 2018.

Source: Author from ISIWoS

Three domains are of great interest to neuroeconomists. The first comprises certain studies focusing on revealing the neural correlates of decision making under conditions of risk and uncertainty (Dohmen, Falk, Huffman, & Sunde, 2018; Duijvenvoorde, Blankenstein, Crone, & Figner, 2016). The second targeted the so-called intertemporal choice, a process by which participants are required to make decisions about what and how much to do at various points in time when the choices at one time influence the possibilities available at other points in time (Takahashi, 2009; Tang, Zhang, Yan, & Qu, 2017). Thirdly, studies on social decision making reveal to what extent social exchange, bargaining and competitive games, as well as assessing another intentions, affect the neural reward or penalty domains of decision makers (Gray et al., 2017; Ruff & Fehr, 2014).

1.2. A subfield of neuroeconomics: consumer neuroscience

As the field of neuroeconomics expanded, new subfields resorting to neuroscience attempted to clarify the origin of specific behaviors among humans. This is the case of *consumer neuroscience,* an interdisciplinary area that benefits from neuroscientific methods and findings to gain understanding of the (neuro-) physiological fundamentals of consumer behavior.

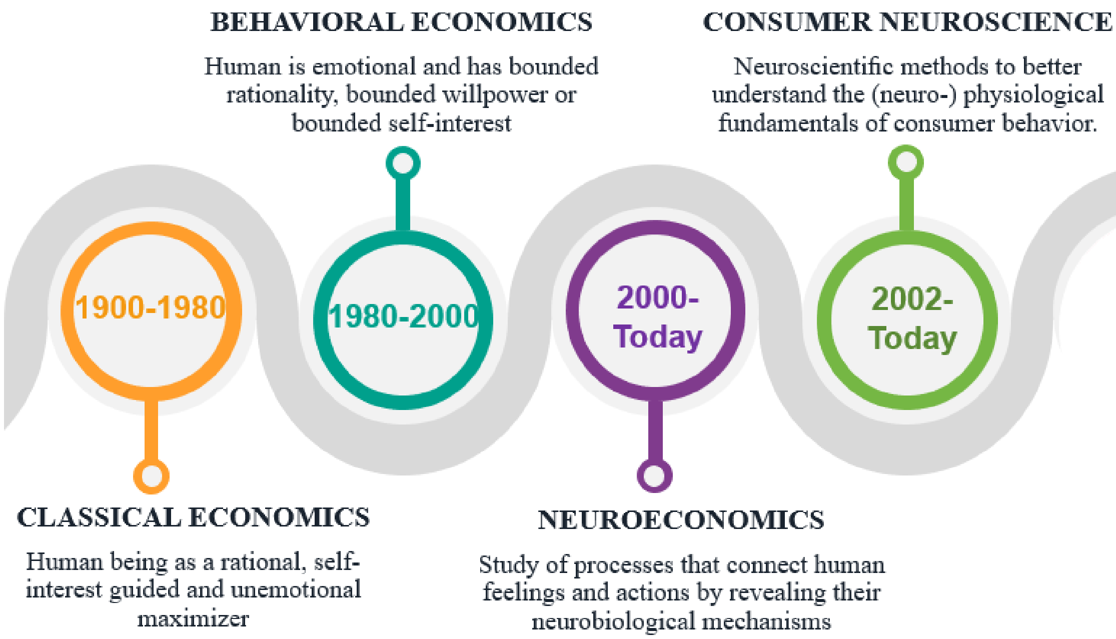

Figure 2. Evolution of the study of human behavior in XIX and XX centuries

Source: Author

To understand the origin of consumer neuroscience, it is of utmost importance to first consider the definition of consumer behavior that has been explored by a vast amount of research, starting with Jacoby (1976) to Nessim & Richard (2001). The American Marketing Association (AMA) after compiling all the previous interpretations, defined consumer behavior as a dynamic interaction of affect and cognition, behavior, and the environment in which human beings conduct the exchange of products and services in the market place (AMA, 2018). Traditional consumer behavior research has yielded a great number of theoretical models such as the Technology Acceptance Model (Davis, 1985) or the Elaboration Likelihood Model (Petty & Cacioppo, 1986). The aim of these models is to provide an explanation for how consumers process marketing stimuli with the goal of predicting their behavior.

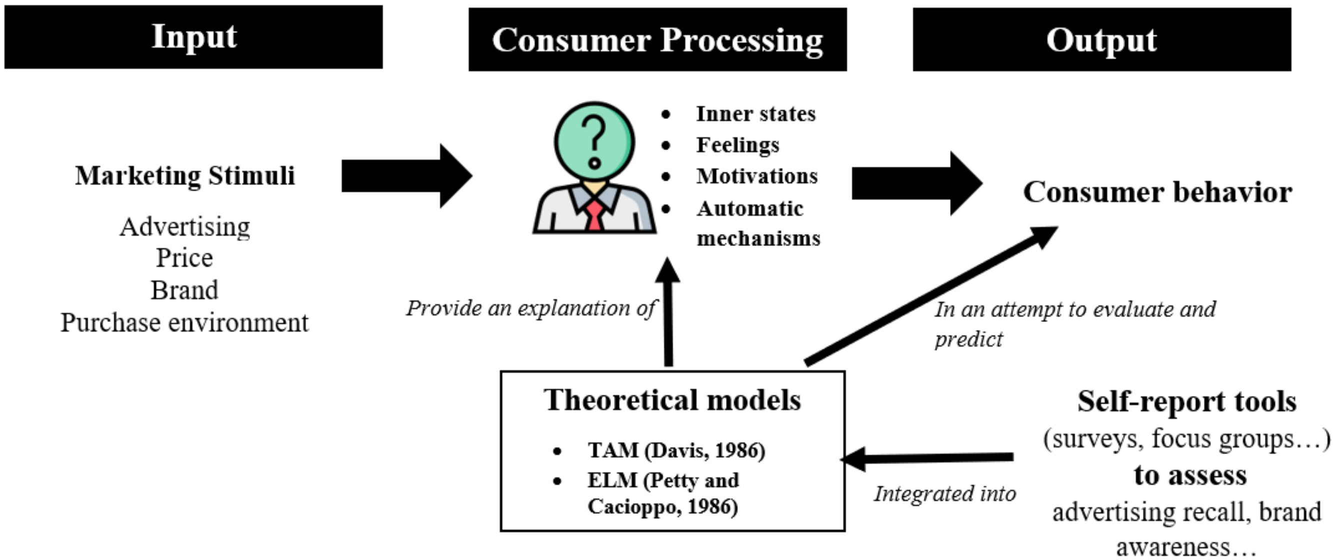

Figure 3. Traditional approach to consumer behavior research

Source: Author

Two types of limitations arise from this research approach. Firstly, the models are theoretical only approximations to the way marketing stimuli might be processed by consumers, suffering from the risk of over-implication and coming to inaccurate inferences. Secondly, most traditional research resorted to self-report tools, namely questionnaires, focus groups or interviews, that capture conscious expressions, feelings and verbal-language-based responses from consumers regarding advertising recall, brand awareness or purchase intentions. Although these techniques are relatively swift and inexpensive (Berger, Wagner, & Schwand, 2012), they are subject to the following examples of bias:

- they are susceptible to social desirability and subjectivity.
- they do not capture lower-order emotions (e.g., cognitive load, fears, anger).
- they may include sensitive issues (e.g., race, religion, culture).
- they may not be able to capture cognitive and affective unconscious processes (despite that these trigger 95% of consumer decisions, (Zaltman, 2003).
- they do not facilitate a continuous collection of data on a real-time basis while a subject is executing a task or responding to a specific stimulus.

The debatable usefulness of theoretical models combined with the scarce ability of self-report tools to accurately explore automatic, emotional and second-by-second reactions of consumers in marketing environments has paved the way for the resorting to more objective tools, notably neuroscience techniques, in the consumer behavior research. These techniques, such as the functional magnetic resonance imaging (fMRI) or electroencephalography (EEG), require knowledge and methodologies from the disciplines of biology, neurology and psychophysiology. Their application to the field of consumer behavior offers remarkable advantages (Solnais, Andreu-Perez, Sánchez-Fernández, & Andréu-Abela, 2013):

- They enable identifying the underlying processes responsible for the behavior of interest, as similar behaviors may result from different psychological processes.
- They allow understanding the role of inner emotional responses, which may play an important part in the consumer decision-making process.
- They enable to simultaneously track consumer neural responses at the same time as processing marketing stimulus of interest thus eliminating the risk of recall bias commonly associated with self-reports.

Professor Ale Smidts is recognized as the first to name the use of neuroscientific techniques by the marketing discipline in 2002. Henceforth, worldwide researchers and professionals, notably Hansen, Thomsen, and Beckmann, (2013), Weber, Mangus, and Huskey, (2015) and Venkatraman et al., (2015), have made use of consumer neuroscience to extend traditional consumer behavior theories, to better understand consumer reactions in marketing environments and to improve the effectiveness of marketing-mix strategies. The most renowned definition of consumer neuroscience is from Reimann, Schilke, Weber, Neuhaus, and Zaichkowsky (2011), who describe it as “the study of the neural conditions and processes that underlie consumption, their psychological meaning, and their behavioral consequences.” Though consumer neuroscience is also commonly referred to as neuromarketing, this fashionable term could be misinterpreted as a more accurate definition is that of the practical implementation of the knowledge gained by consumer neuroscience for managerial purposes (Hubert & Kenning, 2008).

Numerous factors corroborate the potential of this young discipline:

- Papers published in high impact journals focusing on consumer neuroscience in 10 years have been multiplied by eleven, from 1 paper in 2006 to a total of 117 in 2018 (see section 3.1. of this dissertation).

- Daniel Kanheman, a psychologist, received the Nobel Prize in Economics in 2002 for integrating insight from psychological research into economic science, especially concerning human judgment and decision-making under uncertainty.
- Foundation in 2005 of the Association for Neuropsychoeconomics and its related JCR journal the *Journal of Neuroscience, Psychology & Economics*.
- Setting up of new consumer neuroscience departments in the most famous market research firms and advertising agencies such as Millward Brown, Nielsen and Ipsos.
- Special issues in 2008 of the *Journal of Consumer Behavior* on the question of neuromarketing and in 2012 by the *Journal of Consumer Psychology* of neuropsychological insight into the perspectives of brand.
- Creation in 2011 of the Neuromarketing Business Association (NMSBA), a reference in the discipline for its work in the organization of worldwide congresses and the launching of the journal *Neuromarketing Theory & Practice*.
- Publication of the book "Think Fast, Think Slow" by Kanheman (2011) contributing to describe the brain functions of two intuitive models.
- Noteworthy growth of the number of companies and customers specialized in consumer neuroscience. In 2017, the Neuromarketing Science & Business Association enlisted a total of 123 companies worldwide with four located in Spain.
- The Marketing Science Institute[2] (2018) concludes that the use of neuroscience in understanding consumer behavior as a main research priority in the marketing field for the period 2018-2020.

Applying neuroscience to the field of consumer behavior has however elicited controversy and ethical concerns in customer associations, governments and institutions due to the use of a large quantity of sensitive information pertaining potentially to vulnerable segments of society (Murphy, Illes, & Reiner, 2008). Nevertheless, there are no real reasons why the field of marketing should not profit from neuroscience as do other disciplines such as engineering and biology. On the contrary, consumer neuroscience should be viewed as a new and promising field of research

[2] The Marketing Science Institute constitutes the most well-known research-based organization with a network of marketing academics from business schools all over the world as well as marketing executives from 60+ leading companies.

that aims to reveal signs about decision-making processes and behaviors in consumers. Although neuroscience can lend assistance in revealing the underlying mechanisms by which marketing stimuli are processed, it only consists of a tool and data as to consumer cognitive and affective states, as well as information about brain regions elicited by specific stimuli. It does not pretend to offer "the perfect way" to sell goods neither does it open the "black box" (i.e. the brain).

1.3. Problem approach and research objectives

As noted, the amount of research focusing on consumer neuroscience has increased considerably in the last decade. Based on the elements identified by Borden (1964) as crucial to the development of marketing-mix strategies, the key domains in which consumer neuroscience studies have centered their attention are advertising, product, price, branding and information and communication systems (specifically, e-commerce). A brief summary of the most common subdomains is listed below:

- A great number of studies aimed at obtaining insight into the neural mechanisms elicited by different types of **messages**. Research at this domain, in particular, investigated neural activity during health messaging (Falk, Berkman, Whalen, & Lieberman, 2011), powerful political speeches (Schmälzle, Häcker, Honey, & Hasson, 2015), deceptive and subliminal advertising (Craig, Loureiro, Wood, & Vendemia, 2012), and the neural correlates of product valuation in the context of famous endorsers (Stallen et al., 2010).
- A great variety of research turned their focus to the neural networks elicited by different **product** designs (Van der Laan, De Ridder, Viergever, & Smeets, 2012), nutrition labels (Enax, Krapp, Piehl, & Weber, 2015) and sustainable signals (Enax et al., 2015).
- Other studies investigated the influence of different levels of **price** in neural reward-systems and perceived quality (Plassmann & Weber, 2015), the neural basis of consumer willingness to pay (Linder et al., 2010), and the brain activity linked to shopping addiction (Raab, Elger, Neuner, & Weber, 2011).
- Researchers resorted to neuroscientific tools to clarify the preference systems triggered at the neural level by well-known **brands** (McClure et al., 2004), to reveal the neural differences

between familiar versus non-familiar brands (Esch et al., 2012), and to generate depictions of brand associations in the brains of consumers (Chen, Nelson, & Hsu, 2015).

- Several studies, finally, focused on the neural correlates of trust, distrust, usefulness and ease of use in **online purchase environments** (Dimoka, 2010; Dimoka & Davis, 2008).

Figure 4. The five most researched domains in consumer neuroscience
Source: Author

Despite the exceptional growth in the last decade of the number of analyses carried out in the field of consumer neuroscience, many studies conclude that it is still a field in its early stages and more research is needed to clarify the neural mechanisms triggered by marketing stimuli with the goal of improving management strategies. So far, advertising together with product in the marketing domain has drawn the most attention of consumer neuroscience studies (33% each), followed by e-commerce (12%), brands (11%), social influence (6%) and price (5%) (see section 3.1. of this dissertation). Exploring the processing of advertising is, furthermore, one of the five research priorities for 2018-2020 proposed by the Marketing Science Institute (2018). It is also one of the marketing-mix variables in which worldwide firms invested the most in 2017, notably 380 billion US dollars (Magna, 2018) and whose expected growth rate for 2018 is of +4.1%.

Generating efficient experimental designs to account for consumer processing of products in online contexts is another research priority for the next three years according to the Marketing Science Institute (2018). The trend in online purchasing is global and irreversible: user penetration is at 53.8% in 2018 and is expected to attain 60% in 2022. In 2017, retail e-commerce sales worldwide amounted to $2.3 trillion and e-retail revenues are projected to grow to $4.88 trillion in 2021 (Statistica, 2018). These figures have an even more impact in Spain, the fourth best online seller in Europe where 70% of the users purchase on the online market place (eShopWorld, 2018).

This scenario marked by the prominence of advertising, e-commerce and consumer neuroscience requires delving deeper into the neural basis of consumer perceptions, attitudes, intentions and even behaviors triggered by elements of advertising and website environments that remain poorly studied. Revealing their origin can lead to advertising campaign designs with greater impact as well as easier-to-use, trustee and secure purchase websites. This dissertation opts for addressing these research gaps by means of the fMRI consumer neuroscience technique. Specifically, the study aims to contribute to research on the neural correlates of five forgotten elements in audiovisual advertising: voice gender, message framing, voice age, temporal framing and gender congruence of product-voice combinations. It also offers data on the underlying neural mechanisms of the three key elements of the e-commerce environment, notably risky and secure payments, risk facets and e-assurance services.

The **general objective** of this thesis is, therefore, to advance in the understanding of the neural processes by consumers of audiovisual elements in advertising and e-commerce contexts. This main goal is pursued by means of the following **specific objectives**:

- Outline the usefulness of resorting to neuroscience techniques, specifically fMRI, in consumer behavior research.
- Elucidate the neural background of the effects of voice gender (male and female) and message framing (loss and gain) in the context of environmental advertising, as well as assess relationships between such neural reactions and attitudinal responses.
- Explore the underlying neural mechanisms of voice age (young and old) and the temporal framing (past and future) in environmental advertising while evaluating the links between neural and behavioral responses.

- Throw light on the neural processing of congruent and incongruent gender product-voice combinations in advertising, and study the brain areas activated in response to gender congruent advertisements that covary with traditional self-report attitudes toward advertisements.
- Obtain more insight into the mechanisms that underlie preferences toward two e-payment systems, namely traditional debit cards and Paypal.
- Examine the neural differences between the three most widespread facets of risk (financial, privacy and performance) in low-involvement online purchase environments.
- Compare the underlying brain mechanisms linked to three e-assurances, namely seals of approval, rating systems and assurance statements.
- Advise advertising managers and associations which type of voice (gender or age) and frame (gain/loss or future/past) of the message generate the highest subconscious value.
- Offer empirical evidence of the most trusted and secure e-assurance and e-payment systems and determine the least aversive online risk facet.

1.4. Thesis structure

This research project begins with this introductory chapter that offers the reader a clear and concise description of the origin and evolution of the field of consumer neuroscience. Chapter 2 reviews the first three non-pure neuroscientific tools that capture, nonetheless, objective and automatic responses among consumers before turning to the three main neuroimaging techniques of consumer neuroscience, namely fMRI, EEG and MEG. The chapter pays special attention to their different advantages and weaknesses. The chapter finalizes by proposing the opportunities of these tools in consumer behavior research.

Chapter 3 continues by centering attention on the contribution of fMRI, the most common consumer neuroscience technique, to consumer behavior research. This is initiated by presenting an overview of the available research on consumer behavior resorting to neuroscientific tools, namely fMRI, EEG and MEG. The chapter then describes the more relevant and applied technique in the arena, notably fMRI, by explaining its basic notions. The chapter ends by evoking the most attractive marketing variables whose understanding can be greatly improved by resorting to fMRI.

Chapter 4 is centered on the domains and subdomains of marketing that would benefit from neuroscientific analyses. In particular, this chapter justifies why advertising and e-commerce are areas of analysis with a high potential in future consumer neuroscience research. Specifically, Chapter 4 focuses on the media elements of advertising, especially those inserted in environmental messages, whose psychological origin deserves more attention in the coming years, namely message frames, types of voice and product-voice combinations. It also throws light on the need to explore the psychological basis of elements forming part of online websites notably e-payments, e-assurances and risk facets, aiming to reduce consumer concern during online purchases.

The central section of the thesis comprises six different studies regarding the subject of the neural processing of elements inserted in audiovisual advertising (three studies) and the underlying neural mechanisms of key elements on the e-commerce environment (three studies). The purpose of this section is to offer examples of the knowledge that consumer neuroscience can add to consumer behavior research (specifically to advertising and e-commerce) by paying special attention to the theoretical and practical implications of the findings.

The six studies are found in chapters 5, 6, 7, 8, 9 and 10. These are, in corresponding order, "Neural correlates of gender congruence in audiovisual commercials for gender-targeted products: An fMRI study;" "Neural correlates of voice gender and message framing in advertising: A functional MRI study;" "Neural effects of environmental advertising: an fMRI analysis of voice age and temporal framing;" "A neuropsychological study on how consumers process risky and secure e-payments;" "How consumers process online privacy, financial and performance risks: an fMRI study;" and "Consumer processing of e-assurance signals: a neuropsychological study."

Finally, chapter 11 offers a general reflection on the results obtained in the six studies and a series of conclusions of interest to academia as well as business. It also points out the study limitations, as well as future lines of consumer neuroscience research.

The structure of this dissertation is summarized in Table 1.

Table 1. Thesis structure

CHAPTER 1 - Introduction	• Human decision making: from classical models to neuroeconomics • A subfield of neuroeconomics: consumer neuroscience • Problem approach and research objectives • Thesis structure
CHAPTER 2 - Consumer Neuroscience: Tools and Opportunities for consumer behavior research	• Research tools of consumer neuroscience • Opportunities of neuroscience for consumer behavior research
CHAPTER 3 - The role of fMRI in consumer neuroscience: What has it been done and what is it left to do?	• Understanding fMRI methodology • An overview of consumer neuroscience studies using fMRI • Two avenues to follow: fMRI applied to advertising and e-commerce
CHAPTER 4 – Media elements in advertising and e-commerce: Why do these domains deserve further consideration?	• Looking at the advertising domain • Looking at the e-commerce domain • Conclusion
CHAPTER 5 – Neural correlates of gender congruence in audiovisual commercials for gender-targeted products: an fMRI study	• Introduction • Theoretical background • Research hypotheses • Material and methods • Results and discussion
CHAPTER 6 – Neural correlates of voice gender and message framing in advertising: a functional MRI study	• Introduction • Theoretical background and hypotheses • Method • Results • Discussion
CHAPTER 7 – Neural effects of environmental advertising: an fMRI analysis of voice age and temporal framing	• Introduction • Research and propositions • Materials and methods • Results • Conclusions
CHAPTER 8 – A neuropsychological study on how consumers process risky and secure e-payments	• Introduction • Literature review and research objectives • Method • Results • Discussion and conclusions
CHAPTER 9 – How consumers process online privacy, financial and performance risks: an fMRI study	• Introduction • Materials and methods • Results • Conclusions
CHAPTER 10 – Consumer processing of e-assurance signals: a neuropsychological study	• Introduction • Conceptual background and hypotheses • Method • Results • Conclusions
CHAPTER 11 – Conclusions	• Main conclusions • Implication for management • Limitations and future lines of research

Source: Author

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CHAPTER 2

CONSUMER NEUROSCIENCE: TOOLS AND APPLICATIONS FOR CONSUMER BEHAVIOR RESEARCH

This chapter reviews the characteristics of the main tools of consumer neuroscience as well as the discipline’s contribution and applications in the field of consumer behavior. It first describes the non-neuroscientific techniques that have been useful in detecting automatic responses of consumers toward marketing stimuli before centering attention on its three main neuroimaging techniques, fMRI, EEG and MEG, and their pros and cons. Finally, this chapter proposes applications of these neuroscientific tools that may lead to advances in consumer behavior research, as well as certain drawbacks deriving from its application.

2.1. Research tools of consumer neuroscience: strengths and weaknesses

The serious limitations of traditional market research methods in the form of quantitative self-report survey questionnaires and qualitative research such as in depth interviews and focus groups to measure internal cognitive responses to external marketing stimuli are well documented (Ohme et al., 2011). Consumer neuroscience techniques emerged to complement and add new, more objective and richer information about inner processes experienced by consumers when exposed to marketing-mix variables. An enlightening overview of the contrasts between traditional self-reports and consumer neuroscience techniques is listed in Table 2.

Table 2. Differences between traditional self-report and neuroscientific tools.

Self-report tools	Neurological tools
Subjective	Objective
Likely social desirability bias	Avoid social desirability bias
Conscious processing	Unconscious processing
Delayed measurement	Second-to-second measurement
Not recommended for sensitive topics	Recommended for sensitive topics
Dependent on language	Not dependent on language
Require recall	Does not require recall

Source: Author

Before application of these brain imaging tools to the domain of marketing, techniques from the discipline of psychophysiology were put to use and took the first steps in capturing automatic reactions among consumers. This chapter therefore first takes a look at these pre-neuroscientific tools (namely, biometrics and eye tracking) before focusing on the most common brain-mapping techniques in consumer neuroscience.

2.1.1. Biometrics

Psychophysiology is the branch of psychology that is concerned with physiological bases (i.e. automatic body reactions) of psychological processes (such as attention or affect). This discipline dating from the 1960s applies biometrics (physiological or automatic responses to an external stimulus) to connect reports, readings and behavior with internal psychological states or sensations. This field has become increasingly widespread in consumer behavior research since the 1980s as it provides an impartial and reliable measurement of a consumer's unconscious and affective reaction to a marketing stimulus (Venkatraman et al., 2015). Common physiological responses include heart rate, electromyography and skin conductance.

- Heart rate

This biometric, also called pulse, refers to the rate of the heartbeat and is usually measured with an electrocardiogram that quantifies the electrical activity of the heart using external skin electrodes. Heart rate is controlled by two antagonistic systems: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) (Potter & Bolls, 2011). SNS represents the body's automatic response to external stimuli. Activation of this system increases heart rate, also called heart rate acceleration, offering an independent measurement of arousal linked to the bodily sensation of feeling energized. The PNS, in turn, raises a relaxed state that is characterized by slower heart rate known as heart rate deceleration (Venkatraman et al., 2015). A deceleration of the heart rate in response to a marketing stimulus implies an increase in the ability to focus on the stimulus and thus provides an independent indication of attention (Lang et al. 1999). Research in the field of consumer behavior has resorted to heart rate to evaluate the influence of color on consumer emotions (AL-Ayash, Kane, Smith, & Green-Armytage, 2016), to assess attention and affect in online advertising (Guixeres et al., 2017) and to explore the effect of vocal-pitch difference on automatic attention to voice changes in audio messages (Potter, Jamison-Koenig, Lynch, & Sites, 2016).

- Electromiography (EMG)

Facial EMG measures microscopic voluntary and involuntary facial muscle movements by placing electrodes on the skin's surface to record the electrical activity of particular muscle groups *(*Harris, Sheth, & Cohen, 2008*)*. The most common facial muscles subject these analyses are the corrugator (placed brow above nose bridge) and the zygomatic (located above the corner of the mouth). Movement of the zygomatic muscle is voluntary, associated with smiling and positively valanced emotion. The corrugator, in turn, is associated with frowning and negatively valanced emotion (Cacioppo et al., 1986). Responses from the corrugator are involuntary, and recordings of these muscle movements measure unconscious emotional responses to marketing stimuli (Ohme, Matukin, & Pacula-Lesniak, 2011). A large number of consumer research studies have used EMG to explore consumer emotional processes when viewing green advertising (Martínez-Fiestas, Isabel Viedma del Jesus, Sanchez-Fernandez, & Montoro-Rios, 2015), when comparing the power of engagement of radio and television (Peacock, Purvis, & Hazlett, 2011), and when assessing the impact of emotional words on the emotional and cognitive responses of listeners (Lee & Potter, 2018).

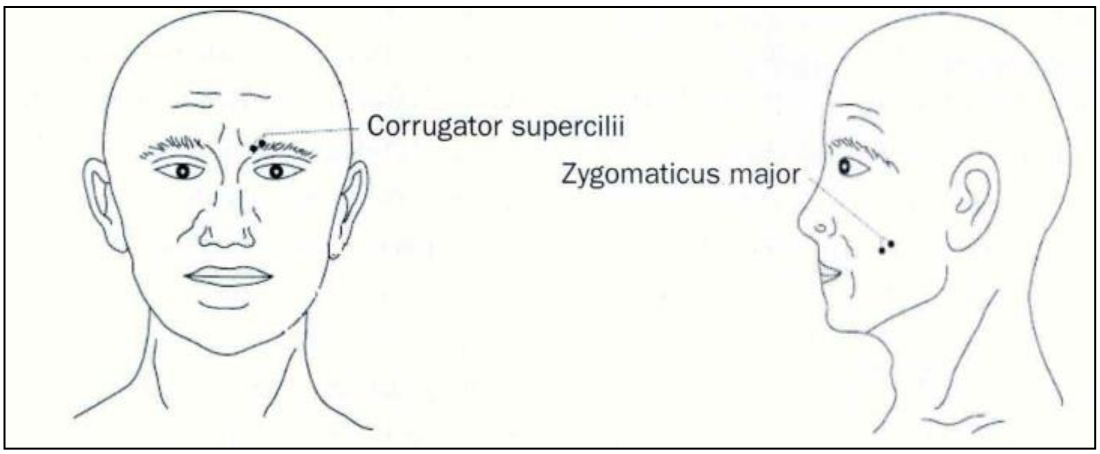


Figure 5. Location of the corrugator (frown) and zygomatic (smile) muscles.

Source: Author from Martínez-Fiestas et al. (2015).

- Skin conductance

This reliable *biometric tool*, also referred to as electrodermal or galvanic response, measures skin conductance and autonomic nervous system arousal or excitement in response to sensory and emotionally charged marketing stimuli (Harris et al., 2008) using electrodes impregnated with an electrolyte gel to record the electrical activity of the skin of the hand. Changes in the skin's electrical activity are known as electrodermal activity. An increase in skin conductance can be interpreted, therefore, as a physiological activation and a function of preparing energy for the body (Martínez-Fiestas et al., 2015). In consumer behavior research, electrodermal activation has been applied widely to measure consumer responses to sexual (Belch, 1981) and tourism advertising (Li, Walters, Packer, & Scott, 2016), to assess emotional responses toward food packaging (Liao, Corsi, Chrysochou, & Lockshin, 2015) and testing (Verastegui-Tena, van Trijp, & Piqueras-Fiszman, 2018), as well as to advance in the understanding of sustainable consumer emotional responses (Gam, Ko, & An, 2016).

Figure 6. Position of the electrodes to record skin conductance.
Source: Author from Martínez-Fiestas et al. (2015).

2.1.2. Eye tracking

In addition to psychophysiological tools, consumer behavior research has taken advantage of the advance of eye tracking systems to explore automatic responses among consumers. Eye tracking serves to measure eye movements and changes in pupil dilation and contraction, direct indications of levels of attention. This tool has a high temporal resolution (60-120 Hz) and provides insight into temporal processes. Compared to the older camera-based systems, modern eye trackers use an optical camera to identify the position of the pupil and cornea using infrared/near-infrared light that evokes corneal reflection (Venkatraman et al., 2015). The tracking of a participant's gaze when exposed to marketing stimuli offers the option to capture not only which information is processed but the order and duration of these processes. The most common eye tracking methods and their utility in the study of consumer behavior are listed in Table 3.

Table 3. Overview of common eye tracking methods and their utility to the study of advertising effectiveness.

Measure	Definition	Role in attention	Application to consumer behavior
Time to first fixation	• The amount of time that it takes a respondent to look at a specific area of interest from stimulus onset.	• The fact that a stimulus is first to be 'selected' may be due to its superior visual salience (Simola, Kivikangas, Kuisma, & Krause, 2013)	• The fact that an ad or one of its elements is able to catch attention faster is an indicator of it gaining an advantage in the competition for attention.
Number of fixations and fixation duration	• Number of fixations refers to the amount of times a respondent looks at a specific area of interest. • Fixation duration refers to the length of the fixations within an area of interest.	• More frequent and longer fixations are made on interesting or relevant objects of a scene (Djamasbi, Siegel, Skorinko, & Tullis, 2011). • Fixation frequency and duration are indicators of cognitive activity and processing effort during reading and problem solving (Boucheix & Lowe, 2010).	• More frequent and longer fixations may reflect stronger cognitive engagement with the marketing stimulus. • Can be used as quantitative measures of marketing strategies effectiveness in both catching and holding visual attention.
Pupil size	• Dimensions of the pupil (in millimetres).	• Positively associated with increased cognitive processing load (Palinko et al., 2010). • Positively associated with emotional arousal during picture viewing (Bradley et al., 2008).	• Can be linked to fixation data for a more exhaustive analysis of advertising effects on the viewer.

Source: Author

Table 4 lists a summary of the tools applied to consumer behavior research that are distinct to those of neuropsychological studies, notably biometrics and eye-tracking.

Table 4. Non-neuroscientific tools applied to the field of consumer behavior.

Non neuroscientific tools		Research method	Outcome revealed
	*Heart rate*	Electrical activity of the heart using external skin electrodes	Arousal and attention to external stimuli
	*EMG*	Through electrodes, it records activity of zygomatic and corrugator muscles	Affective valence of stimuli
	*Skin conductance*	Electrodes located in the skin allows to measure autonomic nervous system arousal or excitement in response to sensory and emotionally charged marketing stimuli	Emotional intensity
	*Eye-Tracking*	A camera and infrared technology monitor eye movements, in terms of speed and duration of attention	Tracks visual attention in reaction to predetermined areas of interest

Source: Author

2.1.3. Brain imaging techniques

These recent technological and research advances relate to brain-mapping techniques that offer the advantage of providing a direct measurement of brain activity by observing the brain itself (Hubert & Kenning, 2008). The following overview describes the tools used by the vast majority of modern consumer neuroscientific studies, namely functional magnetic resonance imaging (fMRI), Electroencephalography (EEG) and Magnetoencephalography (MEG).

- fMRI

This recent magnetic resonance imaging technique is a non-invasive tool that detects regional changes in the level of blood oxygenation in the brain (called the fMRI‘s BOLD signal), as a result of metabolic changes in blood flow produced by the neural activity. This is done by means of an MRI scanner, which measures the contrasts between the activity levels of the different brain regions that are associated with particular mental functions, while permitting to visually represent and localize this result through MR brain images (Solnais et al., 2013). *The fMRI is* excellent in identifying the specific brain location at a very high resolution (approximately 1 mm^3) and provides a good temporal resolution (approximately 2-5 seconds).

The fMRI's core strength is precisely this high level of spatial resolution that can record neural activity by mm^3 and mm^3. However, fMRI recordings can be highly susceptible to internal (endogenous) artifacts such as head movements, speech, respiration, and upper-body muscle contraction and movement. The external (exogenous) recording environment can also contaminate the fMRI signal, and hence interpretation. Analysis of fMRI data requires artifact to be quantified and removed using computer software programs (Solnais et al., 2013). In addition, fMRI cannot record certain cognitive processes because brain activation has a very small impact on the blood - oxygenated levels detectable by fMRI (Sanei & Chambers, 2007).

Decision consumer neuroscience research has been conducted predominantly with fMRI research tools because of its topographical accuracy of brain activity. Recent fMRI studies have identified neural structures especially in the frontal lobes hypothesized to process reward and value perceptions influencing decision-making processes in marketing environments. Specifically, it has been revealed that the fMRI technique allows to elucidate the underlying neural mechanisms of the four most remarkable constructs of interest in consumer behavior research, namely attention, affect, memory and desirability (Venkatraman et al., 2015).

- EEG

EEG is a non-invasive technique that measures changes in electrical neural activity in the brain cortex. EEG measures the frequency of the brain's electrical currents and changes in voltage via electrodes placed on the scalp, which are then amplified to facilitate appropriate statistical analysis. Electrodes (also called leads) operate as individual channels, which record electrical brain activity. Researchers can use one or over 100 electrodes with high-density-array recording systems". One electrode attached to the mastoid bone operates as a reference (baseline) to compare electrical activity from the other electrode sites (Harris et al., 2008)

Electroencephalography provides high temporal resolution (from 250 – 400 milliseconds) but low spatial resolution (approximately 1 cm^3) because it is restricted to measuring only cortical brain activity. This latter constitutes its major limitation. Technical issues can compromise, furthermore, the quality of EEG recordings such as technician error during data collection, faulty equipment, variations in electrode placement or poor electrode scalp contact (resulting in high impedance). Moreover, the subject's emotional states, educational level of development, age, and neurological and cognitive conditions can also affect the quality of the EEG data recordings. Nevertheless, increasingly, functional imaging technological advancements have achieved higher spatial localization of EEG recordings using the LORETA software (low-resolution electromagnetic tomography), which uses three-dimensional head modeling to accurately identify neural substrates (Harris et al., 2008); Venkatraman et al., 2015).

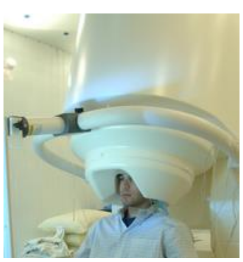
EEG is the most commonly used neuroscience method in advertising research. Unlike fMRI, the current technique only offers the chance to reveal the neural mechanisms triggered by two main consumer behavior constructs, namely attention and affect (Venkatraman et al., 2015).

- MEG

MEG is similar to EEG but measures magnetic fields produced by electrical currents occurring naturally in the brain, using very sensitive magnetometers. MEG has good temporal resolution and greater spatial localization recording of brain structures at a deeper subcortical level than EEG. MEG has been used in consumer behavior research to measure cognitive and affective appeals of advertising messages as well as decision-making processing, but to a much lesser degree than fMRI and EEG (Baumgartner, Heinrichs, Vonlanthen, Fischbacher, & Fehr, 2008). The constructs of interest for consumer behavior that this tool helps to illuminate are the same as EEG, notably attention and affect.

All in all, fMRI, EEG and MEG present the common advantage of being non-invasive techniques, so that repeated measurements can be made with healthy volunteer subjects. While fMRI will better respond to the ‘‘where’’ question (i.e. the precise identification of the specific areas activated in response to marketing stimuli), the ‘‘when’’ question (i.e. the moment-by - moment tracking of brief neural activity changes as a stimulus evolves through time) will be better answered with EEG or MEG. fMRI and MEG experiments also require much more economic effort than EEG. These different technologies therefore present different pros and cons for a consumer neuroscientific experiment. These must be evaluated according to the research purpose, the population of study and the budget possibilities. The first methodological reviews of modern consumer neuroscience recommend a multi-method approach that combine different neuroimaging techniques such as fMRI and EEG, so as to take advantage of their respective strengths and thus compensate for their limitations (Solnais et al., 2013). Below is provided a comparative table of the three most used neuroimaging techniques for an overview of the advantages and drawbacks derived from the technology they use and their revealed constructs of interest for consumer behavior research (Table 5).

Table 5. Overview of the three most used neuroimaging techniques in consumer behavior research.

Consumer neuroscience tool	Measure of brain activity	Technology	Revealed constructs of consumer behavior	Advantages	Weakenesses
fMRI 	Detecting changes in the oxygenation level of the blood and visualizing this result through brain images that evidence the contrasts of activity between brain regions.	MRI scanner inside which the subject lies during the time of the experiment.	Attention Affect Memory Desirability	Non-invasive technique High special resolution Covering most of deeper brain structures	Low temporal resolution High costs Constraining running process for the subject, which may requires high incentives to gather enough participants.
EEG 	Measures of the frequency of the brain's electrical currents and changes in voltage via electrodes placed on the scalp	Electrodes spread on the subject's head (usually 64 sensors)	Attention Affect	Non-invasive technique High temporal resolution Low costs	Low spatial resolution No measures of deeper brain areas
MEG 	Measures magnetic fields produced by electrical currents occurring naturally in the brain	Very sensitive detectors of the small magnetic field of the brain, called SQUID (superconducting quantum interference devices)	Attention Affect	Non-invasive technique High temporal resolution Higher spatial resolution than EEG	Higher costs than for EEG

Source: Author from Solnais et al. (2013) and Venkatraman et al. (2015)

Following previous research (Dimoka et al., 2010; Harris, Ciorciari, & Gountas, 2018; Venkatraman et al., 2015), we hereby conclude that the only techniques strictly from neuroscience are those measuring changes in electrical or metabolic neural activity, namely fMRI, EEG and MEG. Other tools such as biometrics or eye-tracking are of course useful to advancing in the domain of consumers' automatic responses, but they only measure physiological (and not neurological) changes in response to marketing stimuli. Accordingly, the only tools strictly measuring consumer neurological responses, and therefore the only ones pertaining to consumer neuroscience, are fMRI, EEG and MEG.

2.2. Opportunities of neuroscience for consumer behavior research

The use of the above-described neurological techniques has generated many advances in the basic understanding of information processing, decision making, and behavior by directly and objectively measuring the brain activity that underlies various decision-making, cognitive, emotional, and social processes. Their application to the consumer behavior field is currently offering new cutting-edge foundations and serve as a reference discipline for consumer behavior research that could help further advance our knowledge of the complex interplay of consumer behavior and information processing, decision making, and behavior. The purpose of this section is just to outline and propose opportunities that the application of neuroscientific tools may spawn for consumer behavior research.

2.2.1. Opportunity 1: Localizing neural correlates of consumer behavior constructs

A fundamental task for cognitive neuroscience is to localize mental processes onto the brain by linking a mental process (e.g. endogenous attention, affective state, aversion, risk, ambiguity, reward, etc.) into one or more brain areas. Neuroimaging data capture brain activity when a subject performs a mental or behavioral task, thereby essentially mapping mental processes to specific brain areas. Because the cognitive neuroscience literature has already identified the neural correlates of many mental processes and created maps of the brain, consumer behavior researchers can learn about the functionality of the brain areas associated with consumer behavior constructs by localizing their neural correlates and drawing upon knowledge of their functional roles. In other words, consumer behavior researchers can shed light on the nature of consumer behavior constructs by mapping them into brain areas with existing functional or neurological connotations from the cognitive neuroscience literature.

A recent review of studies resorting to neuroscience to explore consumer processing of marketing variables (Harris et al., 2018) identified the main constructs of interest to consume behavior research as well as the brain areas involved with their processing (see Table 6 and Figure 7).

Table 6. Listing of the main constructs of interest ~~for~~ to consumer behavior research and their neural mechanisms

Construct of interest	Neural correlates	Construct of interest	Neural correlates
Value	Ventromedial Prefrontal cortex Posterior cingulate cortex Dorsomedial Prefrontal cortex Anterior insula Ventral striatum Medial orbitofrontal cortex Nucleus accumbens	**Decision making**	Medial orbitofrontal cortex Dorsolateral prefrontal cortex Anterior cingulate processes Inferior orbitofrontal cortex Medial prefrontal cortex Ventral cingulate cortex
Conflict	Anterior cingulate cortex	**Self-reflection**	Superior and medial frontal gyrus
Fear	Amygdala	**Emotion**	Amygdala
Trust	Ventromedial prefrontal cortex Dorsomedial prefrontal cortex Anterior prefrontal cortex Dorsolateral prefrontal cortex	**Memory**	Hyppocampus
Reward and risk	Ventral Striatum Medial orbitofrontal cortex Insula Nucleo accumbens	**Disgust and anger**	Insula
Prediction	Dorsomedial prefrontal cortex Dorsal anterior cingulate cortex Insula	**Attention**	Occipital and parietal regions Right frontal gyri
Willingness to pay	Orbitofrontal cortex Dorsomedial prefrontal cortex Insula	**Envy**	Dorsal anterior cingulate cortex

Source: Author, adapted from (Harris et al., 2018)

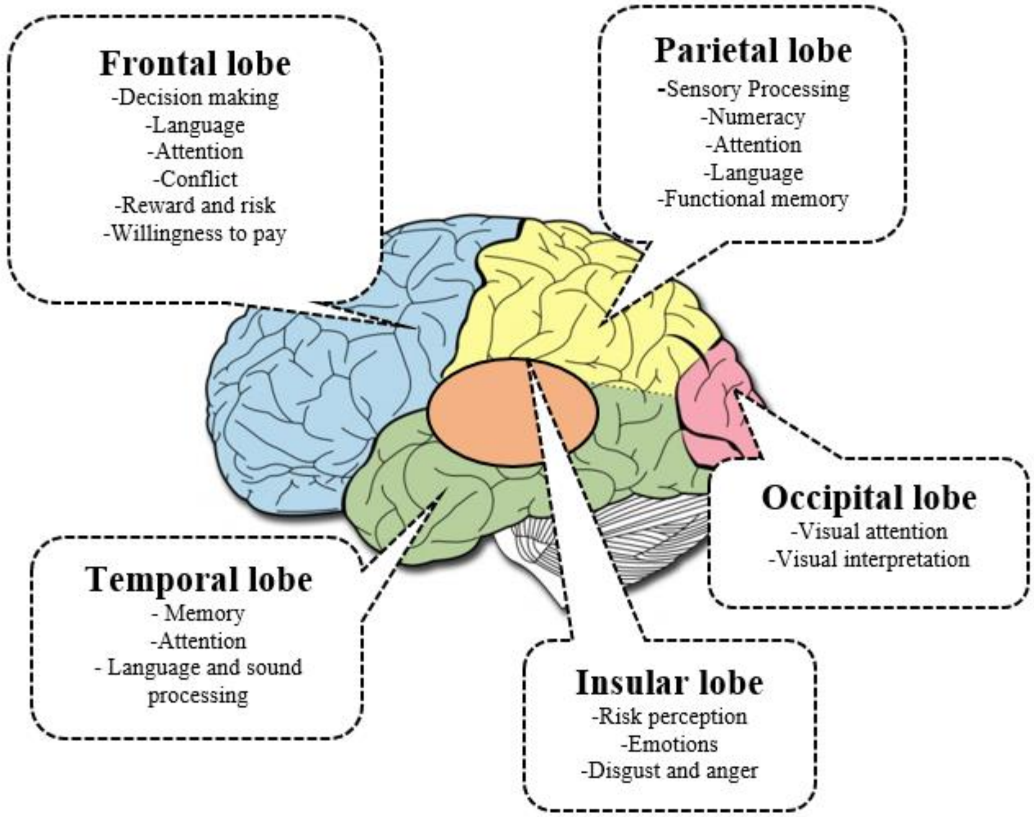


Figure 7. The main regions and functions of the brain of interest to consumer behavior research
Source: Author, from Solnais et al. (2013) and Harris et al. (2018)

2.2.2. Opportunity 2: Capturing hidden processes through brain imaging data (inaccessible through self-reports)

Neuroimaging studies can be designed to trigger unconscious processes such as hidden or automatic processes that are not accessible to introspection and self-reporting. Researchers from the University College London (2007), for example, explored whether a subliminal image reaching the retina has an impact on brain activity in the primary visual cortex, an area in the occipital lobe. The findings reveal that subjects responded to the stimuli even when unconscious of it. Nevertheless, the findings also demonstrate that the brain does not pick up on these stimuli if it is too occupied with difficult (as opposed to simple) tasks. Neuroimaging studies could thus open doors to consumer behavior researchers to examine locked unconscious, hidden, and automatic constructs that constructs subject to biased, questionable, or potentially unreliable self-reports (Dimoka, Pavlou, & Davis, 2011).

2.2.3. Opportunity 3: Identifying the antecedents and consequences of consumer behavior constructs

Brain imaging tools can test whether and how marketing-mix stimuli (such as advertising designs or purchasing web layouts) trigger brain activation in areas mapped by consumer behavior constructs. They are able, for example, to objectively test whether an element of advertising provokes intention or behavior changes in consumers by revealing activation in the brain's value and prediction areas. The study of Falk and her research team (Falk, Berkman, Mann, Harrison, & Lieberman, 2010) established that neural responses to persuasive healthy messages can predict variability in behavior change (specifically, increases in intentions to use sunscreen) in the following week. The same research team also linked neural activity during health messaging with reductions in smoking, findings that represent a great leap beyond those obtained by self-reports (Falk, Berkman, Whalen, & Lieberman, 2011).

2.2.4. Opportunity 4: Inferring temporal ordering among consumer behavior constructs

Functional brain imaging tools such as EEG or fMRI offer a good temporal resolution that can determine the temporal order of brain activations connected with consumer behavior constructs. Neuroimaging studies can use a common marketing-mix stimulus (to trigger activation in several brain areas), and can measure the temporal ordering of resulting brain activations. Since one of the three key prerequisites of causality is temporal precedence (Zheng & Pavlou, 2010) brain data can reveal temporal precedence among consumer behavior constructs, helping capture their temporal ordering and dynamics and potentially leading to identification of causal relationships (Dimoka et al., 2011).

2.2.5. Opportunity 5: Challenging and bolstering consumer behavior theories

Brain imaging data, in terms of theory development, might question existing consumer behavior theories and assumptions that do not correspond to the brain's circuitry. Dimoka (2010), for example, carried out an fMRI experiment that explored the location, timing, and level of brain activity that underlies trust and distrust as well as their underlying dimensions. Her results reveal that trust and distrust activate different brain areas and offer different effects, lending credence to why trust and distrust are distinct constructs associated with different neurological processes. Stallen et al. (2010) implemented an fMRI design to identify the processes that underlie the effect of celebrities presenting advertisements on product memory and purchase intention. The results allow to extend the theory on the effects of the famous on advertising by revealing that their effectiveness stems from a transfer of positive affection from the celebrity to the product. Furthermore, a recent fMRI study attempted to explain the origin of the influence of Fair Trade Labeling (e.g. an emblem conveying information on social standards during the production process) on food valuation and choice (Enax et al., 2015). The findings reveal that fair certification of a production increased both the level of willingness to pay and activity in the ventral striatum, a brain area responsible for reward and positive values.

Despite the great potential of neuroscientific tools in the field of consumer behavior, their application has several drawbacks described below.

- Cost and accessibility

While the cost of psychophysiological tools is manageable (currently it costs between 15,000 € and 25,000 € to equip a laboratory), neuroscientific tools require a greater economic effort (between 100 € and 600 € per scanning hour) given the need to resort to technicians with specialized knowledge. While the use of repeated measurements garnered from each participant, coupled with the precision of the objective data require fewer subjects per study (most fMRI studies only require 20 to 30 subjects), cost is still an issue that is best answered by the research team assuming the cost of the studies relative to their expected findings. Another problem is that these tools are found in medical facilities (Dimoka et al., 2010).

- Artificial settings

The experimental context of neurophysiological tools gives rise to an artificial environment that can restrain the external validity of consumer neuroscience research. Moreover, certain neurophysiological tools differ in their level of artificiality. While fMRI requires the participants to not move within the full-body tube for more than 3 millimeters during the experiment, biometric tools require electrodes attached to the body that may induce stress and aversion. Moreover, eye tracking systems require subjects to wear special equipment such as headgear, leading to an artificial setting (Dimoka et al., 2010)

- Labor-Intensive Data Extraction and Analysis

Data derived from the application of neuroscientific tools require an intense processes of analysis that include movement correction (fMRI or eye tracking), preparation for proper recordings (EKG electrode placing), manual data extraction (observation in eye tracking studies), and large volumes of imaging data (fMRI/EEG). The preparation of fMRI data, for example, requires slice timing correction, realignment, coregistration, segmentation, normalization, and smoothing.

- Ethical issues

Ethical problems in neuroscience research have spawned a new field called *neuroethics* concerned with the discipline's legal, moral, and social implications. To avoid falling into these quandaries, traditional neuroscience research has resorted to measures such as the protection of participant data and the full disclosure of the goals, risks and benefits. Applying neuroscience to the field of consumer behavior, due to the large quantity of sensitive information, implies not only observing ethical norms, but also protecting vulnerable segments of society from marketing exploitation, and accurate media and marketing representations. Certain governmental institutions and consumer advocates point to five main problems provoked by consumer neuroscience research: i) a rise in the incidence of illnesses triggered by encouraging harmful products; ii) a promotion of degrading values; iii) an increase in the efficiency of advertising and political propaganda; iv) misinformation afforded to participants as to the purpose of the experiment, its voluntary character or its confidentiality policy; and v) a lack of measures of security during fMRI or EEG experiments (Sebastian, 2014).

The Neuromarketing Science and Business Association (NMSBA) has therefore drawn up a code of ethics for consumer neuroscience. Observance of the code is, in fact, a precondition to membership (NMSBA, 2013). The association calls on researchers i) to be honest in their analyses and findings; ii) not to take advantage of participant incomprehension of neuroscience measurements; and iii) to offer transparency throughout the duration of their experiments.

The idea that the goal of consumer neuroscience is to open a "black box" (i.e. the brain) without considering ethical issues appears to be exaggerated. There are no real reasons why a field such as marketing should not profit from neuroscience as do other disciplines such as engineering and biology. On the contrary, consumer neuroscience should be viewed as a new and promising field of research that aims to reveal mechanisms taking part in decision-making processes and behaviors. Although neuroscience can help reveal the underlying mechanisms by which marketing stimuli are processed, it is only a tool that collects data as to consumer cognitive and affective states, as well as information about bran regions elicited by specific stimuli. It does not unveil "the perfect way" to sell goods or services. Therefore, managers and professionals in companies still should be able to use and incorporate neuroscience information when formulating marketing plans and strategies. With this in mind, the creation of interdisciplinary professional groups where psychologists interchange data with neurologists and business workers is key to edge-cutting companies of today.

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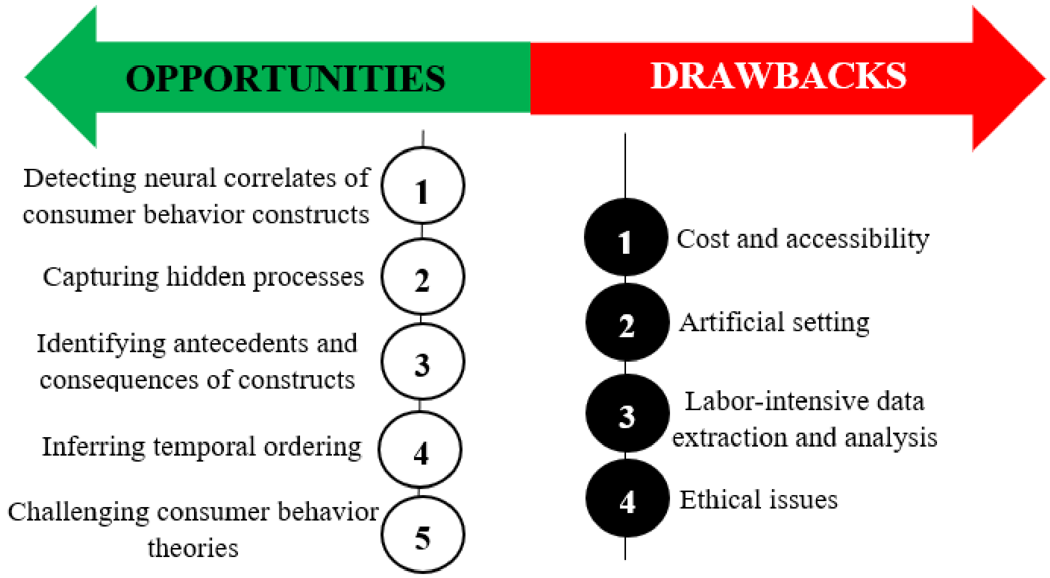

Figure 8. The main opportunities and drawbacks of applying neuroscientific tools to consumer behavior research.

Source: Author from Dimoka et al. (2010).

In sum, while application of neuroscientific tools in the field of consumer behavior warrants care and reflection, the great potential that these techniques in academic and practical domains should encourage their use to complement data and information gleaned from traditional self-report tools.

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CHAPTER 3

THE ROLE OF fMRI IN CONSUMER NEUROSCIENCE: WHAT HAS IT BEEN DONE AND WHAT IS LEFT TO DO?

This chapter begins by presenting a wide picture of the state of research on the use of neuroscientific tools (fMRI, EEG and MEG) in the field of consumer behavior. Then it focuses on the most relevant application, notably fMRI, assisting the reader by explaining basic functions. Finally, the chapter draws attention on the most attractive marketing variables that could be greatly improved by using fMRI. This chapter contributes, therefore, to achieve a better understanding of the current scope of consumer neuroscience while simultaneously suggesting guidelines as to its most noteworthy domains, techniques and types of analysis that can serve to focus the direction of future research.

3.1. An overview of consumer neuroscience studies: a bibliometric analysis[3]

It is a well-proven fact that the number of papers published on the question of consumer behavior combined with neuroscientific techniques has risen in the last decade marked by a particular upswing since 2013 (Harris, Ciorciari, & Gountas, 2018). In fact, certain research indicates the it is necessary to clear up the current situation of consumer neuroscience by offering insight into what has been done and what is left to do (Agarwal & Dutta, 2015). An overview focusing on the papers published on consumer neuroscience, its main neuroscientific techniques, and the most investigated marketing-mix areas, would help clarify the evolution, current scope and potential domains of interest for consumer neuroscience. This section opts for addressing those research gaps by implementing a bibliometric analysis that combines: i) a comprehensive empirical review of research on consumer neuroscience, ii) performance analysis tools and iii) science mapping tools. Together, these approaches will help attain an overview of the field of consumer neuroscience by identifying and visualizing its conceptual subdomains (particular topics/themes or general thematic areas) and motor themes.

Specifically, the data set consists of a corpus containing papers extracted from ISI Web of Science (ISIWoS 2011) published from 2006 to 2018 focusing on application of neuroscientific tools to consumer behavior research. With this aim, the following query #1 was submitted on 16 July 2018:

query #1: TS[4]= ("consumer neuroscience" OR "neuromarketing" OR "fMRI" OR "functional magnetic resonance imaging" OR "functional MRI" OR “electroencephalography” OR “EEG” OR “Magnetoencephalography” OR “MEG”).
query #2: TS= ("advertising" OR "advertisement" OR "commercial" OR "message")
query #3: TS= ("brand" OR “branding")
query #4: TS= ("product" OR “food product")
query #5: TS= ("neuroIS" OR “online commerce")
query #6: TS= ("price")
query #7: AND combination of query #1 with query #2

[3] This section was submitted to a journal and it is currently under review.
[4] TS field is a search based on the “Topic”.

query #8: AND combination of query #1 with query #3
query #9: AND combination of query #1 with query #4
query #10: AND combination of query #1 with query #5
query #11: AND combination of query #1 with query #6
query #12: OR combination of query #7, #8, #9, #10 and #11

AND

LANGUAGE: (English)

AND DOCUMENT TYPES: (Article or Review or Book)

Data analysis was carried out by means of Scimat software (Cobo, 2011; Cobo, López-Herrera, Herrera-Viedma y Herrera, 2012), a technique that is useful to examine the social, intellectual and conceptual framework of a specific area of research. This tool led to visualization of i) the number of papers published in consumer neuroscience between 2006 and 2018, and ii) the main authors contributing to the academic development of the discipline, iii) the main journals publishing consumer neuroscience papers, and iv) the highly developed, emerging, motor and basic themes and subthemes explored in the papers.

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3.1.1. Papers published in consumer neuroscience from 2006 to 2018

Figure *9* illustrates the evolution of the academic discipline by means of the number of papers published on consumer neuroscience from 2006 to 2018. In sum, 117 empirical and theoretical articles appeared in the selected period. It is worth noting that papers using non-neuroscientific tools (i.e. biometrics or eye-tracking) were excluded from the analysis as they do not directly measure neurological responses and, therefore, cannot literally be considered as consumer neuroscience tools (Solnais, Andreu-Perez, Sánchez-Fernández, & Andréu-Abela, 2013). Previous research, by contrast, evaluated the progress of the discipline between the years 2000 to 2015 included both non-neuroimaging and neuroimaging techniques (Andreu-Sánchez, Contreras-Gracia, & Campos-Freire, 2014). Only the outdated study by Solnais et al. (2013) assessed such growth by considering specifically neuroscientific tools. The findings of the current research highlight for the first time the promising prospect of the research carried out in the last four years as to the potential of applying neuroimaging techniques in the arena of consumer behavior (Harris et al., 2018) –see Figure 9–. Despite earlier research exploring constructs of interest to marketing (e.g. Ambler, Braeutigam, Stins, Rose, & Swithenby, 2004; Deppe et al., 2005 or McClure et al., 2004), it was not until 2006 that consumer behavior research in the area of marketing turned to specific neuroimaging techniques (Yoon, Gutchess, Feinberg, & Polk, 2006).

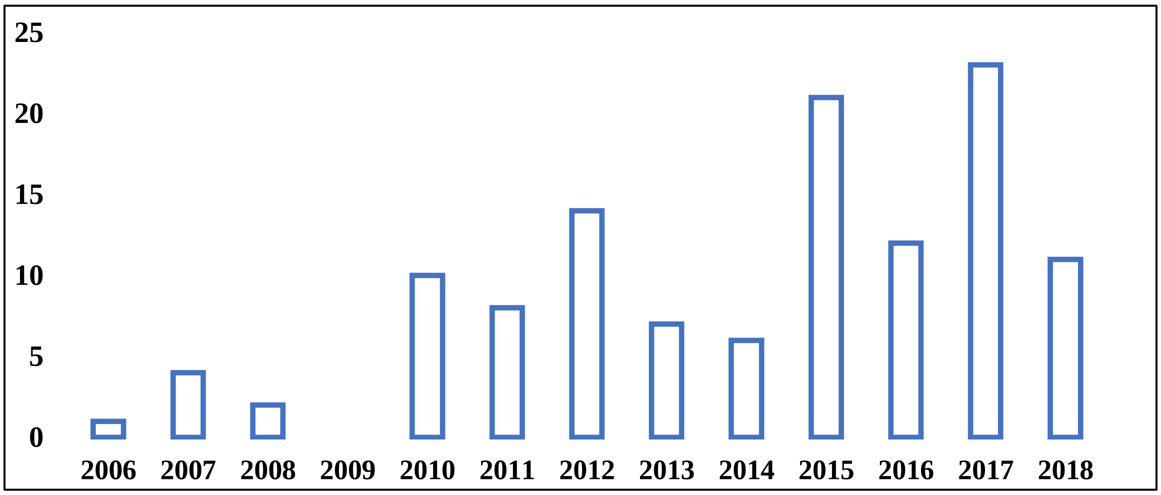


Figure 9. Number of papers in ISIWoS (y-axis) focused on consumer neuroscience from 2006 to 2018.

Source: Author from ISIWoS

With the aim of offering insight into the most studied marketing variables resorting to neuroimaging, at the time that draw more precise boundaries of the scope of consumer neuroscience and the main applied approaches and techniques, we now make a summary of the 117 selected papers. Specifically, we pay special attention to the category of journal (namely, business, marketing, psychology, neuroscience, engineering, information systems, biology or general), neuroimaging technique used and marketing-mix variable studied (see Table 7).

Table 7. Summary of the selected studies

Study	Cites	Category of Journal	Neuroscientific Technique/approach	Marketing mix variable of interest
(Plassmann, O'Doherty, & Rangel, 2007)	393	Neuroscience	fMRI	Price
(Plassmann, O'Doherty, Shiv, & Rangel, 2008)	382	General	fMRI	General marketing mix variables
(van der Laan, de Ridder, Viergever, & Smeets, 2011)	187	Neuroscience	Review of general neuroimaging	Product
(Hilke Plassmann, O'Doherty, & Rangel, 2010)	163	Neuroscience	fMRI	Price
(Dimoka, 2010)	126	Information systems	fMRI	E-commerce
(Falk, Berkman, Mann, Harrison, & Lieberman, 2010)	124	Neuroscience	fMRI	Advertising
(Venkatraman, Payne, Bettman, Luce, & Huettel, 2009)	114	Neuroscience	fMRI	Price
(Reimann, Zaichkowsky, Neuhaus, Bender, & Weber, 2010)	102	Marketing	fMRI	Product
(Yoon et al., 2006)	99	Marketing	fMRI	Product
(Riedl, Hubert, & Kenning, 2010)	96	Information systems	fMRI	E-commerce
(Schmitt, 2012)	94	Marketing	Review of general neuroimaging	Brand
(Falk, Berkman, Whalen, & Lieberman, 2011)	86	Psychology	fMRI	Advertising
(Venkatraman, Huettel, Chuah, Payne, & Chee, 2011)	80	Neuroscience	fMRI	Price
(Khushaba et al., 2013)	79	General	EEG	Product
(Plassmann, Ramsøy, & Milosavljevic, 2012)	77	Marketing	Review of general neuroimaging	Brand
(Klucharev, Smidts, & Fernandez, 2008)	70	Neuroscience	fMRI	Product
(Plassmann, Ambler, Braeutigam, & Kenning, 2007)	61	Marketing	Review of general neuroimaging	Advertising
(Solnais et al., 2013)	60	Marketing	Review of general neuroimaging	General marketing mix variables
(Reimann, Castaño, Zaichkowsky, & Bechara, 2012a)	46	Marketing	fMRI	Brand

(Venkatraman et al., 2015)	45	Marketing	fMRI and others	Advertising
(Hilke Plassmann, Venkatraman, Huettel, & Yoon, 2015)	39	Marketing	Review of general neuroimaging	General marketing mix variables
(Boksem & Smidts, 2015)	39	Marketing	EEG	Advertising
(Esch et al., 2012)	37	Marketing	fMRI	Brand
(Venkatraman, Clithero, Fitzsimons, & Huettel, 2012)	37	Marketing	Review of general neuroimaging	Brand
(Weber et al., 2007)	37	Neuroscience	fMRI	Product
(Riedl, Mohr, Kenning, Davis, & Heekeren, 2014)	31	Information Systems	fMRI	E-commerce
(Van der Laan, De Ridder, Viergever, & Smeets, 2012)	30	Neuroscience	fMRI	Product
(Dimoka, 2012)	30	Information systems	Review of general neuroimaging	E-commerce
(Smidts et al., 2014)	29	Marketing	Review of general neuroimaging	General marketing mix variables
(Javor, Koller, Lee, Chamberlain, & Ransmayr, 2013)	28	Neuroscience	Review of general neuroimaging	Advertising
(Telpaz, Webb, & Levy, 2015)	25	Marketing	EEG	Product
(Venkatraman & Huettel, 2012)	24	Neuroscience	Review of general neuroimaging	Price/economic
(Stallen et al., 2010)	23	Psychology and economics	fMRI	Advertising
(Falk et al., 2010)	23	Neuroscience	fMRI	Advertising
(van Meer, van der Laan, Adan, Viergever, & Smeets, 2015)	22	Neuroscience	Review of general neuroimaging	Product
(Michael Deppe et al., 2007)	22	Neuroscience	fMRI	Product
(Falk, Morelli, Welborn, Dambacher, & Lieberman, 2013)	19	Psychology	fMRI	Advertising
(Riedl, Davis, & Hevner, 2014)	18	Information Systems	Review of general neuroimaging	Advertising
(Falk et al., 2016)	17	Neuroscience	fMRI	Advertising
(Falk, Spunt, & Lieberman, 2012)	17	Biology / neuroscience	fMRI	Political
(Kenning & Linzmajer, 2011)	17	General	Review of general neuroimaging	Product

(Mirja Hubert, 2010)	17	Psychology	Review of general neuroimaging	General marketing mix variables
(Falk, O'Donnell, & Lieberman, 2012)	15	Neuroscience	fMRI	Advertising
(Hilke Plassmann & Weber, 2015)	13	Neuroscience	fMRI	Product
(Stallen, Smidts, & Sanfey, 2013)	13	Neuroscience	fMRI	Social influence
(Reimann, Castaño, Zaichkowsky, & Bechara, 2012b)	13	Marketing	fMRI	Brand
(Cascio, O'Donnell, Bayer, Tinney Jr, & Falk, 2015)	12	Marketing	fMRI	Social influence
(Laura Nynke van der Laan, de Ridder, Viergever, & Smeets, 2014)	12	Neuroscience	fMRI	Product
(Dimoka, 2011)	11	Neuroscience	fMRI	Social influence
(van der Laan & Smeets, 2015)	9	Biology / Neuroscience	fMRI	Product
(Emily B. Falk, Cascio, & Coronel, 2015)	9	Marketing / Communication	Review of general neuroimaging	Advertising
(Lajante, Droulers, Dondaine, & Amarantini, 2012)	9	Psychology, Marketing and Neuroscience	Review of general neuroimaging	General marketing mix variables
(Montag et al., 2017)	8	Neuroscience	fMRI	E-commerce
(Laura N. van der Laan, de Ridder, Charbonnier, Viergever, & Smeets, 2014)	8	Neuroscience	fMRI	Product
(O'Donnell, Bayer, Cascio, & Falk, 2017)	7	Neuroscience	fMRI	Social Influence
(van der Laan, Barendse, Viergever, & Smeets, 2016)	7	Neuroscience	fMRI	Product
(Karmarkar & Yoon, 2016)	7	Psychology	Review of general neuroimaging	General marketing mix variables
(Daugherty, Hoffman, & Kennedy, 2016)	7	Business	EEG	Advertising
(Chen, Nelson, & Hsu, 2015)	7	Marketing	fMRI and machine learning	Brand
(Weber, Eden, Huskey, Mangus, & Falk, 2015)	7	Psychology	Review of general neuroimaging	Advertising
(Wang & Han, 2014)	6	Neuroscience	EEG	E-commerce
(Bosshard, Bourke, Kunaharan, Koller, & Walla, 2016)	5	Psychology	EEG	Brand
(Enax, Krapp, Piehl, & Weber, 2015)	5	Neuroscience	fMRI	Product
(Enax, Weber, et al., 2015)	5	Psychology	fMRI	Product

(Agarwal & Dutta, 2015)	5	Neuroscience	Review of general neuroimaging	General marketing mix variables
(Reimann & Schilke, 2011)	5	Marketing / Business	Review of general neuroimaging	Product
(Babiloni, 2012)	5	Engineering	Review of general neuroimaging	Engineering
(Couwenberg et al., 2017)	4	Marketing	fMRI	Advertising
(Vezich, Katzman, Ames, Falk, & Lieberman, 2016)	4	Neuroscience	fMRI	Advertising
(Hsu & Yoon, 2015)	4	General	Review of general neuroimaging	General marketing mix variables
(Lindner et al., 2015)	4	Neuroscience	fMRI	Social Influence
(Melchers et al., 2015)	4	Neuroscience	fMRI	Advertising
(Baek, Scholz, O'Donnell, & Falk, 2017)	3	Psychology	fMRI	Social influence
(Pogoda, Holzer, Mormann, & Weber, 2016)	3	Neuroscience	fMRI	Product
(Cosic, 2016)	3	General	Eye tracking and Gazepoint	Advertising
(Casado-Aranda, Sánchez-Fernández, & Montoro-Ríos, 2017)	2	Neuroscience, Psychology and Economics	fMRI	Advertising
(Casado-Aranda, Martínez-Fiestas, & Sánchez-Fernández, 2018)	2	Environmental research	fMRI	Advertising
(Pegors, Tompson, O'Donnell, & Falk, 2017)	2	Neuroscience	fMRI	Advertising
(Stanton, Sinnott-Armstrong, & Huettel, 2016)	2	Business	Ethics applied to general neuroimaging	General marketing mix variables
(Goucher-Lambert, Moss, & Cagan, 2017)	2	General	fMRI	Product
(Berčík, Horská, Wang, & Chen, 2016)	2	General	Eye tracking and fMRI approach	Product
(Seixas, Ferreira, Marques dos Santos, Martins, & Ramalho, 2016)	2	Business	fMRI	Product
(Sénécal, Fredette, Léger, Courtemanche, & Riedl, 2015)	2	Business	fMRI	E-commerce
(Schmidt, Skvortsova, Kullen, Weber, & Plassmann, 2017)	1	Biology/Neuroscience	fMRI	Price
(Nittono & Watari, 2017)	1	Psychology	EEG	Brand
(Goto et al., 2017)	1	Psychology	EEG	Product
(Kang et al., 2017)	1	Medicine	fMRI	Advertising

(Çakar & Gez, 2017)	1	Business and neuroscience (Book)	Review of general neuroimaging	Advertising
(Brusoni, Venkatraman, Cappa, Laureiro-Martínez, & Zollo, 2015)	1	Neuroscience	Review of general neuroimaging	General management variables
(Isabella, Mazzon, & Dimoka, 2015)	1	Marketing	Review of general neuroimaging	General variables
(Schmidt et al., 2018)	0	Neuroscience	fMRI	Product
(Knutson & Genevsky, 2018)	0	Psychology	Review of general neuroimaging	E-commerce
(Heinonen, 2018)	0	Psychology	fMRI	General marketing mix variables
(Ramsøy, Skov, Christensen, & Stahlhut, 2018)	0	Neuroscience	EEG	Product
(Reimann, 2018)	0	Psychology, Marketing and Neuroscience	fMRI	Product
(Marco Hubert et al., 2018)	0	Marketing	fMRI	E-commerce
(Cooper et al., 2018)	0	Psychology	fMRI	Advertising
(Casado-Aranda, Liébana-Cabanillas, & Sánchez-Fernández, 2018)	0	Marketing	fMRI	E-commerce
(Casado-Aranda, Laan, & Sánchez-Fernández, 2018)	0	Neuroscience	fMRI	Advertising
Casado-Aranda, Sanchez-Fernandez, & Montoro-Ríos, 2018)	0	Information systems and Psychology	fMRI	E-commerce
(Daugherty, Hoffman, Kennedy, & Nolan, 2018)	0	Marketing	EEG	Advertising
(Çakir, Çakar, Girisken, & Yurdakul, 2018)	0	Marketing	fMRI	Product
(Marco Hubert et al., 2017)	0	Information systems	Review of general neuroimaging	E-commerce
(Krampe, Strelow, Haas, & Kenning, 2018)	0	Marketing	fMRI and MEG	Advertising
(van Meer et al., 2017)	0	Neuroscience	fMRI	Product
(Montazeribarforoushi, Keshavarzsaleh, Ramsøy, & Briesemeister, 2017)	0	Psychology	Review of general neuroimaging	General marketing mix variables
(Manippa, Padulo, van der Laan, & Brancucci, 2017)	0	Neuroscience	fMRI	Product
(Cartocci et al., 2017)	0	Psychology	EEG	Advertising

(Leanza, 2017)	0	Psychology and Neuroscience	Review of general neuroimaging	Advertising
(Jakub BerčíkElena Horska, Elena HorskaRoderik Viragh, Roderik Viragh, & Andrej Šulaj, 2017)	0	Business	Eye tracking and review of general neuroimaging	Product
(Hensel, Iorga, Wolter, & Znanewitz, 2017)	0	Psychology	Review of general neuroimaging	Ethical issues
(Guixeres et al., 2017)	0	Psychology	fMRI	Online Advertising
(Fehse, Simmank, Gutyrchik, & Sztrókay-Gaul, 2017)	0	Psychology	fMRI	Product
(Girisken & Çakar, 2016)	0	Business	fMRI	Advertising
(Chan, Boksem, & Smidts, 2018)	0	Marketing	fMRI	Brand
(B. Weber, 2016)	0	Business	Review of general neuroimaging	General marketing mix variables
(Lehmann & Reimann, 2012)	0	Psychology	fMRI	Product

Source: Author

With regards to methodological aspects, 30% of the articles focus on develop theoretical reviews of the neuroimaging tools and consumer behavior while the remaining pertain to empirical research. Furthermore, most of the studies (60%) resort to fMRI, whereas only 9% preferred EEG and only a minority (1%) reported MEG use (see Figure 10).

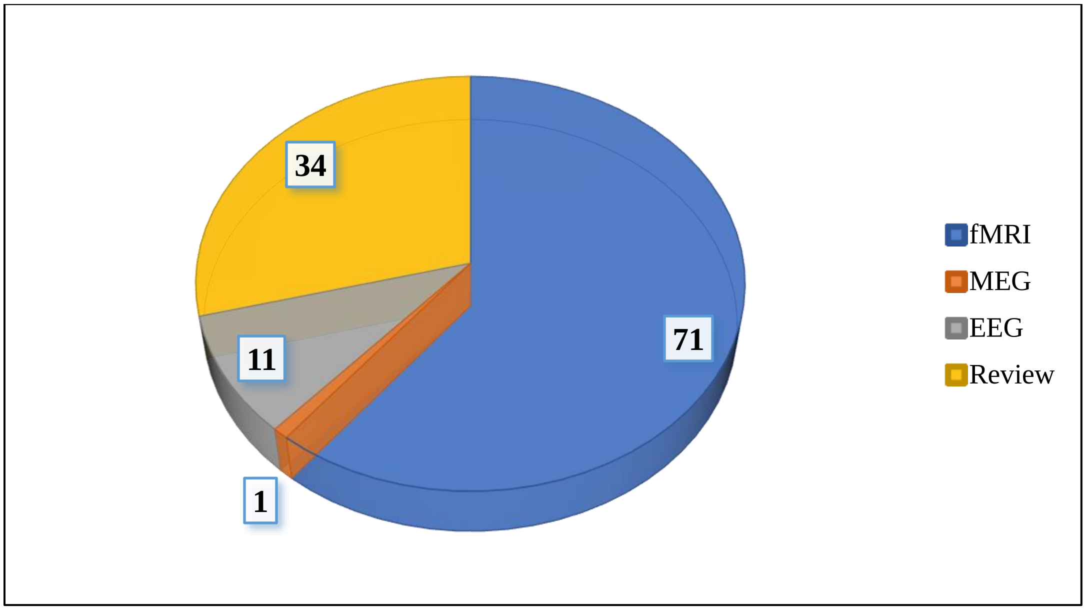


Figure 10. Distribution of studies according to neuroimaging techniques/approaches

Source: Author

It is also of interest to look at the evolution of these approaches across time. The results in Figure 11 depict the growth in importance of fMRI and EEG techniques in consumer neuroscience studies, and illustrate the increase of fMRI studies in the last four years to the detriment of EEG. Despite the fact that reviews played an important role from 2009 to 2015, they currently are decreasing.

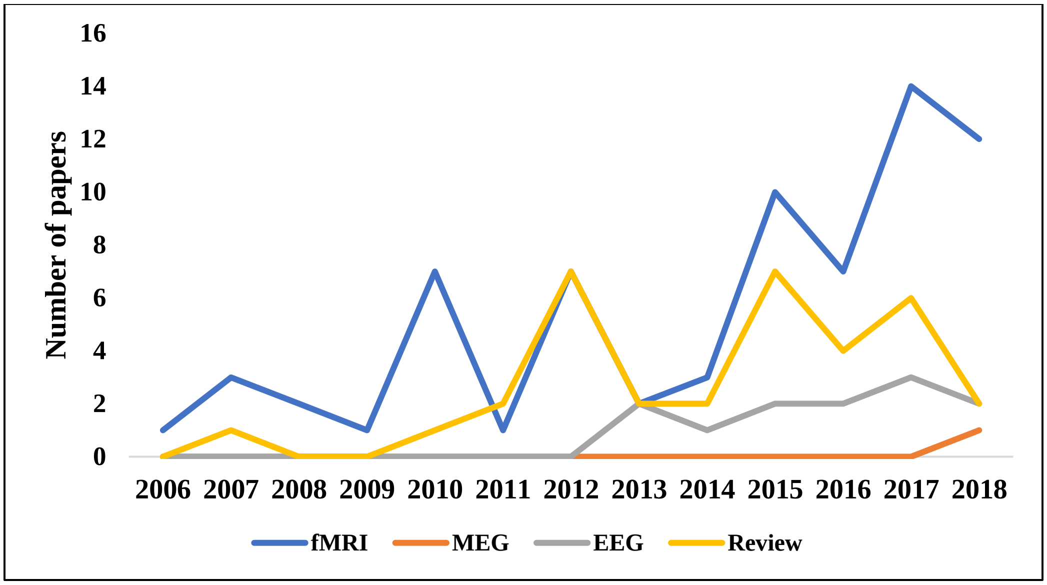


Figure 11. Distribution of studies in consumer neuroscience applying fMRI, MEG, EEG and reviews across time

Source: Author

The overview of the studies also allows us to identify the type of marketing stimuli that has received the most attention in traditional consumer neuroscience studies. Overall, advertising and product were the most common marketing stimuli (33% each) followed by e-commerce (12%) and brand (11%). To a minor extent, the studies resorted to social influence/peers/environment (6%) and price (5%) as their stimulus of interest (see Figure 12).

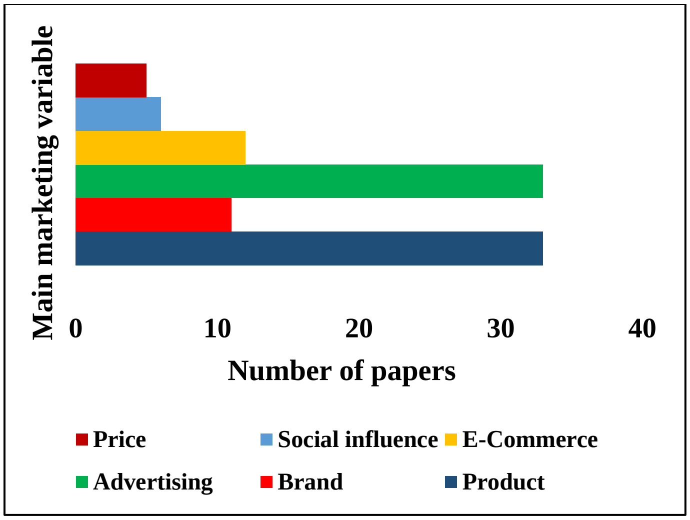


Figure 12. Distribution of marketing stimuli used in consumer neuroscience research[5]

Source: Author

Aiming to outline the marketing mix variable receiving the greatest amount of attention in consumer neuroscience in the most recent years, and consequently that with the most potential, this study also carried out a longitudinal diachronic analysis (Figure 13).

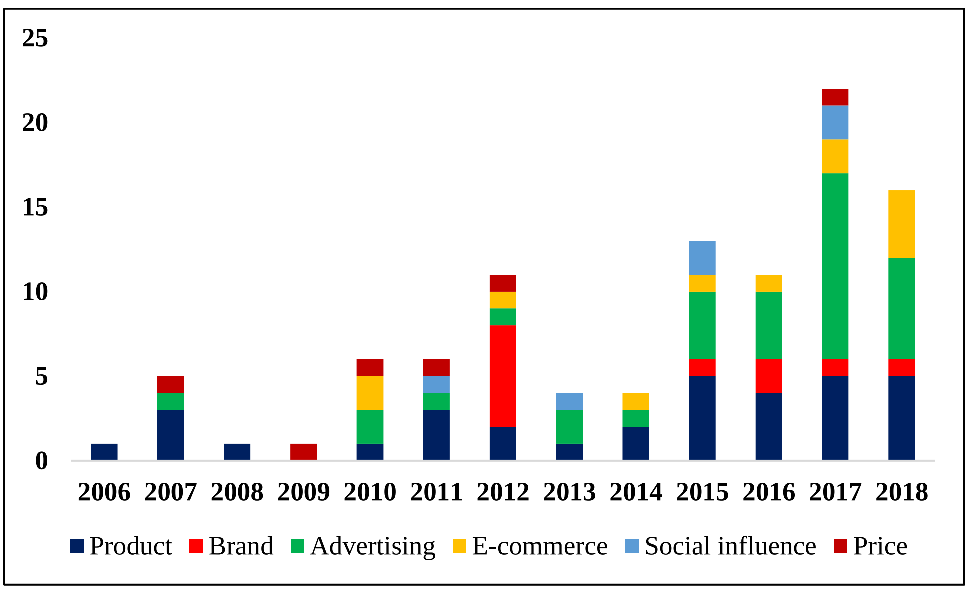


Figure 13. Distribution of consumer neuroscience studies using product, brand, advertising, e-commerce, social/contextual influence and price stimuli across time

Source: Author

[5] Studies focusing on general marketing mix are not included.

Figure 13 highlights three interesting findings: i) that the relevance of brand stimuli in consumer neuroscience studies seems to decrease; ii) that advertising is consolidated as the marketing variable with the highest importance in the last two years; and iii) research on consumer neuroscience is focusing in recent times on the neural processing of stimuli from the emerging field of e-commerce (Statistica, 2018).

3.1.2. Authors with the highest contribution to consumer neuroscience

lists the number of publications of the most renowned authors applying neuroimaging techniques to the study of consumer behavior. Only authors with at least four papers are represented. European researcher Bernd Weber and the American Emily Falk stand out with 16 and 15 papers each. It is worth noting that the most of productive authors are linked to institutions related to “neuroscience,” “psychology,” “business” and “marketing” thus revealing the interdisciplinary nature of consumer neuroscience.

Table 8 8 lists the number of publications of the most renowned authors applying neuroimaging techniques to the study of consumer behavior. Only authors with at least four papers are represented. European researcher Bernd Weber and the American Emily Falk stand out with 16 and 15 papers each. It is worth noting that the most of productive authors are linked to institutions related to "neuroscience," "psychology," "business" and "marketing" thus revealing the interdisciplinary nature of consumer neuroscience.

Table 8. Authors with a minimum of four consumer neuroscience publications between 2006 and 2018.

Author	Number of papers	Author	Number of papers
Weber, Bernd (Univ Hosp Bonn, Dept Epileptol, Bonn, Germany)	16	**Viergever, Max A.** (University Medical Center Utrecht, Image Center Institute, Netherlands)	7
Falk, Emily B. (University of Pennsylvania, Annenberg School for Communication)	15	**Venkatraman, Vinod** (Temple University, Fox School of Business, PA, USA)	7

Plassmann, Hilke (Inst Europe Adm Affaires, F-77305 Fontainebleau, France)	10	**Sánchez-Fernandez, Juan** (University of Granada, Mkt. Dept., Spain)	6
van der Laan, Laura N. (Universiry of Amsterdam, Center for Health Communication, Netherlands)	8	**Riedl, Rene** (Austria Univ Applie Sci Upper Austria, Sch Management)	6
Smeets, Paul A. M. (University Medical Center Utrecht, Image Center Institute, Netherlands)	8	**Huettel, Scott A.** (Duke Univ, Durham, Neuros, NC USA)	6
Lieberman, Matthew D. (SCN Lab Director, Harvard University, USA)	8	**Dimoka, Angelika** (Temple University, Fox School of Business, PA, USA)	5
Smidts, Ale (Marketing Departmetn, Erasmus Univ, Rotterdam, Netherlands)	7	**Casado-Aranda, Luis-Alberto** (University of Granada, Mkt. Dept., Spain)	5
Reimann, Martin (Univ So Calif, Dept Psychol, Los Angeles, CA 90089 USA)	7	**Neuhaus, Carolin** (Department of NeuroCognition, University of Bonn, Germany)	5
O'Donnell, Matthew Brook (University of Pennsylvania, Annemberg School for Communication)	7	**Trautner, Peter** (Department of NeuroCognition, University of Bonn)	4
Kenning, Peter (Zeppelin Univ, Chair Mkt, D-88045 Friedrichshafen, Germany)	7	**Yoon, Carolyn** (Univ Michigan, Ann Arbor, MI 48109 USA)	4

Source: Author

3.1.3. Journals with the highest number of consumer neuroscience papers

The recent academic interest in applying neuroscience techniques to the study of consumer psychology and behavior is a multidisciplinary phenomenon. Studies are indeed being published not only in neuroscientific journals (*Neuroimage*, *Journal of Neuroscience* or *Social Cognitive and Affective Neuroscience*) but also, and more often, in marketing journals such as the *Journal of Marketing Research* or the *Journal of Consumer Psychology*, as well as in interdisciplinary journals as the *Journal of Neuroscience*, *Psychology and Economics* and *Frontiers in Psychology*. This fact again throws light on the interdisciplinarity character of the field of consumer neuroscience and a greater predisposition of marketing journals to accept neuroscientific methodologies.

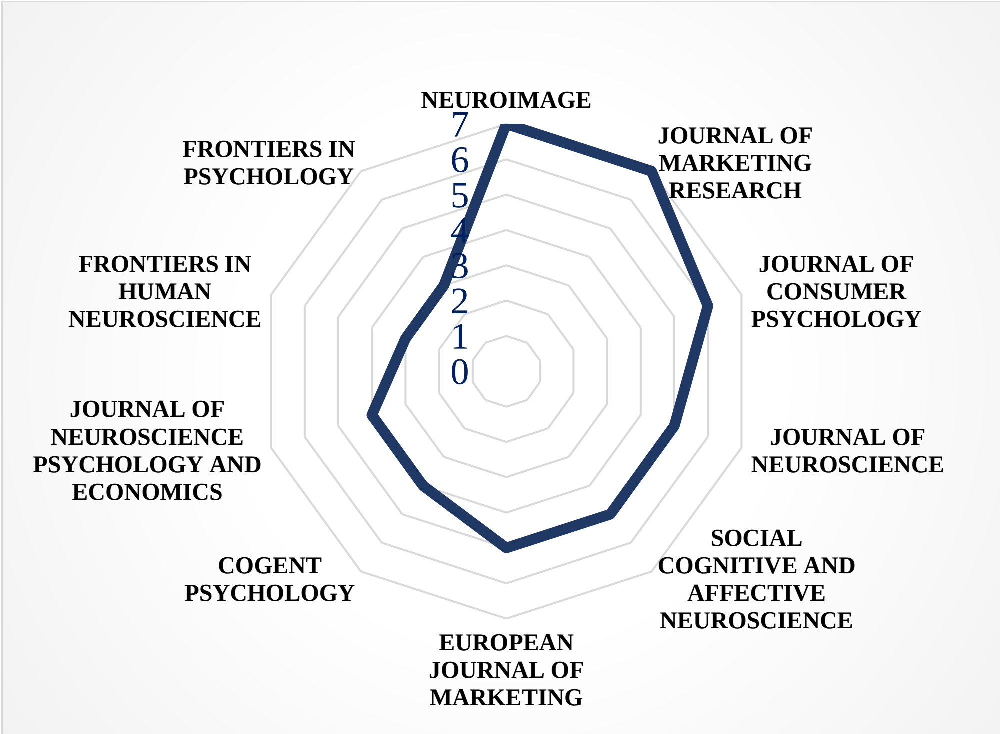


Figure 14. Main journals publishing consumer behavior research applying neuroscientific tools

Source: Author

3.1.4. Themes and subthemes of consumer neuroscience

The last goal of this section is to examine the intellectual structure of consumer neuroscience on the basis of the main publications on this topic from 2006 to 2018. To carry this out the study resorted to a co-work analysis by means of Scimat software (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011), which allows to i) design strategic diagrams useful to detect the potential of research themes in the consumer neuroscience field, and ii) carry out performance analyses to measure (quantitatively and qualitatively) the relative contribution of themes and thematic areas to the whole research field based on basic bibliometric indicators (i.e. the number of published documents).

To construct the strategic diagrams, it is first necessary to detect the research themes based on a co-word analysis. This was initiated by computing a co-occurrence matrix by assuming that the co-occurrence frequency of the two keywords is extracted from the corpus of documents by counting the number of documents where the two keywords appear together. The second step consisted of computing the equivalence index among keywords (Callon et al., 1991), called e_{ij}:

$$e_{ij} = \frac{c^2 ij}{ci*cj}$$

,where cij corresponds to the number of documents where the two keywords i and j co-occur and ci and cj represent the number of documents where eachappears (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2012). At the end of this phase, the keywords were clustered to topics/themes by using the simple centers algorithm (Cobo et al., 2011) that automatically returns labelled clusters. This resulted in the indentification of strongly linked keyword network.

The clustering process therefore yields a set of interconnected networks or themes. Thus, in this context, each keyword network or theme is characterized by two parameters (Cobo et al., 2012):

i) *Centrality*, measures the degree of interaction of a network with other networks. It is a therefore a value associated with the importance of a theme in the development of a whole research field. It is defined as:

$$c = 10 * \sum ekh$$

where *k* a keyword belonging to the theme and *h* a keyword belonging to other themes.

ii) *Density* refers to the internal strength of the network, understood as a measurement of the theme's development. It is calculated as:

$$d = 100 * \sum \frac{eij}{w}$$

where with *i* and *j* keywords belonging to the theme and w the number of keywords in the theme.

A strategic diagram is precisely a two-dimensional space built by plotting themes according to their centrality rank (c_r) and density rank (d_r), calculated as:

$$c_r = \frac{rank_i^c}{N}; d_r = \frac{rank_i^d}{N}$$

Where $rank_i^c$ is the position of theme i in the theme list in ascending order of centrality and $rank_i^d$ is the position of the theme i in the theme list in ascending order of density. N, the number of themes in the whole network, is introduced to standardize the c_r and d_r values of the range [0,1].

The combination of high and low levels of density and centrality render splitting the two-dimensional strategic diagram into four groups of themes illustrated in Figure 15. In a theme, the keywords and their interconnections draw a network graph called a thematic network. Each thematic network is labelled using the name of its most significant keyword (usually identified by the theme's most central keyword).

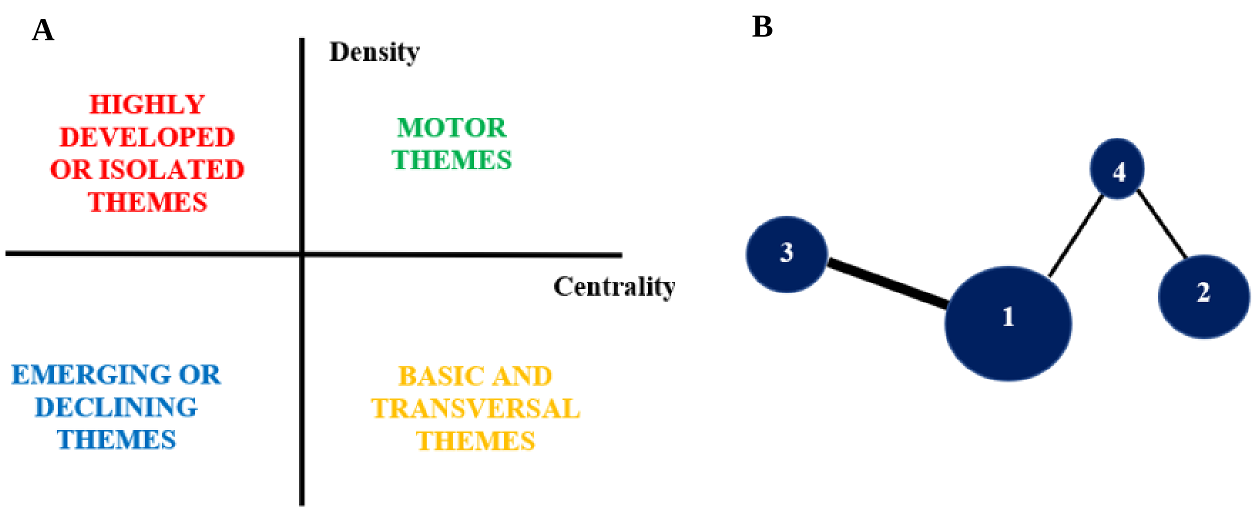


Figure 15. (A) Quadrants in a strategic diagram. **(B)** Example of a thematic network

Source: Author from Cobo et al. (2011)

Figure 16 depicts the results of the strategic diagram analysis with the size of the spheres proportional to the number of published documents associated with each theme. Because of their strategic situation (upper-right quadrant), with great centrality and density, the themes DECISION MAKING (96 papers), NEUROMARKETING (27 papers), PREDICTION (22 papers) and BEHAVIOR (30 papers) are presumed to be developed from the conceptual stand point, that is, they are *motor-themes* of the field. Accordingly, it appears that the most immediate consumer neuroscience research may be based on predicting consumer behavior and decision-making by using tools from neuromarketing. The themes SYSTEM (4), AFFECT (3) and MARKETING (4) were the most *declining* themes of the field in that period likely due to the need of neuroscience to explain the effects on constructs such as affect or intention from the field of marketing. Terms such as MEMORY (16), VALUE (12) or NEUROECONOMICS (17) constitute basic and *transversal themes* of interest for general consumer behavior research. FOOD CHOICE (10), PREFERENCE (11), INFORMATION SYSTEMS (12) or TRUST (7) constitute *themes traditionally investigated* but growing in importance in the recent years. SOCIAL INFLUENCE (21), finally, constitute a theme of high relevance that has seen ha great recent development.

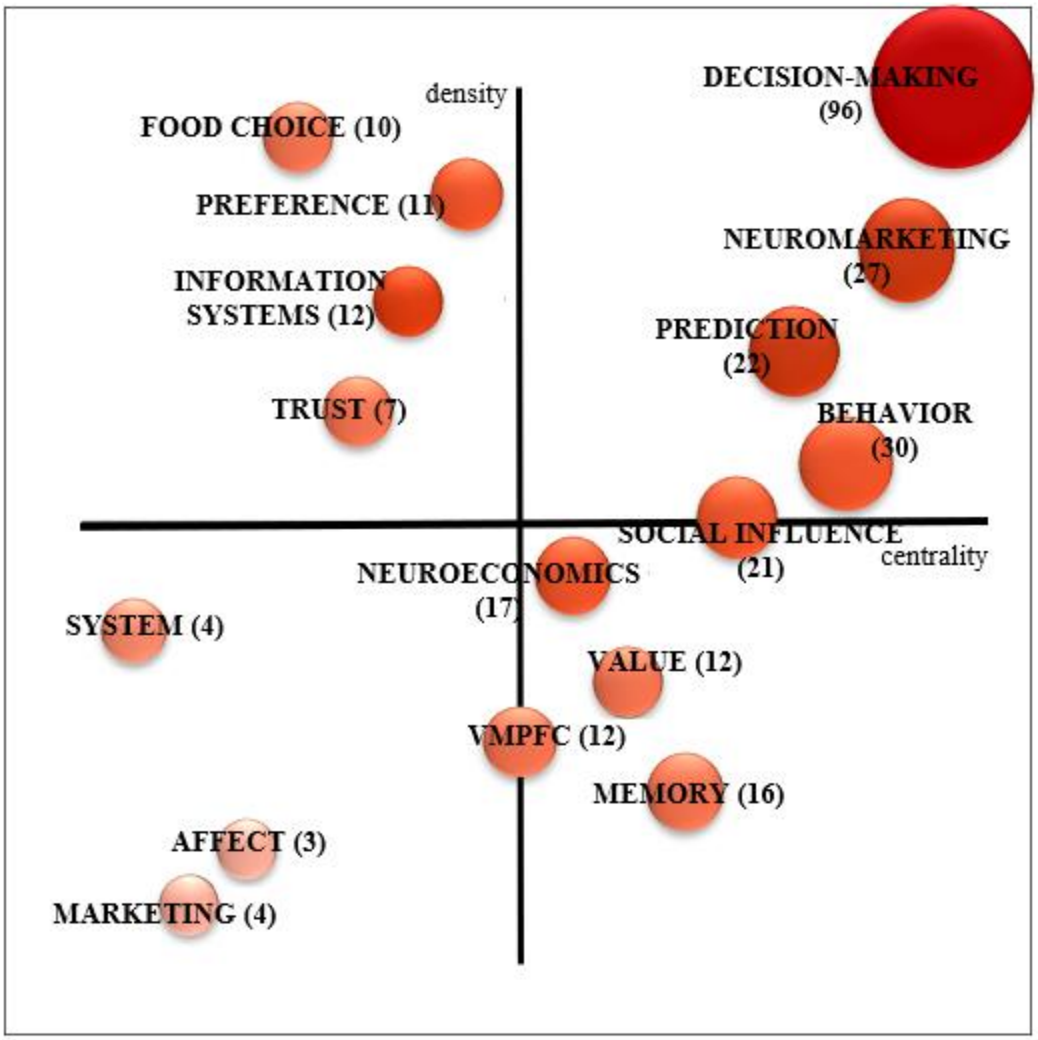


Figure 16. Strategic diagram for the period 2006-2018 based on published documents.

The study then turns to the development of the most relevant thematic networks intended to clarify the relations among keywords and the most frequent themes in consumer neuroscience. These led to several conclusions as to the most prevalent themes identified by the consumer neuroscience community. In these thematic networks, the size of the spheres is proportional to the number of papers corresponding to each keyword and the thickness of the link between two spheres i and j is proportional to the equivalence index e_{ij} (Cobo et al., 2011).

- Because of its position in the upper-right quadrant of the strategic diagram, DECISION-MAKING was considered a *motor-theme* in the last decade and is mainly associated with the discipline of *consumer neuroscience* and its most recurrent tool in behavioral neuroscientific studies, namely *fMRI*, as well as brain-related terms such as *neural response* and *OBTFC*.

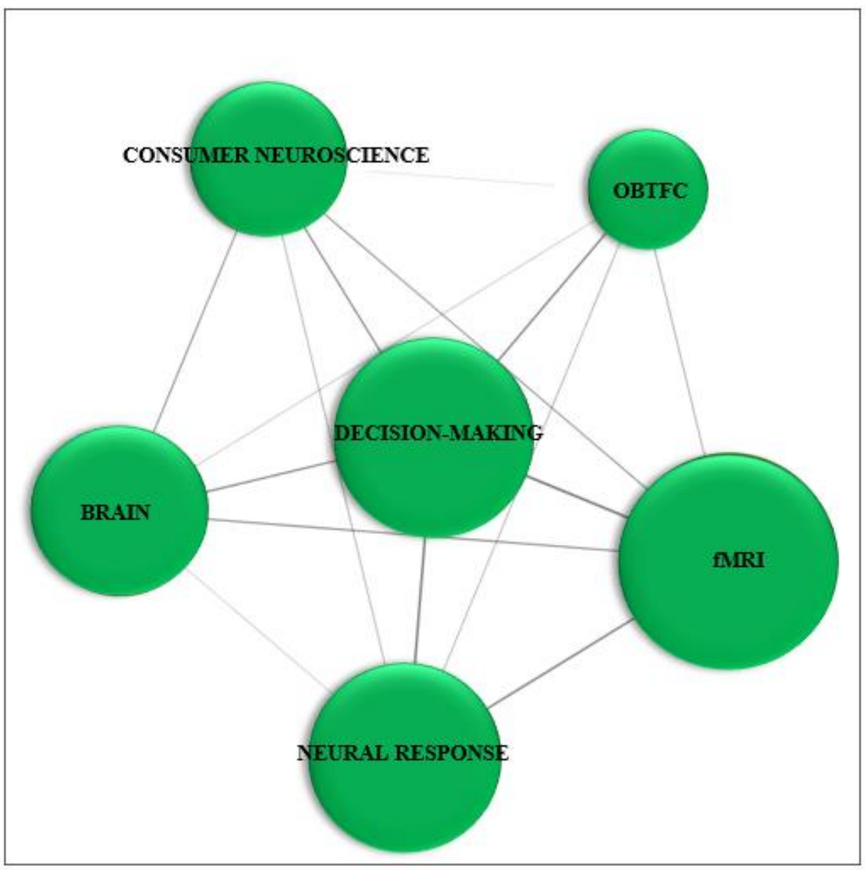
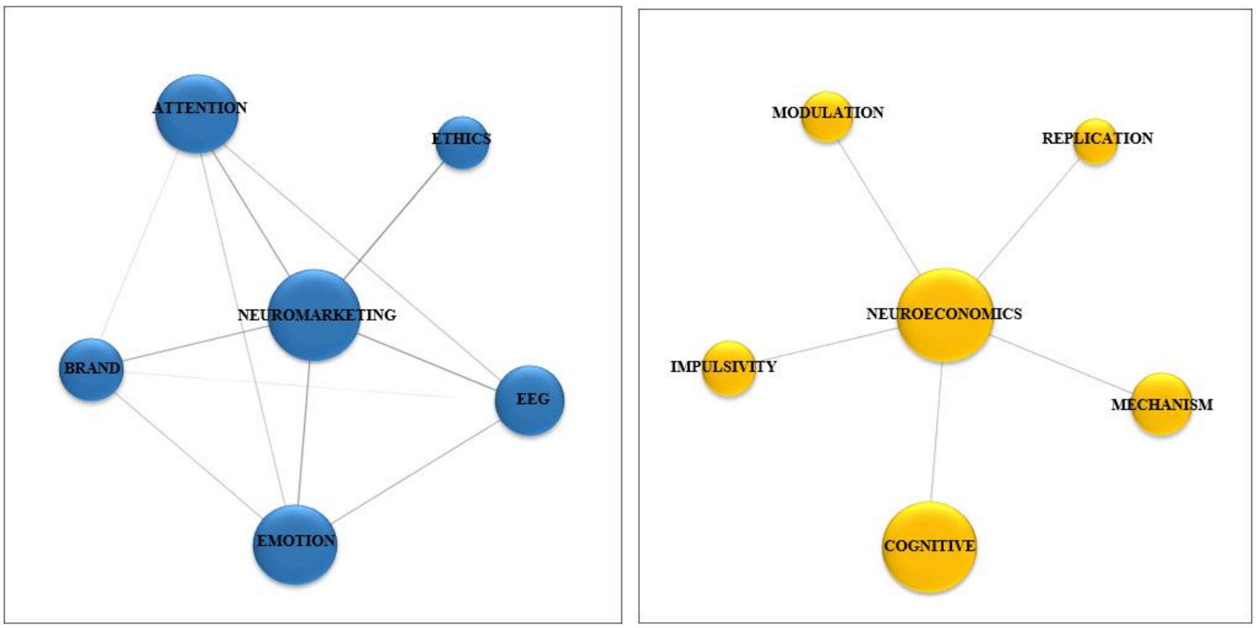


Figure 17. Keywords related with the *motor-theme* DECISION-MAKING

Source: Author

- NEUROMARKETING and NEUROECONOMICS respectively constitute *motor* and *basic themes*. NEUROMARKETING, on the one hand, reveals a strong relationship with *emotion* and *attention*, two of the main constructs of interest of the discipline. It also relates to *brand* (one of the most traditional marketing variables investigated by consumer neuroscience) and *EEG*, another common technique along with the fMRI. Interestingly, the term *ethics* is associated presumably as a



result of the recent ethical concerns that brain-mapping analyses are provoking in consumer associations and institutions. The NEUROECONOMICS thematic network, in turn, corroborates that this represents a basic discipline for current consumer neuroscience studies, in line with the explanation advanced at the beginning on this dissertation (see sections 1.1 and 1.2). Its associated terms, namely *modulation, impulsivity, cognitive, replication* and *mechanism*, refer to the main domains covered by this discipline.

Figure 18. Keywords related with the *motor-theme* NEUROMARKETING and the *basic-them* NEUROECONOMICS

Source: Author

- PREDICTION and BEHAVIOR are also considered *motor-themes.* These are two highly related fields in consumer neuroscience as neural responses derived from the evaluation of marketing stimuli are commonly used to predict consumer behavior changes. Certain terms linked to PREDICTION are *activation, responses, reward, uncertainty* and *prefrontal cortex*. In other words, prefrontal lobes are usually responsible for neural responses or activations predicting reward or uncertain environments. And precisely most studies appear to predict BEHAVIOR changes in the *advertising* domain (e.g. *tobacco* advertisements) and create brain-based *models* attempting to reveal the importance from the consumer perspective (namely, *self-relevance*). This lines up with idea depicted in Figure 12 that advertising constitutes one of the most attractive and potential marketing areas of interest for consumer neuroscience.

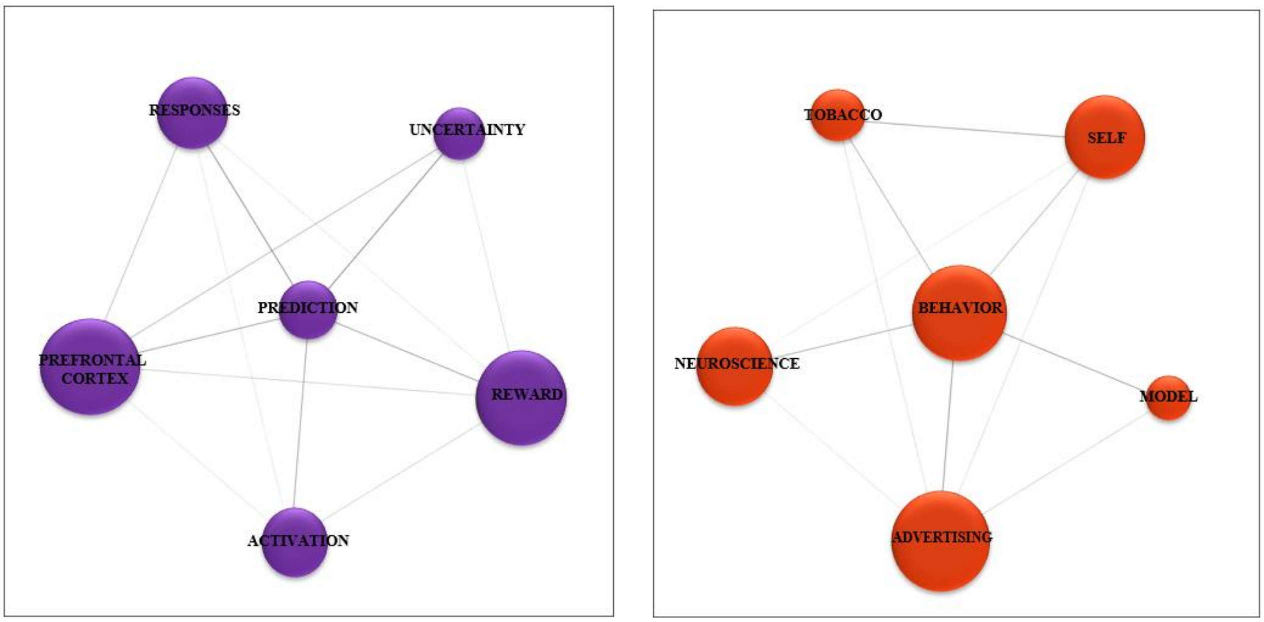
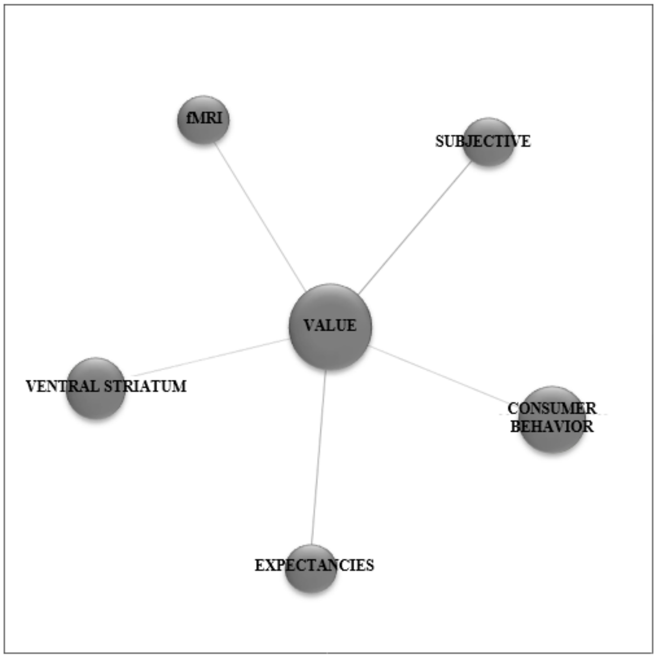
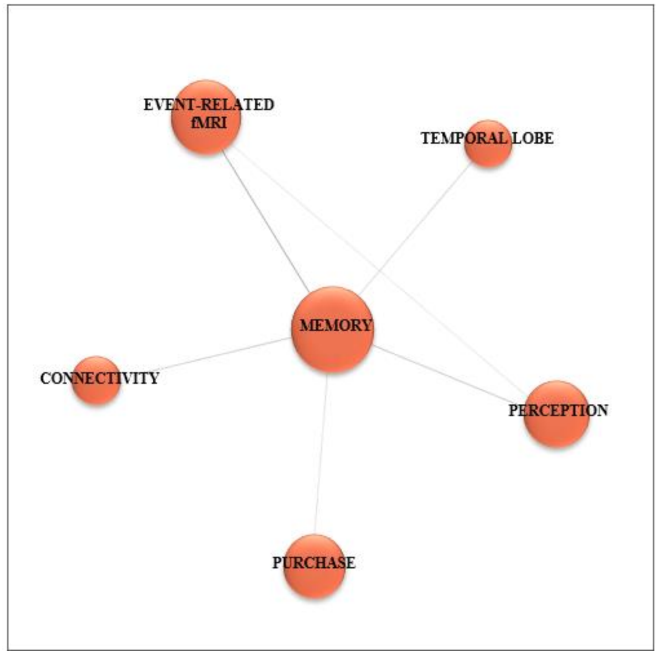


Figure 19. Keywords related with the *motor-themes* PREDICTION and BEHAVIOR

Source: Author

- Because of their medium centrality and low density, VALUE and MEMORY constitute *transversal themes*. Given the importance for consumer neuroscience to



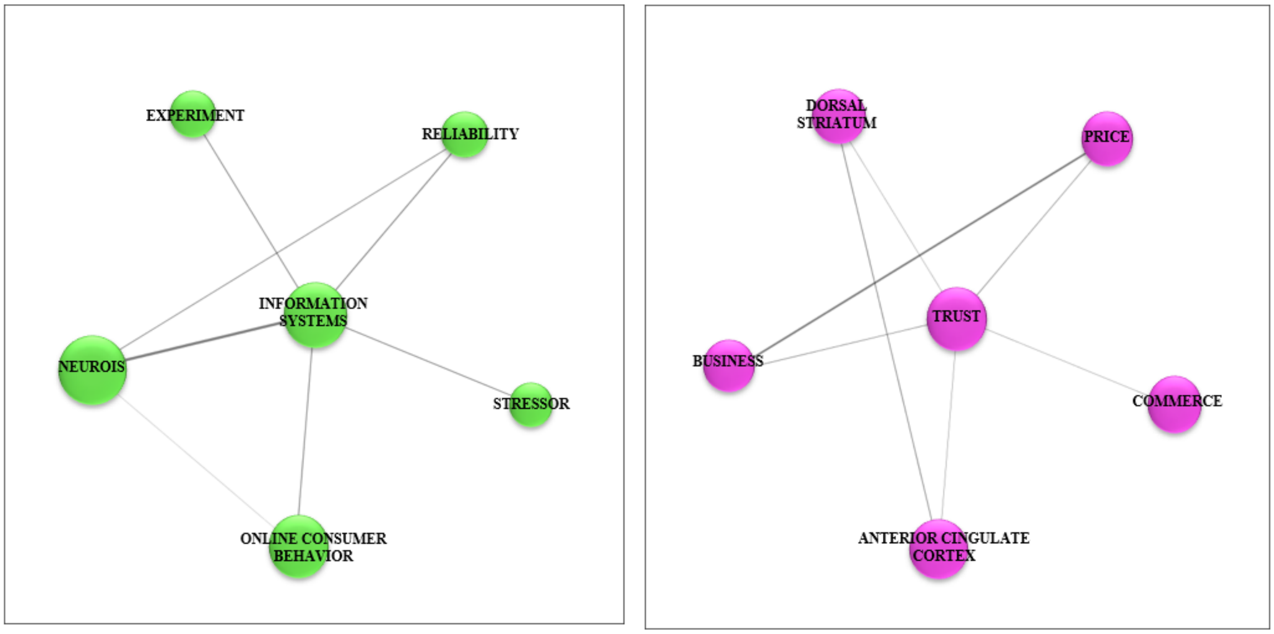


study the neural correlates of the value and memory triggered by marketing stimuli, it is conceivable that the two terms will continue to come up in further consumer behavior investigations. Specifically, VALUE is greatly linked to the brain area associated with *ventral striatum*, *expectancies, consumer behavior* and the fMRI neuroscientific technique. MEMORY, in turn, is associated with neural concepts (such as *event-related fMRI*, *connectivity* or *temporal lobe*) and consumer reactions to stimuli (such as *perception* or *purchase*).

Figure 20. Keywords related with the *transversal-themes* VALUE and MEMORY.

Source: Author

- Figure 21 depicts two related themes that, in spite of great development, are just starting to gain relevance in the field of consumer neuroscience. On the one hand, recent literature on consumer behavior is focusing on carrying out *experiments* about consumer adoption of INFORMATION SYSTEMS, specifically in the field of *online consumer behavior*. This new avenue, labelled *neurosIS*, will play, according to some authors, a key role in further consumer neuroscience studies



(Dimoka, Pavlou, & Davis, 2011). Similarly, the neural correlates of TRUST (e.g. *dorsal striatum* or *anterior cingulate cortex*) in purchase and *commerce* environments are potential lines of future research on consumer neuroscience.

Figure 21. Keywords related with the *highly-developed themes* INFORMATION SYSTEMS and TRUST.

Source: Author

- One of the most important themes developed in recent years in the field of consumer neuroscience is SOCIAL INFLUENCE. This occurs when a customer's emotions, perceptions or behaviors are affected by others. Studies along this line, are resorting to *neuroimaging* to reveal the neural correlates of *empathy* or *mentalizing*. Their findings indicate that the *medial frontal cortex* may be a brain area responsible for such processes.

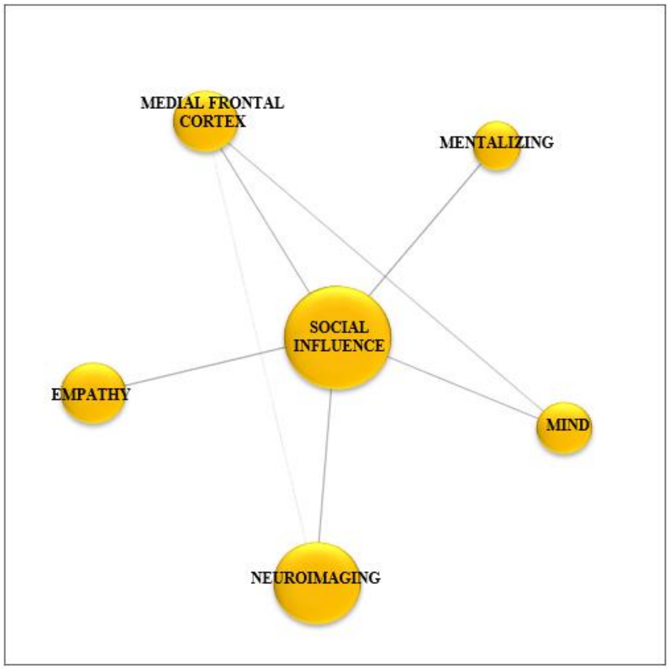


Figure 22. Keywords related with the theme SOCIAL INFLUENCE
Source: Author

Observations of the results of the overview of consumer neuroscience studies carried out in this section lead to four conclusions: i) coming years will see a large number of publications in consumer neuroscience applying fMRI as a main technique of analysis, ii) these studies may center their attention on traditional marketing variables such as advertising, as well as emerging environments such as e-commerce and social influence, at the expense of brands and surveys of neuroimaging and neuroeconomics studies, iii) further consumer neuroscience studies are likely to focus on revealing the neural correlates of marketing constructs with the goal to predict behavior changes, and iv) marketing journals are recently more prone to publishing papers that resort to neuroscientific tools in consumer behavior research.

3.2. Understanding fMRI Methodology

The importance assigned to fMRI in recent consumer neuroscience (32% of the studies resort to this tool, see section 3.1. An overview of consumer neuroscience studies: a bibliometric analysisof this thesis) can be ascribed to the following three reasons:

- fMRI constitutes the only neuroimaging tool that allows measuring not only reactions along the scalp (like EEG) but, more importantly, deeper brain structures where decision-making processes of interest to consumer behavior largely take place.
- The high spatial resolution of fMRI allows measuring with great accuracy the brain activity of different psychological states or mental processes (e.g. the decision-making process between alternative online payment systems) deriving from exposition to marketing stimuli.
- Unlike other neuroimaging techniques, fMRI displays strong signal fidelity, reproducibility, and consistency (e.g., Belliveau et al., 1991).

Despite the increase in interest in fMRI within the marketing domain, functional neuroimaging is still overwhelmingly complex for most consumer behavior scholars. Furthermore, becoming skilled at neuroimaging tools, such as fMRI, requires much time and effort (Dimoka, 2012). Thus, the purpose of this section is to list the neuroscience literature that outlines the basic neuroscientific foundations of fMRI with the goal to offer insight into the origin of brain activations and their consequences for consumer experimental analyses. Along this line, the current study first describes from the physics of the origin of the MRI signal and its relationship with neural processes. Then it clarifies how the MRI signal can be applied to neuroscience experiments. The section ends with a glossary of the 20 most common terms in fMRI environments.

3.2.1. Magnetic Fields and Pulse Sequences

fMRI uses strong magnetic fields (magnetic influence of electrical currents and magnetized materials) to create images of the brain. The main magnetic field in fMRI scanners is static over time and is expressed in units of tesla (T). The Earth's magnetic field is one twenty thousandth

(.00005) of T. Typical fMRI scanners create even stronger static magnetic fields, which vary from 1.5 to 7.0 tesla. These magnetic fields are necessary to stimulate the hydrogen atoms of water which is present in the blood of the brain. Outside the fMRI scanner, the hydrogen atoms in the participant's body spin in random directions but once they are inside the scanner their hydrogen atoms spin in an uniform direction. To create an image of the brain, the fMRI scanner sends radiofrequency (RF) pulses (e.g. energy) into the participant's static magnetic field. The radiofrequency pulse propels the hydrogen atoms away from a uniform direction but gain their uniform spin subsequent to the radiofrequency pulse. The measurement of this return is the basis for creating brain images (i.e. MR signal). To generate and receive a radiofrequency pulse, a so-called radiofrequency coil is needed. This coil is usually placed directly around the participant's head (Reimann, Schilke, Weber, Neuhaus, & Zaichkowsky, 2011).

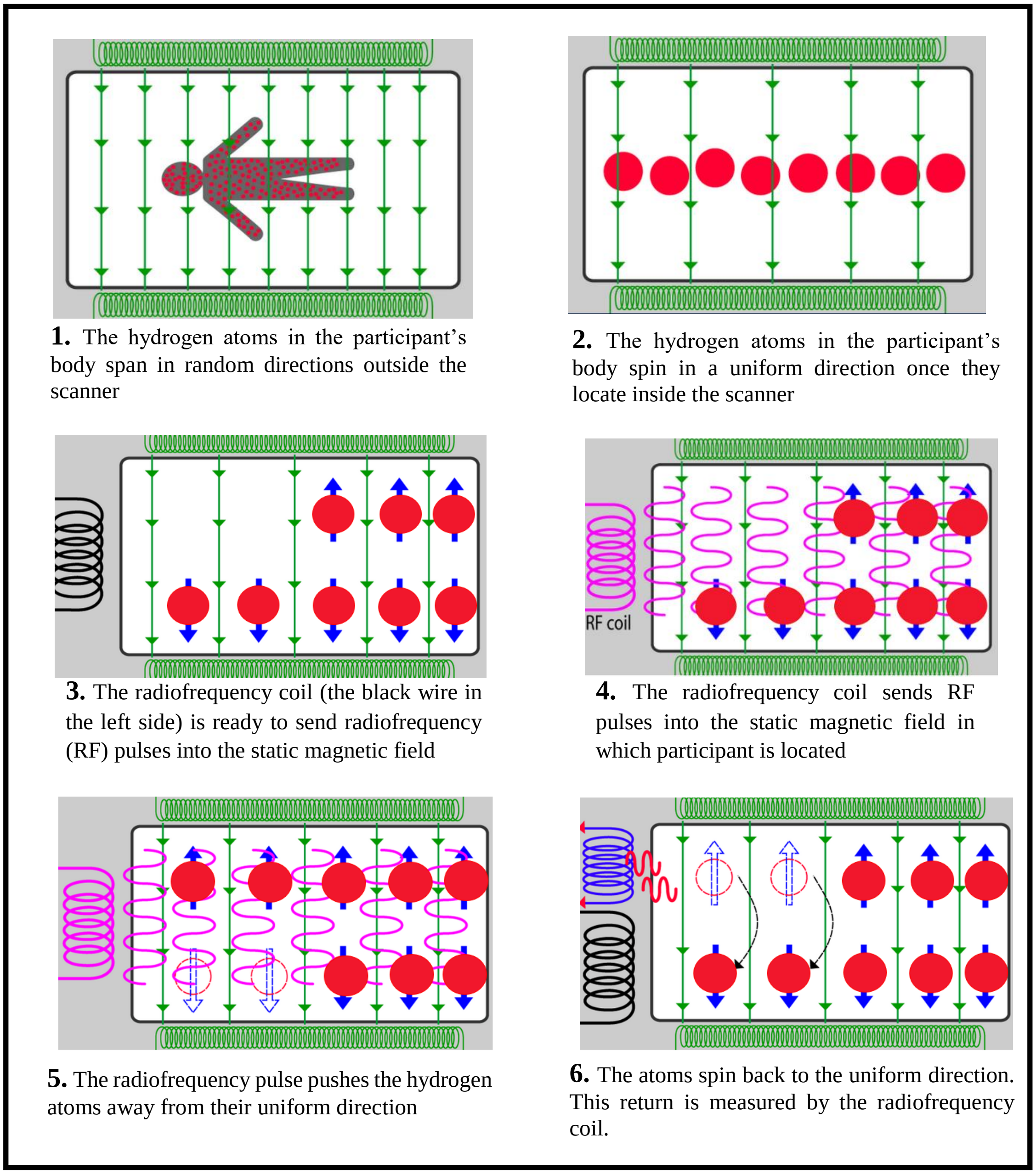


Figure 23. Sequence the MRI machine applies to induce and receive signals from hydrogen nuclei in water molecules.

Source: Author from Prasanna (2012)

Note: The magnet is depicted as green coils of wire. The magnetic fields produced by the magnet is represented by the green lines with arrows. The magnetic field is continuous and in this example procedes from the top to the bottom (direction of arrows).

3.2.2. Blood oxygenation

The transmission of radiofrequency sequences of pulses by fMRI enables it to differentiate between oxygenated blood, which increases in active brain areas, and deoxygenated blood. Oxygenated blood is significantly less magnetic than deoxygenated blood. Hence deoxygenated blood is key for to creation of MR signals. In fMRI consumer studies, neuroscientists draw conclusions about cognitive processes based on changes in MR signals within specific parts of the brain. Yet many links intervene between these mental processes and the MR signal (Huettel, Song & McCarthy, 2004). These processes derive from signaling and integration within groups of neurons, a neural activity that requires energy in the form of adenosine triphosphate (ATP). Because the brain does not store energy, it must create ATP through the oxidation of glucose. Both oxygen and glucose are supplied through an increase of blood flow to active neurons. The increase in blood flow replaces deoxyhemoglobin in the blood of the active area with oxygenated hemoglobin. As deoxyhemoglobin has magnetic field gradients that alter the spins of nearby hydrogen nuclei, the presence of deoxyhemoglobin reduces the MR signal intensity (Huettel, Song & McCarthy, 2004). By replacing deoxyhemoglobin in the blood flow with oxygenated hemoglobin, the increase in blood flow results in a local increase in MR signal, which receives the term blood oxygen level dependent (BOLD) signal or hemodynamic response function (HRF). The signal increase (BOLD effect) is proportional to brain activity (Dimoka, 2012), and through this mechanism, the BOLD signal can detect increases in neural activation in a specific brain area when a subject is stimulated by marketing stimuli.

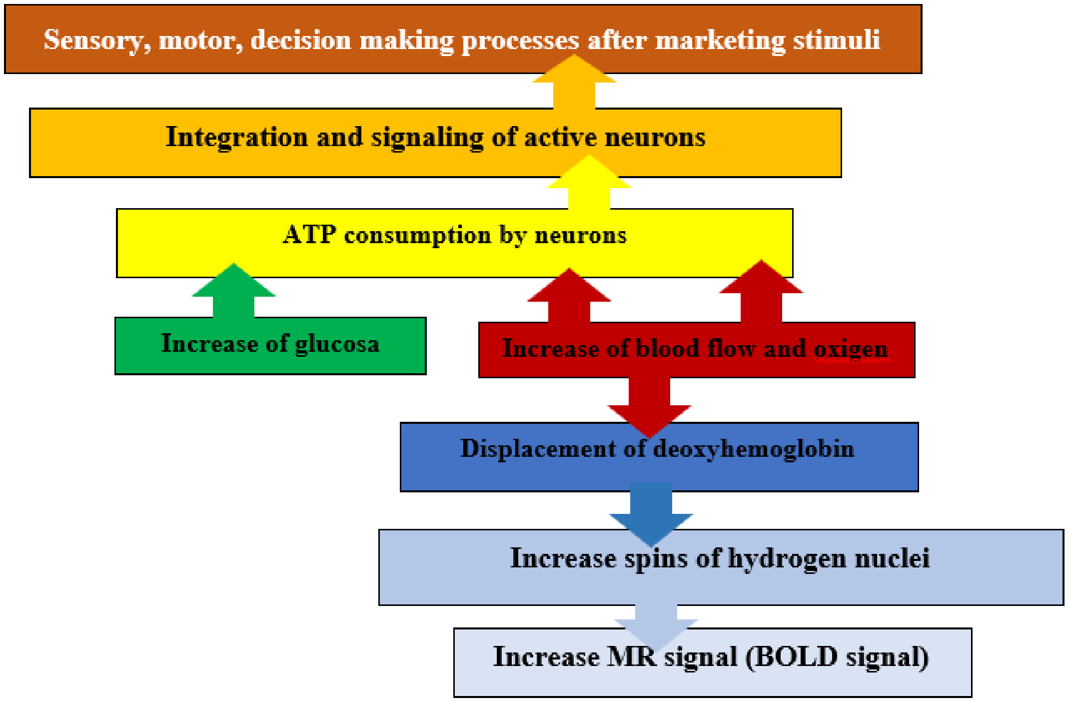


Figure 24. Overview of the sequence of physiological changes leading to fMRI data. Source: Author from Huettel et al. (2004).

3.2.3. Experimental procedure

During a typical fMRI experiment, the participant lies horizontally on a stretcher that is introduced into the fMRI scanner. Experiments carried out within the scanner usually last from 30 minutes to 1 hour. The first stage, so-called shimming, consists of correcting the inhomogeneities of the static magnetic field due potentially to imperfections in the magnet or by the presence of external objects, including the participant's body. Secondly, several high-resolution **structural scans** of the brain are conducted with the aim to i) acquire a source image that will serve to compare data of the images obtained in the experimental task, and ii) verification by a neurologist responsible for medical safety issues. During the structural scans, the subject does not carry out any tasks. Thirdly, the **functional images** are obtained while the participant engages in experimental tasks. Participants usually respond by pressing buttons on a response box. An example of a task is requiring the subjects to chose between two payment systems on an online market purchase.

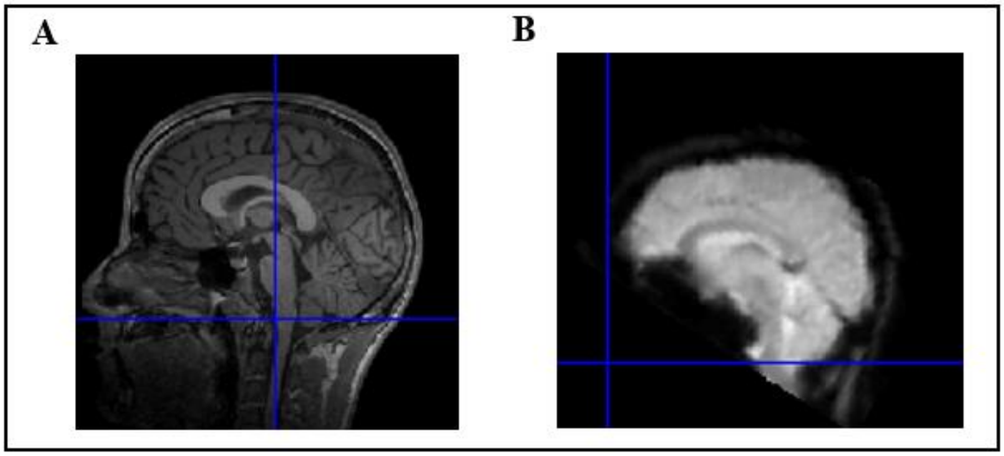


Figure 25. Overview of **(A)** a high-resolution structural image and **(B)** a low-resolution functional image.

Source: Author

The general approach used in fMRI data analyses consists of conducting tests of association aimed at studying the link between brain activity (related to certain mental functions as evidenced by neuroscience) and behavior. The brain areas related to specific constructs of interest and mental processes that form the basis for the development of research hypotheses are known as *neural correlates* (Dimoka, 2012). Specifically, a typical consumer neuroscientist study manipulates the subject‘s psychological state or mental processing (e.g. the decision-making processing between alternative advertisements) by means of a specially designed stimulus while simultaneously measuring brain activity (Solnais et al., 2013). Brain activity can be statistically inferred via time series data of the activated brain voxels (volumetric pixels) in three-dimensional space using multivariate statistics such as the general linear model (GLM). Statistical parametric activation maps (SPMs) are then created based on statistical analyses of time-series images that compare the intensity of BOLD signals with regards to a baseline condition (such as the brain at rest). Accordingly, by using tests of association such as the Student‘s t-test or the Fisher‘s F-test within ANOVA, it is possible to conclude whether the difference in the activation of certain brain regions between both tasks is statistically significant at the targeted p-value (Weber, Huskey, Mangus, Westcott-Baker, & Turner, 2015). Using a specific code of colors according to a p-value, this result is typically visualized through statistical maps depicting the spatial distribution of the statistically significant differences across brain regions (the so-called glass-brain visualizations, see example in Figure 26).

It is then possible in a second step to evaluate the correlation between the specific regional brain activations and self-reported, conscious behavior by means of correlations tests such as the Pearson or Spearman coefficients. This practice is largely implemented in consumer neuroscience studies as the images reveal that activations of specific brain regions can serve to predict attitude or behavior changes (e.g. Falk, Berkman, Whalen, & Lieberman, 2011, for an example).

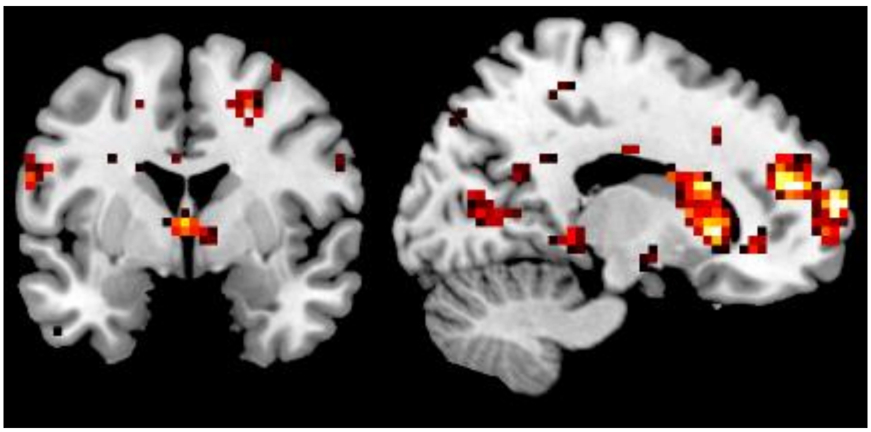


Figure 26. Overview of a glass-brain visualization.

Source: Author

The reader may have already realized that in proposing testable hypotheses, it is often necessary to assume that certain brain areas are associated with specific consumer behavior constructs. These assumptions can however be misleading as brain region X can be activated by a cognitive process P, as well as other processes L, M, N. Similarly, a cognitive process P can trigger not only region X, but also regions W, Y and Z (Weber, Mangus, & Huskey, 2015). In other words, activation of a region does not necessarily equate to specific cognitive process. This type of bias is known as the “reverse inference problem” (Poldrack, 2006) and consumer neuroscientists should deter it: i) by complementing brain imaging data with traditional observations or self-reports, and ii) by seeking support from relevant literature to specify expected areas of brain activation and only developing tentative hypotheses about differences in brain activations across different conditions (Dimoka, 2012).

With the aim of offering consumer behavior researchers with a better understanding of the technical aspects linked to fMRI experiments, Table 3 lists a glossary comprising the 20 most recurrent fMRI concepts, terms and ideas.

Table 9. Glossary of the most common fMRI terms in consumer behavior experiments.

Term	Definition / Explanation
Blocked design	The separation of experimental conditions into distinct blocks, so that each condition is presented for an extended period of time.
Confounding factor	It is a variable that influences both the dependent variable and independent variable causing a spurious association.
Contrast or subtraction	In experimental design, the direct comparison of two conditions that are assumed to differ only in one property, the independent variable.
Control condition	Condition that gives a standard with which experimental conditions can be compared. Also known as base condition.
Correlation analysis	In fMRI environments, correlation analyses typically evaluate the correspondence between a predicted hemodynamic response and the observed data.
Event-related design	Presentation of discrete, short-duration events with randomized timing and order
Experimental condition	Condition containing the stimulus or tasks which is the most remarkable for research hypothesis. Also referred as task condition.
fMRI data processing	Necessary steps to analyze raw fMRI data. It consists of 3 main steps: 1) pre-processing (slice timing, realignment, co-registration, segmentation, normalization and smoothing), 2) first-level individual analysis, and 3) second-level group analysis.
Gradient coils	Electromagnetic coils that create controlled spatial variation in the strength of the magnetic field.
Hemodynamic response (or BOLD signal)	The change in MR signal on functional images following local neuronal activity. The hemodynamic response results from a decrease in the amount of deoxygenated hemoglobin present within a voxel.
MNI space	A commonly used space for normalization of fMRI data; its coordinates are derived from an average of MRI structural images from several hundred individuals.
MR signal	The current measured in a detector coil following excitation and reception
Neural correlates	Brain areas activated by a specific construct
Peak	The maximal amplitude of the hemodynamic response, occurring typically about 4 to 6 seconds following a short-duration event.
Pulse sequence	A series of changing magnetic field gradients and oscillating electromagnetic fields that allows the MRI scanner to create images sensitive to a particular physical property.
Repetition time	The time interval between successive excitation pulses.
Reverse inference	Reasoning from the outcome of a dependent variable to infer the state of an independent variable (or an intervening unobservable variable).
Signal	For fMRI, an important class of signals includes changes in intensity associated with the BOLD response.
Time course	The change in MR signal over a series of fMRI images
Voxel	A three-dimensional brain volume element.

Source: Author, adapted from Dimoka (2012)

All in all, this section advances the key role that human water molecules play in creating MR signals and the logical sequence leading neural processing to elicit the hemodynamic function. The study then focused on the experimental procedure of fMRI scanning before finally outlining the general approach used in fMRI data analysis and the ways to solve one of the main issues of fMRI experiments, notably the reverse inference problem.

3.3. Two avenues to follow: fMRI applied to advertising and e-commerce

Apart from expounding the potential of fMRI, our survey of consumer neuroscience studies has thrown light on the most attractive marketing variables to be analyzed in prospect field research, notably advertising and e-commerce. This section offers an exhaustive review of the studies applying fMRI to elucidate the neural processing of elements and constructs involved with advertising and e-commerce environments. In doing so, the study clarifies the research gaps pertaining to both domains that could greatly be addressed by fMRI so as to gain a better understanding of way consumers process both variables.

3.3.1. fMRI in advertising

Advertising effectiveness research over time has been marked by a great diversity of models. The Black-box Models (Tellis, 1988) considered that a message was effective if the output was increased after ad exposure. Cognitive Models advised that communication was more persuasive if it contained positive cognitive responses (Belch, 1981; Mackenzie, Lutz & Belch, 1986). Later Affective Models suggested that priority should be placed on the generating emotions among consumers (Bagozzi, 1988; Pechmann, Zhao, Goldberg, & Reibling, 2003). The most recent research on the subject (Matthes & Beyer, 2017; McKay-Nesbitt, Manchanda, Smith, & Huhmann, 2011; Ruiz & Sicilia, 2004) advocates combining consumer emotional and cognitive reactions. Following this new line, the effectiveness of a message depends on the combination of cognitive (such as attention, memory or beliefs) and affective responses (emotional reactions) generated by a combination of communicative elements.

Deficiencies in the self-report study techniques to measure reactions among consumers to this combination have paved the way in recent years for the use of more objective techniques such as fMRI. One of the main benefits of adopting this method in advertising research is that it sheds light on how certain media features produce specific media effects (Weber, Mangus, et al., 2015). In other words, it is possible to clarify the psychological origin of consumer reactions toward media elements in advertising.

Prior to the use of fMRI to explore neural processing of advertising with marketing purposes (i.e. before publication of some studies included in the review of section 3.2.), several neuroscientists were interested in the underlying neural mechanisms triggered by different types of messages. Klucharev et al. (2008), for example, investigated the origin of higher memory and attitudes toward messages when accompanied by endorsements by experts with findings that expert context was associated with distributed left-lateralized brain activity in the prefrontal and temporal cortices related to active semantic elaboration. Furthermore, experts enhanced subsequent memory effects in the medial temporal lobe (i.e. in the hippocampus and the parahippocampal gyrus) involved in memory formation. In a similar context, Stallen et al. (2010) delved into the processes that underlie the effect of fame on product and message memory and purchase intention. Their findings highlight that the effectiveness of celebrities stems from a transfer of positive affect from celebrity to product.

One year later, Falk et al. (2011) resorted to fMRI to test whether neural activity in response to messages designed to help smokers quit could predict smoking reduction above and beyond self-reports. Their results were successful as a positive relationship was observed between activity in the MPFC region of interest and successful quitting (increased activity in the MPFC was associated with a greater decrease in expired carbon monoxide). The same research team revealed the neural-behavior relationship in persuasive messages in the domains of skin care (Falk et al., 2010) and politics (Falk, Spunt, & Lieberman, 2012).

Other scholars, namely Craig, Loureiro, Wood, and Vendemia (2012), collected fMRI data while participants were subject to messages with differing levels of perceived deceptiveness (believable, moderately deceptive, and highly deceptive). The first findings confirmed multistage frameworks of persuasion where the authors observed two distinct stages of brain activity: (1) precuneus activation followed by (2) superior temporal sulcus and temporal-parietal junction activation. Secondly, the authors evidenced a disproportionately greater amount of brain activity associated with claims that are moderately deceptive than those that are either believable or highly deceptive. The authors, consequently, provoked a new reflection on which consumers may be particularly vulnerable to deceptive advertising. One year later, Bakalash and Riemer (2013) explored the relationship between message-elicited emotional arousal and memory of the message, as well as the mechanisms involved in this relationship. Their results reveal greater amygdala activation in memorable (versus unmemorable) messages, reinforcing the association between message-elicited emotional arousal and memory of the message. These findings are indicative of a sociocognitive emotional memory process which has been neglected in past research.

More recently, Schmälzle, Häcker, Honey, and Hasson (2015) investigated the neural substrates elicited by rhetorically powerful and weak political speeches. Their results reveal that rhetorical speeches elicited strongly engaged bilateral regions of the superior temporal gyri and medial prefrontal cortex, suggesting that these regions, as opposed to the weak ones, took more control of the listeners. In a study attempting to predict message success beyond traditional techniques, Venkatraman et al. (2015) postulated that functional magnetic resonance imaging offers better explaination of the greater variance in advertising elasticities than the baseline traditional methods. Notably, activity in the ventral striatum is the strongest predictor of real-world, market-level responses to advertising. Through the variant of fMRI, notably optic brain imaging (fNIRS), Girisken and Çakar (2016) investigated the effect of voice-over in banking and finance messages. Their results indicate that the use of voice-over during TV ads possibly results in a decrease in attention and emotional engagement levels among participants. One year later, Couwenberg et al. (2017) investigated the neural responses to functional and experiential executional elements in television ads by resorting to functional magnetic resonance imaging (fMRI). Their findings show that functional and experiential executional elements engage different brain areas associated with lower- and higher-level cognitive processes, and that the extent to which these particular brain areas are activated is associated with higher ad effectiveness. Finally, Krampe et al. (2018) examined neural reactions among consumers to different merchandising communication strategies at points-of-sale (PoS) by fNIRS. Their conclusions demonstrated that the dopaminergic brain area, notably the orbitofrontal cortex (OFC), might play a crucial role in processing and predicting merchandising communications.

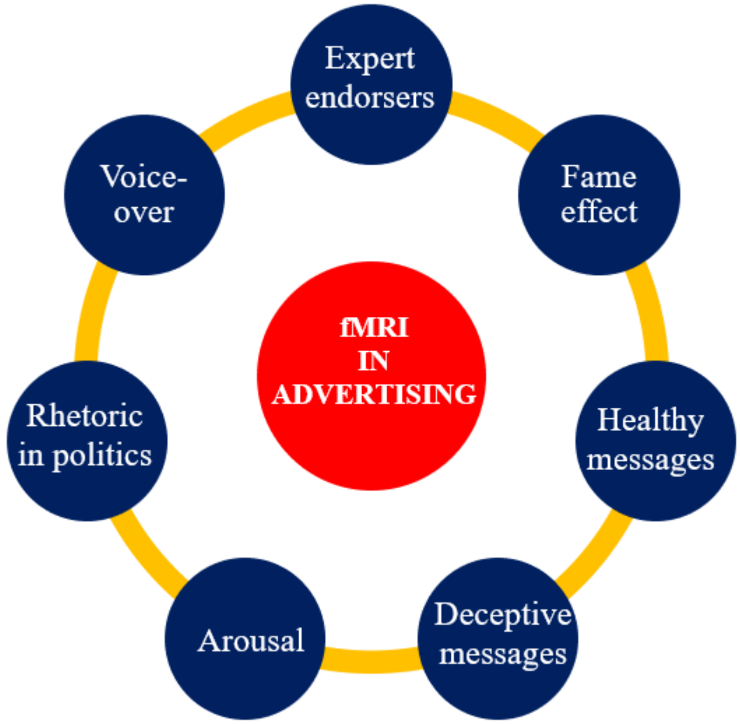


Figure 27. Overview of the main advertising stimuli explored with fMRI

Source: Author

Despite the fact that consumer neuroscience studies have made great steps in understanding the processing of several media features in advertising, scholars still advise carrying out more fMRI experiments in order to elucidate the neurological origin of attitudes and perceptions triggered by traditional or new media elements (Mangus, et al., 2015). For example, little is known about the neural processing of the loss and gain frames inserted in environmental or nutritional advertising (Vezich et al., 2016). Along the same line, authors such as Antes and Mumford (2009) and Atance and O'Neill (2001) conclude that the neural processing of future and past frames in healthy or environmental advertising deserve further attention. Furthermore, no research has examined to date the neural underlying mechanisms of male/female and young/old voices as well as their links to behavioral responses, such as attitudes or intentions toward advertisements (Martín-Santana, Muela-Molina, Reinares-Lara, & Rodríguez-Guerra, 2015). In spite of the large amount of literature analyzing the effects of gender congruence on advertising valuation (Rodero, Larrea, & Vázquez, 2013), it is also surprising to observe how most studies omit clarifying the question of the origin of the media effects provoked by congruent and incongruent product-voice combinations in advertising.

All in all, the scarce attention drawn to the message frames in environmental advertising together with the inconsistences regarding the effectiveness of different types of voice and their combinations with products, justifies deeper consideration by consumer behavior literature. What is more, no research to date has examined the psychological origin of consumer attitudes, perceptions or behaviors toward the afore-mentioned media elements. This dissertation opts for addressing those research gaps by resorting to a technique from consumer neuroscience, notably the fMRI. Specifically, the current project presents three chapters (5, 6 and 7) aiming to contribute to the research on the neural correlates when evaluating the five forgotten elements in audiovisual advertising, namely voice gender, message framing, voice age, temporal framing and gender congruence of product-voice combinations.

3.3.2. fMRI in e-commerce

The current commercial market organization and offer has progressively changed due to the technological revolution of the end of the 20th century. The last two decades have seen the creation of new options for consumers to save time and money, and benefit from a variety of improved services linked to the introduction of new tools of information and communication (Vroman, Arthanat, & Lysack, 2015). Information and Communication Technologies (ICTs) and the adoption of the Internet by business has facilitated both the use of institutional networks (Facebook or Twitter) as well as the emergence of electronic commerce (e-commerce).

The American Marketing Association (2018) defines e-commerce as the wide variety of Internet-based business models which incorporate elements of the marketing mix to guide users to a website with the purpose of purchasing a product or service. Online shopping today provides consumers with the tremendous advantages of an ongoing accessibility, a wide variety of high-quality information, a face-to-face relationship with producers, effortless price comparisons, as well as a great ease in establishing an immediate communication with firms (Chiou & Ting, 2011).

The rapid growth of online shopping is a fact with user penetration at 53.8% in 2018 and expectations to hit 60% in 2022 (Statistica, 2018). Consequently, online consumer behavior has emerged as a major area of research in various scientific disciplines such as psychology, marketing, and Information Systems (IS). While many of the early studies in these disciplines focus on how consumers adopt and apply online shopping (e.g. Hansen, 2005), more recent research has focused on purchase and online repurchase behavior (e.g. Chen, Yen, Kuo, & Capistrano, 2016). Nevertheless, little research in this field has resorted to traditional neuropsychological tools that are more appropriate for investigation as the constructs present in online environments, such as trust, risk, security, ambiguity or value, are associated with unconscious and automatic information processing mechanisms that cannot be addressed easily through self-reports (Dimoka 2010).

Recent advances in cognitive neuroscience are uncovering the neural bases of cognitive, emotional, and social processes, as well as offering new insight into the complex interplay between Innovation Technology and information processing, decision making, and behavior among consumers, organizations, and markets. This idea of drawing upon cognitive neuroscience literature to inform information systems research is termed "NeuroIS" (Dimoka et al., 2011). Seven main opportunities in encouraging transactions by online consumers emerge from the application of NeuroIS (Dimoka et al., 2010):

- Understanding the neural correlates of the antecedents of e-commerce adoption by shedding light on their nature, dimensionality, distinction and convergence (e.g. risk, trust, ambiguity, etc).
- Uncovering additional "hidden" predictors and inhibitors of e-commerce adoption, such as deception, and identifying patterns for detecting website deception.
- Designing collaborative tools to engage consumers in social learning by identifying patterns of cooperative social behavior.
- Assessing how consumers react to a website's information design (e.g. search data or assurance signals).
- Identifying underlying habits and learned patterns in website use.
- Localizing the neural correlates of (seller and product) uncertainty and examining whether they are viewed as distinct constructs by consumers.
- Identifying product quality signals to mitigate product uncertainty based on the neural correlates of product uncertainty.

Yet little research has turned to fMRI to address the previous opportunities. The study of Dimoka and Davis (2008) aimed to uncover the neural mechanisms that underlie technology adoption (TAM) by identifying the brain areas activated when users interact with websites that differ in their level of usefulness and ease of use. Besides identifying the neural correlates of the TAM constructs, the study contributed to understanding their nature and dimensionality, as well as to uncover hidden processes associated with intentions to use a system. The authors also identified certain technological antecedents of the TAM constructs, and indicated that the brain activations associated with perceived usefulness and perceived ease of use predict self-reported intentions to use a system. Along the same line, Dimoka (2010) resorted to fMRI to observe the location, timing, and level of brain activity that underlies trust and distrust and their underlying dimensions. In carrying out the research, Dimoka highlighted subjects with four experimentally manipulated online seller profiles that differ in level of trust and distrust. The results reveal that trust and distrust activate different brain areas and have different effects that help explain why trust and distrust are distinct constructs associated with different neurological processes. In a similar context, Riedl et al. (2010) turned to fMRI to assess whether there are gender differences in online trust in the framework of exposure to eBAY offers. Their results corroborate that most of the brain areas that encode trustworthiness differ between women and men. The findings suggest that more brain areas were activated in women than men.

The most recent study in this domain was carried out by Hubert et al. (2018) and aimed at examining how consumer personality trait impulsiveness influences trustworthiness evaluations of online-offers with different trust-assuring and trust-reducing elements by measuring the brain activity of consumers. The results indicate that both impulsive and prudent shoppers exhibit similar neural activation tendencies. Yet differences exist in the magnitude of activation patterns in brain regions such as the dorsal striatum, anterior cingulate, the dorsolateral prefrontal cortex and the insula cortex that are closely linked to trust and impulsiveness.

Besides these studies, little work has focused on the psychological origin of attitudes toward website layouts or the neural correlates of constructs such as ambiguity, disappointment, risk or security. More research is required, in fact, to evaluate the effect on the brains of consumers of different assurance features such as seals of approval or consumer rating systems (Hu, Wu, Wu, & Zhang, 2010). Furthermore, no research centered the underlying neural mechanisms of traditional and new e-payment systems such as debit cards and Paypal (Cotteleer, Cotteleer, & Prochnow, 2007) in spite of the importance they have acquired in recent years (Statistica, 2018).

Another compelling aspect of analysis is the online risk (e.g. financial risk, social risk, performance risk, privacy risk, etc.) that exerts the highest subconscious aversion and negative feelings among consumers with the aim to advise online retailers on ways to reduce ambiguity and risk during the purchase (Luo, Li, Zhang, & Shim, 2010). Accordingly, this thesis opts for addressing these research gaps by resorting to a technique from consumer neuroscience, notably fMRI. Specifically, the current project presents three chapters (8, 9 and 10) aiming to contribute to the research on the neural correlates of the evaluation of three key elements of the e-commerce environment, notably risky and secure payments, risk facets and e-assurance services.

3.3.3. Conclusions

This chapter aims to offer a thorough overview of the research in the field of consumer behavior that resorts to neuroscientific tools (fMRI, EEG and MEG). With that goal in mind, the study developed a bibliometric analysis of 117 articles published on the subject of consumer neuroscience from 2006 to 2018 and identified the most recurrent neuroscientific techniques, marketing-mix variables, authors and journals. This exploration was completed by implementing strategic diagrams and keyword networks with the aim to detect their potential and from the bibliometric indicators contribute to thematic areas throughout this field of research field. The findings highlight that i) fMRI is the most common technique in consumer neuroscience and its use is expected to grow in the coming years; ii) the marketing domains with the highest attractiveness for consumer neuroscience scientists are product, advertising and e-commerce at the expense of brands and price; iii) the most renowned authors in consumer neuroscience belong to institutions linked to “neuroscience,” “psychology,” “business” and “marketing” thus revealing the interdisciplinary nature of consumer neuroscience; iv) marketing journals are recently more prone to publishing papers that resort to neuroscientific tools for consumer behavior research; v) further consumer neuroscience research is likely to focus on revealing the neural correlates of marketing constructs with the goal to predict behavior changes, as depicted in the strategic diagrams and keyword networks.

The second aim of this dissertation is to assist the reader to understand the basic theory behind the function of fMRI, the most commontechnique in consumer neuroscience. Specifically, attention was centered on the sequence the MRI machine follows to create the fMRI data and its relationship with the physiological changes provoked by marketing stimuli. Finally, the study focuses on the utility of fMRI data to consumer neuroscience research and how specialists can apply it to experimental designs. A combination of charts, illustrations and a glossary of technical terms offer a better understanding of the fMRI principles and links with consumer behavior experiments.

Finally, the study focused on the most attractive marketing variables whose understanding could be greatly improved by applying the fMRI technique. The study explains why more research is required to reveal the underlying brain mechanisms of consumer evaluations of i) the different media elements linked to advertising (i.e. message frame, voice and product-voice combinations) and ii) the diverse domains in e-commerce environments, namely e-payments, assurance services of risk facets.

All considered, this chapter contributes to a better understanding of the current scope of consumer neuroscience while simultaneously suggesting guidelines as to the most noteworthy domains, techniques and types of analysis of future research.

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CHAPTER 4

MEDIA ELEMENTS IN ADVERTISING AND E-COMMERCE: WHY THESE DOMAINS DESERVE FURTHER CONSIDERATION?

After concluding that advertising and e-commerce constitute marketing domains largely explored in the field of consumer neuroscience, this chapter warrants why they also represent areas of analysis with a great potential in future consumer neuroscience research. This chapter focuses particularly on the media elements of advertising, and specifically those forming part of environmental messages (message frames, types of voice and product-voice combinations) whose psychological origin deserves more attention in the coming years. This chapter also throws light on the necessity of exploring the psychological basis of elements incorporated in online websites, notably e-payments, e-assurances and risk facets, with the aim of reducing consumer concerns during online purchases. All considered, Chapter 4 highlights marketing domains and subdomains whose analysis should be greatly enhanced through application of neuroscientific tools.

4.1. Looking at the Advertising Domain: media elements of great interest to consumer neuroscience

4.1.1. Advertising effectiveness

Firms around the world invested 380 billion dollars in advertising in 2017 and these figures are expected to rise +4.1% in 2018 (Magna, 2018). Advertising plays an important role in the business world as it influences attention, attitude and recall (Tu, Kao, & Tu, 2013), as well as consumer attitude toward product purchase and intention of purchase (Connell, Brucks, & Nielsen, 2014). Moreover, commercials are key tools to increase brand awareness and product sales (Liu, Zhang, & Keh, 2017). Therefore, if designed properly, commercials can shape consumer decisions and direct consumption toward a specific product. Professionals and academics of communications are therefore required to design efficient advertising campaigns, aiming to make the most of every euro invested. With this goal in mind, special attention should be afforded to include the most effective media elements (e.g. colors, shapes, voices, frames or combinations of product-voices) in the messages to sell products.

A series of different models of effectiveness in the field of advertising research have, over time, been analyzed from different perspectives. According to the Black Box Model (Tellis, 1988), a message is persuasive if it increases the number of visits or results in greater diffusion. This model establishes a correspondence between advertising and behavior. Cognitive models consider that an advertisement is persuasive if its elements produce positive or negative cognitive responses (e.g. attention, recall; Belch, 1981). These approaches consider advertising as an additional source of information and advocate that consumer decisions are purely rational. Yet only later did researchers recognize that emotions and feelings generated by the message are relevant to the consumer (Affective models: Pechmann & Stewart, 1988). The most recent research in this field (Bartsch & Hartmann, 2017; McKay-Nesbitt, Manchanda, Smith, & Huhmann, 2011) therefore, advocates integrating both emotional and cognitive reactions. Following this new approach, the level of persuasion of a message depends on the combination of cognitive (attention, memory and beliefs) and affective responses (emotional reactions) triggered by a specific media element.

The study of the most persuasive media elements is traditionally addressed through declarative or self-reports, mainly surveys, focus groups and interviews (Aribarg, Pieters, &

Wedel, 2010; Chung & Sparks, 2015). The reader may be already aware of the limitations that these techniques offer (see Chapter 1 and 2 of this dissertation for a detailed description) as they do not capture lower-order emotions (e.g. cognitive load, fears, anger) and are susceptible to social desirability and subjectivity. A direct consequence of the drawbacks of self-reports is that a large part of consumer unconscious and irrational behavior remains unclear. This explains the scarce consensus among traditional advertising literature with regards the effectiveness of several media elements (Spence & Pidgeon, 2010; Rodero, Larrea, & Vázquez, 2013). As explained in previous chapters, consumer neuroscience is a field attempting to overcome the limitations of traditional self-reports by identifying the psychological origin of consumer reactions toward media elements in advertising (Weber, Mangus, et al., 2015). Techniques such as fMRI, in fact, elucidate the neural correlates of different media elements, and allow exploring to what extent attitudes and intentions toward advertisements can be predicted based on brain activations related to value, reward or pleasantness (Weber et al., 2015).

The following two sections describe the media features whose effectiveness are inconsistent in traditional literature and, therefore, could be greatly enhanced by application of neuroscientific tools such as fMRI. The comprise specifically the media elements common to general advertising before focusing on the specific domains of an emerging type of advertising, notably environmental messages.

4.1.2. Media elements in general advertising: the specific case of product-voice combinations

Given the ability of advertising to shape consumer reactions and direct behavior toward specific aims, previous studies have focused on the impact of several media features on media effects such as attitude, intention, recall and choice. O'Connor (2015), of example, explored the role played by color and contrast in visual communications designs in terms of supporting aesthetics as well as promoting functional legibility. The authors conclude that a proper mix of color and contrast not only helps to distinguish contours, detail and depth, but also helps attract and divert attention, thereby clearly delineating key areas of text such as headlines and logos. Another case is the study carried out by Van der Laan, De Ridder, Viergever, and Smeets, (2012) which explored to what extent the level of attraction of food packages in advertisements could affect food choices and perceived value. Their results reveal that the more the participants liked the aesthetic packages, the greater their attitudes and intentions toward the advertised products. In a different context, Fennis, Das, and Fransen (2012) examined the effects of vivid advertising content in two types of appeal in print ads (informational or descriptive and transformational or experiential) as a function of individual differences in chronically experienced vividness of visual imagery. Their results indicate that advertisers should use vivid, concrete worded copy in informational print ads and vivid, experiential illustrations in transformational print ads. More recently, Elsen, Pieters and Wedel (2016) investigated how advertising evaluation depends on the duration of exposure. Their experiments reveal that upfront ads, which instantly convey what they promote, are evaluated positively both after brief and long exposure. In turn, mystery ads, which suspend conveying what they promote, are evaluated negatively after brief but positively after long exposure.

A line of research that has emerged in this context with the aim to determine the effectiveness of audiovisual advertisements (Rodero et al., 2013). This type of advertising usually combines visual (video or image) and auditory components (a voice providing information). Traditionally, the visual and auditory elements of these commercials are gender congruent as products targeting females are combined with a female voice and products targeting males are combined with a male voice. For example, commercials of electric shavers, characteristic male products, are most often accompanied by male voices, whereas, hair removal creams, typically female products, are generally expressed by females.

A

B

Image 28. Example of **(A)** a male product advertised and endorsed by a male voice (and endorser), and **(B)** a female product advertised and endorsed by a female voice (and endorser).

Source: Author[6]

Despite the fact that gender-targeted products are most commonly presented by a gender congruent voice, studies on the effects of gender congruence in commercial effectiveness arrive at ambiguous results. Some point to more positive product/commercial evaluations, greater purchase intention, credibility and commercial effectiveness when the gender of a product matches the gender of the presenter (the so-called "match-up hypothesis," Debevec & Iyer, 1986; Strach, Zuber, Fowler, Ridout, & Searles, 2015). In other words, consumers of both genders evaluate commercials as more positive when the gender-targeted product is combined with a gender congruent voice. An explanation proposed for this finding is that gender congruent voices are linked to a conception of greater expertise and a strong personal identification with the presenter (Strach et al., 2015).

Other studies, on the other hand, do not concur that gender congruence increase positive commercial evaluations or that it does so only under specific conditions. Whipple and McManamon (2002) indicate that although there is a significant increase of the effect of gender congruent presentations among female targeted products, this is not the case for products targeting males. Rodero et al. (2013) suggest that congruence only increases media effects when there is a strong association between the product and a pre-existing stereotype. For example, since male

[6] Screenshot by author of the Gillette and Veet official websites (accessed July, 2018).

stereotypes linked to a tie are stronger than those to a lawn mower, then the male voice will be more effective in commercials for a tie than for a lawn mower.

These well-proven inconsistencies in traditional advertising research when evaluating congruent or incongruent product-voice combinations could be solved by means of fMRI explorations of the psychological origin of the evaluation and attitudes. What leads a consumer to evaluate as more attractive or persuasive a congruent or incongruent advertisement? Precisely Chapter 5 of the current dissertation consists of a published paper attempting to address this research gap. The purpose is i) to elucidate the neural background of the effects of congruent and incongruent gender product-voice combinations in advertising, and ii) investigate which brain areas reveal activation in response to gender congruent AV commercials and covary with traditional self-reported attitudes towards the commercials. Revealing the origin of the greater attitudes or preferences toward congruent or incongruent commercials would, in fact, help advertising professionals in the design, implementation and evaluation of their communication campaigns.

4.1.3. Media elements in environmental advertising

The next 10 years will see an increase in extinction risk for 8 to 23% of the species, a rise of sea levels of about 15 centimeters and a global surface temperature rise of more than 0.5°C compared to the average of 1981-2010 (IPCC, 2014). The proliferation of social issues related to environmental problems requires collective action. As there is a clear link between global warming and human activity (Stocker, 2014), a number of actions have been advanced to alleviate the problem. One means that offers a great potential to alter undesired behavior and encourage beneficial actions in citizens is social marketing. This refers to the branch of marketing that is concerned with the use of marketing knowledge, concepts, and techniques to enhance social ends, as well as the social consequences of marketing strategies, decisions, and actions (American Marketing Association, 2018). Environmental or “green” advertisements include ecological sustainability or nature-friendly messages that target the needs and desires of environmentally concerned stakeholders (Martínez-Fiestas, Viedma del Jesus, Sánchez-Fernández, & Montoro-Rios, 2015). Given the role of advertising in molding consumer decisions, these types of messages could be useful to encourage beneficial actions such as the consumption of environmentally friendly products (Connell, Brucks, & Nielsen, 2014).

Image 29. Example of a green advertisement.
Source: Author[7]

Traditional research in the field of environmental advertising has centered its attention on the impact of media features on the sustainable attitudes, intentions and behaviors of citizens. Such is the case of the study by Baek, Yoon, and Kim (2015) that examined whether environmental advertisers using assertive language (e.g. imperative, direct) can expect to have varying persuasive impacts depending on how much effort the recipients of the message invest in completing environmentally friendly requests. Their findings indicate that assertive messages cause individuals to show more favorable attitudes and behavioral intentions toward recycling when they invest significantly more effort in following the requests. By contrast, nonassertive messages are more effective for individuals who invest little effort. A broader research project undertaken by Leonidou, Leonidou, Palihawadana, and Hultman (2011) offered a comprehensive assessment and trend analysis of green advertising practices of international firms and research over a 20-year period. The authors, among other findings, highlighted that stronger and more specific the emphasis of the claim lead to greater attitudes and intentions toward the advertised behavior on the part of citizens.

[7] Screenshot by author of a Green Peace website (https://goo.gl/89TtMR) (accessed July, 2018).

The following two points focus on two specific combinations of media elements characteristic of environmental advertising whose effectiveness among researchers is vaguely consistent. A better understanding of their impact on consumers could be achieved, therefore, by resorting to fMRI.

- End-state and voice gender

Gain and loss end-states (or frames) are a communication strategy often used to design campaign messages because the framing of a message may alter the perception and attitudes of individual (risk-averse with gain-frame and risk-seeking with loss-frame) even when the information is equivalent (Prospect Theory: Tversky & Kahneman, 1986). In the context of environmental communication, gain (loss) frame reveals the positive (negative) impact of environmentally responsible (irresponsible) acts (Martínez-Fiestas et al., 2015).

The use of gain versus loss framing has been explored in a wide range of communication contexts (e.g. Borah, 2011; Cao, 2016). Most of this empirical research has been developed in the field of health psychology. Yet a distinction has been made between preventive behaviors which are perceived as low in risk (e.g. sunscreen use) and detection behaviors (e.g. testing for HIV) perceived as having a great short term risk. Here, the evidence indicates that loss frames are more effective in encouraging detection behavior and gain frames to in bolstering preventive behavior (Rothman, Bartels, Wlaschin, & Salovey, 2006).

In the field of environmental advertising research, Spence and Pidgeon (2010) concluded that sustainable behavior should be considered as prevention action since responsible consumption aims to avoid potential negative impacts on the climate. Therefore, it should be easier to promote by resorting to gain-framed messages, a reasoning supported by Ojala (2008) and Martínez-Fiestas et al. (2015). In spite of the greater persuasiveness of gain frames in environmental communication, the meta-analysis conducted by O'Keefe and Jensen (2009) concluded that further research should focus on analyzing mechanisms through which gain-framed messages exert their effect on behavior. Consumer neuroscience therefore could fill this research gap by revealing the underlying brain mechanisms when evaluating gain and loss frames.

Since gain- or loss-framed messages are pronounced conjointly by male or female voices in daily environmental advertising, it is reasonable to study the effect of voice gender on consumer attitudes and perceptions toward sustainable messages. Changing the gender of voice-over announcer campaigns has been shown to alter the credibility of an ad's message (Roberts, 2010), the attitudes toward the ad (Potter, Jamison-Koenig, Lynch, & Sites, 2016) and the intentions to purchase (Wiener & Chartrand, 2014).

Phonetics and social psychology studies justify this fact by biological differences between voices along parameters such as Fundamental Frequency (F0, pitch) or Format Frequencies (Gélinas-Chebat & Chebat, 1996). Researchers in advertising have carried out empirical comparisons of male and female voices and generally concluded that the male voice may generate greater credibility, confidence, expertise power and is therefore more persuasive than the female voice (Martín-Santana, Muela-Molina, Reinares-Lara, & Rodríguez-Guerra, 2015). The study of Dolliver (2010), on the other hand, did not identify any differences in the persuasiveness of the voice gender. Furthermore, other studies conclude that ad persuasiveness depends not only on the voice, but on the elements of the message such as frame and brand (Páez et al., 2008). Neuroscientific tools such as fMRI in these cases could be of service to clarify these inconsistencies in traditional research by revealing the neural correlates of the evaluation and perceptions of male and female voices.

Taking into account the little consensus in traditional research with regards to the end-state and voice gender in environmental messages, Chapter 6 of the current dissertation presents a published paper that aims to: i) identify whether there are different brain regions activated in response to gain versus loss frames, ii) test whether there are different brain regions responding to the male versus female voice, iii) assess whether brain activations in response to gain- vs. loss-frame contrast predict attitudes toward ads, and iv) test whether brain activations in response to male vs. female contrasts predict attitudes toward ads. The findings of these analyses may serve to advise managers and associations which voice and end-state generates the greatest subconscious values.

- Temporal frame and voice age

Another media feature typical of environmental messages is temporal framing, a concept that here refers to the display of an ecological message using a specific reference to time (Chandran & Menon, 2004). In environmental communication, a future frame reveals the consequences of acting in the future for/against the environment, while a past frame emphasizes the consequences of having acted for/against the environment (Antes & Mumford, 2009).

Most communication research analyzes temporal framed messages from the standpoint of the Construal Level Theory (Trope & Liberman, 2010). According to this model, the more (vs. less) distant the framing of an event, the more likely it is represented in abstract (vs. concrete) terms. This suggests that altering the framing of a message's temporal distance could systematically affect the way future events (e.g. energy savings) are construed and thus, influence evaluation, processing and decision making (Xu, Arpan, & Chen, 2015).

As in the case of great temporal distance messages, future- (vs. past-) framed messages are more abstract and impersonal, and thought to facilitate a greater amount of active analysis in imaging how an environmental event could potentially take place (Antes & Mumford, 2009). Designing environmental messages focused on the past, in turn, triggers subjective and experiential thoughts which maximize a potential self-threat associated with past behavior. Based on this reasoning, most studies conclude that future messages may be more persuasive. The argument is that they lead to a better execution of strategy because they facilitate a more balanced contemplation of the problem, they lead people to apply broader categorization schemes and simpler structures, and they relate to future personal goals (Liberman, Sagristano, & Trope, 2002; Martin et al., 2011). However, certain creative problem solving studies (Atance & O'Neill, 2001; Scott, Lonergan, & Mumford, 2005) find that past contexts provoke better solutions in participants due to the guidelines that their past experiences afford when encountering similar situations. Other research posits that future-framed messages, which fail to consider contextual information, may not be as persuasive in solving ethical/environmental problems as past-framed messages (Nokes & Ohlsson, 2010).

All in all, studies show discord as to the most effective temporal framing in the field of environmental messages. Here again, investigations using neuroscientific tools such as fMRI could lend assistance in understanding these inconsistencies in traditional research by revealing the neural correlates of the evaluation and perceptions of future and past frames.

Different voices (e.g. old and young voices) in a typical ecological media campaign pronounce environmental messages evoking the past or future. For example, Greenpeace recently resorted to young and old male voices for the following advertisements: "By changing normal bulbs for LED bulbs, you will save more than 85% of energy" (future-framed message) and "Last year we cleaned beaches and rivers to report plastic pollution" (past-framed message).

Despite the is previous literature analyzing the effect of voice gender, no research to date has delved into the question of the media effects (e.g. attitudes toward advertisements) of voice age (Zäske & Schweinberger, 2011). To better understand media effects generated by young vs. old voices it is necessary to turn to phonetics and social psychology studies focusing on biological differences. Specifically, young voices share a greater speaking rate, intensity and projection (Harnsberger, Brown, Shrivastav, & Rothman, 2010) and a higher pitch (Weger, Meier, Robinson, & Inhoff, 2007). These natural, age-linked characteristics may have relevant effects in terms of affective variations of voice quality as high-pitch tones (e.g. young voices) are commonly associated with positive emotional reactions, whereas low-pitch tones (e.g. old voices) are linked to negative responses (Rodero et al., 2013). Other research findings indicate an increase in working memory among participants listening to young vs. old voices (Mammarella, Fairfield, Frisullo, & Domenico, 2013). Despite these advances, media effects such as attitudes toward persuasive messages pronounced by these different voices still remain unclear (Zäske et al., 2013). Neuroscientific tools could also contribute in these cases to evaluate the neural bases of the evaluation and perception of voice age.

All in all, the rare consensus in traditional research as to the impact of temporal framing and voice age in environmental messages on consumers calls for further exploration through more objective techniques such as neuroscientific tools. Chapter 7 of this dissertation, a published article related to fMRI application, addresses this research gap by i) testing whether different brain areas are activated in response to future vs. past frames, ii) identifying whether different brain areas are activated in response to young vs. old voices, and iii) assessing whether brain activations in response to future vs. past frame and young vs. old voice contrasts are linked to the attitude toward the messages. The findings of Chapter 7 of this dissertation thus provide invaluable insight into the unconscious origin of attitudes toward environmental messages and indicate which voice and temporal frame of a message generates the greatest subconscious value.

4.2. Looking at the e-commerce Domain: media elements of great interest for consumer neuroscience

4.2.1. E-commerce: an irreversible trend

The trend of online commerce (e-commerce) is global and irreversible. Companies around the world in 2017 sold about 2.3 trillion US dollars worth of products. Furthermore, user penetration is at 53.8% in 2018 and it is expected to hit 60% in 2022 (Statistica, 2018). Spain's e-commerce market is also expected to expand significantly in the next five years by about 25% (Cetelem 2016). Due to this rapid growth of shopping through the Internet, online consumer behavior has emerged as a major area of research in various scientific disciplines such as psychology, marketing, and Information Systems (IS). While many of these early studies focus on how consumers adopt and apply online shopping (e.g. Hansen, 2005; Moon, 2004), more recent research has centered on the main factors that encourage consumers to purchase and repurchase from the same firms (e.g. Chen, Yen, Kuo, & Capistrano, 2016).

Figure 30. Worlwide e-commerce sales in trillions of U.S. dollars

Source: Shopify (2017)

Previous literature along this line has examined the main factors that influence consumer attitudes or intentions toward online purchases. Yang, Pang, Liu, Yen, and Michael Tarn (2015), for example, explored the perception of risk and trust of online payment systems and proposed a conceptual model of trust and specific risk facets. The results of the model advanced by these authors indicates that consumers in the current stage of worldwide online payments systems have built up trust as an antecedent to perceived risks. Moreover, perceived total risk is negatively related to trust while perceived risks can be classified into two types: (i) system dependent risk (caused by functional defects, deposit costs or security problems in online payments), which is positively related to trust; and (ii) and transactional risk (consequence of the conduct of different parties involved in the online transaction) which is negatively related to trust.

In a similar context, Kalinic and Marinkovic (2016) attempted to explore the determinants of user intention in mobile commerce adoption. To that aim, the authors developed a conceptual user adoption model based on technology acceptance model variables and on specific factors such as social influence, personal innovativeness, customization, and individual mobility. Their empirical results demonstrate that social influence and customization have a significant affect on perceived usefulness while mobility, customization, and personal innovativeness has a significant affect on perceived ease of use. Moreover, perceived usefulness and perceived ease of use, in turn, have a direct positive effect on behavioral intention.

Chiang and Dholakia (2003) offer three essential variables that are likely to influence online consumer intentions: (i) convenience of shopping channels, (ii) product type, and (iii) perceived product price. Their findings suggest that convenience and product type are the variables that influence the intention of consumers to engage in online shopping. Moreover, when offline shopping is perceived as inconvenient, their intention to shop online rises. Online shopping intention, by contrast, is greater when consumers perceive the product to be search goods than experience goods.

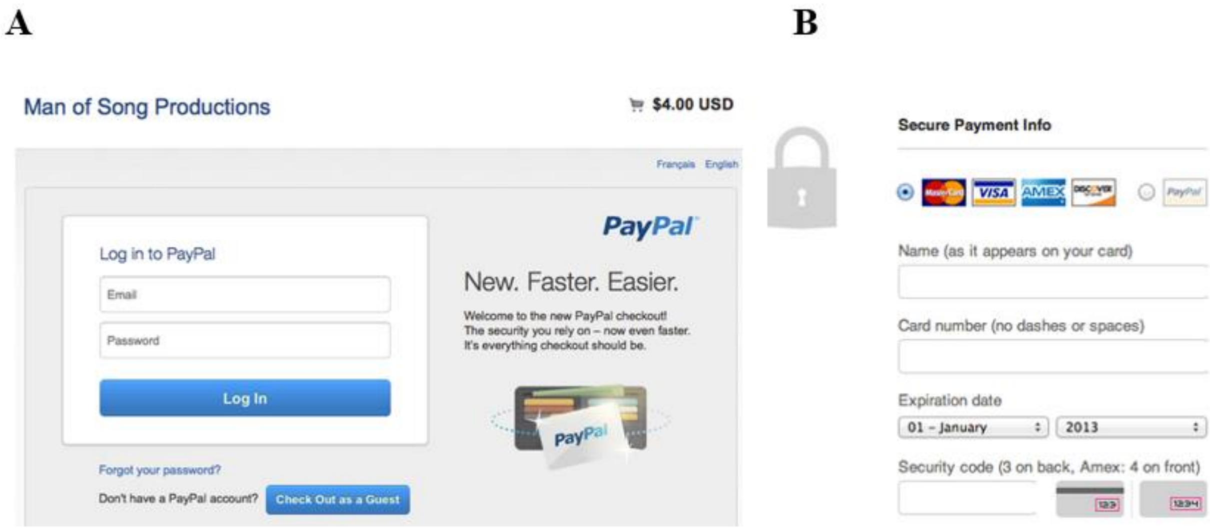

Figure 31. **(A)** Examples of Paypal and **(B)** debit/credit cards in online transaction layouts.

Source: Author[8]

Despite that the effects of the above-mentioned factors on consumer attitudes and intentions toward online purchases is unanimous in the literature, little is known about the impact they exert on consumers of traditional (i.e. debit card) versus modern payment systems (i.e. Paypal), the relevance of the different facets of perceived online risk (such as financial, performance or privacy risk), or the influence of assurance services (such as seals of approval or business statements) on online consumer trust perceptions. This chapter exposes the need to further deepen knowledge in these domains to better identify their impact on online consumer behavior.

4.2.2. E-payments

A key process necessary to complete economic transactions on the Internet is online payment (e-payment), defined as the transfer of an electronic value of payment from a payer to a payee through an e-payment mechanism (Lim 2008). The development of e-commerce has seen an ongoing transformation of types of payments from brick-and-mortar retailers to online systems. As a result, a large number of these online payment systems (e-payments) have been developed resorting to debit/credit cards and virtual payment systems or e-wallets (e.g. Paypal). According

[8] Screenshot by author of Paypal and Amazon websites (accessed July, 2018).

to a recent report (Worldpay, 2016), 31% of the worldwide transactions in 2015 profited from e-Wallet systems such as Paypal, whereas 25% and 17% used credit and debit card systems. In Spain, the country of the current study, the payment system ratio in 2015 is analogous with 24% and 25% using credit or debit cards and 21% e-wallets such as Paypal.

Despite the projections of an enormous growth of online payment systems, they have not achieved the performance and diffusion expectations for the most part due to issues of risk and security (Hong, Zulkiffli, & Hamsani, 2016; Mohd Suki & Mohd Suki, 2015), trust (Chen et al., 2016) and complexity of use (Chou, Lee, & Chung, 2004). These processes that consumers commonly experience when encountering with different e-payments are related to risk, ambiguity and security (Dimoka, 2010) and, therefore, linked to unconscious and automatic information processing mechanisms that cannot be readily addressed by self-reports. Chapter 8 of the current dissertation resorts to fMRI to investigate neural responses to risky and secure online payment systems, as well as the underlying neural and self-reported mechanisms linked to two e-payment methods (debit cards and Paypal). The results offer invaluable insight into the unconscious origin of consumer choice of payment systems.

4.2.3. Risk facets

Given the importance of perceived risk as an antecedent to greater attitudes toward intention to adopt online purchases (Hong et al., 2016), specialists of e-commerce have deliberated extensively as to its definition (Bauer, 1960), main causes (Sun, 2014) and dimensions or facets (Crespo, del Bosque, & de los Salmones Sánchez, 2009). The notion of perceived risk is originally defined by Bauer (Bauer, 1960) as uncertainty in the sense of lack of knowledge as to what could happen after the purchase and the likely negative consequences. Subsequent studies concur in considering perceived risk as a multidimensional construct that can be subdivided into several facets, which together, explain the overall sense of risk associated with online purchasing (Chiu, Wang, Fang, & Huang, 2014).

Yet e-commerce studies do not concord in their focus of the different facets of risk (Hartono, Holsapple, Kim, Na, & Simpson, 2014). Pires et al. (2004) conclude that perceived risk comprises six facets: financial (likelihood of suffering a financial lost due to hidden costs), performance (possibility of the item failing to meet expectations), physical (probability of a harmed purchase), psychological (chance that the specific purchase be inconsistent with the consumer's self-image), social (likelihood that the purchase will lead to disdain by others) and convenience (probability that the purchase will result in loss of time in terms of late delivery). The findings of the study on this question carried out by Forsythe et al. (2006) isolated three risk-related facets: financial, product and time. Chiu et al. (2014), in turn, identify financial, performance, privacy (likelihood that website shopping will lead to a loss of private and payment data) and product delivery as the main risks. Recent research, however, considers financial, privacy and performance risks as the widest, most studied, influential and common facets in online environments, and recommend delving deeper into their processing as a first step in the understanding of the origin of general concerns induced by online purchases (Chang & Tseng, 2013; Featherman & Hajli, 2016). Ignorance as to the most important facet of risk may explain why businesses have not been coherent when directing their efforts to reduce online risk perception (Chang & Tseng, 2013). Three determinants can explain the lack of unanimity in previous research: i) the lack of control of the purchase involvement (Kaplan & Nieschwietz, 2003; Liu, Marchewka, Lu, & Yu, 2005), ii) the heterogeneity of the sampling as to the level of online expertise or propensity of risk (Kusumasondjaja, 2015), and iii) the unconscious and automatic nature of risk related more closely to low-order processes than to conscious, self-reported mechanisms (Dimoka, 2010).

In an attempt to fill these research gaps more objectively, namely by resorting to fMRI, Chapter 9 of this dissertation presents a published paper that clarifies the neural underlying mechanisms of the widest, most studied, influential and common risk facets, namely financial, privacy and performance (Featherman & Hajli, 2016), in a low-involvement purchase environment. Implications from its findings, if followed by retailers, could greatly improve web contents and purchase processes, as well as bolster online sales.

4.2.4. Assurance services

Previous literature examining the main deterrents in business to consumer commerce suggests that trustworthiness, reputation, perceived risk and accessibility can dramatically influence online commerce (Aljukhadar, Senecal, & Ouellette, 2010; Li, Ye, Law, & Wang, 2010). Whereas reputation may constitute a great advantage to well-known firms, several studies claim that online retailers can enhance consumer willingness to buy by resorting to trust mechanisms (Bahmanziari, Odom, & Ugrin, 2009; Karimov, Brengman, & Van Hove, 2011). An initial improper use of trust tools will blemish subsequent efforts as initial trust is thought to lower perceived risk and, consequently, increase purchase intentions and expectations (D'Alessandro, Girardi, & Tiangsoongnern, 2012).

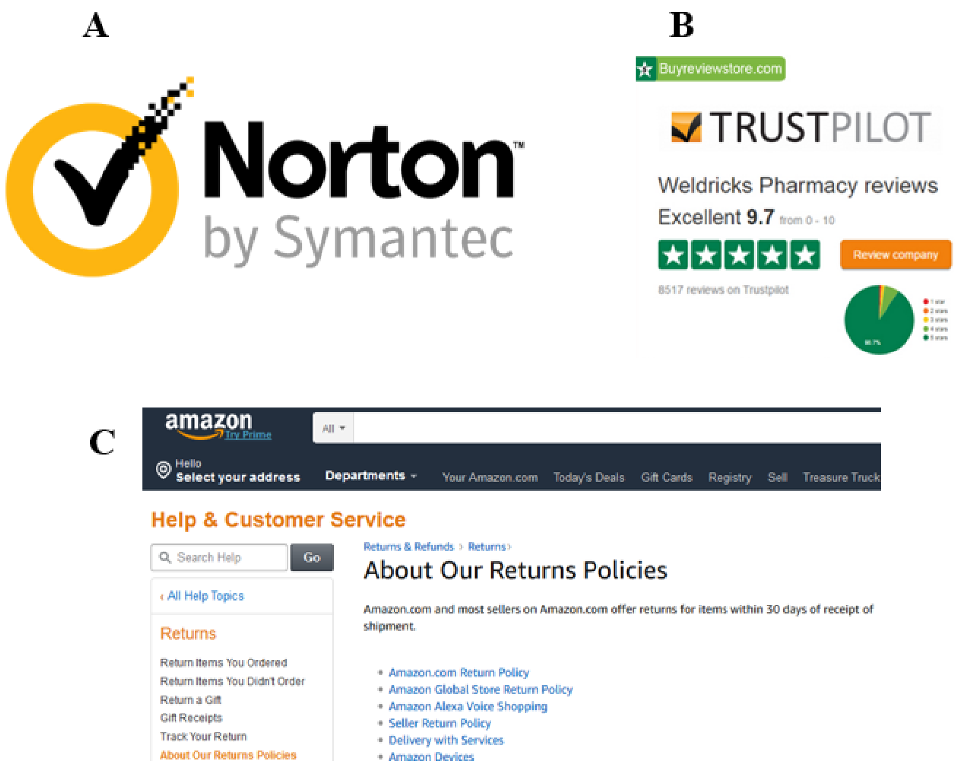

Figure 32. **(A)** Examples of a seals of approval by Norton, **(B)** rating systems by "Buyreviewstore," and (C) assurance statements by Amazon.

Source: Author[9]

There are many mechanisms available to vendors to build trust. E-commerce studies point to three types of online trust mechanisms (e-Assurances hereafter) that increase trust in e-commerce retailers. Specifically, **seals of approval** refer to assurances provided by a third-party vendor only after an independent evaluation of the retailer's website and related activities. This type of e-Assurance involves a great amount of testing and is accompanied by certification from a

[9] Screenshots by author of Norton (https://goo.gl/k1NSx7), BuyReviewstore (https://goo.gl/KqSWM2) and Amazon (https://goo.gl/y75bWP) (accessed July, 2018).

third party. Secondly, **rating systems** can bestow Web sites with different quantities of "stars" according to customer feedback and serve to rate a vendor's performance in terms of privacy policies, shipping fees, ease to utility and guarantees. Thirdly, **assurance statements** are e-Assurances managed by the online retailer through different combinations of statements referring to privacy policies, guarantees, free shipping, return policies, contact information and frequently-asked-questions (Kaplan & Nieschwietz, 2003). While each of those mechanisms is designed to enhance trust and reduce perceived risk, they resort to different sources. Seals use independent verification through third parties, ratings use customer feedback, and assurance statements are the vendor's self-reported statements about their policies and procedures.

E-commerce literature, deriving from these differences, has evaluated the effects of internal and external e-Assurance signals on initial trust conferred to products sold in B2C e-commerce. The conclusions of these studies are far from consistent. Certain authors point to a greater trust linked to assurance statements (Bahmanziari et al., 2009; Pennington, Wilcox, & Grover, 2003), while others strongly posit a greater impact on the trust of rating systems (Wu & Wu, 2016) or third-party assurances (Kim & Kim, 2011). Instead of resolving the discordant findings, recent research has focused on analyzing the effects on trust of different modalities of assurance statements such as privacy disclosure (Bansal, Zahedi, & Gefen, 2016), return policies (Wang, Beatty, & Foxx, 2004) and ethical performance (Yang, Lin, Chandlrees, & Chao, 2009). Though the implications of these studies are undoubtedly remarkable, no research to date has properly tested the effects of seals of approval, rating systems and assurance statements on trust by controlling several essential variables such as product involvement, risk propensity or consumer level of experience.

Chapter 10 of this thesis advances a study that resorts to neuroscience (fMRI) to compare the underlying brain mechanisms linked to each type of e-assurance. The results offer invaluable insight into the subconscious origin of trust conveyed to different types of e-Assurances. It serves professionals interested in selling online products as to which type of assurance system they should include in their web site.

4.3. Conclusion

A great amount of research has reached similar conclusions when assessing the effectiveness of specific media elements in advertisements such as colors, food packages, vividness of visual imagery or duration of a commercial. The current chapter points out that there are still inconsistencies in the evaluation of the effects of certain audiovisual elements (voice gender, message frames or product-voice combinations) on consumer attitudes, intentions and behaviors. This chapter evidences that these media features can be greatly enhanced by turning to techniques of neuroscience that offer marketers means to measure underlying brain mechanisms. Chapter 5, 6 and 7 also offer published studies on fMRI subjects that relate to these research gaps.

The current chapter focuses, secondly, on e-commerce, an emerging domain in the field of marketing. The growth of online transactions coupled with the worldwide expansion of Internet-based information exchange have, however, triggered fear, distrust and risk among online consumers. The specialized literature has therefore attempted to explore factors that may reduce online perceived risk and increase trust so as to promote online retailer sales. The current chapter proposes elements included in retailer websites that merit deeper exploration that could solve the inconsistencies in traditional research. This current study suggests in particular placing priority on the necessity of investigating the different e-payments, assurance services and risk facets as prospect research in the online consumer behavior arena. Given the unconscious and automatic nature of constructs like risk, trust or distrust, the analyses should resort to more objective and precise tools, namely neurological techniques. Chapter 8, 9 and 10 also offer studies that approach these research gaps by means of fMRI techniques.

Taken together, this chapter concludes expounding the need to further explore little studied aspect of advertising and e-commerce environment by resorting to neurological tools, as they are a powerful means to identify the psychological mechanism behind why consumers react in one way or another when encountering advertisements or online products.

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CHAPTER 5

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NEURAL CORRELATES OF GENDER CONGRUENCE IN AUDIOVISUAL COMMERCIALS FOR GENDER-TARGETED PRODUCTS: AN FMRI STUDY

Casado-Aranda, Luis-Alberto; Van der Laan, L. Nynke; Sánchez-Fernández, Juan.

This paper explores neural and self-report responses to gender congruence in product-voice combinations in commercials. An fMRI study was carried out in which participants (n = 30) were presented with gender-targeted pictures of characteristic male or female products accompanied by either gender congruent or incongruent voices. The findings show that attitudes are more positive toward commercials with gender congruent than with gender incongruent product-voice combinations. fMRI analyses revealed that primary visual brain areas, namely calcarine and cuneus, responded stronger to congruent than incongruent combinations suggesting that participants enhanced their endogenous attention toward congruent commercials. Incongruent combinations, by contrast, elicited stronger activation in areas related to the perception of conflicts in information processing and error monitoring, such as the supramarginal, inferior parietal gyri and superior and middle temporal gyri. Interestingly, increased activation in the posterior cingulate cortex (an area related to value encoding) predicted more positive attitudes toward congruent commercials. Together, these results advance our understanding of the neural correlates of processing congruent and incongruent audiovisual stimuli. These findings may advice advertising professionals in designing successful campaigns of everyday products, namely by making use of congruent instead of incongruent product-voice combinations.

5.1. Introduction

Advertising plays an important role in the business world as it influences attention, attitude and recall of commercials (Tu, Kao, & Tu, 2013), as well as consumer attitude toward product purchase and intention of purchase (Connell, Brucks, & Nielsen, 2014). If designed properly, commercials can shape consumer decisions and direct consumption toward specific products. Previous studies evaluated the impact of several media features (such as color, packaging or commercial content, Pileliené & Grigaliünaité, 2017; Van der Laan, De Ridder, Viergever, & Smeets, 2012; Martínez-Fiestas, del Jesus, Sánchez-Fernández, & Montoro-Rios, 2015) on media effects (such as attitude, intention, and choice). Audio visual (AV) commercials usually combine visual (video or image) and auditory components (a voice providing information). Traditionally, the visual and auditory elements of these commercials are gender congruent as products targeting females (FP) are combined with a female voice (FV) and products targeting males (MP) are combined with a male voice (MV). For example, commercials of men's swimwears, typically male-targeted products, are most often accompanied by male voices, whereas, hair removal creams, typically female-targeted products, are generally presented by females.

Communication effectiveness research has focused on the attitudes toward commercials including male/female voices, gender-targeted products and, above all, congruent/incongruent gender product-voice combinations. Yet, the studies reveal inconsistent results with regard to the impact of those media features on consumer attitudes toward commercials (Rodero, Larrea, & Vázquez, 2013). The two determinants that may explain the lack of unanimity in previous research on gender-targeted products and voices are both related to the use of self-report tools (surveys, questionnaires). First, these tools can be subject to social desirability and subjectivity biases: they may show biased responses to sensitive gender-related issues which people are uncomfortable to reveal opinions about (Lewinski, Fransen, & Tan, 2014). Second, self-report tools cannot measure processes of which the person itself is not aware, i.e., unconscious and automatic cognitive processes related to endogenous attention, value encoding or conflict monitoring in response to advertising with product-voice combinations.

As neuroscientific techniques enable the measurement of these unconscious processes in a non-biased manner, they may be a useful complement to self-report tools in the study of product-voice combinations. Neuroscientific techniques are able to identify psychological responses of consumers based on objective physiological data and track consumer response in real time (i.e., measurements are possible during the processing of the stimulus of interest, something which is not possible with self-reports as taking self-reports during a task can raise conscious processes and biases). Applying neurological tools to the study of consumers' emotional and cognitive responses to marketing stimuli has indeed sparked growing interest in recent years and resulted in the birth of a new field commonly referred to as ''consumer neuroscience" or "neuromarketing". This interdisciplinary field studies the neural background of consumption decisions and consumer behavior (Reimann, Schilke, Weber, Neuhaus, & Zaichkowsky, 2011). Recent studies have employed neuroscientific techniques to evaluate processes underlying consumer decision-making in marketing areas such as e-commerce, political advertising, environmental communication and packaging research (Dimoka, 2010; Casado-Aranda, Martínez-Fiestas, & Sánchez-Fernández, 2018). One of the main benefits of neuroscientific techniques in communication research is that it facilitates exploring the neural origin of media effects provoked by specific media features. In other words, it sheds light on the underlying mechanisms of media effects (Falk, Berkman, & Lieberman, 2012; Weber, Mangus, & Huskey, 2015).

Following this mainstream, the current study applies a neuroscientific tool aiming to: i) elucidate the neural background of the effects of congruent and incongruent gender product-voice combinations in advertising; and ii) investigate in which brain areas activation in response to gender congruent AV commercials covaries with traditional self-reported attitudes towards the commercials. This study employed functional Magnetic Resonance Imaging (fMRI), a technique that offers an indirect measure of brain activation (Solnais, Andreu-Perez, Sánchez-Fernández, & Andréu-Abela, 2013).

5.2. Theoretical Background

5.2.1. Gender-targeted Products

Many consumer products are imbued with gender association (e.g. Grohman, 2009). This starts already at a young age with, for example, advertisements associating color pink with toys for girls while dark blue is used for toys for boys. Moreover, examples of gender association in advertising are also often showcased through props (Prieler, 2016). Gender identity is therefore generated and attained in a large manner through consumption. As a consequence of purchasing male-targeted products, males are thought to see themselves as part of a group that behaves according to masculine norms, while females are part of a different group with consumption following a feminine identity (Gal & Wilkie, 2010). Commercials are designed for each target group so that individuals can identify themselves with particular products. For example, personal relevance of the product to a certain target audience (e.g. male or female) can be increased by making references to characteristics typical of the specific target audience (Sherry et al., 2014).

The findings of a recent fMRI study by Wang et al. (2016) reveal that safe sex video commercials targeted specifically at the participant's race and sexual orientation are associated with greater activity in the brain regions related to processing self-relevance (such as the medial prefrontal cortex and precuneus) and regions related to learning, memory and language processing (i.e. hippocampus, bilateral inferior and middle temporal gyrus). Similarly, fMRI studies analyzing the underlying processing of own-group vs. other group-related stimuli found that evaluating personality traits in own-age vs. other-age individuals (Ebner et al., 2011), or comparing relevant personal qualities to those of an acquaintance (Modinos, Ormel, & Aleman, 2009), increase the activity in the brain areas related to self-relevance processing (the medial Prefrontal Cortex). In addition, studies comparing own- and other-race faces indicate that categorizing own-race faces induces greater activations in the right (R) medial frontal cortex and in the bilateral ventral occipito-temporal cortex (Proverbio & De Gabriele, 2017).

5.2.2. Voice Gender

The gender of the voice pronouncing the information about the product is an element of great interest in communication research. Several authors have noted that changing the gender of voice-over announcer campaigns may alter the perceived credibility of the commercial's messenger and message (Potter, Jamison-Koenig, Lynch, & Sites, 2016), the attitude toward the commercial (Potter & Choi, 2006) and the intention to purchase (Chebat, El Hedhli, GéLinas-Chebat, & Boivin, 2007).

Studies comparing the effects of male vs. female voices in advertising reveal ambiguous results. Some conclude that male voices convey a higher level of credibility, trustfulness, authority, expertise power and, consequently, are thought to be more persuasive (Klofstad, 2016). Phonetics and social psychology studies explain these findings through biological differences in terms of pitch and factors like noise or perceived sensuality (Pennock-Speck & del Saz Rubio, 2009). However, Martín-Santana, Muela-Molina, Reinares-Lara, and Rodríguez-Guera (2010) find no evidence for effectiveness differences related to the gender of the voice. Certain authors suggest that the higher level of confidence associated with the male voice is based more on traditional stereotypes (Rodero et al., 2013; Whipple & McManamon, 2002).

Neuroimaging studies show evidence of involvement of the inferior frontal gyrus and the cerebellum in voice gender perception (Casado-Aranda, Sánchez-Fernández & Montoro-Ríos, 2017; Joassin, Maurage, & Campanella, 2011). Analyses of emotional speech processing or perception of opposite/same-gender voices could, in fact, betray an interaction between voice gender and the listener's gender (Junger et al., 2014) as listening to voices of the opposite sex induces stronger activation of the fronto-temporal neural network (Junger et al., 2013) and listening to voices of both sexes induces an increase of activation in the posterior cingulate (Chun, Park, Park, & Kim, 2012). The parahippocampal gyrus, in turn, is activated in both males and females while hearing laughter of the same sex (Chun et al., 2012). Thus, though the general mechanisms underlying voice perception and gender differences are becoming increasingly clear, no advertising research to date has focused on brain responses to male and female voices.

5.2.3. Congruency Between Gender-Targeted Products and Gender of the Presenter's Voice

- *Behavioral studies*

As noted earlier, traditionally, gender-targeted products are most commonly presented by a gender congruent voice. However, results of studies on the effects of gender congruence in commercial effectiveness are ambiguous]. Some of these studies found more positive product/commercial evaluations, higher purchase intention, credibility and commercial effectiveness when the gender of a product matches the gender of the presenter (the so-called "match-up hypothesis," Debevec & Iyer, 1986; Pedelty & Kuecker, 2014; Strach, Park, Park, & Kim, 2015). In other words, consumers of both genders evaluate commercials as more positive when the gender-targeted product is combined with a gender congruent voice. An explanation proposed for this finding is that the gender congruent voice is linked to a conception of higher expertise and a strong personal identification with the presenter (Strach et al., 2015).

Other studies, on the other hand, do not find that gender congruence increases positive evaluations towards the commercials or that it does only under specific conditions. Whipple and McManamon (2002) Whipple and McManamon (2002) indicate that though there is a significant increase of effect of gender congruent presenters among female targeted products, this is not the case for products targeting males. Lien, Chou, and Chang (2012) investigated the match-up effect between a spokesperson's attractiveness type, a product's image and the effect of the spokesperson's sex. Their results indicate that for female-gendered products, the advertising effect is more positive with a female spokesperson than with a male spokesperson, regardless of the image of the product (sexy or cute). However, ads with male spokespersons selling cute-image products can create more favorable reactions that those with male spokespersons selling sexy-image products. Rodero et al. (2013) suggest that congruence only increases media effects when there is a strong association between the product and a pre-existing stereotype. For example, since male stereotypes linked to a tie are stronger than those to a lawn mower, then the male voice will be more effective in commercials for a tie than for a lawn mower. More recently, Hendriks, van Meurs and van der Meij (2015) assessed whether the use of foreign accents in radio commercials is more effective for congruent (e.g. a German accent and sausage) than incongruent products (e.g. a German accent and wine) combinations. Their results show that despite foreign-accented commercials resulted in more negative evaluations than non-accented commercials, incongruent accent-product combinations did not differ from congruent accent-product combinations with regard to the attitude towards the commercial.

- *Neural studies*

To date no research has examined brain responses to male and female targeted products and to male and female voices in a commercial context, let alone their congruent and incongruent combinations. Research in other fields (such as the more basal level AV integration) indicate that passive viewing and listening to AV stimuli (i.e. faces and voices, faces and music, or letters and speeches) consistently elicits activation in the superior temporal gyrus (Callan, Jones, Munhall, Callan, Kroos, & Vatikiotis-Bateson, 2003; Erickson, Heeg, Rauschecker, & Turkeltaub, 2014; Hölig, Föcker, Best, Röder, & Büchel, 2017; Kokinou, Kotz, Tavano, & Schröger., 2015; van Atteveldt, Formisano, Goebel, & Blomert, 2007; Venezia et al., 2017). A few studies assessed whether different brain areas were activated when participants were exposed to congruent compared to incongruent AV stimulation. Erickson et al. (2014), in a recent activation likelihood estimation meta-analysis, concluded that specific brain activation patterns are only found when comparing AV congruent vs. incongruent (or vice versa) contrasts. The findings reveal, in particular, that brain areas involved in the processing of congruent (vs. incongruent) AV syllables (e.g. either written or heard) are detected in the more proximal visual areas of the occipital cortex (e.g. the calcarine sulcus, the cuneus and the lateral occipital cortex). Congruent versus incongruent AV language/signal processing also elicits an increase of activity in visual areas such as the calcarine sulcus and the ventral occipitotemporal cortex (Blau, van Atteveldt, Formisano, Goebel, & Blomert, 2008; Ghazanfar, Chandrasekaran, & Logothetis, 2008; Heim, Friederici, Schiller, Rüschemeyer, & Amunts, 2009).

Other studies suggest that areas involved in error processing and the perception of conflict in information processing, such as the left inferior parietal (Durston, 2003; Gau & Noppeney, 2016; Ojanen et al., 2005) and the supramarginal gyrus (Lange, Christian, & Schnitzler, 2013), are activated when participants are exposed to discrepant audio-visual stimuli. Furthermore, Szycik, Jansma, and Münte (2009) find stronger signal changes for incongruent (vs. congruent) stimuli in the posterior part of superior temporal gyrus (STG). Together with the STG, the middle temporal gyrus (MTG) is also more strongly activated when subject to incongruent vs. congruent AV speech (Erickson et al., 2014). Furthermore, these findings are bolstered by the conclusions of a number of specialists (Komeilipoor, Cesari, & Daffertshofer, 2017; Pekkola et al., 2006a; Szycik et al., 2009).

5.3. Research Hypotheses

Though the studies above assess congruence in completely different fields, their findings serve to formulate the following hypotheses which are tested in the current study. Hypothesis 1: We hypothesize stronger activation in areas related to visual encoding (occipital areas, calcarine or cuneus gyri) when processing gender congruent (MV x MP + FV x FP) as opposed to incongruent (MV x FP + FV x MP) AV commercial combinations. Hypothesis 2: we hypothesize that the areas involved in error monitoring and conflicting AV processing (STG, MTG, supramarginal and left inferior parietal lobe) are more strongly activated in response to commercials with incongruent (MV x FP + FV x MP) compared to congruent (MV x MP + FV x FP) product-voice combinations. Furthermore, given the importance from the neuromarketing perspective of understanding the role of specific brain areas in predicting self-report responses such as attitudes toward commercials, this study also investigates which brain regions activated during viewing commercials with gender congruent (vs. incongruent) product-voice combinations covary with individual differences in self-reported attitudes toward congruent-incongruent commercials. In line with previous research, we expect these attitudes to covary in the areas most commonly involved in value encoding such as the orbitofrontal cortex, the posterior cingulate cortex and the striatum (Bartra, McGuire & Kable, 2013).

5.4. Materials and Methods

5.4.1. Participants

Thirty heterosexual right-handed subjects —15 females and 15 males, average age 30.0 years (*SD*: 10.4)— were recruited via social networks and the institutional website of the University of Granada between April and June 2017. Through a screening questionnaire that participants filled at the beginning of the fMRI session, participants were screened subjects to make sure the MRI exclusion criteria were not met. This questionnaire assessed whether subjects had a history of head injury, psychiatric illness, claustrophobia, pregnancy and metal implants in the body. Further, prior to the MRI scan, informed consent was obtained from each participant. The study protocol was approved by the Vice-rector for Research and Transfer of University of Granada (through Ethics Committee of Human Research, REF: 828) and the Research Centre of the Mind, Brain and Behavior. For approval, those institutions followed the protocol of the World Medical Association Declaration of Helsinki (2013) as well as that suggested by The Neuromarketing Science and Business Association. The latter constitutes an institution that has drawn up a code of ethics for consumer neuroscience studies and calls on researchers: i) to be honest in their analyses and findings; ii) not to take advantage of the incomprehension of participants of neuroscience measurements; and iii) to offer transparency throughout the duration of experiments. The high level of requirement of those protocols assures a drastic protection of the subject in the current research.

5.4.2. Procedure

The study was carried out during one session. Participants arrived at the laboratory one hour prior to the fMRI task and after instruction and verification that all study procedures were understood, they completed the informed consent questionnaire. Participants then underwent a series of fMRI scans including two localizer scans, a structural scan, and functional scans. Over the course of the functional scans, participants performed a fMRI task in which they were asked to pay attention to the stimuli. After leaving the scanner, participants viewed a set of product-voice combinations. After completion of the session, participants were thanked and reimbursed.

5.4.3. Stimuli Experimental Design

The study followed a 2 x 2 design with two within-subject independent variables (Gender-targeted product and Gender Voice) of two levels each: Male Product (MP) / Female Product (FP), and Male Voice (MV) / Female Voice (FV). An independent sample (n = 70), rated a total of 60 products on gender stereotype (7-likert scale, where 1= very masculine and 7= very feminine). For the present study, only products that scored as extreme gender-targeted were selected. This resulted in a total of 12 products ($M_{\text{male products}} = 2.11$ vs $M_{\text{female products}} = 6.48$; $t(69) = -21.92$, $p < 0.001$) of which six were typically male and six were typically female. Male-targeted products were an electric shaver, men's swimwear, men's deodorant, shaving cream, a tie and men's shoes. Female-targeted products, in turn, were a bikini, sanitary napkins, lipstick, nail polish, high-heels and hair removal cream. In the same independent sample (n = 70), the manipulation checks of the experimental stimuli were done: i) differences in voice clarity between male and female voices was tested (t (69) = -1.10, p = .28), ii) it was tested whether congruent vs. incongruent product-voice combinations were different in comprehension (t (69) = 1.44, p = .15), and iii) it was tested whether congruent product-voice combinations were perceived as more congruent than incongruent product-voice combinations (t (69) = 12.51, $p < 0.001$).

All spoken messages were adapted from existing commercials. Each message consisted of 8 to 12 words pronounced by one neutral female and one neutral male voice. The messages were recorded digitally with a high-quality microphone (type C 2000 B by AKG) at a sampling rate of 44100 Hz and a 16 bit quantization in a sound-proofed room using Audacity software (http://audacity.sourceforge.net). An average fundamental frequency for each speaker was set (male, 124 Hz; female, 205 Hz) and the stimuli were shifted in fundamental frequency by the amount of the F0-difference, i.e., 81 Hz so as to assure objective voice comparisons. The recordings were then equalized by the PSOLA re-synthesis function of the PRAAT speech editing software. Intensities were normalized using the Cool edit speech software. Furthermore, all auditory stimuli were filtered for ambient noise and standardized for the average root mean square (RMS) power and set at a sound pressure level (SPL) sensation of 70 dB on an average to assure comfort, intelligibility and audibility given the background noise of the scanner. The presenters were professionals with similar tessitura and voices regulated by the same type of intonation, inflections, emphasis and pauses.

5.4.4. The fMRI Task

During the fMRI task subjects passively viewed the products and listened to the voices. All 12 products (6 male and 6 female-targeted) were combined with a male and female voice presenting persuasive messages. This, therefore, resulted in 24 unique blocks: 6 blocks for the MP x MV condition (i.e. 6 different male products accompanied by the male voice), 6 blocks for the FP x FV condition (i.e. 6 different female products accompanied by the female voice), 6 blocks for the MP x FV condition (i.e. the same male products but accompanied by the female voice) and 6 blocks for the FP x MV condition (i.e. the same female products but accompanied by the male voice). There were, therefore, 12 blocks of product-voice congruent conditions (MP x MV and FP x FV) and 12 blocks of incongruent conditions (MP x FV and FP x MV). The order of presentation of the blocks was random.

Each block, 27 seconds in length, consisted of five different images of the same gender-targeted product. Each image, displayed for 5.4 seconds, was accompanied by a voice message pronounced by either a male or female voice. Blocks were separated by 15 seconds inter trial baseline periods (“+”) (see Figure 33). Participants were required after every four blocks to answer the following question: “Taking into account the presenter of the last product, what is your attitude toward the commercial?” Stimuli were presented via an MRI compatible sound system with electrostatic headphones with E-Prime Version 2 Professional software. The total duration of the task was 23.8 minutes.

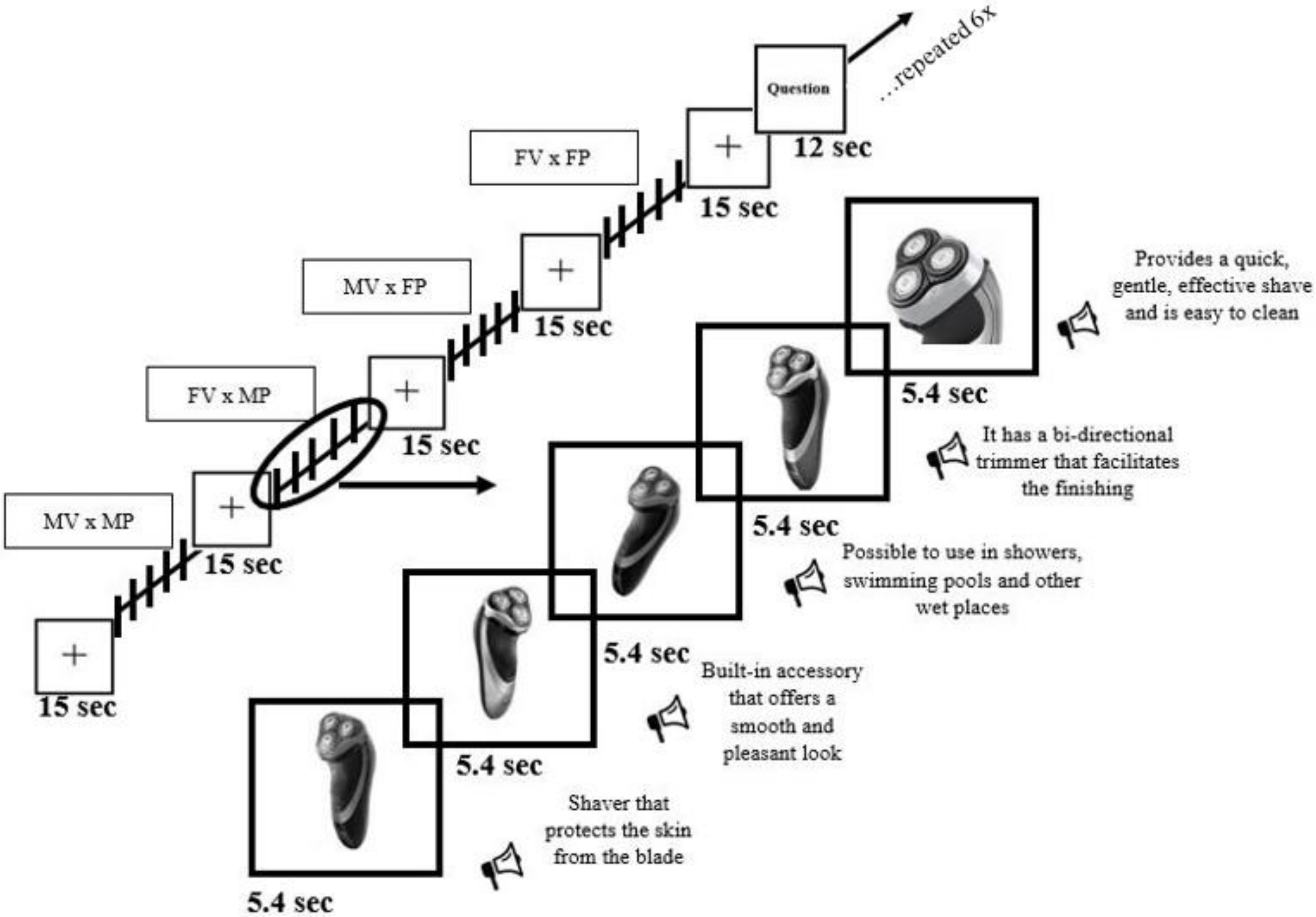

Figure 33. The left side is the fMRI task structure. The order corresponds to the first group of four blocks. The conditions (MV x MP, FV x MP, MV x FP and FV x FP) are presented in random order in the subsequent seven repetitions. To the right is an example of a condition with five pictures of a male-targeted product (MP) presented by a female voice (MV).

5.4.5. Self-Report Measures

Directly after the MRI scan, the participants carried out a behavioral task where they evaluated one commercial of each of the four conditions (MP x MV; MP x FV; FP x MV; FP x FV) viewed in the fMRI task. After each message, the subject responded by means of a semantic differential scale using the following five pairs of adjectives: a) sad/happy, b) boring/exciting, c) non-informative/informative, d) irrelevant/relevant, and e) dislike/like. A composite score of attitude toward the commercial in line with earlier self-report studies (e.g. Venkatraman, et al. 2015) was calculated from the average of the five questions. The results of the internal consistency analysis (Cronbach's alpha) of the attitude toward the four messages was acceptable in all cases ($\alpha = .782$ for MP x MV; $\alpha = .95$ for MP x FV; $\alpha = .93$ for FP x MV; and $\alpha = .94$ for FP x FV).

5.4.6. Statistical Analysis of Self-reports

Statistical analyses were carried out with the IBM Statistical Package of Social Science (IBM SPSS Version 20). Paired-Sample t-tests were carried out to determine whether participants showed significantly higher attitudes toward commercials presenting congruent or incongruent AV combinations.

5.4.7. Image Acquisition and Preprocessing

MRI scanning was implemented with a Siemens Trio 3T scanner equipped with a 32-channel head coil. The structural image T1 was acquired by a 3D MP-RAGE sequence with a sagittal orientation and a 1 mm x 1 mm x 1 mm voxel size (TR = 2300 ms, TE = 2.96 ms). Functional scans were acquired with a (T2*-weighted) echo-planar imaging (EPI) sequence (TR = 3000 ms, TE = 35 ms, Flip Angle 90° and a plane reduction of 3 x 3 x 3 mm corresponding to the slice thickness, slice order: descending). The distance factor was 25% so as to attain a total of 36 slices, a slice matrix of 64 x 64 mm, and a Field of View of 192 mm with an axial orientation. A total of 477 functional scans were acquired.

Data were preprocessed and analyzed using Statistical Parametric Mapping (SPM12, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) run with MATLAB R2012a (The MathworksInc, Natick, MA). Default settings were used unless stated otherwise. To allow stabilization of the BOLD signal, the first five volumes (15 seconds with a "cross" on the screen) of each run were discarded prior to analysis. Corrections were then applied by means of interpolation as to the differences in the time of slice acquisition with the initial slice serving as the reference. Functional images were realigned to the first image of the time series. Functional and structural images were co-registered and normalized (retaining 3 x 3 x 3 mm voxels) to the Montreal Neurological Institute (MNI) template. Finally, functional images were smoothed with the Gaussian kernel (FWHM = 6 mm). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined. The Volume Artefact tool from ArtRepair (http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html) then served to detect and repair anomalously noisy volumes. Volumes that moved more than .5mm/TR were repaired. Based on this, two participants (one female one male) were excluded from the analysis because too many volumes (>30%) required repair.

5.4.8. The fMRI Analyses

Statistical maps were generated for each participant by fitting a boxcar function to the time series, convolved with the canonical hemodynamic response function. Data were high pass filtered with a cutoff of at 128 s. The following conditions were modeled as regressors: 1) six onsets referred to the MP x MV blocks, each 27 sec in length, 2) six onsets referred to the MP x FV blocks, each 27 in length, 3) six onsets referred to the FP x MV blocks, each 27 sec in length, 4) six onsets referred to the FP x FV blocks, each 27 sec in length, 5) six onsets of the inquiries about positive or negative attitudes toward the commercial, each 12 sec in length; and 6) the rest periods (fixation points of 15 sec in length) were treated as the baseline on the General Linear Model (GLM) implemented in SPM12. Six rigid body motion correction parameters (the parameters from the realignment) were also included as nuisance covariates.

On the first level, two contrasts were calculated: i) congruent (MP x MV + FP x FV) minus incongruent (MP x FV + FP x MV) onsets, applying a T-contrast to the first and fourth regressors of the model [1 -1 -1 1]; and ii) incongruent (MP x MV + FP x FV) minus congruent (MP x MV + FP x FV) onsets, applying a T-contrast to the second and third regressors of the model [-1 1 1 -1].

To determine which brain regions showed differential activation for congruent and incongruent periods, the contrast images of congruent minus incongruent periods (and vice versa) were entered into one-sample t-test analyses in the second level random-effects phase. To identify the brain regions where AV congruency-related activation varies with individual differences in attitudes toward congruent (vs. incongruent) combinations, the contrast image of congruent (MP x MV + FP x FV) minus incongruent (MP x FV + FP x MV) periods were entered into a one-sample t-test with as covariate the subtraction of the average scores of attitudes toward congruent combinations and the average scores of attitudes toward incongruent combinations. This procedure constitutes a common practice in neuroscience studies applied to Social Sciences and marketing in particular (Gearhardt, Yokum, Stice, Harris, & Brownell, 2014; Langleben et al., 2009).

The cp_cluster_Pthresh (https://goo.gl/kjVydz) routine served to set the cluster extent threshold to a meaningful value. This function is implemented in Matlab and it can be employed to find the cluster-size threshold (number of voxels) for a given (whole brain corrected) p-value after the SPM estimation of the second level. Particularly, this tool offers a non arbitrary uncorrected threshold and cluster extent equal to $p < .05$ corrected for multiple comparisons (FWE) across the whole brain. In the congruent versus incongruent analyses (and vice versa), the threshold resulted in $p < .001$ uncorrected with a cluster (k) 36. Following previous research in the Social Science arena, (Gearhardt et al., 2014), we used a more liberal threshold in the exploratory analysis regarding the relation between neural responses and attitudes toward commercials, since we look into the most important areas involved in value (e.g. orbitofrontal cortex, striatum or posterior cingulate cortex). In this case the study resorted to a threshold of $p < 0.001$ uncorrected with a cluster extent of 20 voxels.

The study aim was, in fact, to assess the effect of congruency and not to assess the main effects of product (male vs. female) and voice (male vs. female). However, for completeness and to facilitate future meta-analyses, we report the analyses and results of the main effects in the Appendix B.

5.5. Results

5.5.1. Self-report Results

A Paired-samples t-test indicated that attitudes to commercials with congruent combinations yielded significantly more positive scores (MP x MV + FP x FV) than incongruent (FP x MV + MP x FV) combinations (t (27) = 2.90, p = .007, Cohen's r = .55) (see Figure 34).

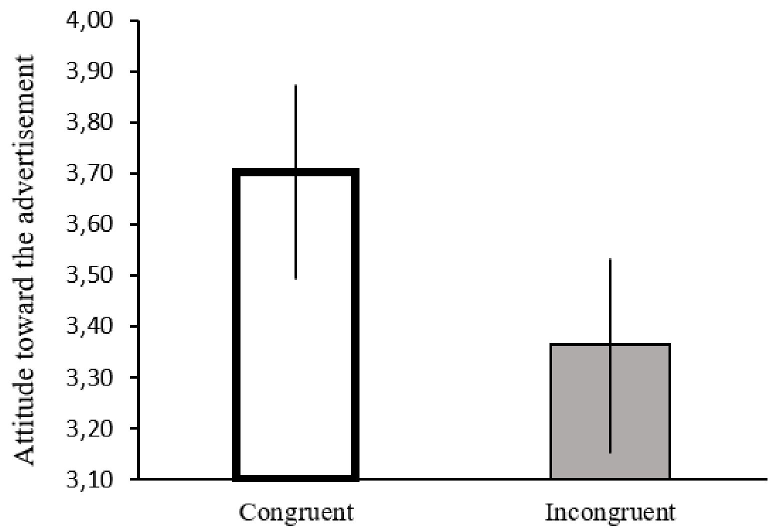

Figure 34. Results of the behavioral analysis. Y-axis: attitude toward the commercial (At); x-axis: congruent (MP x MV + FP x FV) and incongruent (FP x MV + MP x FV) voice combinations. Attitudes toward commercials with gender congruent product-voice combinations are more positive when compared to incongruent combinations ($t(27) = 2.90$, $p = .007$). Error bars indicate standard deviation.

A two-way RM ANOVA with attitudes toward advertisements as dependent variable, congruent and incongruent combinations as independent variables and the gender as a between subject factor did not reveal a significant interaction effect between the level of congruency of the advertising and the gender ($F(1,27) = .05$, $p = 0.825$). Thus, both males and females showed higher scores toward congruent AV advertisements ($M_{males} = 3.77$, $SD_{males} = 0.23$; $M_{females} = 3.63$, $SD_{females} = 0.23$) when compared to the incongruent counterparts ($M_{males} = 3.40$, $SD_{males} = 0.28$; $M_{females} = 3.32$, $SD_{females} = 0.28$).

5.5.2. Functional Imaging Results

- *Congruent and incongruent combinations*

Clusters in the left calcarine gyrus and left cuneus areas were more strongly activated ($p < .001$ uncorrected, $k = 36$) when exposed to commercials with gender congruent (MP x MV + FP x FV) as opposed to incongruent (MP x FV + FP x MV) combinations (see Figure 35A, Table 10).

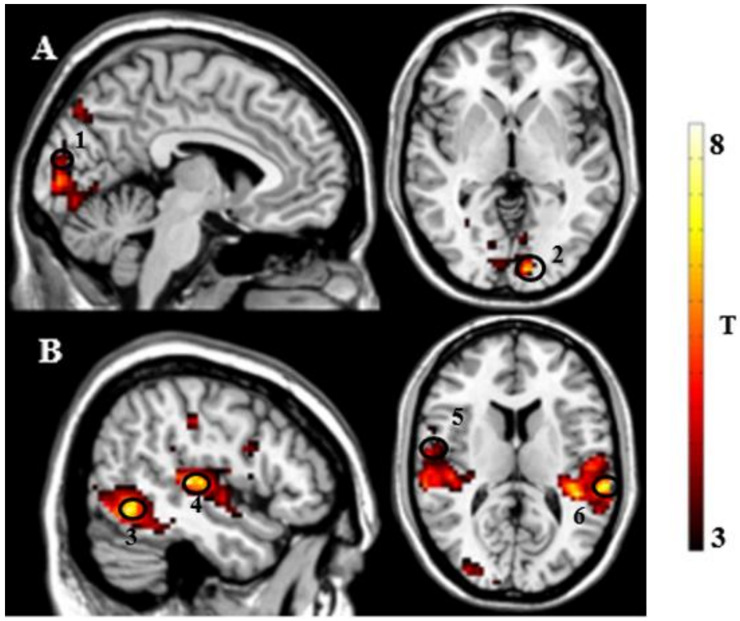

Figure 35. Illustration of the brain regions activated during (A) the congruent (MP x MV + FP x FV) > incongruent (MP x FV + FP x MV) contrast: (1) calcarine gyrus and (2) cuneus gyrus; (B) Incongruent (MP x FV + FP x MV) > Congruent (MP x MV + FP x FV) contrast: (3) inferior and middle occipital gyri (4) bilateral superior temporal gyri, (5) middle temporal gyrus, and (6) supramarginal gyrus and inferior parietal lobe. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($3 < T < 8$), superimposed on the mean anatomical image of all subjects (MNI-space)

Table 10. Brain regions differentially activated in response to congruent (FP x MV + MP x FV) versus incongruent (MP x MV + FP x FV) commercials.

Brain region	Peak MNI-coordinates (mm)			Z-value	T	K	Effect Size[b]
	x	y	z				
Congruent minus incongruent [a]							
L calcarine gyrus	-9	-91	2	5.25	7.02	158	.99
L cuneus	-9	-94	14	4.83	6.17		.91
	-15	-88	20	5.09	6.69		.96
Incongruent minus congruent [a]							
L middle temporal gyrus	-57	-32	5	5.76	8.19	578	1.09
L superior temporal gyrus	-51	-22	5	5.56	7.72		1.05
R superior temporal gyrus	57	-22	5	5.68	8.01	477	1.07
R inferior occipital gyrus	48	-58	-13	5.59	7.79	395	1.06
R middle occipital gyrus	27	-88	8	4.18	5.02		.79
R supramarginal gyrus	60	-22	41	4.34	5.28	36	.82
R inferior parietal lobe	51	-22	38	3.81	4.44		.72

[a] Peak coordinates of clusters significant at $p < .001$, $k \geq 36$ voxels are reported

[b] Effect Size = $Z/\sqrt{N}$

Clusters in several brain regions such as the middle temporal (MTG), bilateral superior temporal (STG), inferior and middle occipital gyri, supramarginal gyrus, and inferior parietal lobes were more strongly activated ($p < .001$ uncorrected, k = 36, see Table 100, Figure 35B) in response to commercials with gender incongruent (FP x MV + MP x FV) than congruent (MP x MV + FP x FV) combinations.

Differences between males and females in brain responses to congruent and incongruent conditions were also tested. A two-sample t-test analysis revealed no significant differences between males and females when the congruent condition (MP x MV + FP x FV) was compared to the incongruent condition (MP x FV + FP x MV), or vice versa.

- *Relation between neural responses and attitudes toward commercials*

Activation in the superior temporal gyri, R Heschl's gyri and R posterior cingulate cortex (PCC) during viewing of congruent minus incongruent combinations covaried significantly (positive) with the difference in attitudes score toward congruent minus incongruent commercials

($r_{STG} = .57$; $r_{Heschl} = .61$; $r_{PCC} = .56$). Thus, participants with more positive attitudes to congruent (as opposed to incongruent commercials) reveal significantly stronger activation in these areas while viewing gender congruent compared to incongruent commercials (Figure 36, Table 11. Brain regions in which activation covaries with differences in attitudes toward congruent (MP x MV + FP x FV) minus incongruent (MP x FV + FP x MV) commercials.).

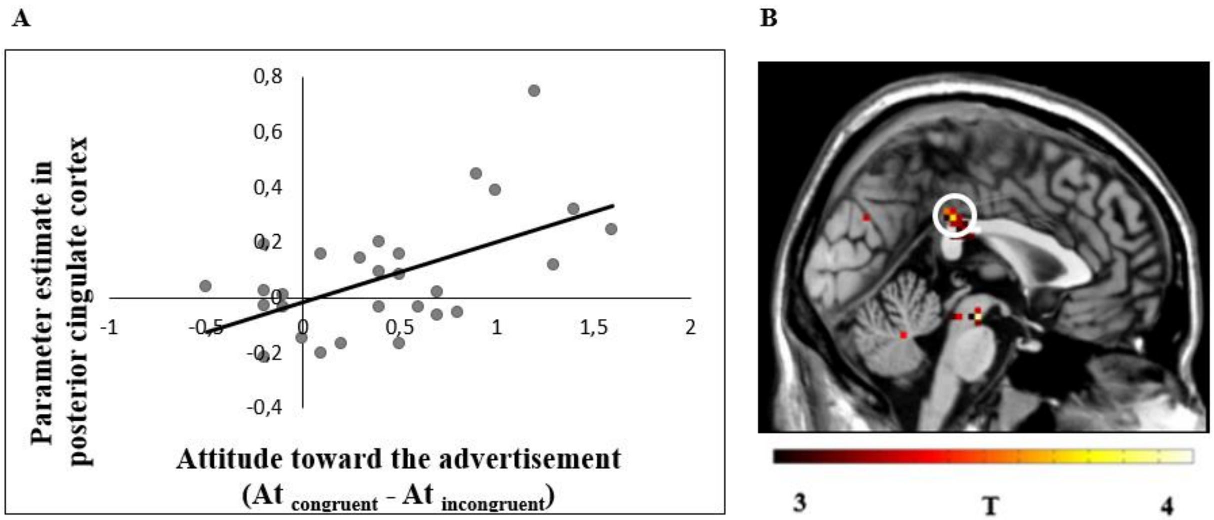

Figure 36. Activation in the left Posterior Cingulate Cortex during commercials with gender congruent (minus incongruent) combinations of voice and product covaries with attitude toward congruent minus incongruent commercials. **(A)** Plot showing the correlation between parameter estimate of congruent vs. incongruent in the Posterior cingulate cortex cluster and the attitude toward congruent (vs. incongruent) commercials. **(B)** Brain regions in which activation during viewing commercials with gender congruent minus incongruent combinations covaries with differences in attitudes toward congruent minus incongruent commercials. Circle indicates right PCC cluster. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($3 < T < 4$ for visualization), superimposed on the mean anatomical image of all subjects (MNI-space)

Table 11. Brain regions in which activation covaries with differences in attitudes toward congruent (MP x MV + FP x FV) minus incongruent (MP x FV + FP x MV) commercials.

Brain region	Peak MNI-coordinates (mm)			Z-Value	T	K	EffectSize[b]
	x	y	z				
Congruent minus Incongruent [a]							
L superior temporal gyrus	-51	-34	14	4.44	5.51	57	.84
L Heschl's gyri	-36	-22	17	4.38	5.40		.83
R posterior cingulate cortex	6	-31	23	4.04	4.82	22	.76
R posterior cingulate cortex	6	-40	23	3.39	3.85		.64

[a] No clusters survived at $p < .001$, $k \geq 36$. Peak of clusters significant at $p < .001$, $k \geq 20$ voxels are reported

[b] Effect Size = $Z/\sqrt{N}$

5.6. Discussion and Conclusions

No advertisement research to date has examined brain responses and behavioral reactions to male and female targeted products presented with male and female voices. This is the first study that examines the neural origin of the gender congruence effect on product and presenter combinations in advertising with both self-report and neural tools. Generally, the findings show that congruent and incongruent product-voice combinations are processed differentially at both neural and self-report levels. In line with literature on the media effects of these combinations (Rodero et al., 2013), the current findings reveal more positive attitudes toward congruent compared to incongruent commercials. Interestingly, the neural findings provide some explanation for the origin of the higher attitudes conferred to congruent commercials: congruent product-voice combinations give rise to stronger activation in primary visual areas which is tantamount to higher endogenous attention, while incongruent AV commercials elicit activation in areas linked to error and inconsistency processing.

More specifically, brain areas identified in earlier studies involved with congruent AV stimuli integration, namely the left calcarine gyrus and left cuneus, are more strongly activated in response to congruent compared to incongruent combinations. The meta-analysis of Erickson et al. (2011) on the AV integration of speech signals concluded that the brain areas involved in the processing of congruent AV speech (e.g. the same written and heard syllable) are in the more proximal visual areas of the occipital cortex (such as the middle or superior occipital gyri), the bilateral fusiform gyrus, the cuneus and the calcarine. Though the earlier studies on congruence in AV processing used very simple stimuli, the results of this study suggest that these areas also activate in response to congruence when stimuli are more complex, i.e., gender congruence of product and voice.

Earlier studies on the neural processing of multisensory stimuli (e.g., AV) showed that activation in primary visual areas (such as the calcarine and cuneus areas) are the result of attentional shifts toward visual cues (Yamagishi, Goda, Callan, Anderson, & Kawato, 2005) and enhancements of the endogenous attention (Liu, Pestilli, & Carrasco, 2005; Pekkola et al., 2006b). In the framework of this paper, the found increases in primary visual activations during congruent product-voice combinations may suggests that participants took more notice of congruent (vs. incongruent) commercials. Indeed, this reasoning is in line with the conclusions of van Ee, van Boxtel, Parker, and Alais (2009) and Fairhall and Macaluso (2009) who posited that congruent auditory or tactile information, and combined auditory-tactile information, promote attentional control over incongruent visual stimuli. According to these authors, the enhanced capacity for attentional selection of the congruent stimulus results from a boost of its perceptual gain which is attributed to top-down feedback from multisensory attentional processes that select the congruent feature of the input signal. In other words, audiovisual integration and spatial attention interact to contribute to a more thorough perception of a fused AV commercial, thus supporting Hypothesis 1.

In line with Hypothesis 2, areas involved in the processing of incongruent (vs. congruent) AV stimuli, namely the bilateral posterior superior (STG) and the middle temporal (MTG) gyri as well as the supramarginal and parietal lobes, are more strongly activated in response to incongruent as opposed to congruent combinations. The role of the posterior STG and MTG areas in AV integration is largely supported by specialized literature (Blau et al., 2008; Möttönen, Schurmann, & Sams, 2004; Naghavi, Eriksson, Larsson, & Nyberg, 2011). Recent studies suggest that these areas are specifically involved in processing of incongruent (vs. congruent) AV speech (Erickson et al., 2014; Ojanen et al., 2005; Szycik et al., 2009), combinations of faces and voices (Kokinous et al., 2015) and incongruent visual-semantic information (Hein et al., 2007). Other research points to an increase in activation in those areas when comparing congruent vs. incongruent combinations of music and faces (Jeong et al., 2011), speech information (Van Atteveldt, Formisano, Goebel, & Blomert, 2004) and spoken phrases in audio and video (Calvert, 1999). The main differences between the current study and that of Calvert (1999) is the type of stimulation. Calvert (1999) analyzed the congruency of stimuli that differ in the temporal domain (out of sync sound and video), while, as noted above, the present study indicates that the congruency effect on the neural level is also found with a higher cognitive level stimulus (gender voice and gender product). Moreover, this paper suggests that incongruent combinations of AV stimuli of a higher cognitive level and complexity (e.g. gender products and voices) are processed in specific areas in the temporal lobe, notably the STS and MTS.

The stronger activation in the supramarginal and left inferior parietal lobe during incongruent stimulation might be related to increased conflict detection, mismatch and contradiction when presented with inconsistent (vs. consistent) AV inputs (Durston, 2003). These results are bolstered by research comparing incongruent vs. congruent AV speech (Gau & Noppey, 2016; Szycik et al., 2009) and language production (Heim et al., 2009). The superior, middle and inferior occipital gyri were also strongly activated by incongruent AV combinations. Previous research revealed that those areas may play a key role in (incongruent) multisensory stimuli. Specifically, Macaluso, George, Dolan, Spence & Driver (2004) related those areas to spatial multisensory interactions and Meienbrock, Naumer, O.Doehrmann, Singer & Muckli, (2005) to the incongruent AV integration. Consequently, different areas in the occipital lobe are involved in congruent and incongruent AV stimuli. While the calcarine and the cuneus appear to be more affected by AV synchrony and increases in endogenous attention (e.g. congruent product-voice combinations), more superior and inferior areas seem to be associated with the multisensory interaction of incongruent combinations (e.g. incongruent product-voice combinations).

This paper's last goal was to identify the brain regions where product-voice congruency-related activation varies with individual differences in attitudes toward congruent (vs. incongruent) product voice combinations. The findings reveal that participants with more positive attitudes toward congruent commercials show stronger activation during congruent (vs. incongruent) periods in several brain regions, including the right posterior cingulate cortex (PCC). The PCC receives input via connections and integration from the ventromedial prefrontal cortex, a brain area that reflects subjective value of stimuli (Bartra et al., 2013). Specifically, the right PCC is thought to encode stimulus salience (Maddock, 1999). It also responds during selection of a favorite brand in a forced choice paradigm (Deppe, 2005) and during purchasing decisions (Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007). It has also been shown that the right ventral PCC plays a role in evaluating emotion content from visual sensory input (Vogt, Vogt, & Laureys, 2006). In our study, the stronger PCC activation during congruent commercials in participants who granted a higher rating to the congruent AV commercials may reflect a higher subjective value and reward conveyed by commercials which include congruent (vs. incongruent) combinations of voice gender and gender-targeted products.

Theoretically, the current findings contribute to the literature challenging the notion of the importance of increasing positive perceptions toward commercials. Previous research focused on the self-reported media effects of smartphone advertising (Martins, Costa, Oliveira, Gonçalves, & Branco, 2018) or exposing the viewer to idealized female images (Wan et al., 2013) and congruent product-voice combinations (Rodero et al., 2013). This study sheds light on the subconscious origin of the more positive self-reported attitudes conferred to very common elements in commercials (such as gender congruence in product-voice combinations) aiming to encourage the purchase of products of daily use. It also constitutes a new step in the neuromarketing field with the application of neurological tools aiming to explore consumer processing of visual and audio information. Previous research in this direction employed fMRI to compare the neural processing of successful and unsuccessful advertising (Daugherty, Hoffman, & Kennedy, 2016), to test the effect of counterarguing in antidrug campaigns (Weber, Huskey, Mangus, Westcott-Baker, & Turner, 2015), to explore advertising appeals and their relationship to product attractiveness (Chang, O'Boyle, Anderson, & Suttikun, 2016) or to elucidate the neural mechanisms of social influence (Mason, Dyer, & Norton, 2009). This study advances and spells out the processing of the combination of two elements, voice gender and gender product, whose subconscious mechanisms were previously not investigated in advertising research. Finally, this paper contributes to the literature analyzing the neural processing of multisensorial integration. Previous studies examined the role of emotion in the neural processing of music and face combinations (Jeong et al., 2011) or the neural correlates of visual letters and speech sounds (Blau et al., 2008). The current research goes further and sheds light on the neural responses to more complex AV stimuli (product-voice combinations) with different levels of congruency.

These findings have remarkable managerial implications. First, the findings indicate that managers and communication professionals desiring to design successful advertising campaigns of everyday products should employ female presenters for female-targeted products and male presenters, for male-targeted products. In line with Strach et al. (2015), congruent product-voice combinations not only increase positive attitudes toward commercials but attain a higher degree of subconscious attention than their incongruent counterparts. Despite the scarce unanimity in literature regarding the attitudes provoked by congruent and incongruent product-voice combinations, and regardless of the nature of the match-up condition, this study suggests that incongruent combinations in advertising may trigger subconscious ambivalence and dispute. The current paper goes further to propose, thirdly, that congruent combinations of voice and product in commercials also increase the consumer value and relevance toward the advertised product. The congruent combination elicits brain mechanisms similar to those involved with the maternal love (Noriuchi, Yoshiaki, & Senoo, 2008) or food desire (Linder et al., 2010). Therefore, carefully matching the type of product with a gender-congruent voice in advertising may be key in creating positive expectations and obtaining long-term competitive advantages through purchase relationships with consumers. Accordingly, all efforts made by businesses on offering high-quality products or services, may be worthless when the combination between voice and product is not congruent in the commercial.

It must be noted that this work only measured self-reported attitudes toward commercials and not actual purchasing behavior. Although it is widely demonstrated that more positive attitudes toward commercials are linked to an increase in purchase intention (Raza, Bakar, & Mohamad, 2018), future neuromarketing research should link neural responses to gender congruence in commercials with actual purchasing behaviors. Secondly, the conclusions of this paper should be received with caution due to sample size of 30 participants. Future research applying neuromarketing techniques in AV advertising with larger sample sizes is needed. Thirdly, previous self-report research analyzing product-voice combinations in advertising used a gender-balanced sample aged from 21 to 23 years old (Rodero et al., 2010) or from 19 to 65 years old (Whipple & McManamon, 2002). The former study extrapolated the findings to other age groups; and the latter one did not find age differences in the results. Although the current research can provoke similar results in older individuals, more studies increasing the sample age are needed to corroborate the results.

Despite the large amount of literature analyzing the effects of gender congruence on advertising valuation, it is surprising to observe how most studies omit clarifying the question of the origin of the media effects provoked by congruent and incongruent product-voice combinations in advertising. This is the first study that applies a neuromarketing approach to face this research gap and advances that congruent product-voice combinations receive the greatest attitudes possibly due to the increases in attention, value and relevance they induce during advertising valuation. By contrast, incongruent combinations trigger error monitoring and inconsistency detection. Therefore, this exploratory study constitutes an advance in the understanding of the origin of attitudes and preferences induced by congruent and incongruent advertising.

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NEURAL CORRELATES OF VOICE GENDER AND MESSAGE FRAMING IN ADVERTISING: A FUNCTIONAL MRI STUDY

Casado-Aranda, Luis-Alberto; Sánchez-Fernández, Juan; Montoro-Ríos, Francisco J.

This article examines the neural and behavioral effects of voice gender and message framing in ecological advertising by means of functional magnetic resonance imaging (fMRI) in conjunction with a task presenting persuasive gain- or loss-framed messages (GF or LF) pronounced by male and female voices (MV and FV). Behavioral responses showed more positive attitudes toward ads comprising male voices and gain-framed messages. A whole-brain analysis revealed that visual regions are strongly elicited by loss- (vs. gain-) framed messages, while an area related to personal value computing, future positive aspirations and social benefits —namely the anterior cingulate cortex— is strongly activated by gain- (vs. loss-) framed messages. The male voice triggered stronger activation in areas related to pitch processing and visual scenes, while the female voice provoked a higher neural audiovisual-integration. Furthermore, neural activation in the inferior frontal gyrus significantly predicted attitudes toward ads pronounced by the male voice, and the activation in the orbitofrontal gyrus predicted attitudes toward ads comprising gain-framed messages. Taken together, this paper sheds light on a differential neural processing of gain and loss frames as well as male and female voices. It also suggests that messages expressing social benefits (e.g. environmental) could be processed differently from those reporting individual advantages (e.g. healthy). Finally, it advises managers and associations that market environmentally responsible products and ideas the voice and frame of the message which generate the highest subconscious value.

6.1. Introduction

The growth of social problems resulting from the deterioration of the environment requires collective intervention. Research has in fact demonstrated the link between climate change and pollution provoked by humans (Stocker, 2014), and green consumption has been proposed as a sustainable venture which contributes to avoiding climate change through the purchase and use of environmentally responsible products (Gilg, Barr, & Ford, 2005).

An approach that has an outstanding potential to enhance consumer use of green products is the design of persuasive communication campaigns. The information offered to potential consumers by advertising influences attention and recall, as well as attitudes and intentions to purchase (Tu, Kao, & Tu, 2013). Therefore, if designed properly, advertising can mould consumer decisions and direct them toward the consumption of environmental products (Connell, Brucks, & Nielsen, 2014).

To that aim, most advertising research has evaluated the impact of several media features on media effects such as attitude, intention or behavior (Elsen, Pieters, & and Wedel, 2016; Van Der Laan, De Ridder, Viergever, & Smeets, 2015). Specifically in the field of environmental advertising, research has focused on media features such as the degree of message ambiguity (Leonidou, Palihawadana, & Hultman, 2011) or the level of assertiveness (Baek, Yoon, & Kim, 2015).

One media feature that is the object of special interest is that of message framing, which refers to the emphasis placed on the benefit or cost of carrying out a specific action to reduce environmental problems (Hulme, 2008). In the context of environmental communication, the gain (loss) frame reveals the positive (negative) impact of environmentally responsible (irresponsible) acts (Martínez, Viedma, Sánchez, & Montoro, 2015). In spite of the higher persuasiveness of gain-framed messages, studies in environmental communication research are not unanimous regarding which results are the most persuasive (O'Keefe, & Jensen, 2006).

Specialized communication research has focused on the different levels of persuasiveness of environmental messages when they are pronounced by the female or male voice. In spite of the more common use of the male voice in advertising (70-90%, Piñeiro, 2010), there is a divergence of opinion as to its degree of persuasiveness compared to the female voice (Avery, 2012) when pronouncing messages, in particular messages of green products.

On the whole, there is little consensus regarding the media effects (e.g. attitudes toward ads) generated by the combination of the message frame and voice gender. This, together with the need to complement the self-report surveys which are designed to examine these elements (Maxian, Bradley, Wise, & Toulouse, 2013), underscores the importance of studies that systematically target message framing and voice effects conjointly and employ techniques, such as neuroimaging, that are more appropriate to measure underlying processes and neural mechanisms. One of the main benefits of neuroscience in communication research is that it facilitates the exploration on how certain media features produce specific media effects (Falk, Berkman, & Lieberman, 2012; Weber, Mangus, & Huskey, 2015). Given the potential to use framing and voices in advertising to promote the use of environmentally responsible products, it is essential to understand the underlying mechanisms by which consumers process and judge media features (Sawe, 2017).

The aims of this paper are therefore the following: i) identify whether there are different brain regions activated in response to gain versus loss frames, ii) test whether there are different brain regions activated in response to the male versus female voice, iii) assess whether brain activations in response to gain- vs. loss-frame contrast predict the attitudes toward those ads, and iv) test whether brain activations in response to male vs. female contrast predict attitudes toward those ads.

To attain these goals, we turned to the functional Magnetic Resonance Imaging (fMRI), a tool which detects minute changes in the level of oxygenation of the blood brain (BOLD signal) as a result of metabolic changes in blood flow produced by neuronal activity (Poldrack et al., 2017; Solnais, Andreu, Sánchez, & Andreu, 2013).

6.2. Theoretical Background and Hypothesis

6.2.1. Gain vs. Loss Frames

Gain and loss framing is a communication strategy often used to design campaign messages because a message's framing may alter people’s perceptions and attitudes (risk-averse with gain-framed and risk-seeking with loss-framed) even when the information is equivalent (Prospect Theory: Tversky, & Kahneman, 1981).

The use of gain versus loss framing has been explored in a wide range of communication contexts (e.g., Borah, 2011; Cao, 2016; Lu, 2015). Most empirical research has been developed in the field of health psychology. Yet a distinction has been made between preventive behaviors which are perceived as low in risk (e.g. sunscreen use) and detection behaviors (e.g. testing for HIV) perceived as having a high short term risk (Banks et al., 1995). Here, the evidence indicates that loss frames are more effective in encouraging detection behavior and gain frames to bolster preventive behavior (Rothman, Bartels, Wlaschin, & Salovev, 2006).

Particularly in the environmental advertising research field, Spence and Pigneon (2010) concluded that sustainable behavior should be considered as prevention action since responsible consumption aims to avoid potential negative impacts on the climate. Therefore, it should be easier to promote this by resorting to gain-framed messages, a reasoning that is supported by Ojala (2008) and Martínez et al. (2015). In spite of the higher persuasiveness of gain frames in environmental communication, O'Keefe and Jensen (2006, 2009) in their meta-analysis concluded that more research should focus on analyzing mechanisms through which gain-framed messages exert their effect on behavior.

This study opts for addressing this issue from the neuroscience perspective. Since gain-framed (vs. loss-framed) messages highlight the value of performing the desired behavior (Vezich, Katzman, Ames, Falk, & Lieberman, 2016), then gain-framed messages would more strongly engage regions related to the social and personal value of a message. In that sense, research has found the anterior cingulate cortex (ACC) to be an area involved with the processing of social and individual relevant input (Hughes, & Beer, 2012; Johnson et al., 2006; Rameson, Satpute, & Lieberman, 2010; Yang, Dedovic, Chen, & Zhang, 2012). Gain-framed messages generally also point out positive hopes and aspirations (O'Keefe & Jensen, 2007) which could be connected to areas such as ACC, among others, related to prospects and imagination (Blair et al., 2013; Lui et al., 2008; Spreng, Stevens, Chamberlain, Gilmore & Schacter, 2010). That would be in line with the Feldman-Hall' study (2012), which identified connections between the right ACC and the hypothetical vs. real moral decisions (which potentially ties in nicely with positive environmental decisions). Since gain-framed (vs. loss-framed) messages tend to have a stronger effect on environmental intentions and behaviors (Van de Velde, Verbeke, Popp, & Van Huylenbroeck, 2010), then a well documented area predictive of behavior changes, namely the ventral medial prefrontal cortex (MPFC), could be also more elicited by gain-framed messages. In fact, several studies identify that area to predict a reduction in smoking (Falk, Berkman, & Lieberman, 2012;

Falk, Berkman, Whalen, &Lieberman, 2011) and an increase in sunscreen use (Falk, Berkman, Mann, Harrison, & Lieberman, 2010).

6.2.2. Male vs. Female Voice

Communication research literature has analyzed the media effects of certain characteristics of the voice such as gender. Changing the gender of voice-over announcer campaigns has been shown to alter the credibility of the ad's message (Roberts, 2010), the attitudes toward the ad (Potter & Choi, 2006) and the intentions to purchase (Wiener & Chartrand, 2014).

Phonetics and social psychology studies justify this fact by biological differences between voices along parameters such as Fundamental Frequency (F0, pitch) or Format Frequencies (Gblinas-Chebat, Chebat & Vaninski, 1996). Researchers in advertising have carried out empirical comparisons of male and female voices and generally concluded that the male voice may generate higher credibility, confidence, expertise power and is therefore more persuasive than the female voice (Martín-Santana, Muela-Molina, Reinares-Lara, & Rodríguez-Guerra, 2015). The work of Dolliver (2010), on the other hand, did not identify any differences in the persuasiveness of the gender. Furthermore, other studies concluded that ad persuasiveness depends not only on the voice, but on the elements of the message such as the frame and the brand (Perona, & Barbeito, 2008).

The exact neural mechanisms underlying voice processing among both sexes still remains under debate (Ahrens, Awwad Shiekh Hasan, Giordano, & Belin 2014). Furthermore, no research has examined these mechanisms in the context of advertising. Neuro-imaging studies of mixed-gender samples confirm that the perception generated by the female voice, as opposed to the male voice, elicits greater activation of the right (R) posterior superior temporal gyrus, left (L) postcentral gyrus, and the bilateral parietal lobe (Lattner, 2005; Sokhi, Hunter, Wilkinson, & Woodruff, 2005; Weston, Hunter, Sokhi, Wilkinson, & Woodruff, 2015). Conversely the male voice strongly activated the inferior temporal gyrus when pronouncing coherent phrases (Humphries, Willard, Buchsbaum, & Hickok, 2000).

6.2.3. Combination of Frame and Voice

Because gain- or loss-framed messages are pronounced conjointly by male and female voices in advertising, it is reasonable to study how they can work together to be more persuasive. Language processing literature states that the perception of a voice pronouncing the ad is influenced, among other factors, by the verbal content (Russell, & Fehr, 1987). Along these lines, some studies suggest that it is not only important to analyze how listeners process the "what" (e.g. loss/gain-framed messages), but also how they relate the information with the processing of the "who" relays the message (e.g. male/female voice) (Belin, Bestelmeyer, Latinus, & Watson 2011). Based on this reasoning, this study attempts to evaluate the behavioral and neural mechanisms through which consumers process gain vs. loss frames (GF vs. LF) and male vs. female voices (MV vs. FV) while perceiving messages combining the two voices.

Taken together, we formally propose:

Hypothesis 1: The anterior cingulate cortex and medial prefrontal cortex regions are activated when comparing gain- (GF x MV vs. GF x FV) vs. loss-framed (LF x MV vs. LF x FV) messages.

Hypothesis 2: The inferior temporal gyrus is strongly activated when comparing the male (MV x GF + MV x LF) vs. the female (FV x GF + FV x LF) voice. In turn, the posterior superior temporal gyrus, postcentral gyrus, bilateral parietal lobe and insula are activated when comparing the female (FV x GF + FV x LF) vs. the male (MV x GF + MV x LF) voice.

Our last aim was to assess if activation of brain regions linked to the male (vs. female) voice is related to differences in attitudes toward ads pronounced by male and female voices. Similarly, the study evaluated whether brain activations in gain (vs. loss) frames predicted differences in attitudes toward gain- and loss- framed ads.

Hypothesis 3: Activation of the male vs. female contrast will predict the behavioral measures indexed by the difference between the attitude toward the messages pronounced by the male and female voice.

Hypothesis 4: Activation of the gain vs. loss contrast will serve to predict behavioral measures indexed by the difference between the attitude toward the gain- and loss-frame messages.

6.3. Method

6.3.1. Experimental Design

The main objective of the experimental design is to present five images of environmental products while subjecting participants to different voices pronouncing gain and loss end-state messages. To carry this out, the authors developed a 2 x 2 design with two independent variables (Frame and Voice) containing respectively two levels each (Gain Frame/Loss Frame and Male Voice/Female Voice).

- GF messages were linked to the positive consequences of purchasing environmental products ("Reduction of suspended particles"). LF messages, in turn, were linked to the negative consequences of not consuming environmental products ("Higher levels of ambient noise"). To statistically assure that the gain- and loss-framed messages are perceived in different manners, we conducted a pilot study (n = 68) before the experimental design and fMRI session using a 7- point Likert scale, with 1 meaning "it expresses high disasters" (LF) and 7 "it expresses high benefits" (GF). The findings support the manipulations as all gain-framed messages statistically report higher benefits than the loss-framed messages (t (68) = 30.10; $p < 0.001$). By using the 7- point Likert SAM scale (Bradley and Lang, 1994), we also evaluated the level of arousal of both gain- and loss-framed messages, since these differences could affect neural processing of the messages (Lane, Chua and Dolan, 1999). The results highlight that both gain (M = 4.51; SD = 1.02) and loss (M = 4.14; SD = 1.35) environmental messages generate the same level of arousal (t (68) = -1.81; p = 0.07).

We also conducted a Post-Hoc (n = 70) study to assess whether the messages are more positive vs. express benefits and negative vs. express disasters with a 7- point Likert SAM scale (Bradley and Lang, 1994) to evaluate their degree of positive or negative perception (their valence). We then compared those rates with scores obtained previously regarding the benefits or disasters they express. The findings show no differences between positive (M = 5.95; SD = 0.85) and "express benefits" (M = 6.08; SD = 0.77) features of stimuli (t (70) = 30.10; p = 0.072). Similarly, there are no differences when comparing negative (M = 1.66; SD = 0.58) and "express disasters" (M = 1.72; SD = 0.64) features of stimuli (t (70) = 1.44; p = 0.15). Finally, we explained and ensured that all participants understood correctly the differences between gain- and loss-framed messages one hour before their fMRI task.

Two voices (male and female) delivered with a neutral Spanish accent were chosen for the task. The messages were recorded digitally with a high-quality microphone (type C 2000 B by AKG) at a sampling rate of 44100 Hz and a quantization of 16 bit in a sound proofed room using the Audacity software (http://audacity.sourceforge.net). To be able to compare the voices, the average fundamental frequency for each speaker was determined (male, 124 Hz; Female, 205 Hz) and the stimuli were shifted in fundamental frequency by the amount of the F0-difference, i.e., 81 Hz. The recordings were then equalized using the PSOLA re-synthesis function of the PRAAT speech editing software. Intensities were normalized by the Cool Edit Speech editing software.

Furthermore, all auditory stimuli were filtered for ambient noise and standardized for the average root mean square (RMS) power and given a sound pressure level (SPL) sensation of 70 dB on an average to assure comfort, intelligibility and audibility given the background noise of the scanner. Stimuli were presented via a MRI compatible sound system by means of electrostatic headphones with E-Prime Version 2 Professional software. The products displayed to the subjects were rechargeable batteries, solar-powered window sockets, recyclable clothing, biodiesel, bio-plastic, recycled paper, LED bulbs and recycled furniture.

The experimental design therefore had four conditions arising from the combination of the four levels of factors (LF x MV, LF x FV, GF x MV, GF x FV). All participants were subject to the same task (within-subject design). Given its simplicity and statistical power, a block-related design was chosen (Huettel, Song, & McCarthy, 2008). Each condition (block) consisted of five images of the same ecological product displayed for 4.8 seconds in company of a gain/loss message pronounced by either a male or female voice. Thus, each block lasted 24 seconds. The remaining products and messages can be consulted at https://figshare.com/s/bfeec67c33be1ea6dcb0. Each of the four conditions, and therefore each of the four blocks, was randomly repeated 10 times with 15 seconds baseline intervals ("+") between each message (see Figure 37). Total paradigm duration was 25.7 min.

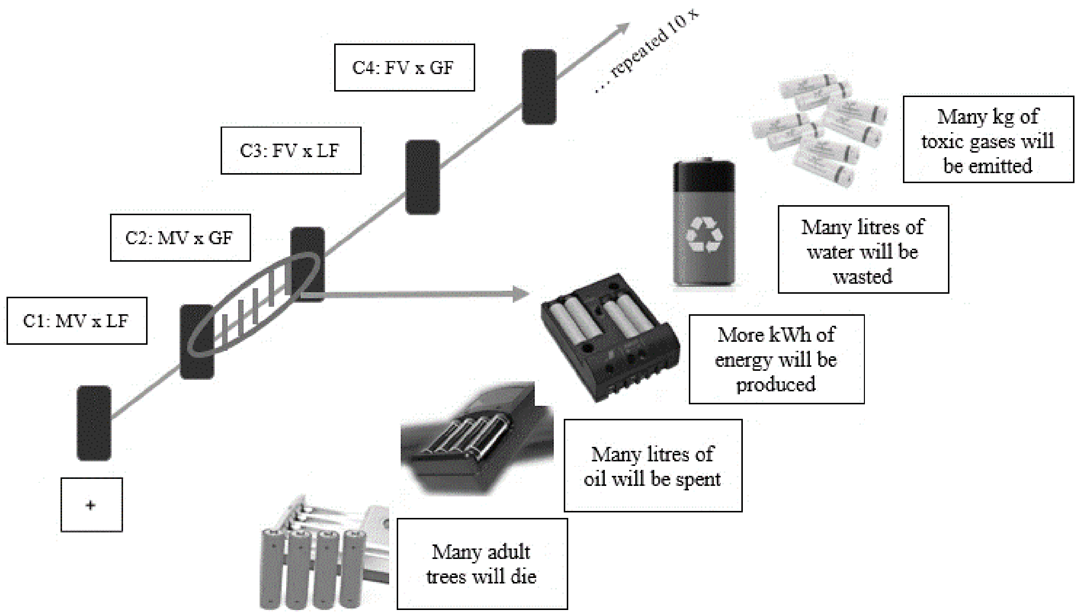

Figure 37. Experimental design of the four main blocks. The distribution corresponds to the first group of four blocks. The conditions (C1, C2, C3 and C4) are random in the subsequent nine repetitions. On the right side is the C2: five loss frame (LF) messages pronounced by a male voice (MV) accompanying images of rechargeable batteries. GF refers to gain frame messages and FV to the female voice.

6.3.2. Participants

Sixteen heterosexual right-handed subjects (8 women and 8 men) of an average age of 24.70 (SD: 5.36) were selected to take part in the experiment via social networks and the institutional website of the XXX University. In the field of consumer neuroscience, current high-impact studies applying neurological tools tend to use small sample sizes (from 12 to 20 participants) to predict behaviors. These include, for example, Demorest et al., (2010), Langleben et al., (2009), Morris et al., (2009), Dietvorst et al. (2009), Guo et al (2016), Hedgcock and Rao (2009), Bakalash and Riemer (2013) and Dimoka (2010). Indeed, Solnais and colleagues (2013) advance that a sampling of 20 participants is the most used for high impact neuroscience consumer studies.

Despite the fact that small sample sizes are quite common in these types of studies, we ran a post-hoc power calculation analysis using the fMRIPower tool (Mumford and Nichols, 2008) to statistically test the reproducibility of the findings. After introducing the SPM design matrix from each contrast in second level analysis, fMRIPower gives the power for each of the brain areas in the AAL atlas. After compiling the statistical power for each of our ROI's with a type l error rate of 0.1, they average near 61%. Therefore, based on these results, this study has a medium-high chance of obtaining statistically significant brain activations.

The experiment was carried out between September and November 2015.The initial survey enquired about attitudes toward the purchase of ecological products and health issues. The attitude to the purchase of ecological products was measured by Ajzen's (2002) scale of planned behavior. This scale consists of five pairs of adjectives (harmful/beneficial, unpleasant/nice, something I dislike/something I like, worthless/valuable, a bad idea/a good idea). Each pair was graded according to a seven-point semantic scale. Among the initial sampling, only the participants with a medium to high attitude toward ecological consumption (M = 5.06, SD = .85 on a scale of 7 points) were retained for reasons of control. All participants also had to be in good health, not be on medication or afflicted by any neurological disease, not abuse drugs and have normal (or corrected to normal) vision and hearing. The experiment also applied the common fMRI exclusion criteria of claustrophobia, pregnancy and metal implants in the body).

To use private medical information, the authors obtained a form from each participant following the ethical commitment consent. Obtention of the consent document, as well as the research in general, was recognized and sanctioned by University of Granada and the Research Centre of the Mind, Brain and Behavior, following the protocol of the World Medical Association Declaration of Helsinki (2013).

6.3.3. Behavioral Measures

Five minutes after the scan, the participants took part in a behavioral task where they evaluated the same messages under of each of the four conditions. To carry this out, they were presented four messages viewed during the scanning: 1) MV x GF, 2) MV x LF, 3) FV x GF, and 4) FV x LF. After each message, each subject recorded his opinion by means of a semantic differential scale using the following five pairs of adjectives: a) sad/happy, b) boring/exciting, c) non-informative/informative, d) irrelevant/relevant and e) dislike/like. Since the preceding adjectives define the attitude toward an advertisement (Venkatraman et al., 2015), this study has attempted to define what gender of voice and what combinations generate more positive attitudes toward the ad in both men and women. The internal consistency (Cronbach's alpha) of the attitude toward the four messages measured by four pairs of adjectives was acceptable in all cases.

6.3.4. Image Acquisition and Preprocessing

The functional images were acquired with a Siemens Trio 3T scanner by descending slice acquisition. The structural image T1 was acquired by a 3D MP-RAGE sequence using a sagittal orientation and a voxel size of 1 mm x 1 mm x 1 mm. The parameters of the functional images (T2*-weighted) were the following: an echo-planar imaging (EPI) sequence sensitive to the BOLD signal, TR = 3000 ms, TE = 35 ms, Flip Angle 90°, and a plane reduction of 3 x 3 x 3 mm corresponding the slice thickness. The distance factor was 25% so as to attain a total of 482 slices, a slice matrix of 64 x 64 mm, and a Field of View of 192 mm with an axial orientation.

Functional data were pre-processed and analyzed using Statistical Parametric Mapping (SPM12). To allow for the stabilization of the BOLD signal, the first five volumes (15 seconds) of each run were discarded prior to analysis. Corrections were then applied by means of interpolation regarding the differences in the time of slice acquisition with the initial slice serving as the reference. The data in the first functional image were then realigned, and afterwards, the authors co-registered the functional and structural images. Then, the data were normalized according to the Montreal Neurological Institute (MNI) template using parameters defined for anatomic image. Finally, functional images were smoothed with the Gaussian kernel (FWHM = 6 mm). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined. The Volume Artifact tool from ArtRepair was then applied to detect and repair anomalously noisy volumes. Volumes that moved more than .5 mm/TR were repaired. Based on these measurements, no participant was excluded from the experiment.

6.3.5. fMRI Analyses

The following conditions were designed using a canonical hemodynamic response function: Male Voice x Loss Frame (MV x LF), Male Voice x Gain Frame (MV x GF), Female Voice x Loss Frame (FV x LF) and Female Voice x Gain Frame (FV x GF). Six rigid body motion correction parameters were also included as nuisance covariates and the rest periods (fixation point) were treated as the baseline on the General Lineal Model (GLM) implemented in SPM12. Low-frequency signal drifts were later filtered using a cutoff period of 128 s.

- *Whole-brain analysis*

On the first level (single subject analysis), the following contrasts were created: i) gain (MV x GF + FV x GF) vs. loss (MV x LF + FV x LF) frames, and the reverse; and ii) the male (MV x LF + MV x GF) vs. the female (FV x LF + FV x GF) voice, and the reverse.

On a second level, one sample t-test was carried out to examine the significant brain activations of the group during the contrasts cited above. To set the cluster extent threshold at a meaningful value, we used the cp_cluster_Pthresh tool, which offers a non arbitrary uncorrected threshold and cluster extent equal to $p < .2$ corrected for multiple comparisons (FEW) across the whole brain. In this case, the threshold resulted in values of $p < .001$ with a cluster (k) 8, similar approach to those adopted by Bischoff, Neuhaus, Trautner & Weber (2013) and Cascio, O'Donnell, Bayer, Tinney & Falk (2015).

- *Multiple Regression Analysis*

After averaging the attitude from each participant toward the gain-, loss-framed, male-and female-pronounced messages shown in the behavioral task, we ran a subtraction analysis of attitudes (i.e. Gain - Loss and Male - Female attitudes). Then, multiple regression analysis was applied to examine whether the neural response to environmental messages (percentage BOLD signal change) in brain regions related to gain (vs. loss) frame are associated with the subtraction between the rating of attitude toward the gain framing (At_{gain}) combinations and the scores toward the loss (At_{loss}) framing combinations ($At1 = At_{gain} – At_{loss}$). We proceeded similarly to test the relationship between the subtraction in the rating of attitude toward the male (At_{male}) vs. female (At_{female}) voices ($At2 = At_{male} – At_{female}$) and brain response. In other words, brain areas found to be correlated with attitudes toward gain-framed messages and those correlated with attitudes toward messages presented by male voices will be predictive of such attitudes.

6.4. Results

6.4.1. Behavioral results

Statistical analyses were carried out with the IBM Statistical Package for the Social Sciences (IBM SPSS Version 19). A two-way Repeated-Measures (RM) ANOVA was applied to assess the main effects of the two within-subject variables "frame" (two levels: gain and loss) and "gender voice" (two levels: male and female), as well as their potential interactions. If the sphericity assumption was violated via the Mauchly's sphericity test, the degrees of freedom were adjusted using the ''Huynh–Feldt'' correction. The alpha level was .05.

The two-way RM ANOVA revealed a significant main effect of the attitude toward voice gender (F (1,15) = 107.76, p < .01) and frame (F (1,15) = 624.196, p < .01), but not a significant interaction between voice gender and frame (F (1,15) = 2.14; p = .164). Specifically, attitudes toward the ads were significantly higher in the mixed-gender sample in the following cases: i) the male (M = 4.98, SD = .115) as opposed to female (M = 4.15, SD = .119) voice pronouncing ecological messages and ii) gain- (M = 5.99, SD = .12) as opposed to loss-framed (M = 3.14, SD = .12) messages. Furthermore, attitudes toward the messages were significantly higher (p < .01) when both voices presented gain-framed ecological messages.

6.4.2. Functional Imaging Results

- *Gain and Loss Frame contrasts*.

The comparison of gain (GF x MV + GF x FV) vs. loss (LF x MV + LF x FV) frames reveals a cluster in the right (R) ACC was strongly activated (p < .001 uncorrected, see Table 12, Figure 38). By contrast, several clusters in the bilateral middle occipital gyri, the inferior occipital gyrus and the lingual gyrus elicited strong reactions (see Table 12, Figure 38) when contrasting the loss frame (LF x MV + LF x FV) with the gain frame (GF x MV + GF x FV).

Table 12. Peak coordinates of brain regions in response to loss frame (LF x MV + LF x FV) against gain frame (GF x MV + GF x FV) contrasts and in response to male voice (MV x LF + MV x GF) against female voice (FV x LF + FV x GF) contrasts.

Brain region	**Peak MNI coordinates (mm)**			**Z**	**T**	**Cluster size**	**Effect size**
	x	**y**	**z**				
LF > GF							
L middle occipital gyrus	-33	-85	-4	4.82	7.97	303	1.25
L lingual gyrus	-18	-88	-10	4.35	6.52		1.09
R inferior occipital gyrus	33	-82	-10	3.91	5.40		0.98
R middle occipital gyrus	30	-85	5	3.39	4.32	59	0.85
GF > LF							
R anterior cingulate	12	35	-7	3.27	4.10	8	0.82
MV > FV							
R middle temporal gyrus	63	-49	11	3.88	5.35	9	0.97
L Supplementary Motor Area	-9	17	59	3.58	4.70	8	0.90
FV > MV							
R superior temporal gyrus	51	-25	8	5.06	8.85	154	1.27
L superior temporal gyrus	-48	-37	11	4.91	8.28	244	1.23
R fusiform gyrus	30	-55	-10	4.63	7.34	63	1.16
R lingual gyrus	18	-82	-13	4.46	6.83	82	1.12
R middle occipital gyrus	27	-85	20	4.42	6.71	206	1.11
L superior occipital gyrus	-24	-88	17	4.19	6.08	87	1.05
L fusiform gyrus	-24	-67	-13	4.07	5.79	93	1.02
R superior parietal gyrus	18	-64	56	3.86	5.28	22	0.97

Note: Peak of clusters significant at $p_{uncorrected} < .001$, $k \geq 8$ voxels are reported. Such uncorrected threshold and cluster extent equal to $p < .2$ corrected for multiple comparisons.

Effect Size = $Z/\sqrt{N}$

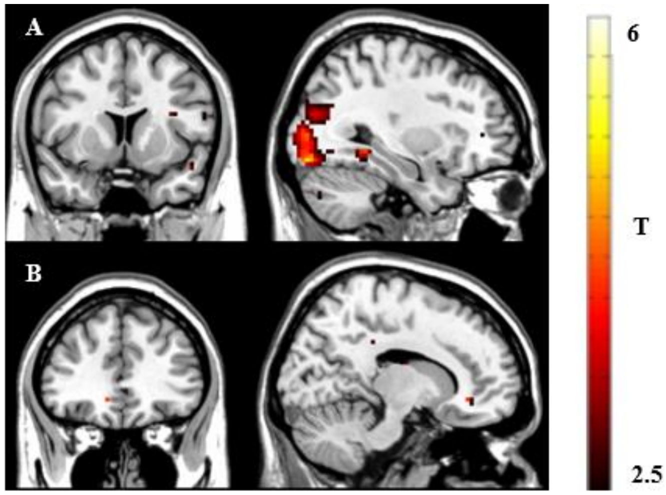

Figure 38. Brain regions activated during: **(A)** loss frame (LF x MV + LF x FV) vs. gain frame (GF x MV x GF x FV) contrast: bilateral middle occipital gyrus, R lingual gyrus, L inferior occipital gyrus. **(B)** gain frame (GF x MV x GF x FV) vs. loss frame (LF x MV + LF x FV) contrast: L anterior cingulate cortex.

- *Male and Female Voices contrasts*.

The comparison of the male (MV x LF + MV x GF) vs. female voice (FV x LF + FV x GF) reveals a strong elicitation of the R middle temporal and left supplementary motor region (SMA). Conversely, the female (FV x LF + FV x GF) vs. male voice (MV x LF + MV x GF) strongly triggered the bilateral superior temporal gyri, the bilateral fusiform, the R lingual, superior and middle occipital, as well as the R superior parietal gyri (see Figure 39).

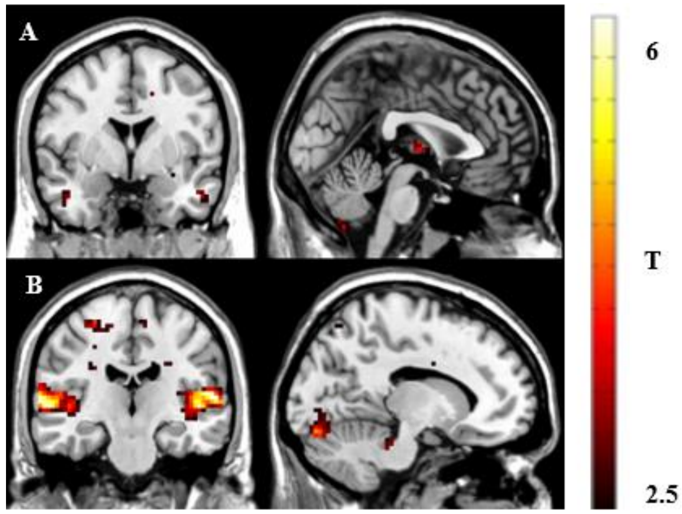

Figure 39. Brain regions activated during: **(A)** male voice (MV x LF + MV x GF) vs. female voice (FV x LF + FV x GF) contrast: L middle temporal gyrus and R SMA. **(B)** Female voice (FV x LF + FV x GF) vs. male voice (MV x LF + MV x GF) contrast: bilateral superior temporal gyri, bilateral fusiform gyrus, L lingual, L middle occipital gyrus, R superior occipital gyrus, L superior parietal gyrus.

- *Relation between neural responses and attitudes toward ads.*

Activations in the cerebellar vermis (r = .16 p = .56), the R postcentral (r = .66, p = .006) and the R middle orbitofrontal gyrus (OBTF) (r = .54, p = .03) during the gain vs. loss correlated significantly (positively) with differences of scores between attitudes toward gain- and loss-framed messages. Thus, the stronger activation in these regions during the gain vs. loss periods served to predict higher scores toward gain messages.

Similarly, activation in the L inferior frontal gyrus (IFG) strongly correlated (positively) with differences of ratings between attitudes toward messages pronounced by the male vs. female voice (r = .705, p = .002). Therefore, the participants who gave the male voice a higher rating showed a higher activation of the IFG during male vs. female voice comparisons (Table 13. **(1)** Peak coordinates of brain regions in which activation covaries with differences in attitudes toward gain (GF x MV x GF x FV) and loss (LF x MV + LF x FV) framed messages. **(2)** Peak coordinates of brain regions in which activation covaries with differences in attitudes toward messages pronounced by male (MV x LF + MV x GF) and female (FV x LF + FV x GF) voices. and Figure 40).

Table 13. (1) Peak coordinates of brain regions in which activation covaries with differences in attitudes toward gain (GF x MV x GF x FV) and loss (LF x MV + LF x FV) framed messages. **(2)** Peak coordinates of brain regions in which activation covaries with differences in attitudes toward messages pronounced by male (MV x LF + MV x GF) and female (FV x LF + FV x GF) voices.

Brain region	**Peak MNI coordinates (mm)**			**Z**	**T**	**Cluster size**	**Effect Size**
	x	**y**	**z**				
(1) GF > LF							
R postcentral gyrus	63	-1	20	3.97	5.54	13	0.99
L cerebellum	-21	-70	-22	3.89	5.36	13	0.97
R middle orbitofrontal gyrus	30	56	-7	3.73	5.01	8	0.93
(2) MV > FV							
L inferior triangulis frontal gyrus	-39	38	11	3.96	5.51	42	0.99
L inferior triangulis frontal gyrus	-51	38	8	3.37	4.29	22	0.84

Note: Peak of clusters significant at $p_{uncorrected} < .001$, $k \geq 8$ voxels are reported. Such uncorrected threshold and cluster extent equal to $p < .2$ corrected for multiple comparisons.

Effect Size = $Z/\sqrt{N}$

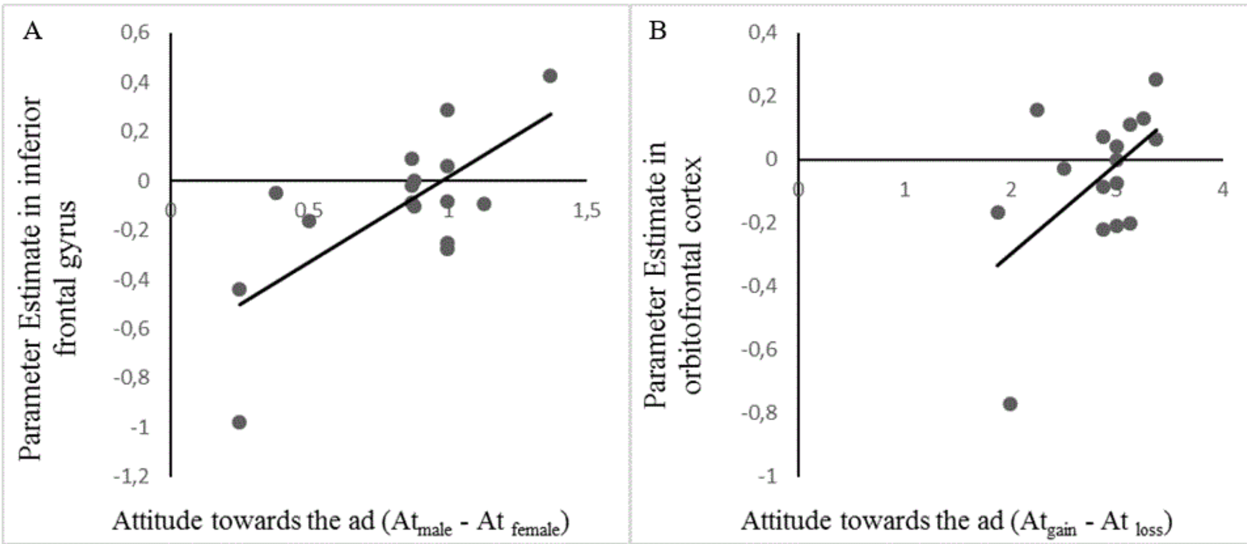

Figure 40. **(A)** Plot showing the correlation between the parameter estimate male vs. female voices in the right inferior frontal gyrus cluster and the attitude toward ads pronounced by male (vs. female) voices. **(B)** Plot showing correlation between parameter estimate gain vs. loss framed messages in left orbitofrontal cluster and the attitude toward gain (vs. loss) messages.

6.5. Discussion

The need to efficiently exploit media features in advertising to encourage the use of environmentally responsible products highlights the importance of understanding the underlying mechanisms through which consumers process and judge the elements of persuasive messages. This is the first study that investigates the effect of voice gender (male/female) and frames (gain/loss) in advertising resorting to both behavioral and neural measures. This approach is closer to the consumer experience when encountering ecological ads in the real world. Generally, the results indicate that the male vs. female voice and gain- vs. loss-framed messages are processed differently at both neural and behavioral levels.

At the neural level, the right ACC is strongly activated when comparing gain- vs. loss-framed messages. The role of the ACC in processing the relevant input with respect to the individual is bolstered by several studies (Herwig, Kaffenberger, Schell, Jäncke, & Brühl, 2012; Passingham, Bengtsson, & Lau, 2010). Together with the MPFC, this region of the brain is involved in reflecting about hopes and aspirations (Johnson et al., 2006), as well as the expectation of positive events in the future (Blair et al., 2013; Sharot, Riccardi, Raio, & Phelps, 2007). Interestingly, a recent research (Lockwood, Apps, Roiser, & Viding, 2015) concludes that the ACC strongly signals the likelihood of a reward to others and is related to social empathy. That conclusion fits nicely with this research as the ACC appears to be not only involved with personal value computing and future positive aspirations, but also encodes the social benefits — environmental in our case— for others, as expounded in Hypothesis 1.

Contrary to expectations, the MPFC was not strongly triggered in gain-framed messages. In a recent study, Vezich, Katzman, Ames, Falk, & Lieberman (2016) found an increase of activity in that region when gain-framed messages (vs. loss) promoted sunscreen use. Yet, contrary to the results of that study, persuasive messages in this paper are more closely linked to the benefits and disadvantages of consuming ecological products for the environment and nature, and not for the individual. The higher involvement of the MPFC in processing of the health benefits for the individual (as opposed to the environment) could be a potential explanation for the absence of activation in that region (Falk, Berkman, Whalen, & Lieberman, 2011; Mays et al., 2015; Sawe, 2017). These findings indeed agree with the conclusions of the study of Sawe and Knutson (2015) analyzing neural valuation of environmental sources. They advanced that the MPFC activity may track personal rather than communal benefits and costs in a responsible behavior such as their donation task, since donation requests were framed as prices to be paid which could prime personal over public considerations.

Loss-framed messages (vs. gain) also strongly activated the middle, inferior occipital regions and the lingual gyrus. These regions are linked to color and shape sensitivity (Hupe, Bordier, & Dojat, 2012). The different colors and shapes of several ecological products which only are exposed during loss-framed messages (and not in gain-framed messages) is a reasonable explanation for these activations.

In line with the expectations of Hypothesis 2, we observe a stronger triggering of the SMA and the middle temporal lobe when participants listened to the male (vs. female) voice. Indefrey, Hellwig, Herzog, Seitz, & Hagoort (2003) related the SMA with the processing of visual scenes described by male voices. The middle temporal lobe, in turn, is linked to pitch processing (Sokhi et al., 2005; Tramo, 2002) which differs between male and female voices (Lattner, 2005). Taken together, the activation of the different regions could reflect their specialization in processing the male voice presenting visual scenes, close to our experimental design.

Parts of the brain eliciting stronger activation while perceiving the female voice, in contrast to the male, are the bilateral superior temporal gyri, superior parietal gyrus, middle/superior occipital and fusiform regions. These findings agree with those of several studies which related the superior temporal and parietal lobes with the processing of the female (vs. male) voice (Junger et al., 2014; Lattner, 2005; Weston et al., 2015). A specific neuroimaging study carried out by von Kriegstein, Eger, Kleinschmidt, & Giraud (2003) analyzed the cortical response to spoken phrases, comparing two recognition tasks targeting either the speaker's voice or the verbal content. The authors observed activation in the bilateral fusiform/lingual and occipital regions of the brain during the verbal task, thus reflecting an implicit translation of auditory sentences into visual representations. This confirms an active role of visual cortical regions in speech analysis. Therefore, the higher activation of these regions during the delivery of the female (vs. male) voice could reflect a higher audiovisual integration of framed messages and ecological products when the message is delivered by a woman.

At the behavioral level, we observe higher ratings of attitudes toward ads presenting gain-framed messages and the male voice. These findings support the higher level of persuasion of messages emphasizing the positive consequences of being environmentally responsible (O'keefe & Jensen, 2009; Martínez et al., 2015), as well as those presented by the male voice (Furnham, & Farragher, 2000; Martín-Santana et al., 2015). The higher attitudes generated by the male voice combined with gain frame (vs. loss frame) is consistent with an increase in evaluations of products linked to low-frequency pronouncements (e.g. male voice) presenting positively valanced messages (Seta, McCormick, Gallagher, McElroy, & Seta, 2010). Contrary to the findings of that study, our participants also gave high ratings to the male voice pronouncing gain-framed messages. This is perhaps due to the higher adequacy of gain (vs. loss) frames to persuade consumers and raise the perceived notion of the severity of the impact of climate change.

Finally, the purpose of the study was to establish in which brain regions male voice and gain frame-related activation predicts attitudes toward male (vs. female) and gain (vs. loss) combinations. In line with Hypothesis 3, the findings reveal that participants who gave a higher rating to the ads pronounced by the male voice showed stronger activation during male (vs. female) periods in the left inferior frontal gyrus (IFG). The IFG region appears to be linked with reward evaluation and content-format integration of persuasive ads. Following this line, Martin, Cox, Brooks, and Savage (2014) evaluated differences in reward and punishment sensitivity between smokers and nonsmokers and found that an increase in activation of the inferior frontal gyrus to the delivery of expected rewards was associated with an increase of craving linked to positive reinforcement of smoking. Secondly, Wang and colleagues (2013) explored the behavioral and neural effects of the interaction between the content (argument strength) and the format (intensity of audio, visual, and content features) of public ads. They identified an increase in left inferior frontal activation in such interaction and interpreted that IFG activation could be an indicator of intensity of processing. Other research has also linked the IFG to the ventral MPFC, an area correlated with subjective values during decisions about obtaining primary rewards (Hare, O'Doherty, Camerer, Schultz, & Rangel, 2008) and charitable decision making (Hare, Camerer, Knoepfle, O'Doherty, & Rangel, 2010). Together, the stronger left IFG activation in our study — indicative of higher attitudes toward male voice messages— may reflect a higher intensity in processing and preference when subject to ecological messages presented by the male (vs. female) voice.

Similarly, L cerebellum, R postcentral and R middle orbitofrontal cortex (OBTFC) areas are more strongly activated during gain-framed messages in participants who give a higher score to those messages, in line with the speculation formulated in Hypothesis 4. Interestingly, the medial OBTFC is proposed as the region that signals the expected value of rewards while learning stimuli-rewards associations, as well as encoding a general unsigned value during anticipation of both appetitive and aversive events (Metereau, & Dreher, 2015; Sawe, 2017). Therefore, the activation of the OBTFC during gain-framed messages could highlight an increase in the subjective value of gain-framed ecological messages.

There are a number of limitations to the present study. Firstly, links are established between neural brain activation and behavioral measures indexed by attitudes toward the ads. Future research should link neural responses with intentions or actual behaviors to more fully understand which brain regions predict consumer ads actual preferences. Secondly, since the products were not presented equally in all the conditions (confounding effect), then the inferences when comparing the different blocks must be regarded with caution. Furthermore, since the project did not provide "non environmental" comparison conditions, it would be inappropriate to claim that the ecological nature of the product is a relevant (causal) factor in determining the results. Environmental decision making requires future research applying fMRI to larger sample sizes, since the findings obtained with 16 subjects have only a relative acceptable statistical power. Finally, the conclusions of this paper should be received with caution due to the selection only of participants with a medium to high attitude toward ecological consumption.

Despite these limitations the present study represents a first step toward understanding consumers' neural and behavioral responses to persuasive gain/loss-framed messages pronounced by the male and female voice. In line with earlier research, this study reveals that the male voice combined with gain-framed messages increases attitudes toward environmental ads. Additionally, this is the first survey of ecological advertising to shed light on the combination of neural responses to framed messages and voice gender. The findings are the following: i) regions of the brain associated with vision are strongly activated by loss- (vs. gain-) framed messages, ii) the ACC is strongly triggered by gain- (vs. loss-) framed messages, iii) the middle temporal and SMA regions respond to the male (vs. female) voice and iv) the superior temporal, occipital and superior parietal regions react strongly to the female (vs. male) voice. Furthermore, the study establishes that both the inferior frontal cortex response to the male voice and the orbitofrontal gyri response to gain-framed messages predict positive attitudes toward environmental ads. Therefore, managers that market environmentally responsible products and ideas, as well as governments or environmental associations, should consider using the male voice in combination with gain frames when communicating ecological messages.

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CHAPTER 7

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NEURAL EFFECTS OF ENVIRONMENTAL ADVERTISING: AN fMRI ANALYSIS OF VOICE AGE AND TEMPORAL FRAMING

Casado-Aranda, Luis Alberto; Martínez-Fiestas, Myriam & Sánchez-Fernández, Juan.

Ecological information offered to society through advertising enhances awareness of environmental issues, encourages development of sustainable attitudes and intentions, and can even alter behavior. This paper, by means of functional Magnetic Resonance Imaging (fMRI) and self-reports, explores the underlying mechanisms of processing ecological messages. The study specifically examines brain and behavioral responses to persuasive ecological messages that differ in temporal framing and in the age of the voice pronouncing them. The findings reveal that attitudes are more positive toward future-framed messages presented by young voices. The whole-brain analysis reveals that future-framed (FF) ecological messages trigger activation in brain areas related to imagery, prospective memories and episodic events, thus reflecting the involvement of past behaviors in future ecological actions. Past-framed messages (PF), in turn, elicit brain activations within the episodic system. Young voices (YV), in addition to triggering stronger activation in areas involved with the processing of high-timbre, high-pitched and high-intensity voices, are perceived as more emotional and motivational than old voices (OV) as activations in anterior cingulate cortex and amygdala. Messages expressed by older voices, in turn, exhibit stronger activation in areas formerly linked to low-pitched voices and voice gender perception. Interestingly, a link is identified between neural and self-report responses indicating that certain brain activations in response to future-framed messages and young voices predicted higher attitudes toward future-framed and young voice advertisements, respectively. The results of this study provide invaluable insight into the unconscious origin of attitudes toward environmental messages and indicate which voice and temporal frame of a message generate the greatest subconscious value.

7.1. Introduction

The growth of social problems resulting from the deterioration of the environment calls for changes in the behavior of members of society. Actions that are environmentally desirable such as lowering greenhouse gas emissions, reducing waste, and increasing clean energy and water, can only be met through higher levels of public participation (Brunson and Reiter, 1996; Mckenzie-Mohr, 2000). An approach with an outstanding potential to foster sustainable behaviors is the design of information-intensive advertising campaigns (VanDyke, Matthew, and John, 2016). Information offered to members of society or potential ecological consumers through advertising enhances awareness of environmental issues (Fraj-Andrés and Martínez-Salinas, 2007), encourages development of attitudes and intentions bolstering green consumption (Connell, Brucks, and Nielsen, 2014) and can even alter behavior (Han, Hsu, and Sheu 2010). Therefore, if designed properly, environmental messages can shape attitudes and decisions, and lead them in the direction of more responsible behaviors. Given the importance to a proper design of messages, most ecological advertising literature has focused on media features such us gain/loss framing (Tu, Kao and Tu, 2013) or message ambiguity (Leonidou, Leonidou, Palihawadana, and Hultman, 2011) on attitudes, intentions or behaviors.

A media feature typical of environmental messages is temporal framing, a concept that in this case refers to the display of an ecological message using a specific reference to time (Chandran and Geeta, 2004). In environmental communication, a future frame (FF) reveals the consequences of acting in the future for/against the environment, while a past frame (PF) emphasizes the consequences of having acted for/against the environment (Antes and Mumford 2009). Despite the importance afforded by many studies to future framing (Kees, 2011; Xu, Arpan, and Chen 2015), environmental communication research has advanced a variety of findings questioning which type of framing is more persuasive (Martin et al., 2011).

Ecological messages are habitually pronounced by voices differing in gender and age. While voice gender (male/female) has gained much interest in communication research, less attention has been paid to the question of whether the age of the voice, young (YV) or old (OV), plays a persuasive role and the current findings regarding this aspect are inconsistent (Mammarella, Nicola, Fairfield, Frisullo, and Di Domenico, 2013; Zäske, Romi, Skuk, Kaufmann, and Schweinberger, 2013).

On the whole, there is little consensus regarding the media effects (e.g. attitudes toward messages) generated by the combination of temporal frames and voice age. Furthermore, most temporal framing and voice research has resorted to self-report techniques whose application requires revision due to the problem of the introduction of biases such as social desirability (Micu and Plummer, 2010). Both of these limitations highlight the importance of studies that analyze temporal framing and voice effects conjointly reverting to techniques such as neuroimaging that accurately measure underlying processes and neural mechanisms. One of the main benefits of adopting neuroscience methods in communication research is that it sheds light on how certain media features produce specific media effects (Weber, Mangus, and Huskey, 2015). Given the potential of combining temporal framing and voice age in messages to promote responsible behavior (Trope and Liberman, 2003; Zäske et al., 2013), it is essential to identify the processes through which members of society and consumers judge media features in environmental advertising.

The aims of this paper are the following: i) test whether different brain areas are activated in response to future vs. past frames, ii) identify whether different brain areas are activated in response to young vs. old voices, iii) assess whether brain activations in response to future vs. past frame and young vs. old voice contrasts are linked to the attitude toward the messages.

To attain these aims, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that provides indirect measurements of brain activation (Poldrack et al., 2017; Solnais, Andreu, Sánchez-Fernández, Andreu Joan, 2013). The study of the frame and voice data also offers a precise blueprint of the fMRI's ability to detect differences in brain activity.

7.2. Research and Propositions

7.2.1. Future vs. Past Framing

Communication research literature is relatively unanimous regarding the effects of different message frames. Several studies (Martínez-Fiestas, Viedma del Jesus, Sánchez-Fernández, and Montoro-Rios, 2015; O'keefe and Jensen, 2016), for example, advance that messages designed with an emphasis on the positive (vs. negative) consequences of environmental responsibility generate higher persuasion. Less attention, however, is paid to temporal framing. Most communication research analyzes temporal framed messages from the standpoint of the

Construal Level Theory (Trope, Yaacov and Liberman, 2010). According to this model, the more (vs. less) distant the framing of an event, the more likely it is represented in abstract (vs. concrete) terms. This suggests that altering the framing of a message's temporal distance could systematically affect the way future events (e.g. energy savings) are construed and thus, influence evaluation, processing and decision making (Trope and Liberman, 2003; Xu, Arpan, and Chen, 2015).

As in the case of high temporal distance messages, future- (vs. past-) framed messages are more abstract and impersonal, and thought to facilitate a greater amount of active analysis in imaging how the environmental event could potentially take place (Antes and Mumford, 2009). Designing environmental messages focused on the past, in turn, triggers subjective and experiential thoughts which maximize a potential self-threat associated with past behavior. Based on this reasoning, most studies conclude that future, messages may be more persuasive. The argument is that they lead to a better execution of strategy because they facilitate a more balanced contemplation of the reflected-upon situation, they lead people to apply broader categorization schemes and simpler structures, and they relate to future personal goals (Liberman, Sagristano, and Trope, 2002; Martin et al., 2011). However, some studies of creative problem solving (Atance and O'Neill, 2001; Scott, Lonergan, and Mumford, 2005) find that past contexts provoke better solutions in participants due to the guidelines that their past experiences afford when encountering similar situations. Other research posits that future-framed messages, which fail to consider contextual information, may not be as persuasive in solving ethical/environmental problems as past-framed messages (Nokes and Ohlsson, 2005).

Neural activation during future and past-framed messages is an issue that also remains unclear (Addis, Wong, and Schacter, 2007). Wang et al. (2010) deduce that the degree of concrete processing evoked by the neural processing of factual (past and present) phrases differs from that of hypothetical (future) phrases. Most researchers agree with this reasoning and find that processing future (vs. past) messages is specifically associated with activation of the medial frontal cortex, lateral superior temporal gyri and other areas linked to imagery/simulation processes such as the lingual and calcarine areas (Gilead, Liberman, and Maril, 2013; Okuda et al., 2003; Szpunar, Watson and McDermott, 2007). Other studies, on the contrary, identify specific brain areas when evoking the past (Okuda et al., 2003; Viard et al., 2011) such as the precuneus, middle and inferior temporal gyri, angular gyrus and hippocampus.

Other research in the language processing field has gone further and identified an overlap in brain activity when exposed to both future and past phrases by both the left (L) lateral superior temporal, medial prefrontal and superior occipital areas (Demblon, Bahri, and D'Argembeau, 2016) and the medial temporal and parietal regions (Okuda et al., 2003; Schacter and Addis, 2009). This discrepancy could be due to differences in the nature of the stimulation. Gilead, Liberman, and Maril (2013), for example, when attempting to pinpoint neural differences in future vs. past thoughts, reverted to concrete and abstract phrases made up of a transitive verb in the third-person, male, singular form, while Schacter and Addis (2009) and Addis et al. (2007) urged participants to remember or imagine personal (not external or impersonal) events of the past or future. Therein lies the interest in clarifying the neural mechanisms of past and future-framed messages when using third-person impersonal sentences characteristic of environmental messages.

7.2.2. Young vs. Old Voices

The voice conveying the message is the main communication tool and can influence attitudes, intentions and behaviors (Montoya, 2000). Communication literature analyzing the media effects of certain characteristics of the voice such as gender arrive at a relatively unanimous conclusion: the male voice generates higher credibility, confidence and expertise power and, consequently, appears to be more persuasive than the female voice (Martín-Santana et al., 2015). However, no research to date has delved into the question of the media effects (e.g. attitudes toward advertisements) of voice age (Zäske and Schweinberger, 2011). To better understand media effects generated by young vs. old voices it is necessary to turn to phonetics and social psychology studies focusing on biological differences. Specifically, young voices share a higher speaking rate, intensity and projection (Harnsberger, Rahul, Brown, Rothman, and Harry, 2008), a higher variability of fundamental frequency (Glaze et al., 1988) and a higher pitch (Weger, Meier, Robinson, and Inhoff, 2007). These natural, age-linked characteristics may have relevant effects in terms of affective variations of voice quality as high-pitch tones (e.g. young voices) are commonly associated with positive emotional reactions, whereas low-pitch tones (e.g. old voices) are linked to negative responses (Rodero, Larrea and Vázquez, 2013). Other research findings indicate an increase in working memory among participants listening to the young vs. old voice (Mammarella et al., 2013). Despite these advances, the media effects such as attitudes toward persuasive messages pronounced by these different voices still remain unclear (Zäske et al., 2013).

Neither has there been a development of research directly on the neural correlates of young and old voices. Studies undertaken on neural mechanisms of high/low timbre or high/low pitch voices such as Hölig. Föcker, Best, Röder, and Büchel (2014), for instance, conclude that the superior temporal sulcus responds to acoustic differences in speech such as timbre (e.g. high timbre: young voice; low timbre: old voice). Similarly, Lattner, Meyer, and Friederici (2005) record a strong response to high-pitched voices (e.g. young or female) in the right (R) superior/anterior temporal lobe and in the Heschl's gyrus and a stronger activation in response to low-pitched voices (e.g. old or male) in the subcallosal and inferior frontal gyri. Wiethoff et al. (2008) also point out that the (para)hippocampus and the middle frontal gyri are positively associated with voice intensity (e.g. higher activation of young voices).

7.2.3. Combination of Temporal Frame and Voice Age

Different voices (e.g. old and young voices) in a typical ecological media campaign pronounce environmental messages evoking the past or future. For example, Greenpeace recently resorted to young and old male voices for the following advertisements: "By changing normal bulbs for LED bulbs, you will save more than 85% of energy" (future-framed message) and "Last year we cleaned beaches and rivers to report plastic pollution" (past-framed message). Given the conjoint presentation of the media features, it is logical to analyze the media effects created by the combination of voice age and temporal frame. Furthermore, language processing literature suggests that it is not only important to analyze how listeners process the "what" (e.g. future/past-framed) of messages, but also how they process the "who" relaying the message (Belin, Fecteau, and Bédard, 2004). In that sense, this study aims to explore the behavioral and neural mechanisms through which participants process the combination of future vs. past frames (FF vs. PF) and young vs. old voices (YV vs. OV).

Based on the main currents advanced by the literature, we formally propose:

Proposition 1: Areas in the brain linked to hypothetical thinking and imagery processing, namely the superior temporal gyrus, lingual and calcarine zones, are activated when contrasting future (FF x YV + FF x OV) vs. (PF x YV + PF x OV) past-framed messages. Areas included within the episodic system, such as the superior and middle temporal gyri, cuneus, angular gyrus and precuneus are activated, by contrast, when comparing past-framed (PF x YV + PF x OV) vs. future-framed (FF x YV + FF x OV) messages.

Proposition 2: The superior temporal sulcus, superior/anterior temporal lobe, Heschl's gyrus, (para)hippocampus and the middle frontal gyri, areas linked to high timbre, high-pitched voices and high-intensity processing, are strongly activated when comparing young (YV x FF + YV x PF) vs. old voices (OV x FF + OV x PF). In turn, areas related to low-pitched voices processing, such as the subcallosal and inferior frontal gyri, are activated when comparing old (OV x FF + OV x PF) vs. young voices (YV x FF + YV x PF).

Furthermore, given the importance from the behavioral perspective of understanding how specific brain areas can predict self-report responses (such as attitudes toward advertisements), this study also tested which brain regions activated during listening to future-past advertisements covary with individual differences in self-reported attitudes toward advertisements referring to future-past framing. Similarly, the study evaluates whether brain activations in response to young (vs. old) voices covary with the differences in attitudes toward advertisements presented by young and old voices. As in the case of previous research, we expected activation to covary in the areas most commonly linked to value such as the thalamus (Clithero and Rangel, 2014) or anterior cingulate cortex –ACC– (Bartra, McGuire, and Kable, 2013).

7.3. Materials and Methods

7.3.1. Participants

Thirty heterosexual right-handed subjects (15 women and 15 men) averaging 29.90 (SD: 9.21) years of age were selected to participate in the experiment via social networks and the institutional website of XXX University (March - May 2016). The initial survey enquired about intentions toward the purchase of environmentally friendly products by means of a seven-point Likert scale (1 = never; 7 = very often), a method that has served in other research to measure environmental behavior (Leiserowit, Maibach, Roser-Renouf, and Smith, 2011). Among the initial sampling, only the participants showing medium to high intentions toward ecological consumption (M = 5.37, SD = 1.43) were retained for reasons of control. All participants also were required to be in good health, medication-free, not afflicted by any neurological disease, not abuse drugs, and have normal (or corrected) vision and hearing. The sampling adhered to other common fMRI exclusion criteria (e.g. claustrophobia, pregnancy and metal implants in the body).

To access private medical information, the authors secured a written form from each participant following the ethical commitment consent. Before the outset of the project, the obtention of the consent, as well as the research in general, was reviewed and approved by the Vice-rector for Research and Transfer of XXX University (through the Ethics Committee of Human Research) following the protocol of the World Medical Association Declaration of Helsinki (2013).

7.3.2. Procedure

The study consisted of one session. Participants arrived at the laboratory one hour prior to the start of the fMRI task. After instruction and verification that all the study procedures were understood, the participants completed the informed consent through a questionnaire. Subjects then underwent a series of fMRI scans, including two localizer scans, a structural scan, and functional scans. Over the course of the functional scans, the participants performed a passive-viewing task asking them to pay attention to some stimuli. After leaving the scanner, participants evaluated completed a survey with a set of messages that differed in temporal frame and age of voice. At the end of the session, participants were thanked and reimbursed.

7.3.3. Experimental Design

The main objective of the experimental design was to put to test persuasive ecological audio messages in the past or future tense pronounced by young or old voices. To carry this out, the authors developed a 2 x 2 design with two independent variables (Temporal Frame and Voice Age), each containing two levels (Future Frame/ Past Frame and Young Voice/ Old Voice).

Future frame (FF) messages highlight the positive consequences of future environmentally responsible behavior (e.g. “If renewable energies are used, reserves of natural energy sources will increase”). Past frame (PF) sentences, by contrast, emphasize the positive consequences of being environmentally responsible (e.g. “If society had acted correctly, climate change effects would be lower”). It is worth noting that only the gain- (vs. loss-) framed messages were chosen for reasons of control and persuasiveness (Dimoka et al., 2015). Furthermore, all the (gain) future or past-framed messages were controlled in a pretest to refer to positive future and past frames.

The well-established higher credibility and persuasiveness of the male voice (Martín-Santana et al., 2015) led us to choose two male voices with a neutral Spanish accent: a ten-year-old (YV) and a forty-year-old (OV). The voices were recorded digitally via Adobe Audition 3.0 software at 44100 Hz, 16 Bit-Stereo. The average fundamental frequency of each speaker was arranged to compare the voices (child voice pitch: 250 Hz; adult voice pitch 120 Hz). The recordings were then equalized with the PSOLA re-synthesis function of the PRAAT speech editing software. Intensities were normalized using the Cool Edit Speech editing software. Furthermore, all auditory stimuli were filtered for ambient noise and standardized for the average root mean square (RMS) power. Then, a sound pressure level (SPL) sensation of 70 dB on an average was applied to assure comfort, intelligibility and audibility given the background noise of the scanner. Stimuli were presented via an MRI compatible sound system by electrostatic headphones with E-Prime Version 2 Professional software.

The experimental design therefore had four conditions arising from the combination of the four levels of the factors (FF x YV, FF x OV, PF x YV, PF x OV). Each condition corresponded to one future/past message pronounced by a young/old voice (between 13 and 15 Spanish words each). During scanning, the subjects were subject to a total of forty 6 s messages randomly repeated ~~3~~ three times each (with a black cross-hair on a homogenous black background screening). The messages were kept short as longer sequences are ill-advised in fMRI-hemodynamic response techniques (Schmälzle, Häcker, Honey, and Hasson, 2015). Each participant was exposed to exactly 35 messages of each category. Moreover, 61 inter-stimuli intervals (ISI; same fixation point) of the same duration were randomly intercepted between messages. Two additional 12 s baseline periods with the same fixation point were presented at the beginning and end of the task. The total paradigm duration was 20.5 min. All the messages and the experimental fMRI task can be consulted in Appendix A and Appendix B.

7.3.4. Self-report Measures

Five minutes after the scan, the participants took part in a behavioral task where they evaluated the messages under each of the four conditions. To carry this out, they were presented with the four 6 s messages viewed previously during the scanning: 1) FF x YV, 2) FF x OV, 3) PF x YV, and 4) PF x OV. All were presented in a pseudorandom order (Dale, 1999) with the variable ISIs ranging from 15 to 12 seconds. The total duration of the task was 1 min and 10 s.

After each message, the subject recorded his/her opinion on a semantic differential scale using the following five pairs of adjectives: a) non-arousing/arousing, b) non-informative/informative, c) irrelevant/relevant, d) dislike/like, and e) discourages/encourages responsible behavior. Since the preceding pairs of adjectives (except the latter) define the attitude toward an ad (Venkatraman et al., 2015), the study attempted to identify which voice ages and temporal frames generated a better attitude. The internal consistency (Cronbach's alpha) of the attitude toward the four messages measured by the five pairs of adjectives was acceptable in all cases.

Statistical analyses were performed using the IBM Statistical Package of the Social Science (IBM SPSS Version 20). Paired-Samples t-tests were set to determine whether participants showed higher attitudes toward advertisements presenting future vs. past messages, and young vs. old voices.

7.3.5. Image Acquisition and Preprocessing

Scanning was carried out with a Siemens Trio 3T MRI by descending slice acquisition and using a standard birdcage coil. Anatomical scans (T1 images) were acquired by a 3D MP-RAGE sequence using a sagittal orientation with 1 mm x 1 mm x 1 mm voxel size. Functional scans used a T2*-weighted gradient echo-planar imaging (EPI) sequence sensitive to the BOLD signal, TR = 2000 ms, TE = 25 ms, Flip Angle 90°, and a plane reduction of 3.5 x 3.5 x 3.5 mm corresponding the slice thickness. The distance factor of 20% resulted in a total of 680 slices, a slice matrix of 64 x 64 mm, and a Field of View of 238 mm with an axial orientation.

Functional data were pre-processed and analyzed using Statistical Parametric Mapping (SPM12, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) and implemented in MATLAB 2010b (Mathworks, Sherborn, MA). To avoid magnetic field saturation effects, image acquisition was preceded by seven volumes which were discarded before preprocessing. Corrections were then applied by means of interpolation with respect to the differences in the time of slice acquisition with the initial slice serving as the reference. The data in the first functional image were then realigned before the authors co-registered the functional and structural images. Next, the data were normalized according to the Montreal Neurological Institute (MNI) template using parameters defined for anatomic images. Finally, functional images were smoothed with the Gaussian kernel (7 mm FWHM). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined. The Volume Artifact tool from ArtRepair (http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html) then served to detect and repair anomalously noisy volumes. Volumes displaced more than .5mm/TR were repaired. Based on these measures, two (female) participants were excluded from the analysis because too many volumes (>30%) required repair.

7.3.6. Analysis of the fMRI Data

The following conditions were modeled using a canonical hemodynamic response function: future frame x young voice (FF x YV), future frame x old voice (FF x OV), past frame x young voice (PF x YV), and past frame x old voice (PF x OV). The rest periods (fixation points) were treated as the baseline. Six rigid body motion correction parameters were also included as nuisance covariates in the General Linear Model (GLM) implemented in SPM12. Data were high-pass filtered with a cutoff of 128 s.

- *Whole-brain Analysis*

On the first level (single subject analysis), the following contrasts were generated: i) future (FF x YV + FF x OV) vs. past (PF x YV + PF x OV) frames, and the reverse, and ii) young (YV x FF + YV x PF) vs. old (OV x FF + OV x PF) voices, and the reverse. On a second level, one-sample t-tests were carried out to examine the significant brain activation of the group during the contrasts mentioned above. The cp_cluster_Pthresh (https://goo.gl/kjVydz) tool was used to set the cluster extent threshold at a meaningful value. This tool offers a non-arbitrary, uncorrected threshold and cluster extent equal to a $p < 0.05$ corrected for multiple comparisons (FEW) across the whole brain. In this case, the threshold resulted in values of $p < .001$ with a cluster (*k*) 40. A more liberal threshold was applied given the exploratory nature of the analysis, as well as for completeness and future meta-analyses with a threshold of $p < 0.001$ uncorrected with a cluster extent of 5 and 10 voxels. Interaction effects between temporal frames and voice ages (e.g. FF x YV vs. FF x OV) were not modeled since the resulting brain activations only refer to the different condition (e.g. a contrast that would be similar to YV vs. OV).

- *Covariate Analysis*

To explore the brain regions where future framing activation ~~relates~~ is linked to the rating of attitudes toward future (vs. past) combinations, the contrast image of the future (FF x YV + FF x OV) vs. past (PF x YV + PF x OV) was entered into a one-sample t-test and the difference between the rating of attitude of future framing combinations (At future), and the scores given to the past framing (At past) combinations serving as a covariate. We proceeded in similar fashion to assess if brain regions related to young vs. old voices covaried with the difference of the rating between young voice combinations (At young) and the ratings of the old voice (At old) combinations.

7.4. Results

7.4.1. Self-report Results

A paired-samples t-test showed significantly higher attitudes toward advertisements presenting future (FF x YV + FF x OV) as opposed to past (PF x YV + PF x OV) frames (t (1, 28) = 2.76, p = .01), as well as those pronounced by young (YV x FF + YV x PF) compared to old (OV x FF + OV x PF) voices (t (1, 27) = 3.95, p = .001) (Figure 41).

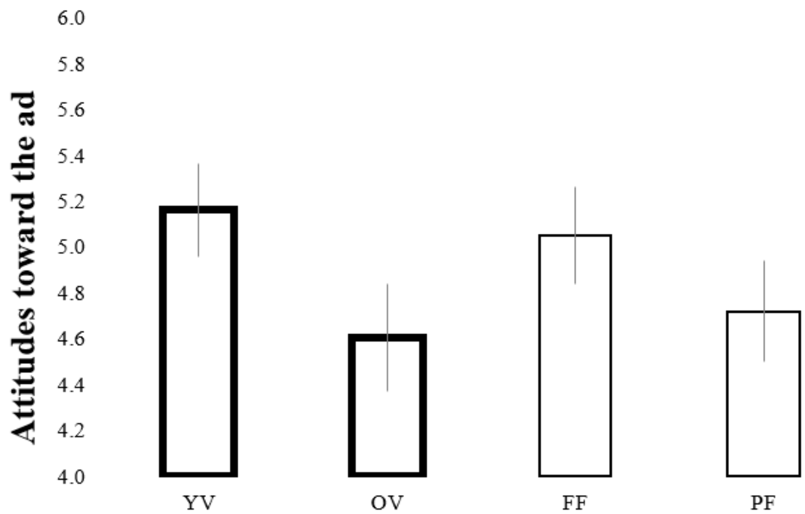

Figure 41. Results of the paired samples t-tests. y-axis: Attitude toward the persuasive advertisements; x-axis: young voice (YV), old voice (OV), future frame (FF) and past frame (PF) combinations. Advertisements pronounced by young voices generated higher attitudes than old voices (t (1,27) = 3.95, p = .001). Advertisements presenting future-framed messages also yielded higher attitudes compared to the past-framed advertisements (t (1,27) = 2.76, p = .01). Standard Deviation is presented.

7.4.2. Functional Imaging Results

- *Future and Past Frame Contrasts*

Clusters in the bilateral superior temporal gyri, R lingual gyrus, L calcarine, L thalamus and R middle frontal gyrus were more strongly activated when comparing future-framed (FF x YV + FF x OV) vs. past-framed (PF x YV + PF x OV) advertisement messages. Conversely, the bilateral middle temporal gyri, the R pre(cuneus) and the L angular gyrus were activated more significantly by past rather than future messages. All results were thresholded at p = .001 uncorrected. See the results in Figure **35**Figure 42 and peak coordinates in Table 14.

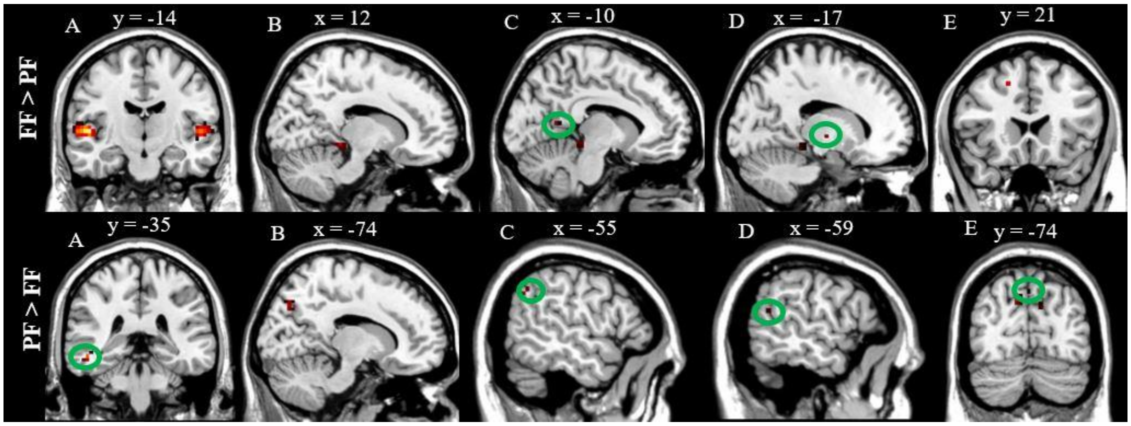

Figure 42. Brain regions activated more strongly in response to future-framed vs. past-framed messages (FF > PF) and past-framed vs. future-framed messages (PF > FF). The upper part of the figure shows a T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.6$), superimposed on the mean anatomical image of all subjects (MNI-space). A: R and L superior temporal gyri; B: R lingual; C: L calcarine; D: L thalamus; E: R middle frontal gyrus. The lower part shows a T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.7$), superimposed on the mean anatomical image of all subjects (MNI-space). A: R middle temporal gyrus; B: R cuneus; C: L angular; D: L middle temporal gyrus; E: R precuneus. See corresponding peak coordinates in Table 14.

Table 14. Brain regions with stronger activation in response to future-framed (FF x YV + FF x OV) vs. past-framed (PF x YV + PF x OV) messages. Brain regions are activated differently in response to past-framed (PF x YV + PF x OV) vs. future-framed messages (FF x YV + FF x OV).

Brain region	**Peak (mm)**	**MNI-coordinates**		**Z**	**T**	**Effect Size** [d]
	x[b]	**y**[b]	**z**[b]			
FF vs. P F						
R superior temporal [a]	50	-14	4	01.05.50	7.57	1.04
L superior temporal [a]	-48	-21	4	4.87	6.24	.92
R lingual [b]	12	-35	-7	3.85	4.49	.73
L calcarine [b]	-10	-56	11	3.47	3.94	.66
L thalamus [b]	-17	-11	0	3.33	3.75	.63
R middle frontal [b]	19	21	46	3.22	3.59	0.61
PF vs. FF						
R middle temporal [c]	50	-35	-11	4.02	4.76	0.76
R posterior cuneus [c]	12	-74	39	3.60	4.13	0.68
R posterior precuneus [c]	1	-74	46	3.16	5.51	.60
L angular [b]	-55	-60	35	3.48	3.95	.66
L middle temporal [b]	-59	-53	18	3.31	3.71	.63

[a] Peak of clusters significant at $p < .001$ uncorrected, $k \geq 40$ voxels are reported.

[b] No clusters survived at $p < .001$, $k \geq 40$. Peak of clusters significant at $p < .001$, $k \geq 5$ voxels are reported.

[c] No clusters survived at $p < .001$, $k \geq 40$. Peak of clusters significant at $p < .001$, $k \geq 10$ voxels are reported.

[d] Effect Size = $Z/\sqrt{N}$

- *Young and Old Voice Contrasts*

The findings indicate, on an average, that the superior temporal, R Heschl's gyrus, L parahippocampus, L medial superior frontal, R anterior cingulum cortex, postcentral, hypoccampus and amygdala areas are significantly more active while subject to ecological messages conveyed by young (YV x FF + YV x PF) as opposed to old voices (OV x FF + OV x FF). The R precentral, L cerebellum and R inferior frontal triangulum gyri, by contrast, are strongly activated by old (vs. young) voices pronouncing environmental messages. All results are thresholded at p = .001 uncorrected. See results in Figure 43 and Figure 44 and peak coordinates in Table 15.

Table 15. Brain regions with stronger activation in response to a young voice (YV x FF + YV x PF) vs. an old voice (OV x FF x OV x PF). Brain regions are activated differently in response to the old voice (OV x FF x OV x PF) vs. the young voice (YV x FF + YV x PF).

Brain region	**Peak MNI-coordinates (mm)**			**Z**	**T**	**Effect Size** [c]
	x[b]	**y**[b]	**z**[b]			
YV vs OV [a]						
L superior temporal gyrus	-52	-35	7	4.94	6.37	.93
R Heschl' s area	40	-25	11	5.56	7.70	1.05
L parahippocapus	-34	-18	-21	4.44	5.45	.84
L medial superior frontal	-13	42	42	4.18	5.02	.79
R anterior cingulum	1	25	-7	4.13	4.93	.78
R postcentral gyrus	36	-28	42	4.12	4.92	.78
R hippocampus	19	-7	-21	4.10	4.89	.77
R amygdala	26	0	-21	3.70	4.27	.70
OV vs YV [b]						
R precentral	50	7	18	4.01	4.74	.76
L cerebellum	-24	-77	-53	3.32	3.73	.63
R inferior frontal triangulum	47	49	7	3.21	3.58	.61

[a] Peak of clusters significant at $p < .001$ uncorrected, k ≥ 40 voxels are reported.

[b] No clusters survived at $p < .001$, k ≥ 40. Peak of clusters significant at $p < .001$, k ≥ 5 voxels are reported.

[c] Effect Size = $Z/\sqrt{N}$

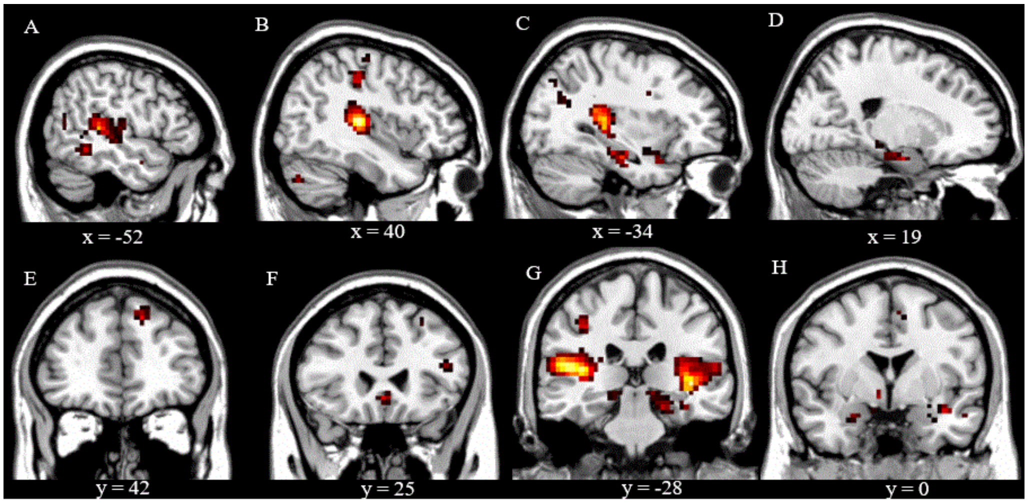

Figure 43. Brain regions with stronger activation in response to YV vs. OV. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 4.2$), superimposed on the mean anatomical image of all subjects (MNI-space). A: L superior temporal gyrus; B: Heschl's gyrus; C: L parahippocampus; D: R hippocampus; E: L medial superior frontal; F: R anterior cingulum; G: R postcentral gyrus; H: R amygdala; See corresponding peak coordinates in Table 15.

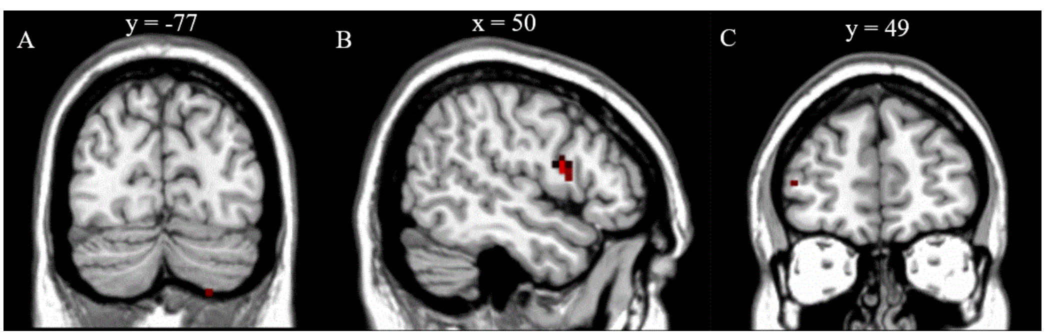

Figure 44. Brain regions with stronger activation in response to OV vs. YV. T-map thresholded at $p < .001$ uncorrected for multiple comparisons ($T > 3.5$), superimposed on the mean anatomical image of all subjects (MNI-space). A: L cerebellum; B: R precentral; C: R inferior frontal triangulum. See corresponding peak coordinates in Table 15.

- *Association Between Neural Responses and Attitudes Toward Advertisements*

The difference between the scores of attitudes toward future- and past-framed messages covary significantly as evidenced with the activation of the R cerebellum (r = 0.593, p = .001), L cerebellum (r = 0.617, p < .001), R fusiform (r = 0.545, p = .003), R thalamus (r = 0.535, p = .003) and L middle occipital areas (r = 0.539, p = .003). Thus, participants who give higher ratings to future-framed messages show significantly stronger activation in these areas during future (vs. past) periods. Similarly, activation in the inferior (r = 0.348, p = .069) and middle (r = 0.467, p = .012) temporal gyri, as well as the ACC areas (r = 0.422, p = .025), are strongly (positively) associated with the differences in scores between attitudes toward messages pronounced by young and old voices. Therefore, participants who give the young voice a higher rating revealed more activation in those regions during young vs. old voice contrasts. See the main results plotted in Figure 45 and Appendix C for all MNI peak coordinates.

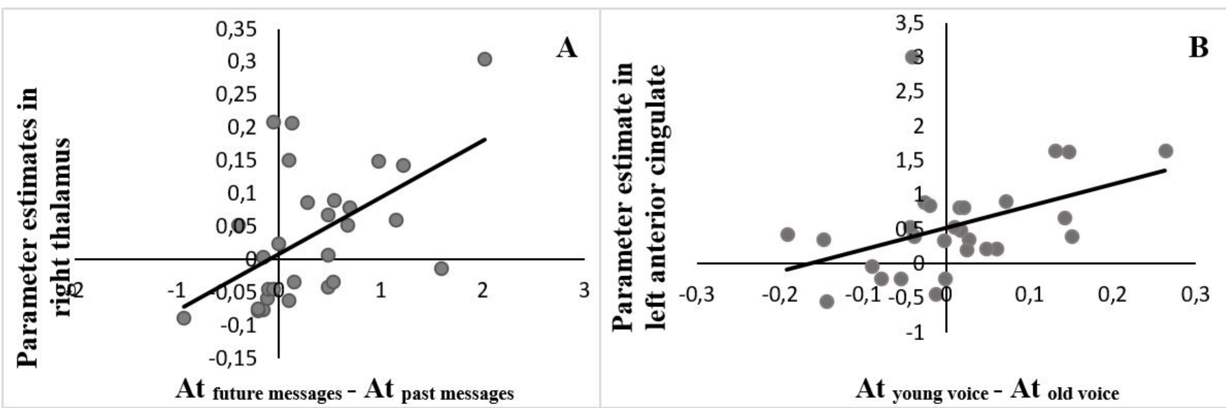

Figure 45. Covariation between neural activation and attitudes toward advertisements. (A) Plot showing the correlation between parameter estimate future- vs. past-framed messages in the right thalamus cluster and the attitude toward advertisements that present future (vs. past) messages. (B) Plot showing correlation between the parameter of young vs. old voices in the left anterior cingulate cluster and the attitude toward advertisements pronounced by a young (vs. old) voice.

7.5. Conclusions

This is the first study linking brain activation and self-report responses to persuasive ecological advertisements applying temporal framing and the age of the voice conveying the message. At the behavioral level, the findings clear up the discrepancy regarding the media effects generated by temporal framing and voice ages, and point to higher attitudes toward environmental advertisements with future framing pronounced by the young voice. At the brain level, the study characterizes a different set of regions in the brain activated by future as opposed to past-framed messages, and young as opposed to old voices and indicate that these are elements that are critical in processing persuasive ecological messages. Furthermore, the study identifies a link between neural and behavioral responses indicating that certain brain activations in response to future-framed messages or young voices covary, respectively, with attitudes toward future and young voice advertisements.

As regards the self-report responses, the current work infers higher attitudes toward advertisements with future-framed messages pronounced by young voices. These findings support the conclusions of other studies (Liberman, Sagristano, and Trope, 2002; Martin et al., 2011) and point to a higher effectivity of ecological messages when designed with an emphasis on the future (vs. past) repercussions of being environmentally responsible. Moreover, this study makes headway in this field of research by evidencing that young voices are more persuasive than old ones in ecological advertising as they do not only provoke a higher working memory (Mammarella et al., 2013), but generate higher attitudes toward the messages.

At the neural level, brain regions eliciting stronger activation during future- vs. past-framed messages include the middle frontal gyrus and bilateral superior temporal areas, the thalamus, and certain areas linked to visual processing. The middle frontal gyrus is thought to play a key role in temporal frame processing as a number of studies have pointed to an increase in activation of this area during the construction of both potential future scenarios and recollection of past events (Addis et al., 2007; Benoit, Szpunar, and Schacter, 2014; Demblon et al., 2016; Szpunar, Chan, and McDermott, 2009; Szpunar et al., 2007). Others, nonetheless, associate activation of this region with prospective memory where the intended action to be remembered occurs in the future (Burgess, Scott, and Frith, 2003). In that line, certain studies point to activation of the middle frontal gyrus in the processing of hypothetical sentences (Gilead, Liberman, and Maril, 2013) and thinking of the future (Fellows and Farah, 2005; Okuda et al., 2003). The findings of this paper support this last reasoning and reveal a specialization of the middle frontal gyrus not only in imaging the future, but also in processing persuasive messages encouraging future sustainable behavior.

Although bilateral superior temporal activations are observed during both remembrance of the past and pondering the future (Addis et al., 2007; Okuda et al., 2003), Burgess, Gonen-Yaacovi and Volle (2011) identify a specific co-activation of this area by the middle (pre)frontal gyrus when imaging the future. In the current study, nonetheless, activation of the bilateral superior temporal gyri only occurs during future- (vs. past-) framed messages. This finding supports the notion that this area, together with the middle frontal gyrus, is involved in prospective memory and future-framed message processing.

The thalamus is widely considered an area within the episodic system (Aggleton, and Brown, 2006; Carlesimo, Costa, Serra, Bozzali, Fadda, and Caltagirone, 2011) responsible for memories of past personal events. In this current study, unexpected thalamic responses to future (vs. past) phrases could reveal a contribution of the episodic system (imaging responsible past behaviors, for example) in the processing of persuasive future messages, in line with the work of Addis et al. (2007). This suggests an influence of past behavior and memories when processing messages aimed at encouraging responsible future behavior, which means that how responsible society was in caring environment in past influences processing of persuasive future messages. The current study also singles out activation in the calcarine and lingual gyri in the comparison of the future vs. the past. These areas are most commonly associated with visual imagery (Ishai ,2002; Lang et al., 1998; Rosenbaum, Sy, Pavlovich, Leibel and Hirsch, 2008). Its activation while exposed to future- (vs. past-) framed advertisements concurs with other studies (Gilead et al., 2013; Szpunar et al., 2009) and could highlight a higher tendency to imagine when thinking about the future in relation to past events.

Contrary to the conclusions of some studies that identify a common set of regions in past and future message processing (Demblon et al., 2016; Schacter and Addis, 2009), the current findings reveal specific brain responses to past vs. future advertisements in the bilateral middle temporal gyri, cuneus, precuneus and angular gyri. Together with the thalamus, the middle temporal gyrus and the posterior (pre)cuneus areas play a critical role in encoding episodic (counterfactual) thinking (De Brigard, Addis, Schacter, and Giovanello, 2013; Haut et al., 2015). Furthermore, Okuda et al. (2003) identify such activations when analyzing recall of past (vs. future) events. The current findings also agree with previous studies (Abraham, Schubotza and von Cramon, 2008; Sestieri, Corbetta, Romani and Shulman. 2011) indicating a strong link between angular gyrus activation and episodic memories. Taken together, the results of this paper bolster Proposition 1 and suggest the involvement of the episodic system not only in imaging future behaviors (through the thalamus), but in processing past ecological messages (through the middle temporal gyrus, cuneus and angular areas).

Different clusters of activation, in line with Proposition 2, are observed in the contrasts between young vs. old voices and old vs. young voices. Specifically, in the first case, the superior temporal gyrus, (para)hippocampus areas, Heschl’s gyrus, medial superior frontal gyrus, postcentral gyrus, ACC and amygdala are strongly activated. Superior temporal and Heschl’s gyrus areas are associated with high-timbre and high-pitched voices, as in the case of young voices (Lattner et al., 2005), while (para)hippocampal and middle frontal regions are positively correlated with voice intensity (e.g. young voices, Wiethoff et al., 2008). Therefore, activations of these areas while the subject listens to young (vs. old) voices strongly supports the involvement of those regions in processing high-timbre, high-pitched and high-intensity voices.

Contrary to expectations, activations in the postcentral, ACC and amygdala areas are recorded when comparing young vs. old voices. On the one hand, some fMRI studies analyzing emotional speech found postcentral activations when comparing female vs. male voices (Weston et al. 2015). Since female voices (like young voices) have a higher timbre and pitch than male voices (like old voices), it is reasonable to identify activation of the postcentral gyrus in young vs. old voices. On the other hand, a large amount of neuroimaging literature provides invaluable insight into the roles of the ACC and amygdala in assessing the salience of emotional and motivational information and the regulation of emotional responses (Drevets and Raichle 1998; Vogt, Finch, and Olson 1992). Although it is necessary to remain prudent when arriving at inverse inference conclusions (Poldrack et al. 2017), activations of the ACC and the amygdala could reflect a higher relevance of ecological messages conveyed by young as opposed to old voices.

Furthermore, contrasts of the old vs. young voice result in the strong activation of areas in the brain including the inferior frontal gyrus, precentral and cerebellum. These results partially support the findings of Lattner et al. (2005) indicating that low-pitched voices (male or old) are processed in the inferior frontal gyrus. The cerebellum and precentral areas have previously been associated with voice gender perception (Joassin, Maurage, and Campanella, 2011; Pulvermüller et al., 2006). Taken together, our findings indicate that these areas are also responsible for encoding the differences of age of the voice, revealing a higher activity linked to old as opposed to young voices.

The final goals of this paper are to determine the brain regions where future messages and young voice activation predicts attitudes toward future (vs. past) and young (vs. old) combinations. The current findings reveal that participants conferring higher scores to the advertisements that present future messages show stronger activation during future (vs. past) periods in some regions of the brain including the bilateral cerebellum, R fusiform, R thalamus and L middle occipital gyrus. Interestingly, the R thalamus is included as an area within the “valuation system” and, therefore, is responsible for encoding the subjective value signal and potentially contributing to value-based decision making (Bartra, McGuire and Kable, 2013; Clithero and Rangel, 2014). Moreover, this area is shown to correlate with choices leading to later rewards (Sripada, Sekhar, Gonzalez, Phan, and Liberzon, 2011) and relevant phrase evaluations (Schiller, Freeman, Mitchell, Uleman, and Phelps, 2009). The stronger right thalamus activation in this study may reflect a higher subjective value and preference for future- (vs. past-) framed ecological advertisements, thus revealing the significance of these messages on increasing attitudes toward ecological messages.

Similarly, the higher ratings given to messages pronounced by young voices and the higher activation in the R inferior temporal, L ACC and R middle temporal gyri are in line with the expectations of Proposition 2. Interestingly, the ACC is associated with computing the subjective value (Bartra et al., 2013) and encoding predictive reward value (Kennerley, Behrensand and Walli, 2014). In fact, several studies link ACC activation with i) choices involving large gains and rewards (Rogers et al. 2004) and ii) the degree of reward expectancy (Brembs, Björn, Lorenzetti, Reyes, Baxter, and Byrne, 2002). Altogether, the higher ACC activation could well be related to higher rewards and subjective values generated by young (vs. old) voices conveying persuasive ecological messages.

It is noteworthy that participants while inside the scanner did not take part in any specific task besides paying attention to the stimuli. To better understand the neural correlates linked to processing audiovisual advertisements, it is advisable to examine neural activation as participants come to active decisions during scanning about future/past ecological advertisements conveyed by either young or old voices. Secondly, the findings indicate links between neural brain activation and attitudes toward the advertisements. Although it is widely accepted that increasing the attitudes toward messages may be a precursor of higher intentions to act according to the advertised behaviors (Ajzen, 1991), future research should link neural responses to intentions or actual responsible behaviors to better understand which brain areas predict actual behaviors or preferences. Thirdly, the findings of this paper should be taken with caution because of a participation limited only to subjects with medium to high intentions toward ecological consumption.

Despite these limitations, this study constitutes a preliminary step in advancing the understanding of consumers' neural and self-report responses to persuasive future/past-framed messages pronounced by young/old voices. In line with other research, the current findings reveal that young voices and future-framed messages increase attitudes toward environmental advertisements. This project is the first to shed light on neural responses to temporal-framed messages combined with voice age in ecological messages. The findings are the following: i) areas of the brain related to imagery, prospective memories and episodic events are strongly activated when subject to future- (vs. past-) framed messages, ii) past (vs. future) messages elicit activations within the episodic system; iii) young voices (YV) elicit stronger activation in areas linked to processing high-timbre, high-pitched and high-intensity voices; iv) areas previously associated with low-pitched voices and voice gender perception are strongly elicited by messages pronounced by older voices (OV). Furthermore, this study singles out that both the right thalamus response to future-framed messages and the ACC response to young voices reflect more positive attitudes toward environmental advertisements. Finally, future fMRI studies could attempt to make sense of unresolved problems in environmental advertising literature such as the proper level of assertiveness (Baek, Yoon and Kim, 2007; O'Keefe, 1997) or degree of specificity (Leonidou et al., 2011; Mendleson y Polonksi, 1995) of messages.

Theoretically, our findings contribute to the literature of the challenges to create persuasive messages or public service announcements (PSAs) to discourage undesirable behaviors such as residential energy waste (Xu, Arpan, and Chen, 2015) or avoiding purchase of unsustainable food (Hanss, and Böhm, 2013; Miranda-Ackerman and Azzaro-Pantel, 2017) and cigarettes (Fish, Peters, Ramsey, Sharplin, Corsini, and Eckert, 2017). This study clarifies the conjoint effects of very common elements in messages aiming to encourage environmental and planet care in future such as temporal framing and voice age. Furthermore, it constitutes a new step in the application of neurological tools to analyze processing environmental messages. Previous fMRI research has compared the neural effects of pro-environmental and non-environmental advertisements (Vezich, Gunter, & Lieberman, 2017) and analyzed the neural correlates of gain/loss frame (Vezich, Katzman, Ames, Falk, and Lieberman, 2016). This research goes further and sheds light on the neural responses to new (and little studied) environmental advertising elements of great potential such as temporal frame and voice age, which, furthermore, are very common to find together in practice. Finally, this paper also clears up previous inconsistent results regarding brain activity when exposed to both future and past messages (Okuda et al., 2003; Schacter and Addis, 2009). By controlling the type of sentence (third-person impersonal sentences), this research identifies different brain mechanisms toward future and past messages. Furthermore, this research confirms for the first time that young voices are indeed processed as more pitched, with higher intensity and more emotion than old ones.

The findings of this paper have remarkable managerial implications as they suggest that environmental messages relative to the future (and not the past) pronounced by young voices (not old) not only increase attitudes toward advertisements, but gain more subconscious relevance and appear to be more emotional. Higher subconscious emotions, relevance and attitudes toward ecological advertisements could be further translated into higher responsible attitudes or behaviors. Therefore, professionals of companies that market environmentally responsible products/ideas, as well as governments or environmental associations, should design their advertising campaigns evoking the future with messages pronounced by young voices.

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Appendices

Appendix A

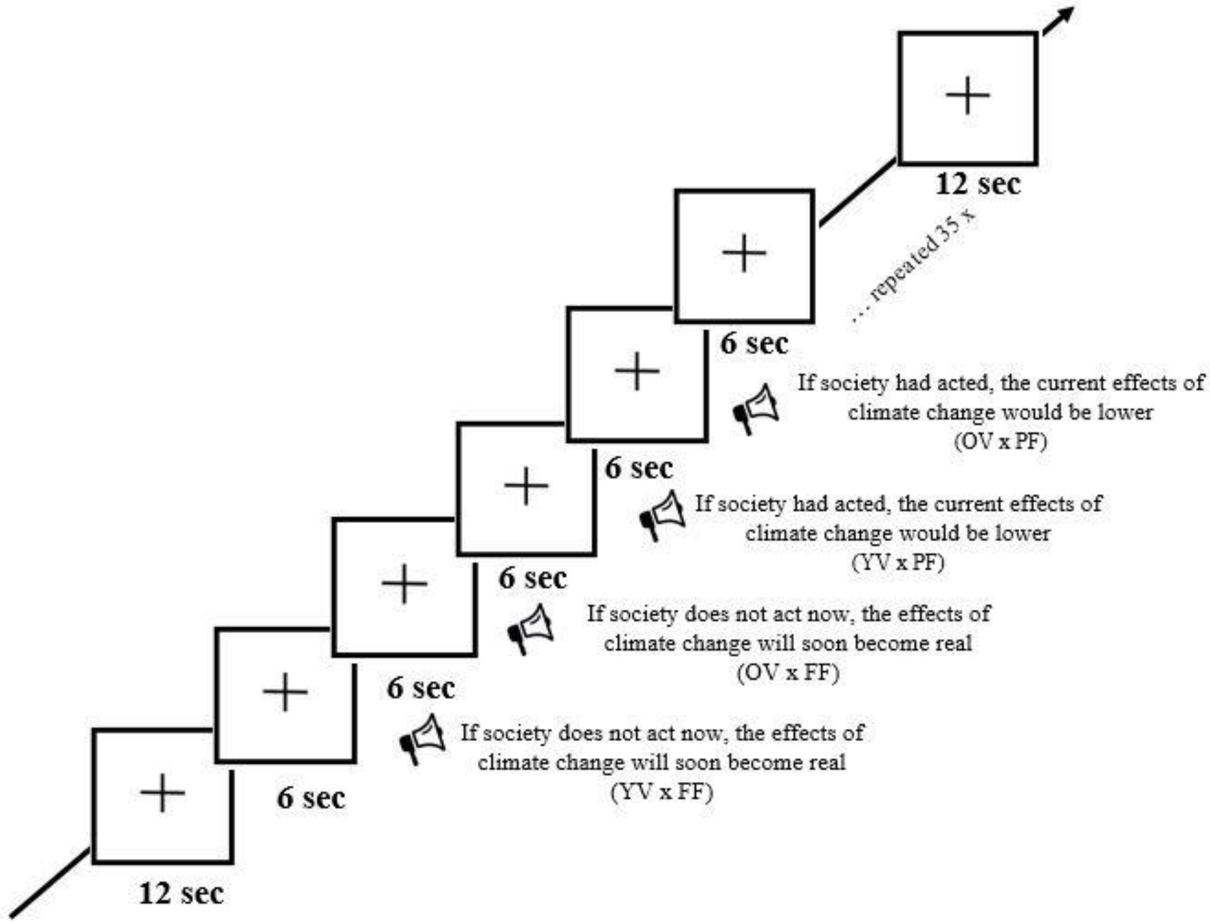
Table 1A. List of messages presented during the fMRI task

Future Framing
If society does not act now, the effects of climate change will soon become real.
If contamination of the ecosystems is halted, many species of the Arctic will return to their home.
Reducing levels of toxicity will significantly improve water and air quality.
Using fewer disposable products will reduce the need for new landfills.
Pamper the planet responsibly is the guarantee of it sustainability for future generations.
Reserves of natural energy sources will increase if renewable energies are used.
Children will breathe and drink more healthily if public transport is used.
Humans will reduce the holes in the ozone if less carbon dioxide is emitted
Turning of the switches off during sleep will reduce the intensity and frequency of fires.
Oceans of the future will be more vivid and clean if canned beverages are avoided.
Disposing trash in appropriate containers will improve the planet's fauna and flora.
If companies act responsibly they will reduce sub-tropical diseases.
The intensity of heat waves will be significantly reduced if LED bulbs are used.
Using water treatment plants will reduce the variability of the supply of water resources.
The creation of environmental awareness will reduce desertification and global salinization.
Halting the use of phytosanitary products will make the world a less harmful place.
2 million more children will live annually if the use of non-rechargeable batteries is minimized.
Refilling more biodiesel and less diesel will decrease the number of circulatory diseases.
Using recycled clothing will reduce the number of pollutant emissions into the atmosphere
A rational use of water will assure its supply in the coming decades.

Past Framing

If society had acted, the current effects of climate change would be lower.
If recycled paper had been used, there would be 13 million more hectares of forest.
A multitude of species would have been preserved if garbage had not been thrown into public areas.
In the world, there would be more forests if there had been more environmental awareness.
If ecosystems had been cared for, migrations would have followed their biological course.
Today's sea level would be stable if toxic emission had been lower.
Consuming fewer transgenic organisms would have reduced diseases and epidemics.
Natural resources would not have been depleted if there had been investment in ecological education.
Being responsible would have saved 1 kilo of toxic gas for every 3 kilometers of bike.
Cultivating the land with natural fertilizer would not have reduced the profitability of the herds.
There would be fewer respiratory illnesses if more public transport had been used.
There would be fewer hurricanes and tornadoes if biodiversity had been protected.
Fair business practices would not have increased the intensity and frequency of rains.
The current quality of life would be higher if renewable energy had been chosen
The reduction of toxic emissions would have slowed the melting of polar glaciers.
If more recycled paper had been used, many gallons of oil would have been saved.
The use of LED bulbs would have produced annual electrical savings in families.
Greater social ecological awareness would have increased recycling and reuse.
A greater purchase of organic products would have improved health.
Preserving biodiversity in the past would have maintained indigenous species.

Appendix B.



Representation of the experimental design during the fMRI task. The order corresponds to the first group of four trials. The conditions (FF x YV, FF x OV, PF x YV and PF x OV) are presented in random order in the subsequent 34 repetitions.

Appendix C

Main peak activation in covariation analysis. (1) Brain regions in which activation covaries greatly in attitudes toward future- (FF x YV + FF x OV) and past-framed (PF x YV + PF x OV) messages. **(2)** Brain regions in which activation covaries greatly in attitudes toward messages presented by young (YV x FF + YV x PF) and old (OV x FF + OV x PF) voices.

Brain region	**Peak MNI-coordinates (mm)**			**Z**	**T**	**Effect Size** [c]
	x[b]	**y**[b]	**z**[b]			
i) **FF vs PF** [a]						
R cerebellum	8	-74	-11	4.65	5.89	.88
L cerebellum	-10	-53	-18	4.62	5.83	.88
R fusiform	33	-63	-7	4.07	4.88	.80
R thalamus	22	-18	0	3.77	4.40	0.71
L middle occipital gyrus	-38	-81	4	3.55	4.07	0.67
ii) **YV vs OV** [b]						
R inferior temporal gyrus	40	-11	-21	3.36	3.81	0.63
L anterior cingulum gyrus	-17	35	25	3.23	3.63	0.61
R middle temporal gyrus	50	-46	7	3.21	3.59	0.61

[a] Peak of clusters significant at $p < .001$ uncorrected, $k \geq 20$ voxels are reported.

[b] No clusters survived at $p < .001$, $k \geq 20$. Peak of clusters significant at $p < .001$, voxel level are reported.

[c] Size effect = $Z/\sqrt{N}$

8

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A NEUROPSYCHOLOGICAL STUDY ON HOW CONSUMERS PROCESS RISKY AND SECURE E-PAYMENTS

Casado-Aranda, Luis-Alberto; Liébana-Cabanillas, Francisco & Sánchez-Fernández, Juan.

Dependable online payment systems (e-payments) are fundamental in promoting future online purchases. Yet little research has focused on either the differences between secure and risky e-payments or consumer reactions to the different systems. This study reverts to neuroscience (fMRI) to i) identify the neural effects pertaining to risky and secure e-payments and ii) reveal the underlying brain mechanisms when confronted with two widespread systems: debit cards and Paypal. Thirty subjects participated in an experiment simulating a low-involvement online purchase. The analysis reveals that perceived risky e-payments activate brain areas linked to negative emotional processing, while areas involved with reward prediction are strongly triggered by secure e-payments. Furthermore, the study not only reveals a greater intention of use toward Paypal, but sees it as more secure, rewarding and affective. Debit card e-payments, by contrast, elicit brain activations associated with negative and risky events. Interestingly, the right cerebellum response (responsible for value encoding) covaried with more positive use intention toward Paypal. These results offer invaluable insight into the unconscious origin of the choice of payment systems among consumers.

Abbreviations:

fMRI: functional Magnetic Resonance Imaging

8.1. Introduction

The current commercial market organization and offer has progressively changed due to the technological revolution of the last years of the 20th century. The last two decades have seen the creation of new options for consumers to save time and money, and benefit from a variety of improved services linked to the introduction of the new tools of information and communication (Vroman et al. 2015). Information and Communication Technologies (ICTs) and the adoption of the Internet by business has facilitated both the use of institutional networks (such as Facebook or Twitter) as well as the emergence of the electronic commerce (e-commerce).

The American Marketing Association (2016) defines e-commerce as the wide variety of Internet-based business models which incorporate elements of the marketing mix to guide users to a website with the purpose of purchasing a product or service. Online shopping today provides consumers with the tremendous advantages of accessibility on an ongoing basis, a wide variety of high-quality information, a face-to-face relationship with producers, effortless price comparison, as well as great ease in establishing an immediate communication with the firms (Chiou & Ting 2011). Furthermore, a growing number of consumers are currently reverting to online systems to seek pre-purchase information and purchase products (Oliveira et al. 2017).

With the rapid growth of shopping through the Internet, online consumer behavior has emerged as a major area of research in various scientific disciplines such as psychology, marketing, and Information Systems (IS). While many of the early studies in these disciplines focus on how consumers adopt and apply online shopping (e.g. Hansen 2005; Moon 2004), more recent research has focused on purchase and online repurchase behavior (e.g. Chen et al. 2016; Hsu et al. 2014). In this framework, a fundamental process necessary to complete economic transactions on the Internet is online payment, defined as the transfer of an electronic value of payment from a payer to a payee through an e-payment mechanism (Lim 2008). However, the scientific community has paid little attention to its effects on consumer's attitudes and behavior.

With the development of e-commerce, there is an ongoing transformation of payments from brick-and-mortar retailers to online systems. As a result, a large number of online payment systems (e-payments) have been developed using debit/credit cards and virtual payment systems or e-wallets (e.g. Paypal). Perceived risk has been proposed as the main determinant of consumer payment system choice. Yet only a few papers have focused on the effects on consumers of risky and secure e-payments, neither on the perceived risk associated with different online payment systems such as debit card systems vs Paypal (Yu, Hsi, & Kuo 2002; Yang et al. 2015). Furthermore, no research in this field to date has resorted to neuropsychological tools that are more appropriate for investigation as risk perception is associated with unconscious and automatic information processing mechanisms that cannot be addressed easily through self-reports (Dimoka 2010). The present study thus constitutes a first step in this direction as it investigates neural responses to risky and secure online payment systems, as well as the underlying neural and self-reported mechanisms linked to two e-payment methods: debit cards and Paypal.

8.2. Literature review

8.2.1. Online payment systems

Numerous classifications are currently being put to use in the analysis of e-payments (Liébana-Cabanillas et al. 2016). The main classification criteria are 1) the moment the payment is submitted (Business Model: Ramezani 2008), 2) the type of payment validation (Wang & Yuan 2010), 3) the nature and medium of the relations (Ondrus & Pigneur 2006; 2007), and 4) the transaction transfer formula (Ruiz 2009). The current study focuses on the last and most widespread of these criteria, and distinguishes between “credit and debit systems” and “virtual payment systems.”

Credit and debit systems are founded on the consumer use of a bank card for transaction payments. The amount of a purchase in a debit card transaction is withdrawn from the available balance of the cardholder’s account. If the available funds are insufficient, the transaction is not completed (except where an overdraft option is in place). In the case of credit cards, the expense is assumed directly by the bank allowing the consumers to maintain a balance of debt subject to interest charges. Two important issues associated with debit systems are security and privacy, as consumer transaction records can be tracked through their debit cards (Yu, His, & Kuo 2002).

Virtual payment systems or e-wallets, in turn, use a customer account within a general system which is linked to a bank or card account necessary for the payment. This paper focuses on the most widespread wallet, namely Paypal (Worldpay 2016) which is the general term for a PayPal account where customers link bank accounts or credit or debit cards. The PayPal system is what is known as a "staged" wallet, meaning that it processes a transaction in two stages. It first collects money from the purchaser before remitting it to the business without necessarily passing along card details to the issuer or the credit card network. Paypal therefore constitutes a quickly growing payment alternative as the system is considered by itself as secure and offers consumers choice and convenience since they can either revert to stored value or take funds from a payment type linked to Paypal (Yu, His, & Kuo 2002). Accordingly, the perception is that Paypal could be a safer, more protective of data and more convenient than debit cards (Sukoco 2012). Debit cards, in turn, could be easier to use (Suhuai et al. 2010). Table 16 presents a rapid listing of the differences between debit cards and Paypal, the two e-payments in which this work is targeted.

Table 16. Comparison of the characteristics of debit card and Paypal payment systems.

Characteristic	Debit card	Paypal
Privacy	Poor: uses actual card number to make transaction. Risk of data theft	Good: uses only Paypal account number without revealing card number on the Internet
Authority	Good: card number and PIN serve to check identity	Good: Paypal account number / mail and PIN serve to establish identity
Bank Account Involvement	Debit card account makes the payment	No involvement as Paypal makes the payment
Users	Any legitimate debit card user	Anyone with a Paypal account and a bank or debit/credit bank account
Real / Virtual World	Can be used in real and virtual worlds	Can be used in real and virtual worlds
Current Degree of Popularity	17% of transactions around the world	31% of transactions around the world
Consumer transaction risk	Medium: appears to be vulnerable to fraud and identification theft	Low: only Paypal account number is vulnerable to fraud
Ease of using	Very easy, only card number and PIN is necessary	Great ease as only an active Paypal account is necessary without using bank information. Yet there are difficulties among low-experienced users
Speed of transaction	Limited to time necessary for filling out card information	Limited to time of "acceptance" of the payment (if client possesses a Paypal account)
Cost of transaction	Regular debit card transaction costs paid by buyers	Apart from regular debit card costs, a fee is paid in general by the seller to Paypal and no fees to the customer. However, at times the seller charges a fee to the consumer

Note: "Privacy" refers to the protection of information sent via Internet and to prevention of unauthorized personnel or company employees from accessing confidential information. The purpose of the characteristic "Authority" is to verify the identities of all parties involved and to prevent third parties from sabotaging information. "Cost of transaction" refers to the cost paid by the seller and buyer.
Source: Author adapted from Yu, Hsi, & Kuo (2002).

According to a recent report (Worldpay 2016), 31% of the worldwide transactions in 2015 reverted to e-Wallet systems such as Paypal, whereas 25% and 17% used credit and debit card systems. In Spain, the country of the current study, the payment system breakdown of 2015 is very similar as 24% and 25% reverted to credit and debit cards, whereas 21% to e-wallets such as Paypal. Furthermore, Spain's e-commerce market is expected to expand significantly in the next five years by about 25% (Cetelem 2016) and, similarly, new online payment systems (such as Paypal, debit cards or ApplePay) will become critical factors for successful business (Cotteleer, Cotteleer, & Prochnow 2007). Indeed, a recent study carried out by Indra (2017) revealed that, compared to 2016, the amount of electronic transactions using debit cards increased a 25% in 2017 in Spain, whereas this growth has been much lower in the case of credit cards (7%). Trying to reflect the tendency of e-payments usage in Spain, our study focused the analysis only on debit cards (and not credit cards) and Paypal, the most widely used e-payments in Spain.

Despite the enormous projections of growth of online payment systems, they have not achieved the expectations regarding level of performance and diffusion for the most part because of issues of risk/security (Hong, Zulkiffli, & Hamsani 2016; Linck, Pousttchi, & Wiedemann 2006; Steinhart et al. 2013; Suki & Suki 2017; Tsiakis & Sthephanides 2005; Xu & Riedl 2011), trust (Chen et al. 2016) and complexity of use (Chou, Lee, & Chung 2004). Recent research in fact concludes that *perceived risk* and *security*, together with product involvement and consumer characteristics, could be the most important determinants of use of e-payment systems (Faqih 2016; Kim et al. 2010).

8.2.2. Perceived risk and security

The concept of perceived risk in online consumer behavior research was originally proposed by Harvard scholar Bauer (1960). This author defines it through two components: uncertainty (lack of knowledge about what could happen after the purchase) and the likely negative consequences after shopping. The most widely accepted definition is by Cunningham (1967) who detailed that perceived risk can be divided into six dimensions: performance risk, financial risk, social risk, psychological risk, time risk and privacy risk (see Pires, Stanton, & Eckford 2004; and Chiu, Wang, Fang, & Huang 2014 for definitions of each type of risk). In the context of online payment, perceived risk is defined by He and Mykytyn (2008) as the "... customer's subjective evaluation of the e-payment system's risk during a purchase in a web-site." Some studies have indeed measured perceived risk (Liébana-Cabanillas 2012; Liébana-Cabanillas, Muñoz-Leiva and

Sánchez-Fernández 2017; He & Mykytyn 2008; Ho & Ng 1994; Pagani 2004) by enquiring as to agreement or disagreement among subjects about statements such as: “Other people could gather information about my online transactions when I use this tool,” “There exists a high potential of monetary loss if I purchase through this tool on the Internet,” “There exists an important risk when purchasing on the Internet through this tool” or “I consider that shopping on the Internet is a risky choice.”

Perceived security, conversely, refers to a customer's subjective evaluation of the e-payment security system (Linck, Pousttchi, & Wiedemann 2006). Since consumers possess different experiences and expectations, they can adopt different attitudes toward the security of online transactions. Some researchers indicate that security is closely related to trust when referring to the level of confidence generated by a secure option (Tsiakis & Sthephanides 2005). Other authors such as Kim, Ferrin and Rao (2008) or Kim et al. (2010) developed a series of items to measure participant agreement or disagreement regarding e-payment security: “I feel secure about this electronic payment system,” “I am willing to use my… on this site to make a purchase” or “Information and transactions through websites are trustworthy.” Some literature suggests that a high level of perceived security toward an e-payment transaction is tantamount to low risk (Hartono et al. 2014). However, no research to date has explored whether perceived risk and security toward e-payments are ends of a single continuum or different constructs. In any case Tsiakis and Sthephanides (2005) indicate that high levels of perceived risk or low levels of perceived security trigger consumers to not adopt the online payment system and, consequently, not participate in the transaction until solutions are implemented to allay their fears. This notion thus affects purchase and “repurchase” online behavior (Kousaridas, Parissis, & Apostolopoulos 2008).

In sum, the level of risk and security of an online payment system can significantly affect its acceptance and, consequently, the purchase of online goods. It is therefore essential to delve deeper into establishing the brain reactions toward risky and secure online payment systems, as well as explore consumer processing of the two types of online payment systems (debit card and Paypal). Understanding the results of the self-report and neural correlates of risky and secure payment systems, and clarifying which payment system (Paypal or debit card) is thought to be more secure, provides invaluable insight into the most appropriate means to achieve online repurchase behavior.

8.2.3. Neural correlates of perceived risk and security

Recent advances in cognitive neuroscience are uncovering the neural bases of cognitive, emotional, and social processes, as well as offering new insights into the complex interplay between Innovation Technology (IT) and information processing, decision making, and behavior among consumers, organizations, and markets. Specifically, certain studies (e.g. Dimoka et al. 2011; Riedl, Davis, & Hevner 2014; Venkatraman et al. 2015) have recently introduced the idea of drawing upon cognitive neuroscience literature in the framework of marketing research and online consumer behavior. These studies identify a set of opportunities that marketing researchers can exploit to inform marketing phenomena, namely localizing the neural correlates of marketing constructs (such as perceived trust, risk or privacy) or capturing hidden mental processes among consumers.

The empirical fMRI study of Dimoka (2010) in the field of online consumer behavior concluded that trust and distrust activate different brain areas and have distinct effects on price premiums. This helps explain why trust and distrust are distinct constructs associated with different neurological processes. Together with Pavlou and Davis, the same author (2008) also identified the brain areas activated when users interact with websites that differ in their level of usefulness and ease of use. In a similar context, Riedl and Javor (2012) revealed the neural correlates of trust. Other authors (Riedl, Hubert, & Kenning 2010) went so far as to analyze whether there are neural differences in online trust from the gender standpoint. Apart from these studies, no research to date has singled out the neural correlates of risk and security in an online payment environment. In view of this research gap, the current study intends i) to objectively approach the constructs of risk and security that are very often related to unconscious and automatic processing mechanisms (Dimoka et al. 2010), and ii) complement the results of traditional self-report tools that do not capture low-order emotions, are susceptible to social desirability and subjectivity, and may include sensitive issues.

Neuroimaging studies bring to light consistent evidence of involvement of several brain areas in risk perception. Specifically, two meta-analyses focusing on decision-making, Krain et al. (2006) and Moh, Biele, & Heekeren (2010), suggest that risky decisions are associated with activity in the orbito and inferior frontal cortex, the superior parietal cortex, and the middle occipital gyrus. Similar results are advanced by Gonzalez and colleagues (2005) and Häusler and colleagues (2016) when exploring neural correlates associated with risky gambles.

Less attention, however, has been paid to neural reactions to secure choices. Building upon the definition of security and its related concept of trust, the confident expectations generated by a secure option would first involve the anticipation of positive rewards. Cognitive neuroscience literature has identified the middle frontal gyrus, precuneus, postcentral gyrus and left insula as key areas associated with increasing reward prediction (Chaudhry et al. 2009; Häusler et al. 2016; Wittmann et al. 2005). In her study assessing the neural correlates of trust and distrust, Dimoka (2010) concludes that trust is also associated with activations in areas such as the caudate nucleus related to the magnitude of those expected rewards. Finally, on the basis that the trustee will act according to the trustor's level of expectation, the notion of trust could lead to predicting how the trustee will perform in the future. In this regard, affective neuroscience literature has found activation in an area of the limbic system responsible for social inferences, namely the anterior paracingulate cortex, when perceiving trustworthy websites (Dimoka 2010; Riedl & Javor 2012).

8.3. Research objectives

Following recent neuroscience research capturing hidden mental processes of marketing constructs, this paper aims to: i) identify neural differences between risky and secure online payment systems, ii) explore whether the two widespread online payment systems (Paypal and debit cards) elicit the same or different brain mechanisms, and iii) assess whether the corresponding areas elicited by online payment systems covary with use intentions toward those e-payments.

Although the studies above assess risk and security in different fields, the findings serve to formulate the following hypotheses: Hypothesis 1 is the expectation of activations related to decision-making in situations of risk (orbito and inferior frontal cortex, superior parietal cortex or the middle occipital gyrus) when processing self-reported risky versus secure online payment systems. Hypothesis 2 supposes that areas involved with reward prediction (middle frontal gyrus, precuneus, postcentral gyrus and left insula), magnitude of the expected rewards (caudate nucleus), and social inferences (anterior paracingulate cortex) are more strongly activated in response to secure as opposed to risky online payment systems. Given that Paypal could be considered a more protected, simpler and convenient payment method (as opposed to debit cards), Hypothesis 3 supposes whether brain areas related to the security processing (such as the middle frontal gyrus, postcentral gyrus or left insula) are strongly activated when comparing Paypal with debit card systems (Mohr, Biele, & Heekeren 2010). Conversely, Hypothesis 4 supposes activation of brain areas associated with risk perception (the superior parietal cortex or the middle occipital gyrus) when comparing debit card with Paypal payments. Given the importance from the interactive marketing perspective of understanding the role of specific brain areas in predicting self-report responses such as use intention toward e-payments, this study also delves into the question of which brain regions activated during viewing Paypal covary with use intentions toward such online payment system. As in the case of earlier studies in this field, the authors of the current study presume activation in the areas most commonly involved in value encoding and reward-sensitive areas such as the posterior cingulate cortex (Bartra, McGuire, & Kable 2013) or the cerebellum (Kühn & Gallinat 2012).

To test these hypotheses, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that offers an indirect measure of brain activation (Solnais et al. 2013).

8.4. Method

8.4.1. Stimuli and procedure

The main objective of the experimental design was to simulate the online purchase process of low-involvement products through a well-known website. The choice was narrowed down to entertainment tickets (concerts, musicals, theater and festival) as the leading sectors in Spanish online transactions are tourism, clothing, accessories and entertainment (ONTSI 2017). The simulated website selected was "Ticketmaster," one of the main ticket sellers in Spain (Datanize 2017).

Participants arrived at the laboratory one hour prior to the fMRI task. After receiving instructions and verifying that all study procedures were understood, they completed an informed consent questionnaire. They were then subject to four conditions during the fMRI task: i) four low-involvement products accompanied by the Paypal symbol, ii) the same products accompanied by a debit card, iii) a *judgement* slide in which participants were asked to express "How risky or secure do you think the purchase of the previous product is by paying with Paypal or by debit card?", and iv) a *choice* slide offering the online payment system to acquire the products. In the *judgement* slide, participants expressed their opinion by pressing one of four buttons: 1. Very risky, 2. Risky, 3. Secure, and 4. Very secure. In the *choice* slide they were asked to press their choice of 1. Paypal or 2. debit card. In addition, there was a baseline condition requiring participants simply to observe a fixation asterisk.

Consumer neuroscience studies tend to have a relatively small sample size (due to the cost, healthy or availability issues, Hedgcock & Rao 2009), which could offer reproductible results only whether few experimental conditions are compared (e.g. no more than two). Investigations of that field, furthermore, are prone to extensively homogenizing as variables included in the study as possible, aiming to control the number of stimuli that could affect the brain mechanisms. Along this line, the authors of this paper focus on comparing only two main e-payments (the most widely used, debit cards and Paypal) in a specific low-involvement purchase online environment.

Each block of trials began with a randomly selected slide of one of the four products accompanied by one of the online payment systems displayed for 8.1 s. This was followed by the *judgement* slide and a 12 s response time, which was shown to be ample time for subjects to read and process the information (Dimoka & Davis, 2008). Next, a white screen with a centered black fixation was displayed for an average of 3 s, jittered from 2 to 4 s in 1-s steps. This white screen has a double function: first, to allow for the stabilization of the brain signal (the so-called Bold oxygenation level dependent, BOLD); second, it works as a control item. Afterward, the same product with the other online payment system was displayed for 8.1 s. Again, the *judgement* slide ran for 12 s. Next, a fixation condition was viewed (3 s) after the *choice* slide (9 s). There were 12 blocks of trials and, therefore, the subjects viewed the same condition 12 times but with different products. In total, they only were exposed three times to the same condition with the same product. The repetition of the same condition in several points in the task is highly recommended in fMRI tasks, aiming to perform an average brain response for each trial. The same products were never repeated consecutively, the order of the blocks was randomized, and finger assignments were counterbalanced across the subjects. The fMRI stimuli were presented via E-Prime Professional 2.0 and lasted 12.5 minutes (see Figure 46). The timing of each trial was adapted from previous fMRI studies (Dimoka, 2010; Riedl & Javor 2012) and the randomization of first type of slide of each block (i.e. the product accompanied by an e-payment) was also implemented by using the "Random" option in the layout of the software E-Prime Professional 2.0. Please, see the SPM manual's website for completeness (http://step.talkbank.org/materials/manuals/users.pdf).

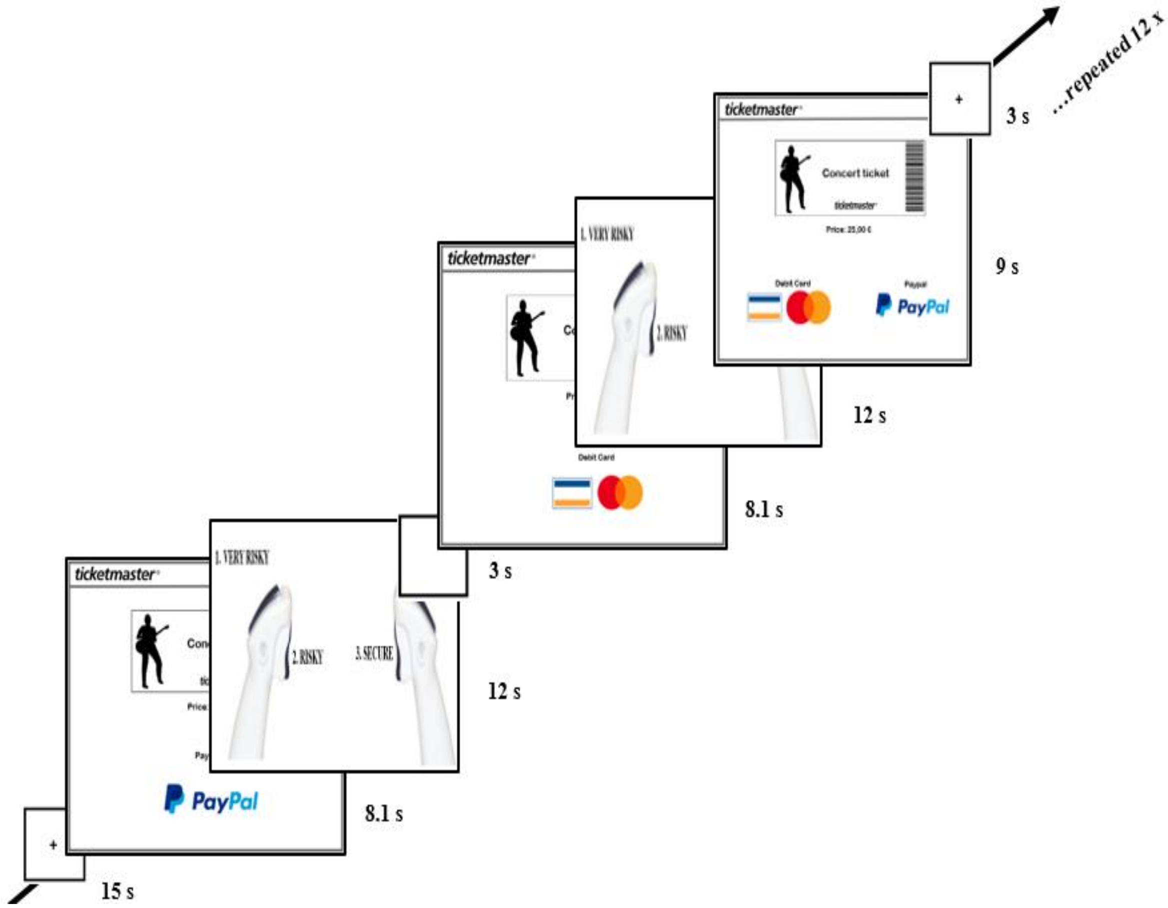

Figure 46. The fMRI task structure. The order corresponds to the first block. The conditions 'ticket for a concert with Paypal' and 'ticket for a concert with a debit card' are presented in random order in the subsequent eleven repetitions. Please, see Appendix A for a complete view of stimuli.

After the scanning, the participants responded to questions about use intentions toward e-payments for each product, as follows: "If you had the choice of using a debit card or Paypal for the purchase of tickets for a concert, indicate your level of agreement, with 1 = totally disagree and 7 = totally agree: i) I would use debit cards in the next months if I wanted to buy tickets for a concert on the Internet; ii) I would use Paypal in the next months if I wanted to buy tickets for a concert on the Internet" (scale adapted from the study of Venkatesh & Bala 2008). After completion of the session, participants were thanked, paid and given one of four entertainment tickets (selected randomly).

8.4.2. Participants

Thirty right-handed subjects were recruited via social networks and the institutional website of the University of XXX between February and April 2017. Given that their computer expertise, access to debit cards and Paypal, online purchase experience and various other sociodemographic characteristics (e.g. age and gender) can influence online payment system processing and use intention (Riedl, Hubert, & Kenning 2010), the authors of the study selected participants showing characteristics with similar levels. Hence the initial survey included questions about those variables as well as other issues related to health.

Specifically, only participants with a high-medium computer expertise were retained as the average expertise level was 5.6 (SD: 0.8) on a seven-point scale (anchored at 1 = low expertise to 7 = high expertise). All of the sample population responded to fully possess access and knowledge of the function of debit cards and Paypal. Furthermore, all stated having used both e-payments in the past. In addition, 68% spent more than 10 h per week using the Internet, and 100% had purchased products or services on the Internet at least once, with 65% purchasing at least once each semester. Collectively, the sampling were good proxies for Spanish online consumers (Statistical National Institute 2017) as 46.66% were female and 53.33% male. In addition, 40% were under the age of 35, 50% between 35 and 55, and 10% between 55 and 65 (average = 36.59 years, *SD*: 10.55).

Participants also assessed the involvement of the four products by expressing their opinions (7-point Likert scale, 1 = nothing and 7 = very) toward the adjectives defined by Zaichkowsky's involvement scale (1986) as follows: important, boring, irrelevant, exciting, means much to me, attractive, trivial, worthy or thrilling. After averaging the scores for each adjective of the involvement index, all subjects reported that tickets for concerts (mean = 2.52 and *SD* = 1.02), theater (mean = 2.85 and *SD* = 1.25), musicals (mean = 2.98 and *SD* = 1.36) and cinema (mean = 2.14 and *SD* = 1.05) were perceived as low-involvement products.

To check for the general familiarity and attitude toward the brand "Ticketmaster," the subjects were asked about their usage duration and about their overall attitude (seven-point Likert scale with "1 = extremely negative" and "7 = extremely positive"). The analysis indicated buying tickets with Ticketmaster for 53.2 months (*SD* = 14.5) and a medium attitude toward the brand (means = 3.92, *SD* = 1.15).

The participants were also assessed for the important trait regarding their level of general risk (risk propensity). The authors measured this by a 7-Likert scale of one item: "I am willing to take substantial risks when online shopping" (adapted from Cho & Lee 2006) with "1 = Totally disagree" and "7 = Totally agree." The analysis revealed no extreme outliers as the risk propensity of all participants was at a relatively medium mean (3.45, *SD* = 1.25).

All participants also were in good health. They took no medication or were afflicted by any neurological disease, did not abuse drugs and had a normal (or corrected to normal) vision and hearing. The experiment also applied the common fMRI exclusion criteria of claustrophobia, pregnancy and metal implants in the body. For access to their private medical information, an ethical commitment consent form was obtained from each participant. Moreover, the study was approved by the local ethical committee following the protocol of the World Medical Association Declaration of Helsinki (2013).

8.4.3. The fMRI analyses

Statistical maps were generated for each participant by fitting a boxcar function to the time series, convolved with the hemodynamic response function. Data were high-pass filtered with a cutoff of at 128 s. The following five conditions were modeled in a general linear model defined for each participant: a) Risky blocks, that is, "1. Very risky" and "2. Risky" self-reported e-payments; and b) Secure blocks including "3. Secure" and "4. Very secure" self-reported e-payments according to the opinions expressed in the *judgement* slide; c) debit card blocks; d) Paypal blocks; and e) inquiries about which online payment system participants would choose to purchase the products (*choice* slide). Six rigid body motion correction parameters (the parameters from the realignment) were also included as nuisance covariates. The rest periods (fixation points) were treated as the baseline on the General Linear Models (GLM) implemented in SPM12. Please, see the explanation of a GLM in fMRI analyses in Appendix B.

To perform the analysis of brain data, brain images are first analyzed and localized for each subject (first level analysis). Then, second-level one-sample t-tests are performed on the aggregate data to create random-effect group analyses for the experimental conditions. On the first level (single subject analysis), the following contrasts were generated: i) risky vs. secure e-payments; and ii) debit card vs. Paypal periods (and the reverse). On the second level, one sample t-tests were carried out to examine the significant brain activation of the group during the contrasts mentioned above. The cp_cluster_Pthresh (https://goo.gl/kjVydz) tool served to set the cluster extent threshold to a meaningful value. This tool offers a non-arbitrary uncorrected threshold and cluster extent equal to $p < .1$ corrected for multiple comparisons (FWE) across the whole brain. In the Risky versus Secure and Debit card versus Paypal analyses (and vice versa), the threshold resulted in $p < .001$ uncorrected with a cluster (k). A rigorous explanation of the procedure of cluster extent thresholding can be consulted in Appendix C.

In addition, a stricter analysis (small volume family-wise error (FWE) corrections at $p < 0.05$) was applied to a priori regions of interest (ROIs) according to our hypotheses. The ROIs were defined according to the Automatic Anatomical Labeling (AAL) atlas (Tzourio-Mazoyer et al. 2002) as implemented in the WFU Pickatlas (Maldjian et al., 2004) integrated in SPM12: orbitofrontal gyrus ROI, AAL frontal superior orbito; inferior frontal gyrus ROI, AAL inferior frontal; superior parietal ROI, AAL parietal superior; occipital middle ROI, AAL occipital middle; middle frontal gyrus ROI, AAL frontal middle left; precuneus ROI, AAL precuneus; postcentral ROI, AAL postcentral; left insula ROI, AAL insula left; caudate nucleus ROI, AAL caudate nucleus. Please, see Appendix D for a detailed overview of the preprocessing and image acquisition procedures. Appendix E includes, furthermore, the main regions and functions of interest for risky and security processing.

8.4.4. Predicting use intentions toward e-payments

After averaging the intention of each participant toward debit card and Paypal usage while purchasing online entertainment tickets, we ran a subtraction analysis of use intentions (i.e. use intentions toward Paypal - Debit card). This was followed by a multiple regression analysis to examine whether the neural response (peak levels activations) in the brain regions related to Paypal (vs. Debit card) were associated with the subtraction between the rating of use intention of Paypal (Int Paypal Debit) and the scores toward debit card use (Int = Int Paypal – Int debit card). In other words, the brain areas found to be correlated with use intentions toward Paypal will covary with use intention toward Paypal. Using the peak level of brain activation is a standard practice in fMRI studies (Dimoka 2010). A more liberal threshold was applied in this exploratory analysis since it enquired into the most important areas involved in value and reward (e.g. posterior cingulate cortex or cerebellum). In this case the study resorted to a threshold of $p < 0.001$ uncorrected with a cluster extent of minimum 5 voxels.

8.5. Results

8.5.1. Self-report results

The statistical software IBM Statistical Package for the Social Sciences (IBM SPSS Version 20) served to evaluate whether there are differences in the use intentions toward Paypal and debit cards when purchasing online entertainment tickets in general, and within each typology of tickets in particular. A Paired-samples t-test indicates that use intention toward Paypal (mean = 4.87, *SD* = 1.37) yield significantly more positive scores than use intentions toward debit cards (mean = 5.80, *SD* = 1.37) across the subjects (t (29) = -2.44; p = 0.021). Looking at those differences within each type of performance, the findings reveal consistencies with the general trend as use intentions toward Paypal when buying tickets for a concert (mean = 5.72, *SD* = 1.46) are significantly higher (t (29) = -2.70, p = 0.009) than those toward debit cards (mean = 4.98, *SD* = 1.54); similar trend when buying tickets for a musical (t (29) = -2.69, p = 0.012), tickets for the theater (t (29) = -2.52, p = 0.018) and tickets for a festival (t (29) = -2.32; p = 0.027).

8.5.2. Functional imaging results

- *Risky and secure e-payments contrasts*

Clusters in the right middle occipital gyrus are more strongly activated when responding to self-reported risky as opposed to secure online payment systems. In turn, when comparing secure with risky e-payments, the study identified activations in the left middle frontal gyrus, right precuneus, left postcentral, right superior parietal gyrus and left insula (see results in Table 17 and Figure 47). Several of those areas survived p < 0.05 small volume correction (FWE) over a priori ROIs, namely the middle occipital gyrus, the middle frontal gyrus, the precuneus, the insula and the postcentral gyrus.

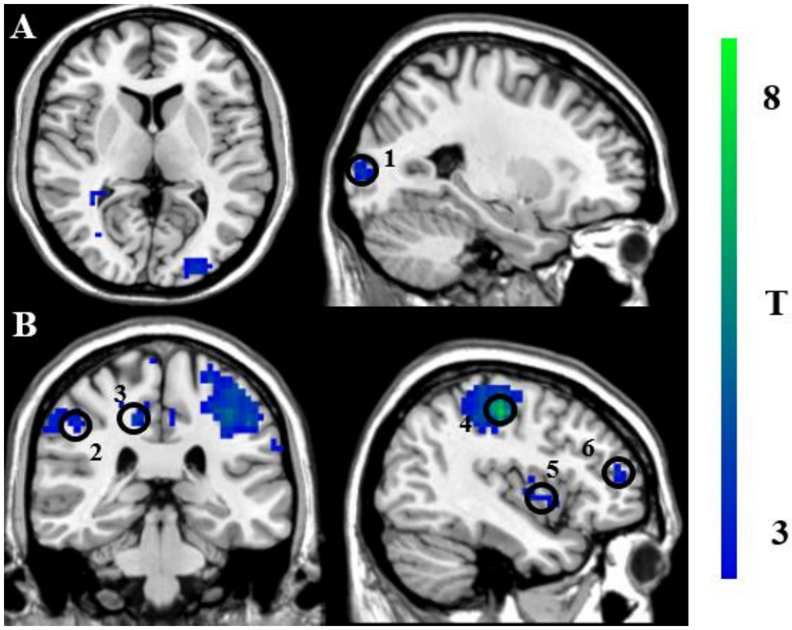

Figure 47. Illustration of the brain regions activated during (A) risky > secure e-payments: (1) middle occipital gyrus; (B) secure > risky e-payments: (2) inferior parietal gyrus, (3) precuneus, (4) postcentral gyrus, (5) insula and (6) middle frontal gyrus.

- *Debit and Paypal contrasts*

The comparison of debit card with Paypal e-payment systems reveals a strongly activated cluster in the left calcarine and right middle occipital gyri. By contrast, several clusters in the right Rolandic operculum and right postcentral gyri elicited strong reactions when contrasting Paypal with debit cards (see results in Table 17, Figure 48). Two of those areas, notably the middle occipital and the postcentral gyri, survived $p < 0.05$ small volume correction (FWE) over a priori ROIs.

Table 17. Peak coordinates of brain regions when responding to Risky versus Secure e-payments contrasts and when responding to debit card versus Paypal contrasts.

Brain region	Peak MNI coordinates (mm)			Z	T	Cluster size	Effect size
	x	y	z				
Risky > Secure							
L Middle occipital gyrus	-27	-91	7	3.81	4.39	45	.70
	-20	-95	18	3.71	4.24		
Secure > Risky							
R Postcentral gyrus	-41	-21	49	5.35	7.08	297	.98
L Insula	-38	-4	-4	3.80	4.37	14	.70
L Middle frontal gyrus	-34	42	14	3.53	3.98	13	.64
R Precuneus	12	-67	32	3.43	3.85	10	.63
R inferior parietal gyrus	47	-32	42	3.43	3.85	19	.63
Debit > Paypal							
L Calcarine	-17	-98	-4	4.93	6.24	39	.90
R Middle occipital gyrus	33	-88	14	4.04	4.74	15	.74
Paypal > Debit							
R Rolandic operculum	47	-11	18	3.69	4.21	11	.67
R Postcentral	57	-14	25	3.39	3.80	9	.62

Note: Peak of clusters significant at p uncorrected < .001, k ≥ 10 voxels are reported. This uncorrected threshold and cluster extent is equal to p < .1 corrected for multiple comparisons. L = left side of the brain; R = right side of the brain. Peak MNI coordinates refer to the specific location of the activated cluster of voxels on the x, y and z axes, according to the Montreal Neurological Institute (MNI) template. Cluster size refers to the number of voxels that contiguously survive to a specific threshold of significance. Effect Size = $Z/\sqrt{N}$, which constitutes a quantitative measure of the strength of voxel or cluster activation.

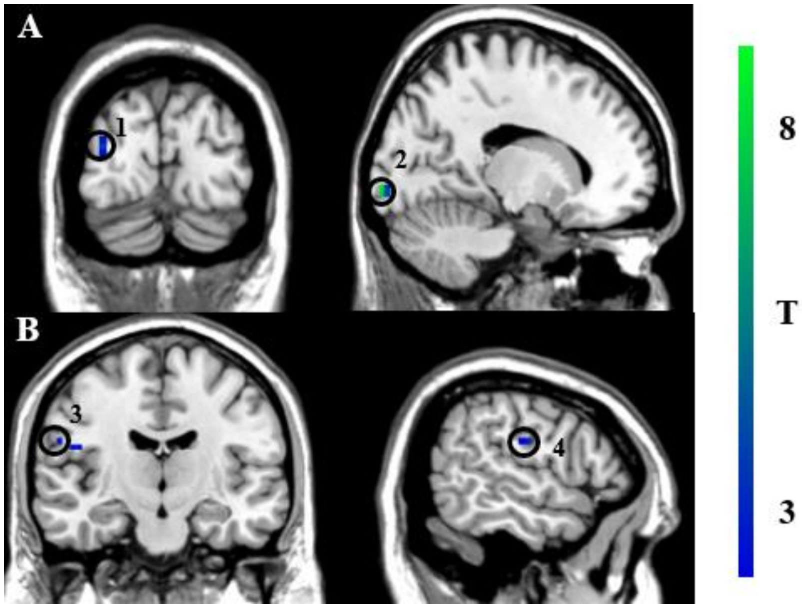

Figure 48. Illustration of the brain regions activated during viewing of **(A)** debit card > Paypal: (1) calcarine, (2) middle occipital gyrus; **(B)** Paypal > debit card: (3) postcentral gyrus, and (4) Rolandic operculum.

- *Relation between neural responses and use intentions toward e-payments*

Activation in the right cerebellum and left fusiform gyrus during the viewing of Paypal minus debit card covaried significantly (positive) with a difference of score of use intentions toward Paypal and debit cards ($r_{\text{cerebellum}} = .51$; $r_{\text{fusiform}} = .48$). Thus, participants with higher use intentions toward Paypal showed significantly stronger activation in these areas while viewing the Paypal online payment system (See Figure 49 and Table 18).

Table 18. Peak coordinates of brain regions in which response to Paypal against Debit Card contrast covaried with use intentions toward Paypal (as opposed to Debit Card).

Brain region	**Peak MNI coordinates (mm)** x	y	z	**Z**	**T**	**Cluster size**	**Effect size**
Paypal > Debit card							
R Cerebellum	15	-70	-42	4.07	4.81	9	.74
L Fusiform gyrus	-41	-46	-21	3.74	4.30	5	.68

Note: Peak of clusters significant at p uncorrected < .001, k ≥ 10 voxels are reported. This uncorrected threshold and cluster extent is equal to p < .1 corrected for multiple comparisons. L = left side of the brain; R = right side of the brain. Peak MNI coordinates refer to the specific location of the activated cluster of voxels on the x, y and z axes, according to the Montreal Neurological Institute (MNI) template. Cluster size refers to the number of voxels that contiguously survive to a specific threshold of significance. Effect Size = Z/√N, which constitutes a quantitative measure of the strength of voxel or cluster activation

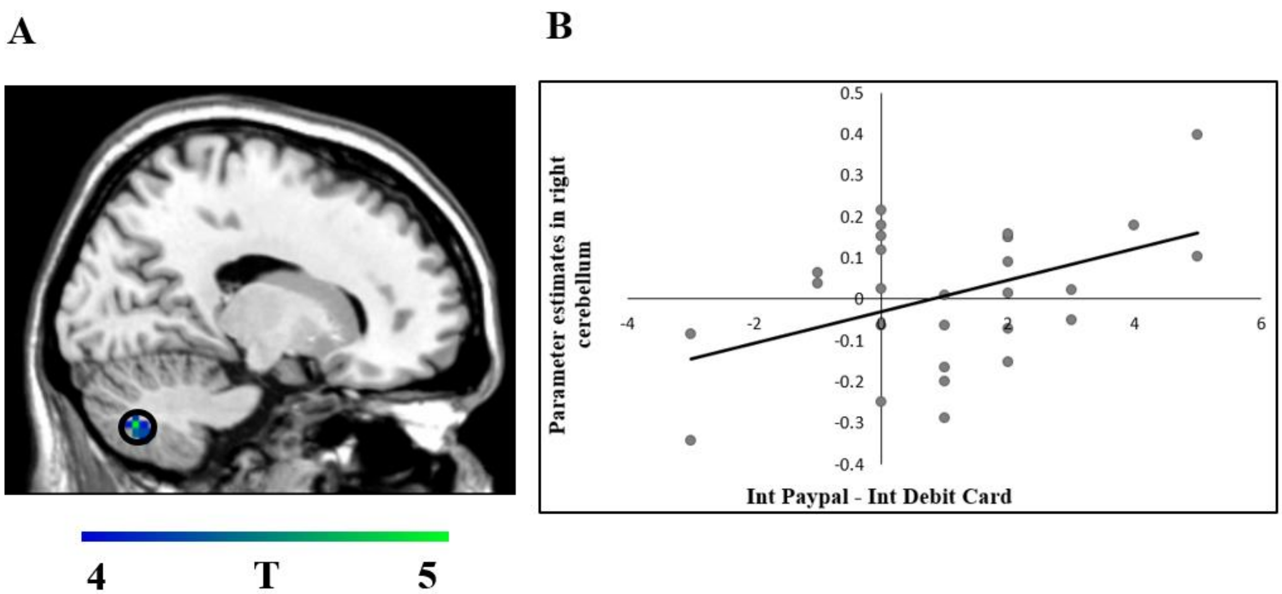

Figure 49. Activation in the right cerebellum during Paypal (versus debit card) correlates with use intention of Paypal. **(A)** Brain regions in which activation during viewing Paypal (versus debit card) strongly covaries in use intentions toward Paypal. Circle indicates right cerebellum cluster. **(B)** Plot showing the correlation between the parameter estimate of Paypal vs. debit cards in the cerebellum cluster and the use intention toward Paypal (vs debit card).

8.6. Discussion and conclusions

This is the first study combining neuropsychological tools and self-reports shedding light on how consumers process online payment systems in a purchase environment. Specifically, the study explores differences in brain activation patterns toward risky and secure e-payments, and compares the processing of two widespread online payment systems (debit card and Paypal). At the behavioral level, the findings advance higher intentions toward Paypal usage during online entertainment ticket purchasing. At the brain level, the study shows that risky e-payments elicit different brain activations when compared to secure e-payments, as well as distinct activation patterns when comparing reactions to Paypal and debit cards. Interestingly, this study also reveals that more positive use intentions toward Paypal correlate with the cerebellum responses to this e-payment system, an area responsible for value and reward encoding.

As regards the self-report responses, this study infers higher use intentions toward Paypal (vs. debit cards) when purchasing low-involvement products, e.g. entertainment tickets. Previous research in this field explored the characteristics (popularity, possibility to move, database safeguarding…) of several e-payment systems, including Paypal (Yu, His, & Kuo, 2002), and revealed that Paypal receives higher perceived usefulness, control and confidentiality than debit/credit cards (Suhuai et al., 2010). The higher use intentions toward Paypal in the purchase environment advanced in this study could be indeed derived from the higher usefulness, confidentiality and control offered by this e-payment, thus supporting the relationship of causality between use intentions and variables identified in other studies (Slade et al. 2015; Yang et al. 2015).

At the neural level, the findings advance that perceived risk and security are not opposite ends of a single continuum but constitute different constructs associated with different neurological processes. Specifically, fMRI data evidence that the middle occipital gyrus is more strongly activated in response to risky as opposed to secure e-payments. This activation is consistent with the conclusions of several studies analyzing risky decisions (Krain et al. 2006; Mohr, Biele, & Heekeren 2010). A great number of investigations find the middle occipital gyrus specifically responsible for anticipating events of negative emotional valence and risk. For example, Herwig and colleagues (2007) advanced middle occipital gyrus activation when exploring neural correlates of a ‘pessimistic’ attitude in anticipating events of emotional valence. Similarly, Matthews and colleagues (2004) revealed that deliberation prior to selection of risky as opposed to safe responses generated greater activation in the middle occipital cortex. Along the same line, Cunningham, Raye, and Johnson (2005) suggested that the left middle occipital gyrus is involved with preventive behavior toward negative valanced events. The literature also largely corroborates the role of the occipital gyrus in human visual processing (Hummel et al. 2013). Taken together, our results suggest the involvement of a typical visual brain area, namely the middle occipital gyrus, in anticipation of self-reported risky e-payments. The results therefore reflect that risky e-payments are processed as more negative given the previous links between the activation of middle occipital gyrus and anticipation of negative valanced events. This reasoning is in agreement with the conclusions of Brühl and colleagues (2011) that the temporo-occipital associative visual areas are activated in anticipation of negative emotional stimuli.

Contrary to expectations, the orbito-inferior frontal and the superior parietal areas were not strongly triggered by risky e-payments. These areas were found to be activated in economic decision-making studies (e.g. Schonberg, Fox, & Poldrack 2011; van Bömmel et al. 2014) while participants choose between options with different levels of risk (e.g. to bet 100€ and win 10% if the decision is correct versus betting 50€ and win 5 % if the decision is correct). Yet, contrary to the results of those studies, participants in this analysis do not make (risky) decisions but expressed their opinion about perceived risk according to the type of e-payment they viewed. The higher involvement of the orbito-inferior frontal and superior parietal areas in risky choice tasks (as opposed to reporting an opinion about perceived risk) could be a potential explanation for the absence of activation. In this sense it is comprehensible that only the middle occipital gyrus, related to deliberation prior to self-reported perceived risk opinion, is activated in response to the self-reported risky e-payments. Consequently, Hypothesis 1 could only be partially retained.

Secure e-payments, in line with Hypothesis 2, are strongly elicited in the middle frontal gyrus, precuneus, postcentral gyrus and insula. Previous research has linked those brain regions to reward prediction (Chaudhry et al. 2009; Häusler et al. 2016; Wittmann et al. 2005). Therefore, the activations observed in response to secure e-payments suggest that online payment systems are processed as more rewarding than risky ones. However, secure e-payments did not trigger the expected activations of areas previously involved with the magnitude of the rewards (such as the caudate nucleus) or social inferences (such as the anterior paracingulate cortex), cognitive processes found in response to trustworthy websites (Dimoka 2010; Riedl & Javor 2012). The absence of those activations could reveal that security and trust in e-payments are distinct constructs associated with different neurological processes. Specifically, it seems that trust in e-payments constitutes a wider construct as it does not activate only brain areas related to reward prediction (similar to security), but also other regions involved with the magnitude of the rewards and social inferences. This aligns with the results of behavioral research considering security as one of the determinants of trust in e-payments (Kim, Mirusmonov & Lee 2010; Yoon 2002).

Parts of the brain eliciting stronger activation while perceiving Paypal, in contrast to those of debit cards, are the postcentral gyrus and the Rolandic operculum area. Together with the insula, the middle frontal gyrus and the precuneus, the postcentral gyrus is one of the areas mentioned above involved with reward prediction (Schonberg, Fox, & Poldrack 2011). In the framework of this paper, an increase of activation of the postcentral gyrus during Paypal visualization could indicate that participants perceived this e-payment as slightly more secure and rewarding than that of debit cards. The Rolandic operculum is a part of the frontal lobe involved with preference judgements. Specifically, Chaudhry and colleagues (2009) found activation in the Rolandic operculum among participants making choices based on affectively driven judgements compared with those driven cognitively. Together, these findings reveal that when consumers are purchasing low-involvement products on the Internet, they process Paypal as a more secure, rewarding and affective payment system than debit cards, thus supporting Hypothesis 3.

In line with the expectations of Hypothesis 4, we observed a stronger triggering of the middle occipital gyrus when participants viewed debit cards (versus Paypal). As noted previously, the middle occipital gyrus is traditionally linked to anticipation of emotional negative-valanced and risky events (Matthews et al. 2004). Indeed, the findings reveal middle occipital gyrus activation when participants were exposed to risky versus secure e-payments suggesting that debit cards are processed as a riskier payment system than Paypal. Given that the participants did not make a (risk) decision while viewing debit cards, it is also reasonable not to identify, in this case, activations in the orbito-inferior frontal or superior parietal areas. What is more, activation of the calcarine gyrus, a brain area related to visual processing (Ishai 2002) in response to debit cards, corroborates prior findings regarding the presence of visual areas when subject to risky and negative emotional stimuli as in the case of debit cards.

Finally, an intention of this study is to determine the regions in the brain linked to Paypal activation that covary with use intentions. In line with these expectations, the findings reveal that participants expressing higher use intentions toward Paypal showed stronger activation during Paypal (vs debit cards) in several brain regions, including the right cerebellum. The cerebellum is traditionally associated with attentional processes, and value and reward encoding. Martin-Sölch et al. (2001) identified differences in cerebellum activation of non-smokers when responding to reinforcement and reward stimuli. Similarly, the findings of Nieuwanhuis et al. (2005) indicate activity of cerebellum suggesting strong sensitivity to the magnitude of monetary rewards and value. Kühn and Gallinat (2012) also found positive correlates of subjective pleasantness in the cerebellum. On the whole, the more pronounced right cerebellum activation while processing Paypal reveals that preferences, subjective values and attentional processes are key factors for the formation of use intention toward e-payments, e.g. Paypal (vs. debit card).

Theoretically, these findings contribute to the literature examining the factors that influence the consumer attitudes or intentions toward online purchases such as the risk and trust (Yang et al. 2015), personal innovativeness (Kalinic & Marincovic 2016; Kim, Mirusmonov, & Lee 2010; Molinillo & Japutra 2017), convenience (Chiang & Dholakia 2003) or perceived usefulness (Shin 2009). This study clarifies the effects of very common variables affecting use intention toward Paypal and debit cards, namely perceived risk and security. It also represents an advance in the research comparing the characteristics of online payment systems (Yu et al. 2002) as no study to date has specifically focused on the differences in use intentions toward Paypal and debit cards in a low-involvement online environment. Furthermore, it constitutes a new step in the application of neurological tools to analyze the processing of IS constructs and to capture hidden consumer mental processes. Previous fMRI research has focused on the neural correlates of trust, distrust, usefulness and ease of use (Dimoka 2010; Dimoka & Devis 2008). This work goes further and sheds light on the neural correlates of little studied constructs, namely perceived risk and security in e-payments. Through the use of fMRI, this study corroborates that risk and security are not opposite ends of a single continuum, but they are different constructs associated with different neurological processes. This study also defines the neural differences between security and trust in e-payments.

The findings of the current study have considerable managerial implications as they suggest: first, that professionals interested in selling online products should go to great lengths to offer secure online payment systems as e-payments perceived as risky are processed in the brain as emotionally negative and unrewarding. In line with Harvard scholar Bauer' study (1960), risky e-payments not only are perceived as uncertain, but the customer' subjective evaluation on a risky online payment system is also subconsciously processed as disgusting and could even force consumer avoid the e-purchase (Featherman & Hajli 2016). Accordingly, all efforts made by companies on offering high-quality products or services, promoting the advantages of their usage or investing huge sums in innovation may be worthless whether the proper e-payment is not included in the website. The current paper goes further to propose, secondly, the inclusion of Paypal, as opposed to debit card systems, in websites as Paypal not only obtains more intentions to use but is perceived by consumers as a secure, valuable, rewarding and affective choice. Purchasing entertainment tickets online via Paypal elicits brain mechanisms similar to those involved with the maternal love (Noriuchi et al. 2008), organically desired food (Linder et al. 2010) or valuable advertising (Casado-Aranda, Martínez-Fiestas & Sánchez-Fernández 2018). Therefore, Paypal is subconsciously perceived as a secure and emotional tool that enhances the online purchase process and may convey consumers complementary benefits to those offered by the purchased product. It may become, therefore, an inherent feature of the product that could play a key role in creating value to consumers and obtaining long-term competitive advantages. To increase trust and security, businesses intending to include debit cards systems in their websites, should offer complementary trustee signals, such as seals of approval, rating systems or business policies (Hu et al. 2010). Indeed, our research concluded that perceived security is one of the determinants of trust in e-payments. Consequently, designing secure websites constitutes a highly advisable strategy, together with others such as offering high accessibility, security statements or comprehensibility (Kim et al. 2010), to increase the perceived trust on websites.

It is noteworthy that links are established between brain activation and behavioral measures indexed by use intentions toward e-payments. Future e-payment research should link neural responses with actual usage to more fully understand which brain regions predict consumer use intention. Secondly, only risk and security constructs were considered as potential determinants of e-payment choice. E-payment research requires future studies applying fMRI to clarify the neural correlates of other variables including privacy, confidentiality or cost of transactions within several online payment systems. What is more, the modulation of brain activations by sociodemographic variables should constitute a key element in such research to fully understand consumer behavior in the online purchase environment. Furthermore, the specific environment required by neurological studies (control of experimental conditions or relatively small sample size) have allowed only the contrast of two e-payments, Paypal and debit cards; further research at that point may investigate the effects on cognitive and affective processing of credit cards or digital wallets

(Akram, Markantonakis, & Sauveron 2016). Finally, the conclusions of this paper should be interpreted with caution due to selection only of participants with medium risk propensity and relatively high use intention toward Paypal, and due to the presentation of only one low-involvement product.

Despite these limitations, the present study represents a first step toward understanding consumer neural and behavioral responses to online payment systems in a real purchase environment. Shedding light on a traditional gap in research, the current behavioral findings highlight higher use intention toward Paypal (vs debit card use) when purchasing online low-involvement products. This project is also the first to advance neural responses to risky and secure e-payments and to compare the processing of two widespread online payment systems, Paypal and debit cards. The findings are the following: i) self-reported risky e-payments activate areas of the brain linked to anticipations of emotional negative-valanced and risky events meaning that they are perceived as more negative than secure e-payments; ii) only the brain areas involved with reward prediction are strongly triggered by secure e-payments, suggesting that perceived security in e-payments constitutes a different and narrower construct than trust; iii) Paypal is processed as a more secure, rewarding and affective payment system, while the debit card system elicits brain activations related to the anticipation of negative and risky events; and iv) the right cerebellum response to Paypal covaries with more positive use intention toward that type of e-payment.

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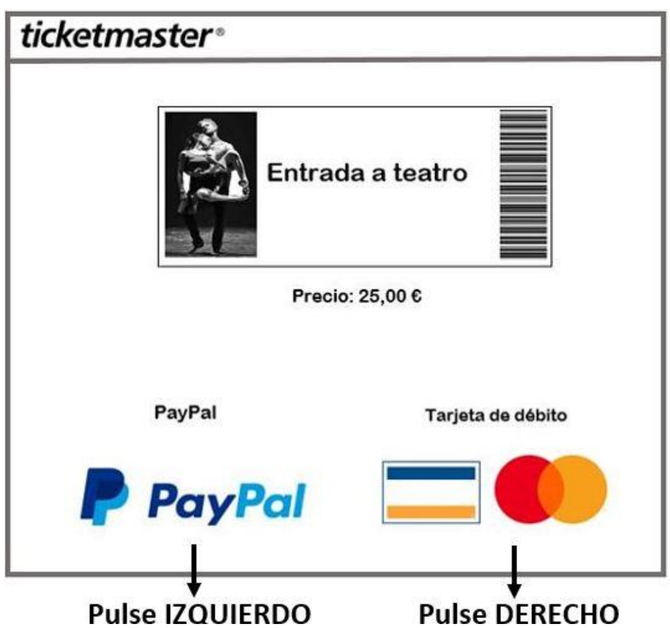
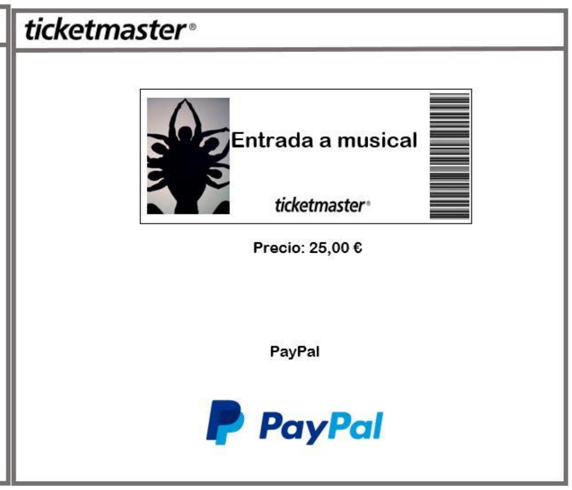
Appendices

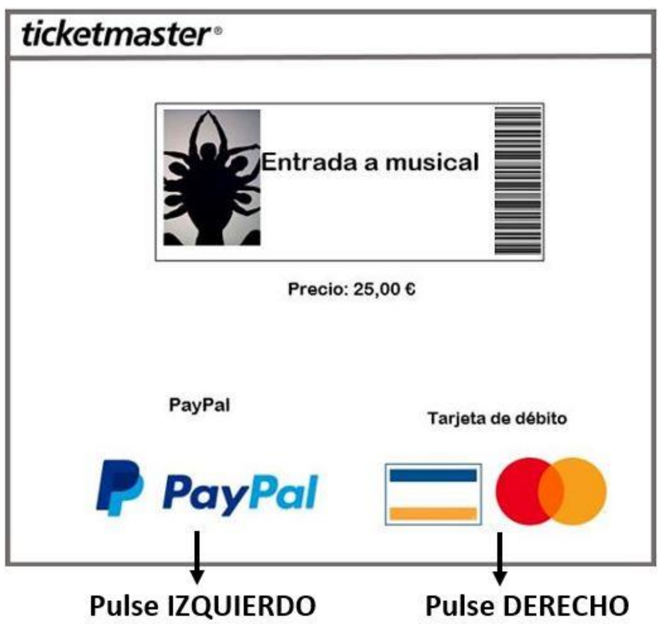
Appendix A. Web-site environment for entertainment tickets

A. *Web Layout for tickets for theater*



B. Web Layout for tickets for musical





C. Web Layout for tickets for festival

D. Web Layout for tickets for concert

Appendix B

A general linear model attempts to find the set of experimental parameters (β) for a design matrix (G) that best accounts for the original data (Y), by minimizing the unexplained error (e). fMRI studies split the brain in voxels, which consist of 3D pixels created by MRI scanning software's to represent the brain. An fMRI brain scan today at a high resolution produces voxels that are about 1 cubic millimeter in size and which "summarize" the activity of around 100,000 neurons over a period of around 1 second. The Y variable of the GLM corresponds to the data, i.e. the measured time course of a single voxel. The voxel time course is "explained" by the terms on the right side of the equation. The value of B0 typically represents the signal level of the baseline condition and is also called intercept. While its absolute value is not informative, it is important to include the constant predictor in a design matrix since it allows the other predictors to model small condition-related fluctuations as increases or decreases relative to the baseline signal level. The other predictors (B1, B2, and so on) represent the expected time courses of different conditions (e.g. Paypal time course). The beta weight of a condition predictor quantifies the contribution of its time course in explaining the voxel time course. While the exact interpretation of beta values depends on the details of the design matrix, a large positive (negative) beta weight typically indicates that the voxel exhibits strong activation (deactivation) during the modeled experimental condition relative to baseline. All beta values together characterize a voxels "preference" for one or more experimental conditions. The error values quantify the deviation of the measured voxel time course from the predicted time course, the linear combination of predictors.

Appendix C

To determine which brain regions are strongly activated and the size of the activation, cluster-extent based thresholding is currently the most popular method for multiple comparisons correction of statistical maps in neuroimaging studies. This approach, used in our study, detects statistically significant clusters (i.e. groups) on the basis of the number of contiguous voxels whose voxel-wise statistic values lie above a pre-determined primary threshold. Tests for statistical significance do not control the estimated false positive probability of each voxel in the contiguous region, but instead control the estimated false positive probability of the region as a whole. Cluster-extent based thresholding generally consists of two stages. First, an arbitrary voxel-level *primary threshold* defines clusters by retaining groups of suprathreshold voxels (i.e. voxels that survive to the specific threshold). Second, a cluster-level *extent threshold*, measured in units of contiguous voxels (k), is determined based on the estimated distribution of cluster sizes under the null hypothesis of no activation in any voxel in that cluster. The cluster-level extent threshold that controls family-wise error rate (FWE) can be obtained from the sampling distribution of the largest null hypothesis cluster size among suprathreshold voxels within the search area (e.g., the brain). Similar to studies in the field, our research bases the selection of the cluster extent (k =10) on an objective method (the cp_cluster_Pthresh tool) that stablishes a moderately strict threshold to a p < .1 corrected for multiple comparisons (FWE).

Appendix D. Image acquisition and preprocessing

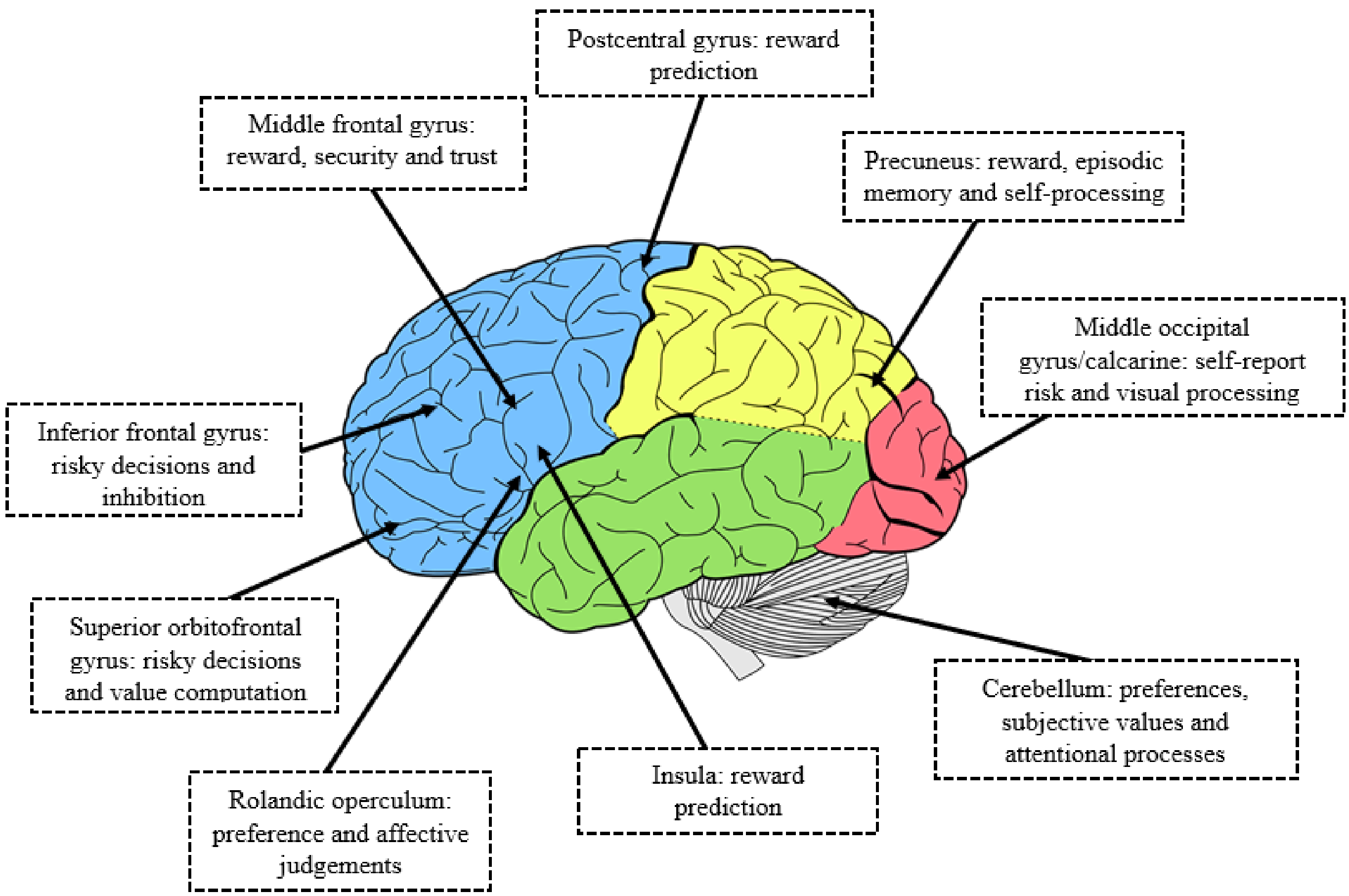
MRI scanning was carried out with a Siemens Trio 3T scanner equipped with a 32-channel head coil. The structural image T1 was acquired by a 3D MP-RAGE sequence with a sagittal orientation and a 1 mm x 1 mm x 1 mm voxel size (TR = 2300 ms, TE = 2.96 ms). Functional scans were acquired with a (T2*-weighted) echo-planar imaging (EPI) sequence (TR = 3000 ms, TE = 35 ms, Flip Angle 90° and a plane reduction of 3 x 3 x 3 mm corresponding to the slice thickness, slice order: descending). The distance factor was 25% so as to attain a total of 36 slices, a slice matrix of 64 x 64 mm, and a Field of View of 192 mm with an axial orientation. A total of 250 functional scans were acquired.

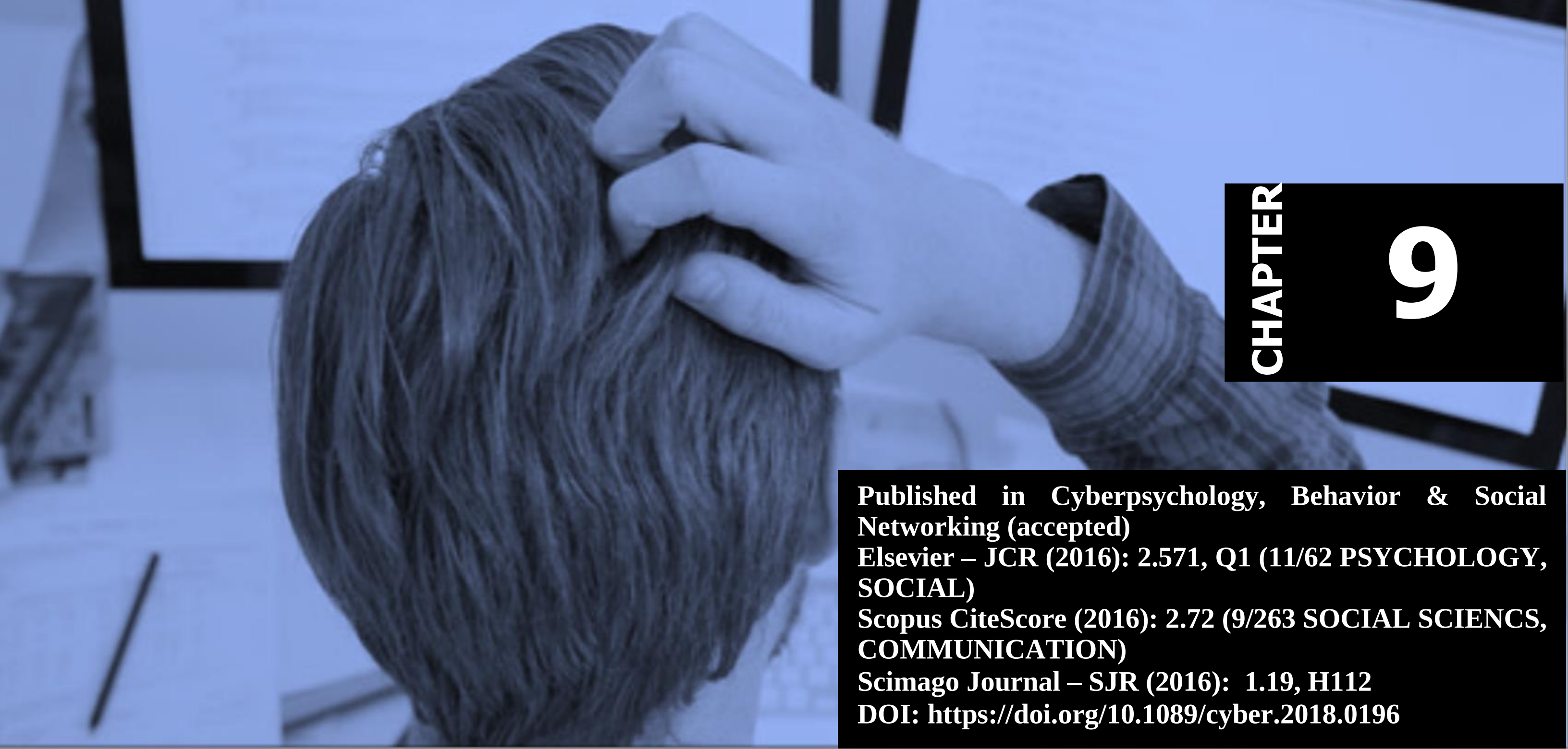
Data were preprocessed and analyzed using Statistical Parametric Mapping (SPM12, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) run with MATLAB R2012a (The MathworksInc, Natick, MA). Default settings were used unless stated otherwise. To allow stabilization of the BOLD signal, the first five volumes (15 seconds with a “cross” on the screen) of each run were discarded prior to analysis. Corrections were then applied by means of interpolation as to the differences in the time of slice acquisition with the initial slice serving as the reference. Functional images were realigned to the first image of the time series. Functional and structural images were co-registered and normalized (retaining 3 x 3 x 3 mm voxels) to the Montreal Neurological Institute (MNI) template. Finally, functional images were smoothed with the Gaussian kernel (FWHM = 6 mm). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined. The Volume

Artefact tool from ArtRepair (http://cibsr.stanford.edu/tools/human-brain-project/artrepair-software.html) then served to detect and repair anomalously noisy volumes. Volumes that moved more than .5mm/TR were repaired. As it was not necessary to repair any of the volumes (>30%), no participants were excluded from the study.

Appendix E

The following figure shows the main regions and functions of the brain of interest for risky and security processing. The blue brain portion refers to the frontal lobe; the green brain portion refers to the temporal lobe; the yellow brain portion refers to the parietal lobe; the red brain portion refers to the occipital lobe.





CHAPTER 9

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HOW CONSUMERS PROCESS ONLINE PRIVACY, FINANCIAL AND PERFORMANCE RISKS: AN fMRI STUDY

Casado-Aranda, Luis-Alberto; Sánchez-Fernández, Juan & Montoro-Ríos, Francisco J.

Despite the enormous growth of e-commerce, consumers still come against risk-related barriers while carrying out online purchases. Specialists of e-commerce have therefore explored the facets of online risk perception with the aim of identifying which has the greatest impact. There is, nonetheless, no consensus as to the facets of risk perception or their relative importance. This is the first study resorting to neurological tools that examines the differences between the three most widespread facets of risk (financial, privacy and performance) in a low-involvement purchase environment. Contrary to behavioral findings, brain data from neurological analyses identify differences between the three facets of risk. Financial risk conveys the lowest subconscious aversion and negative values. Subconscious privacy risk, in turn, confers ambivalence and uncertainty while performance risk elicits the highest levels of disappointment and distrust. Implications from the current findings, if taken into account by retailers, can greatly improve web contents and purchase processes, as well as bolster sales.

9.1. Introduction

The number of online consumers has increased dramatically in the last 20 years. Information and Communication Technologies, coupled with the adoption of the Internet by business, has bolstered online commerce. Nowadays, active e-commerce penetration is at a level of 22% worldwide and specifically at 58% in Spain,(We Are Social, n.d.) the study area of this paper. Despite these figures, e-commerce has generally not achieved the expectations of investment, performance and diffusion due to issues of risk. (McCarty, Prawitz, Derscheid, & Montgomery, 2011) (Hong, Zulkiffli, & Hamsani, 2016) (Mohd Suki & Mohd Suki, 2017) Consequently, the serious efforts on behalf of online retailers to reduce the notion of risk among consumers (e.g. web assurances or business policies) may not be enough as consumers still harbor deep reservations about the management of their private information and the financial risks of online purchases.

Given the importance of perceived risk as an antecedent to greater attitudes toward intention to adopt online purchases, specialists of e-commerce have deliberated extensively as to its definition (Bauer, 1960), main causes (Sun, 2014) and dimensions or facets(Crespo, del Bosque, & de los Salmones Sánchez, 2009). The notion of perceived risk is originally defined by Bauer (Bauer, 1960) as uncertainty in the sense of lack of knowledge about what could happen after the purchase and the likely negative consequences. Subsequent studies concur in considering perceived risk as a multidimensional construct that can be subdivided into several facets, which together, explain the overall sense of risk associated with online purchasing.(Chiu, Wang, Fang, & Huang, 2014)

Yet e-commerce studies do not concord in their focus of the different facets of risk (Hartono, Holsapple, Kim, Na, & Simpson, 2014). Pires et al.(Pires, Stanton, & Eckford, 2004) conclude that perceived risk comprises six facets: financial (likelihood of suffering a financial lost due to hidden costs), performance (possibility of the item failing to meet expectations), physical (probability of a harmed purchase), psychological (chance that the specific purchase be inconsistent with the consumer's self-image), social (likelihood that the purchase will lead to disdain by others) and convenience (probability that the purchase will result in loss of time in terms of late delivery). The findings of the study on this question carried out by Forsythe et al.(Forsythe, Liu, Shannon, & Gardner, 2006) isolated three risk-related facets: financial, product and time. Chiu et al.(Chiu et al., 2014), in turn, identify financial, performance, privacy (likelihood that website shopping will lead to a loss of private and payment data) and product delivery as the main risks. Recent research, however, consider financial, privacy and performance risks as the widest (i.e. they may include other dimensions), most studied, influential and common facets in online environments, and recommend going deeper into their processing as a first step in the understanding of the origin of general concerns induced by online purchases.(Chang & Tseng, 2013) (Featherman & Hajli, 2016) Ignorance as to the most important facet of risk may explain why businesses have not been coherent when directing their efforts to reduce online risk perception. Three determinants can explain the lack of unanimity in previous research: i) the lack of control of the purchase involvement (Kaplan & Nieschwietz, 2003) (Liu, Marchewka, Lu, & Yu, 2005) ii) the heterogeneity of the sampling as to the level of online expertise or propensity of risk (Kusumasondjaja, 2015), and iii) the unconscious and automatic nature of risk related more closely to low-order processes than to conscious, self-reported mechanisms.(Dimoka, 2010)

The current study constitutes the first step to face those research gaps in a more objective way by using a neuroscientific tool, functional Magnetic Resonance Imaging (fMRI). Specifically, it advances a novel approach aiming to elucidate the neural underlying mechanisms of the widest, most studied, influential and common risk facets, namely financial, privacy and performance(Chang & Tseng, 2013) (Featherman & Hajli, 2016), in a low-involvement purchase environment. Delving deeper into the neurological processes triggered by these three types of risk not only serves to examine whether they are indeed different dimensions, but is essential to advance in the understanding of the subconscious origin of the concerns that risk facets induce in online environments.

When comparing the brain regions elicited by risk facets, the authors expected activation of several risk-related specific brain areas, notably the middle frontal gyrus, inferior and superior parietal lobes and precentral gyrus(Krain, Wilson, Arbuckle, Castellanos, & Milham, 2006). Furthermore, some risk studies point to activations of brain areas (DMPFC, anterior insula, thalamus and striatum) linked to the penalty domain.(Bartra, McGuire, & Kable, 2013a) Unrest resulting from post-purchase events, in turn, may activate the angular gyrus and left cingulate,(Krain et al., 2006) brain areas linked to ambiguity. Areas such as the anterior insula related to distrust, a construct firmly linked to risk, are also highly activated when analyzing these facets(Riedl, Hubert, & Kenning, 2010). A specific risk dimension can even elicit activations related to post-purchase regret and disappointment in the precuneus, right cingulate gyrus or anterior insula(Chua, Gonzalez, Taylor, Welsh, & Liberzon, 2009). Moreover, positive data resulting from the measurement of a facet of risk, when contrasted to others, can lead to activation of the dopaminergic reward system of the ventromedial prefrontal cortex (VMPFC).(Bartra, McGuire, & Kable, 2013b) In sum, the facet of risk that elicits the greatest activation of ambiguity, penalty, distrust and disappointment may be indicative of a high level of negativity during the evaluation of products.

9.2. Materials and Methods

9.2.1. Participants

Thirty right-handed participants (15 females, 15 males) averaging 25.04 (SD: 4.32) years of age were selected to participate in the experiment via the institutional website of the University of XXX. All participants were required to fill out informed consent forms according to the declaration of Helsinki and the project was approved by the ethics committee of the University. A total of 29 participants took part in the fMRI analyses as one individual did not adhere to the standards. Selection was limited to participants deemed to have a high to medium computer expertise, report spending more than 10 hours per week on the Internet, and a propensity to medium levels of risk (Cho & Lee, 2006)

9.2.2. Experimental design

The main objective of the experimental design was to simulate the online purchase process of low-involvement products, specifically books (previously corroborated through the Zaichkoswky involvement' scale(Zaichkowsky, 1986)). The analysis was restricted to low-involvement products following previous research(Noteberg, Christiaanse, & Wallage, 2003) and aiming to offer reproductible results. Participants viewed eight different types of books, each penned by fictitious authors, sharing the same number of pages, color (black and white) and cover illustrations. Different images of books were chosen to avoid monotony. A fictitious book website (Bookler.com) deliberately simulated realistic book seller websites.

Participants, after viewing each book, were subject to viewing randomly selected items of measurement linked to one of the three risk facets (financial, privacy and performance) and asked to estimate the level of risk produced by the purchase. In line with the work of Chiu et al.(Chiu et al., 2014), the financial risk dimension was deduced from the item: “It is likely that shopping on this website will lead to financial loss due to hidden costs, maintenance costs or lack of warranty.” The privacy risk dimension, in turn, was inferred from the item: “It is likely that shopping on this website will cause me to lose control over the privacy of my personal and payment information.” The third performance dimension was inferred from the item: “It is likely that the online product I purchased fails to meet the performance requirements originally intended.” Control was carried out by displaying a random slide the Bookler.com layout. After passively reading each item, participants were required to rate their level of agreement by means of pressing four buttons ranging from 1 = highly agree (high risk) to 4 = highly disagree (low risk). After clicking on their choice, they viewed a fixation cross (jitter) and then a new randomly selected book followed by a randomly selected item. The fMRI experiment consisted of 64 trials as each risk facet item (plus one control item) was repeated eight times and each book four times (Figure 50).

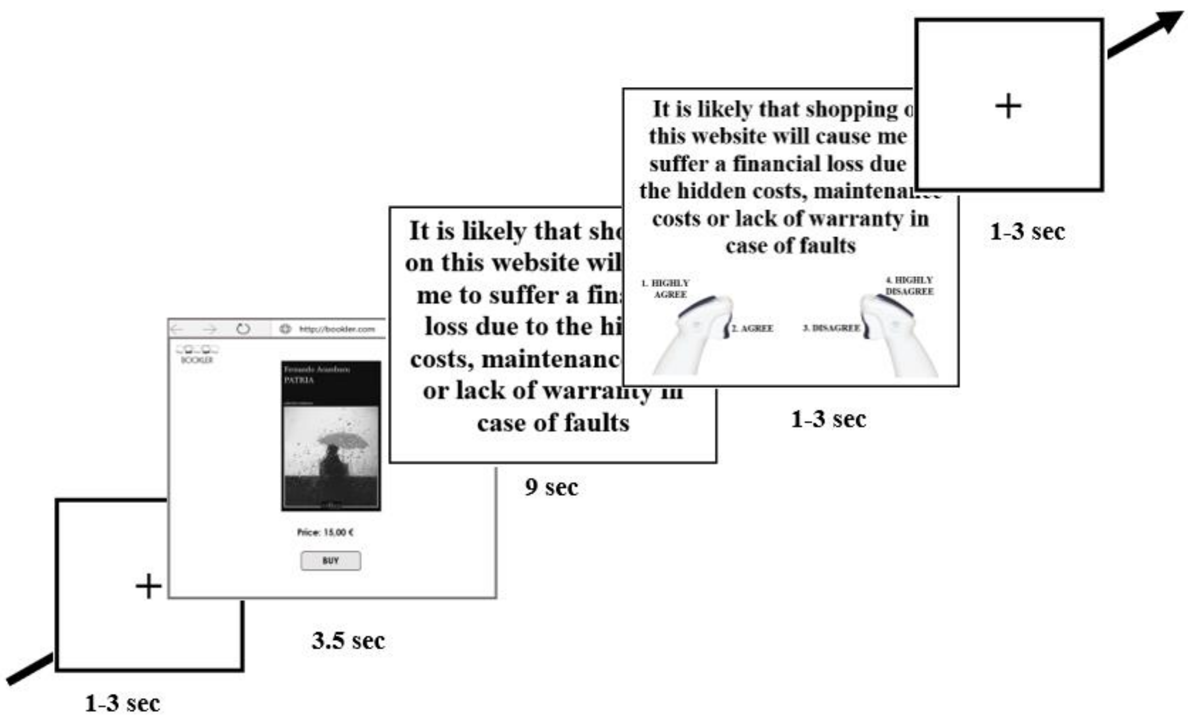

Figure 50. The fMRI task structure. The order corresponds to the first three trials: (i) the book within the Bookler.com environment; (ii) the passive reading of the measurement item (in this case, referred to the financial risk); and (iii) the choice period. The measurement items are presented in random order in the subsequent repetitions.

9.2.3. Image acquisition and analysis

MRI scanning was carried out in a 3 Tesla Trio Siemens Scanner equipped with a 32-channel head coil. Functional scans were acquired by a T2*-weighted echo-planar imaging (EPI) sequence (TR = 2000 ms, TE = 25 ms, FA = 90°, slices = 35, thickness = 3.5 mm, slice order = descending). The distance factor was 20% and the slice matrix was of 64 x 64 mm.

The functional images were preprocessed and analyzed by a Statistical Parametric Mapping program (SPM12, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) run with MATLAB R2012a software. Statistical maps were generated for each participant by fitting a boxcar function to the time series convolved with the canonical hemodynamic response function. This resulted in the estimation of a general linear model (GLM) for each participant. The first action consisted of contrasting the first six seconds of each risk facet period with the remaining, and vice versa. Random effects statistical analyses were run by a Region of Interest (ROI) approach using small volume correction (SVC) as implemented in SPM at an FWE-corrected threshold of p <. 05. Specifically, the authors applied 10 mm spheres around the coordinates as reported by: i) Krain et al. for risk processing(Krain et al., 2006): middle frontal gyrus (-32, 18, 61), inferior (-50, -41, 53) and superior (-30, -59, 50) parietal lobes and precentral gyrus (40, 5, 36); ii) Bartra et al. for penalty domain(Bartra et al., 2013b): DMPFC (4, 22, 44), anterior insula (-36, 20, -6), thalamus (-6, -8, 6) and striatum (-12, 4, 2); iii) Krain et al. for ambiguity(Krain et al., 2006): angular gyrus (52, -54, 53) and left cingulate (-4, 22, 37); iv) Riedl et al. for distrust(Riedl et al., 2010): anterior insula (-40, -16, -4); v) Chua et al. for disappointment and regret(Chua et al., 2009): precuneus (6, -66, 42), right cingulate gyrus (3, 18, 48) or anterior insula (39, 12, 21); and v) Bartra et al. for reward system activation(Bartra et al., 2013b): VMPFC.

9.3. Results

At the conscious level, the participants did not reveal significant differences of the values of risk facets when taking part in the online purchase of books ($mean_{financial} = 2.00$, $SD_{financial} = .59$; $mean_{privacy} = 2.00$, $SD_{privacy} = .53$; $mean_{performance} = 1.98$, $SD_{performance} = .38$). Brain data gleaned from the fMRI analyses, by contrast, do reveal differences.

Comparison of the financial facet vs. the other risk dimensions reveals activation of the VMPFC (Bartra et al., 2013). This comparison also elicited the occipital and temporal areas which are irrelevant to the current study (Figure 51, Table 19). The opposite comparison, in turn, yielded activations of the ROIs related to the negative domain according to Bartra and colleagues (Bartra et al., 2013b) as well as other areas linked to risk as noted by Krain et al. (2006). Furthermore, neither the financial vs. privacy, nor the financial vs. performance, contrasts revealed supra-threshold activations.

Table 19. Brain regions revealing different activations in response to Financial versus the remaining (Privacy and Product) risk facets.

Type of risk	Peak MNI coordinates (mm)			Cluster size	T	Study
	x	y	z			
Financial > Others						
ROIs [a]						
VMPFC	0	40	-12	3	3.52	Bartra et al. (2013)
Whole brain [b]						
Lingual	-8	-88	-6	291	6.62	-
Middle temporal	-61	-4	-13	161	6.60	-
Superior temporal	59	-7	-9	47	5.11	-
Others > Financial						
ROI						
Anterior insula	-36	20	-6	3	3.45	Bartra et al. (2013)
DMPFC	4	22	44	16	4.47	Bartra et al. (2013)
Striatum	-12	4	2	5	4.08	Bartra et al. (2013)
Middle frontal	-32	18	61	3	3.58	Krain et al. (2006)
Inferior parietal	-50	-41	53	8	4.5	Krain et al. (2006)
Superior parietal	-30	-59	50	9	4.32	Krain et al. (2006)
Precentral	40	5	36	22	5.88	Krain et al. (2006)
Financial > Privacy						
-						-
Financial > Product						
-						-

[a] Peaks are significant at p <.05 FWE-corrected on ROI level.

[b] Peaks of clusters are significant at p <.001 uncorrected, k > 20 voxels are reported.

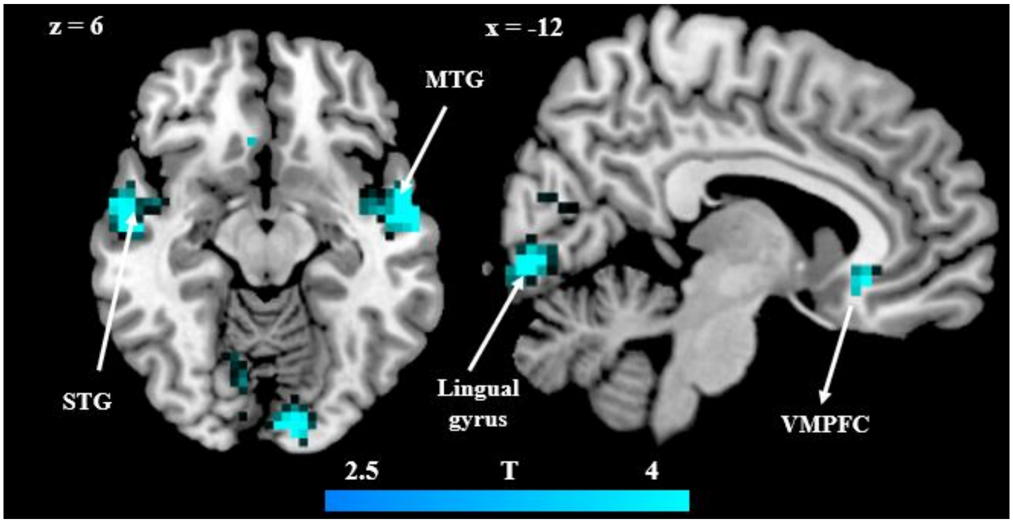

Figure 51. Illustration of the brain regions activated during **financial risk > the remaining risk facets**. ROI VMPFC: ventromedial prefrontal cortex (x = 0, y = 40, z = -12). Whole-brain activations: MTG: middle temporal gyrus; STG: superior temporal gyrus.

ROIs related to the domains of risk, ambiguity and negative were strongly activated when contrasting the privacy dimension vs. the other risks. The analysis comparing privacy vs. financial and performance revealed that the areas elicited at the general level coincide with those conveyed only by the privacy vs. financial dimensions. Privacy vs. performance, in turn, did not reveal supra-threshold activations (Table 20).

Table 20. Brain regions revealing different activations in response to Privacy versus the remaining (Financial and Product) risk facets.

Type of risk	**Peak MNI coordinates (mm)**			**Cluster size**	**T**	**Study**
	x	**y**	**z**			
Privacy > Others						
ROIs [a]						
Striatum	12	10	-2	4	4.64	Bartra et al. (2013)
	12	6	4	8	4.38	Bartra et al. (2013)
Inferior parietal lobe	-50	-41	53	2	3.51	Krain et al. (2006)
Inferior parietal lobe	-40	-47	47	2	3.51	Krain et al. (2006)
Caudate	4	9	10	2	3.46	Krain et al. (2006)
Others > Privacy						
-						-
Privacy > Financial						
ROI						
DMPFC	4	22	44	11	4.17	Bartra et al. (2013)
Thalamus	-6	-8	6	2	3.57	Bartra et al. (2013)
Striatum	12	10	-2	3	4.30	Bartra et al. (2013)
Striatum	-12	4	2	10	4.44	Bartra et al. (2013)
Inferior parietal lobe	-50	-41	53	2	3.51	Krain et al. (2006)
Left cingular gyrus	-4	22	37	20	4.19	Krain et al. (2006)
Angular gyrus	52	-54	33	7	4.19	Krain et al. (2006)
Caudate	4	9	10	2	3.46	Krain et al. (2006)
Privacy > Product						
-						-

[a] Peaks are significant at $p < .05$ FWE-corrected on ROI level.

Finally, the comparison of the risk dimension with the two other facets (and vice versa) did not reveal activations in any ROI. However, significant activations were noted in the comparison of performance vs. financial risk. These activations, reported by Bartra,(Bartra et al., 2013b) Krain,(Krain et al., 2006) Chua(Chua et al., 2009) and Riedl,(Riedl et al., 2010) relate, respectively, to the negative domains of risk, disappointment and distrust. No other supra-threshold activations were identified in the performance vs. privacy contrast (Table 21 and Figure 52).

Table 21. Brain regions revealing different activations in response to Product versus the remaining (Financial and Privacy) risk facets.

Type of risk	**Peak MNI coordinates (mm)**			**Cluster size**	**T**	**Study**
	x	**y**	**z**			
Product > Others						
-						-
Others > Product						
-						-
Product > Financial						
ROI[a]						
DMPFC	4	22	44	2	3.49	Bartra et al. (2013)
Middle frontal gyrus	-32	18	61	6	4.37	Krain et al. (2010)
Inferior parietal lobe	-50	-41	53	10	4.70	Krain et al. (2010)
Superior par lobe	-30	-59	50	2	3.42	Krain et al. (2010)
Precentral gyrus	40	5	36	12	4.07	Krain et al. (2010)
Precuneus	6	-66	42	4	3.66	Chua et al. (2009)
Right Cingulate gyrus	3	18	48	2	3.49	Chua et al. (2009)
Anterior insula	39	12	21	2	3.68	Chua et al. (2009)
Anterior insula	-40	-16	-4	11	4.68	Riedl et al. (2010)
Product > Privacy						
-						-

[a] Peaks are significant at $p < .05$ FWE-corrected on ROI level.

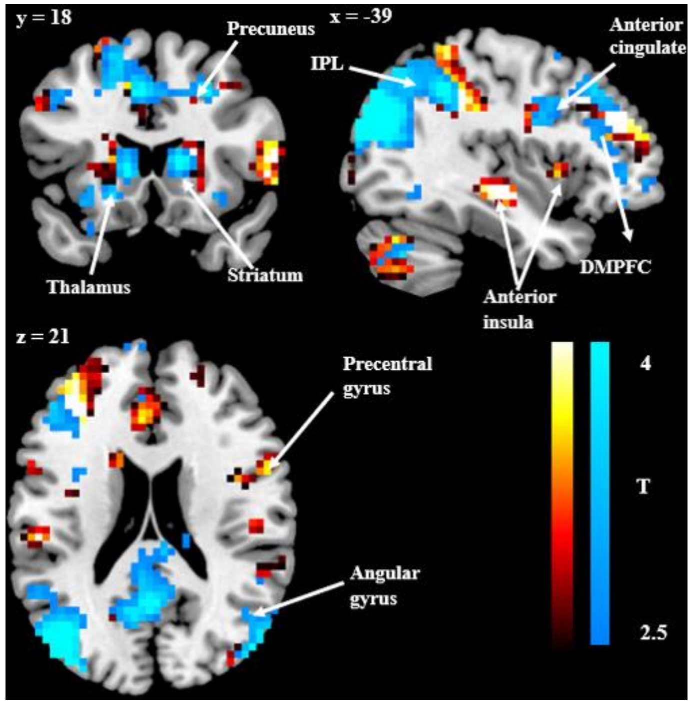

Figure 52. Illustration of the brain regions activated during: **(blue) privacy risk > financial risk**: DMPFC (dorsomedial prefrontal cortex), thalamus, striatum, IPL (inferior parietal lobe), left cingulate and angular gyri; **(red) product performance risk > financial risk**: DMPFC (dorsomedial prefrontal cortex), IPL, anterior insula, right cingulate gyrus and precuneus.

9.4. Discussion

Despite the enormous growth of e-commerce in the 21st century, consumers still encounter barriers during the online purchase process mainly related to perceived risk. E-commerce literature has therefore explored the construct of perceived risk with the aim of revealing the type of risk that exerts the most impact on consumer perception. However, there is no consensus as to the type of dimensions of risk or their relative importance. This is the first study that resorts to neurological tools to objectively examine this gap and ascertain the subconscious origin of the most widespread risk facets, namely financial, privacy and performance. Although behavioral findings do not reveal differences between the three types of risks in a low-involvement purchase environment, brain data confirm that they represent three different dimensions. Interestingly, neurological analyses highlight the dimension of performance as that conveying the highest level of risk, disappointment and distrust.

As regards the self-report responses, this study infers an equivalence at the conscious level of the financial, privacy and performance risk facets involved in low-involvement product purchasing. Specifically, participants report medium levels of risk toward books, a finding that lines up with evidence of preceding studies indicating that consumers do not experience sensations of high risk when carrying out low-involvement purchases due to the fact that these purchases amount to a low amount of effort, importance and money(Garbarino & Strahilevitz, 2004).

The measurements of neurological activations can reveal hidden processes during online purchases as the more conventional measurements of risk cannot capture low-order emotions and are difficult to collect in real time. The current study, along this line, reveals for first time that brain data can indicate that financial, privacy and performance risks are distinct dimensions that can be associated with different neurological processes.

Specifically, the VMPFC region was strongly activated while evaluating financial as opposed to other facets of risk. This type of activation during decision making processes encodes values of positive outcome expectancy (Plassmann, O'Doherty, & Rangel, 2007), higher willingness to pay (Linder et al., 2010) and trust (Dimoka, 2010). Furthermore, the privacy and performance risks vs. financial risk combination reveals an increase in activation in the anterior insula, DMPFC and striatum, areas identified in preceding studies with aversive stimuli,(Iidaka et al., 2002), danger (Liddell et al., 2005), and potential threat (Bartra et al., 2013b). The combination of the privacy and performance facets are also greatly elicited in the corresponding ROIs of middle frontal gyrus, inferior and superior parietal areas and the precentral gyrus, a neural network identified in previous research with risk during decision making.(Krain et al., 2006) Taken together, these results suggest that the dimension of financial risk, when compared to the others, may convey less negative values during the purchase of online low-involvement products. This may indicate that online losses due to hidden costs may subconsciously confer less revulsion than the potential loss of personal information or failure of performance during low-involvement online purchases, notions that could be explained by the low economic effort dictated by low-involvement products such as books.

No ROI showed an increase in activation when contrasting the privacy and performance dimensions. Nonetheless, the comparison of each of these dimensions with the financial construct reveals mechanisms that can offer insight into the type of risk with the greatest impact. The privacy risk dimension, in particular, elicited great responses in the ROIs related to the domain of negativity (Bartra et al., 2013b) (DMPFC, thalamus and striatum), risk processing(Krain et al., 2006) (inferior parietal lobe) and ambiguity (Krain et al., 2006) (angular gyrus and left cingular gyrus). Performance risk, in turn, elicited the ROIs involved with revulsion (DMPFC), regret and disappointment (precuneus, right cingulate gyrus and anterior insula), as well as areas linked to distrust (posterior side of the anterior insula). In other words, despite the fact that both the privacy and performance facets lead to a common negative neural system, only the privacy dimension actually elicits a broader network of areas linked to aversion and ambiguity. Performance risk, however, shows more activation of the areas related to the regret, risk and distrust. Taken together, these findings constitute a step forward as they suggest that when it comes to online low-involvement products, consumers may experience the greatest sense of risk and distrust if there is the possibility that the product fails to meet the original requirements of performance. The loss of control over privacy of their personal and payment information, in turn, confers only subconscious ambivalence and uncertainty during the purchase process.

The current findings therefore theoretically contribute to the literature exploring ways to reduce consumer risk perception in online purchase environments. Previous e-commerce studies along these lines have explored the notions of impact of conventional vs. online shopping on risk perception,(van Noort, Kerkhof, & Fennis, 2007) the antecedents and consequences of perceived risk on services,(Sun, 2014) and specified and validated constructs of security and risk.(Hartono et al., 2014) This study, nonetheless, has gone a step further by exploring the differences between the main facets of risk by controlling risk propensity of consumers and purchase involvement. Unlike previous fMRI research focusing on the neural correlates of trust, distrust, usefulness and ease of use,(Dimoka, 2010) (Dimoka et al., 2011) this neurological study corroborates the differences between three online risk dimensions. Empirically, the findings also through light by first time on the origin of general concerns induced by online purchases in consumers and advance that psychological processes such as perceived risk, trust, ambiguity or disappointment are not equally present in all online risks, but it depends on the risk facet. Previous studies at this line showed that reducing security and performance risks plays an essential role in increasing intentions to use internet banking (Maditinos, Chatzoudes, & Sarigiannidis, 2013), and that performance and convenience risks are mainly felt in high-involvement online purchases (Pires et al., 2004). Unlike, through a neuroscientific tool, this study advances that online sale professionals of low-involvement products (e.g. books, cups or pen drives) should go to great lengths to first meet the performance dimension requirements (e.g. physical conditions and delivery policies) and secondly, accurately define all the policies of consumer information management (e.g. through seals of approval, policy statements or consumer rating systems (Hu, Wu, Wu, & Zhang, 2010) (Bahmanziari, Odom, & Ugrin, 2009). By following these recommendations, website retailers will increase subconscious certainty, trust and security and possibly even enhance consumption.

It must be noted that the current study was restricted to measuring self-reported risk and not authentic cases of risk. Moreover, the study also focused on a low-involvement online environment and selected participants with medium level propensity toward risk. Corroboration of the current findings therefore requires further research in the framework of a broader range of products (e.g. high-involvement) and consumer categories.

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CHAPTER 10

CONSUMER PROCESSING OF E-ASSURANCE SIGNALS: A NEUROPSYCHOLOGICAL STUDY

The growth of online transactions coupled with the worldwide expansion of Internet-based information exchange has triggered fear, distrust and risk among online consumers. Despite the well-proven benefits to retailers when they include assurance services (e-Assurances) such as seals of approval, rating systems or assurance statements in their websites, there is no consensus as the most trustworthy type. To fill this research gap, the current study reverts to neuroscience (fMRI) to compare the underlying brain mechanisms linked to each type. Thirty subjects participated in an experiment simulating a low-involvement online purchase. The neuropsychological analysis reveals that seals of approval are the most trustworthy as they elicit activation of brain areas linked to reward and expected values. Although assurance statements reveal lower scores of trust than seals of approval, they do not arouse negative brain areas. By contrast, products accompanied by rating systems elicit brain areas linked to ambiguity, negativity and risk. Interestingly, more positive trust and purchase intentions toward seals of approval were predicted by the activation of value-computation areas, whereas higher scores of risk associated with rating systems were predicted by negative-related activations. These results offer invaluable insight into the subconscious origin of trust conveyed to different types of e-Assurances.

10.1. Introduction

The exponential increase in online shopping and the unprecedented rate of growth of online retailers has led to an extremely competitive marketplace. The relative ease in which vendors can enter this global environment means that many firms offering products remain unknown to consumers. "Unknown" online vendors hope to build a favorable reputation and seek ways to convince consumers that they are legitimate and trustworthy (Chang, Waiman, & Mincong 2013). In their attempt to increase purchase intention, these vendors search for ways to reduce concerns as to online transactions (Wang, S., Beatty, S. E., & Foxx 2004).

Previous literature examining the main deterrents in business to consumer commerce (B2C) indicates that trustworthiness, reputation, perceived risk and accessibility can dramatically influence online commerce (Aljukhadar, M., Senecal, S., & Ouellette 2010; Li et al. 2010). Whereas reputation may constitute a great advantage to well-known firms, several studies claim that unknown online vendors can enhance consumer willingness to buy by reverting to trust mechanisms (Bahmanziari, T., Odom, M. D., & Ugrin 2009; Karimov, F. P., Brengman, M., & Van Hove 2011). An initial improper use of trust tools will blemish subsequent efforts as initial trust is thought to lower perceived risk and, consequently, increase purchase intentions and expectations (D'Alessandro, Girardi, & Tiangsoongnern 2012).

There are many mechanisms available for vendors to build trust. E-commerce studies point to three types of online trust mechanisms (e-Assurances hereafter) that increase trust in e-commerce retailers: *seals of approval* (assurance provided by a third-party vendor only after an independent evaluation of the retailer's website and related activities), *rating systems* (that rate Web sites with "stars" based on customer feedback) and *assurance statements* (vendor statements with information about returns, privacy and security policies). While each of those mechanisms is designed to enhance trust and reduce perceived risk, they revert to different sources. Seals use independent verification through third parties, ratings use customer feedback, and assurance statements are the vendor's self-reported statements about their policies and procedures.

E-commerce literature, deriving from these differences, has evaluated the effects of internal and external e-Assurance signals on initial trust conferred to products sold in B2C e-commerce. The conclusions of these studies are far from consistent. Certain authors point to a greater trust linked to assurance statements (Pennington et al. 2003; Bahmanziari, Odom & Ugrin 2009), while others strongly posit a greater impact on trust of rating systems (Li & Lorin 2008;

Wu & Wu 2016) or third-party assurances (Kim & Kim 2011; Nöteberg, Christiaanse & Wallage 2003). Instead of resolving the discordant findings, recent research has focused on analyzing the effects on trust of different modalities of assurance statements, such as privacy disclosure (Bansal et al. 2016), return policies (Wang et al. 2004) or ethical performance (Yang et al. 2009). Though the implications of such studies are undoubtedly remarkable, it is vital first to properly test the effects of seals of approval, rating systems and assurance statements on trust by controlling several essential variables such as product involvement, risk propensity or consumer level of experience. Furthermore, no research in this field to date has resorted to neuropsychological tools that are more appropriate as trust and risk formation are associated with unconscious and automatic information processing mechanisms that are not easily addressed through self-reports (Dimoka et al. 2010). The present study thus represents a first step in this direction as it analysis the neural effects of the three most widely spread e-Assurances (seals of approval, rating systems and assurance statements) on online product evaluations.

10.2. Conceptual Background and Hypotheses

10.2.1. Behavioral Research on E-Assurances: Trust and Risk

The growth of online transactions coupled with the worldwide expansion of Internet-based information exchange, social networking, profusion of mobile devices, and e-commerce is accompanied by consumer fear, distrust and high levels of perceived risk (Hille, Walsh, & Mark Cleveland 2015). This is especially the case in the case of unknown companies leading consumers to refrain from conducting online transactions. Implementing mechanisms to increase online trust and reduce risk play a key role these days, as these two variables are widely considered as important antecedents of intention to purchase and price willingness to pay (Kaplan, & Nieschwietz 2003). Thus, without favorable initial trust or low sense of risk, new e-commerce retailers will not sell products and customers will migrate to other websites they deem more trustworthy.

Psychology literature defines trust as an individual's (the trustor) willingness to be vulnerable to another person (the trustee) on the basis that the trustee will act in accordance with the expectations of the trustor (Mayer et al. 1995). In buyer-seller relationships, trust is defined as the buyer's willingness to be vulnerable to a seller based on the belief that the seller will transact in a manner consistent with the buyer's expectations (Dimoka 2010). Following this definition, trustworthy environments (e.g. a trustworthy online marketplace) correspond to the anticipation of positive rewards and highly valuable expectations. Lower levels of trust, on the other hand, are tantamount to high risk (Hartono et al. 2014) which refers to the uncertainty (lack of knowledge about what could happen after the purchase) and the likely negative consequences after shopping (Bauer 1960). Accordingly, riskier online marketplaces provoke ambiguity and negative feelings among consumers.

Based on these two concepts, a great number studies have focused on the mechanisms available to online vendors to build trust and reduce the notion of risk. Most e-commerce publications point out that the main tools affecting perceived trust, risk, the willingness to pay and purchasing intentions are e-Assurances (online signals included that guarantee returns, privacy and security; Yoon 2002), seller accessibility (easy access to information; Li et al. 2010), reputation of seller (positioning that guarantees that the seller has honored or met its obligations toward other consumers; Urban, Amyx, & Lorenzon 2009) and familiarity with the website (degree of acquaintance including knowledge of online sellers and understanding their relevant procedures and interfaces; Kim & Kim 2011).

Following the mainstream currents of e-commerce literature, this study proposes that higher levels of trust and lower levels of perceived risk toward new e-commerce retailers may be bolstered by the characteristics of the website and its e-Assurances. Web assurance services represent a form of institutional-based trust formed through externally provided e-Assurances (such as seals of approval and rating systems) and internally provided e-Assurances (such as assurance statements). As business transactions on the Internet go relatively unregulated, Web assurance services constitute a way to generate institution-based trust. Specifically, s*eals of approval* refer to an assurance provided by a third-party vendor only after an independent evaluation of the retailer's website and related activities. This type of e-Assurance involves a large amount of testing and is accompanied by a certificate from a third party. It stands to reason that third-party certification from independent sources should offer assurance over and above the internally provided assurance structures on the website, and thus result in more trust. *Rating systems* provide Web sites different quantities of “stars” according to customer feedback and serve to rate a vendor's performance in terms of privacy policies, fee shipping, ease to usefulness and guarantees. *Assurance statements*, in turn, are e-Assurances managed by the online retailer through the use of different combinations of statements referring to privacy policies, guarantees, free shipping, return policies, contact information and frequently-asked-questions (Kaplan & Nieschwietz 2003; Bahmanziari, Odom & Ugrin 2008). In sum, while each mechanism is designed to enhance trust and reduce risk, they do so in different ways. Seals use independent verification through third parties, ratings use customer feedback, and assurance statements are vendor's self-reported statements about their policies and procedures. Appendix A lists examples of the three most widely used e-Assurances.

Interactive marketing literature concurs that the presence of a Web seal affects perceived trust, risk and judgment behavior. The study by Noteberg et al. (1999), for example, examined the effect of different Web assurance signals (accountant, bank, computer association, consumer union, self-reported, and none) on likelihood of purchase. The results reveal that the presence of any e-Assurance resulted in greater trust, likelihood of purchase, price willing to pay and less perceived risk. Moreover, studies carried out by Lala et al. (2002) and Kaplan and Nieschwietz (2003) highlighted the same tendency. Nevertheless, there is no consensus as to the effectiveness of each e-Assurance (seals of approval, rating systems or assurance statements) on an increase of trust, willingness to pay, purchase intentions and reduction of perceived risk among potential consumers. Pennington et al. (2003) concluded that only self-reported vendor statements (vs. seals of approval and rating systems) affect system trust and enable successful e-commerce. Similar findings are derived from the studies of Bahmanziari et al. (2009), Lee and Turban (2001), and Milne and Culnan (2004) that reveal that the presence of third-party certifications did not affect consumer trust or purchase intentions. Reversely, Nöteberg, Christiaanse and Wallage (2003) found that third-party assurances (vs. self-proclaimed assurance) significantly increased purchasing likelihood and reduced consumer concern about privacy and transaction integrity. Along the same line, Portz, Strong, and Sundby (2001) found that web seals increase perceived trustworthiness.

In sum, although it is commonly accepted that there is an impact of e-Assurances on perceived trust, risk and purchase intentions in online environments, more research is needed to clarify the effectiveness of each. The inconsistencies found in the literature may be due to the automatic and subconscious nature of the processing of the trust or risk conveyed by e-Assurances. This would therefore deem crucial to delve deeper into establishing the brain reactions elicited by e-Assurances. Understanding the results of the self-report and neural correlates of trust or risk associated with each e-Assurance, and clarifying which e-Assurance is thought to be more trustworthy, will provide invaluable insight into the most appropriate means of developing secure and encouraging online purchase environments.

10.2.2. Neural Correlates of E-Assurances: Trust and Risk

Current advances in cognitive neuroscience are unveiling the neural bases of cognitive, emotional, and social processes, as well as offering insight into the complex interplay between Innovation Technology (IT) and information processing, decision making, and behavior among consumers, organizations, and markets. Certain recent enquiries (e.g. Dimoka et al. 2011; Riedl, Davis & Hevner 2014) have introduced the idea of drawing upon cognitive neuroscience literature in the framework of Information Systems research (hence the term "NeuroIS"). These studies identify a set of opportunities that IS researchers can exploit to gain knowledge on IS phenomena, namely identifying the neural correlates of IS variables or capturing hidden mental processes among consumers.

An fMRI study carried out in 2010 by Dimoka in the field of e-commerce revealed that trust and distrust activate different brain areas and give way to distinct effects on price premiums. This helps explain why trust and distrust are distinct constructs associated with different neurological processes. The same author and colleagues (2008) also identified the brain areas activated when during interaction with websites that differ in level of usefulness and ease of use. Other academics (Riedl, Hubert, & Kenning 2010) went so far as to analyze whether online trust shows neural contrasts from the gender standpoint. Apart from these studies, no research to date has singled out the neural effects of e-Assurances on online product evaluation. Neurological tools, in fact, offer an outstanding means to objectively study the effectiveness of each e-Assurance as the comparison of brain activations elicited by seals of approval, rating systems or assurance statements during product evaluation can reveal different levels of trust and risk.

The likely higher *positive rewards* conferred to products accompanied by one or another e-Assurance may convey positive information and hence lead to involvement of the brain regions linked to reward. Across the wide range of contexts, a broad neural circuit is involved in reward processing. This includes the ventral striatum, brainstem, septal area and ventral tagmental area (Bartra, McGuire, & Kable 2013; Krueger et al. 2007; Riedl & Javor 2010). Specifically, neuroimaging studies exploring product preferences in the field of consumer behavior have shown that the ventral striatum is linked to anticipation of a pleasant primary taste reward (O'Doherty et al., 2002) during the visual inspection of preferred foods (Stoeckel et al., 2008). Similarly, Bartra et al. (2013) carried out a meta-analysis examining the neural correlates of subjective value and found that the ventral striatum is highly involved with positive effects in the reward domain. The authors also advanced that the posterior part of the brain (brainstem) is highly elicited by reward stimuli. Studies exploring the neural processing of rewarding obese participants with food corroborate the brainstem's reward-related function (Volkow et al. 2011; Ralph, Taylor & Picciotto 2012). Krueger et al. (2007) carried out an fMRI study aiming to elucidate the brain regions essential in building a trust relationship. Their findings point to the septal area (which includes the anterior paracingulate cortex) and the ventral tegmental area. Moreover, previous research confirmed the connection of those two areas to reward and trust (Dimoka 2010; Reimann et al. 2011).

In addition to rewarding and positive properties, more trustworthy e-Assurances may also convey greater *valuable expectations***.** Neuroimaging studies offer consistent evidence of involvement of two brain areas in value computation, namely the ventral striatum and the pre-superior motor area (pre-SMA hereafter). In their meta-analysis examining the neural correlates of subjective value, Bartra et al. (2013) found that a specific portion of the right ventral striatum and the pre-SMA responds significantly to expected values of outcomes. Campos et al. (2005) and Linder et al. (2010) concurred that these areas encode value expectancy respectively in eye-movement and in product valuation tasks. On the contrary, a negative value that is likely conveyed during a purchase by riskier e-Assurances may elicit brain regions linked to risk, ambiguity and negative feelings. The dorsomedial prefrontal cortex (DMPFC), among other brain regions (such as the middle occipital gyrus or orbitofrontal gyrus), has been extensively related to danger (Liddell et al., 2005) and the *penalty domain* (Bartra, McGuire, & Kable 2013). Krain et al. (2006) carried out a meta-analysis on decision-making tasks aiming to clarify the neural mechanisms of *risk* and *ambiguity*. Their results confirm that while the middle frontal gyrus, superior frontal gyrus, cingulate gyrus and inferior parietal gyrus are strongly related to the processing of ambiguous stimuli, the superior parietal gyrus and precentral show more response to risky tasks.

10.3. Research Objectives

Implicit processes are possibly present during the reception of e-Assurances that are inaccessible to conscious awareness, as well as conscious processes that are simply not identified in ratings following reception of the signals. These, in fact, might explain inconsistencies in e-

Assurances effectiveness in interactive marketing literature. Following recent neuroscience research capturing hidden mental processes of IS constructs, this paper aims to overcome previous limitations and objectively: i) investigate neural differences between seals of approval, rating systems and assurance statements during evaluation of low-involvement products, ii) and assess whether the corresponding areas elicited by e-Assurances predict self-reported trust, risk, purchase intention and the price customers are willing to pay for products.

Although the studies above assess trust, reward, ambiguity, risk and penalty in different fields, the findings serve to advance that e-Assurances perceived as more trustworthy should elicit activations related to reward (ventral striatum, brainstem, septal area and ventral tagmental area) and value expectations (ventral striatum and the pre-SMA). Reversely, the negative value during product evaluation that is likely conveyed by riskier e-Assurances may elicit brain regions related to risk (superior parietal gyrus and precentral), ambiguity (middle frontal gyrus, superior frontal gyrus, cingulate gyrus and inferior parietal gyrus) and negative feelings (DMPFC). Given the importance from the interactive marketing perspective of understanding the role of specific brain areas in predicting self-report responses such as trust, risk, purchase intentions or price willingness to pay, this study also delves into the question of which brain regions activated during viewing e-Assurances covary with levels of trust, purchase intentions and prices toward products. As in the case of earlier studies in this field, the authors of the current study presume activation in the areas most commonly involved with value encoding and in the reward-sensitive areas such as the superior frontal gyrus, middle frontal gyrus or inferior frontal gyrus (Bartra, McGuire, & Kable 2013). Reversely, the authors expect that risk scores covary with brain regions related to risk and negative evaluations such as thalamus (Aleman, & Swart 2008) or the superior parietal gyrus (Krain et al. 2006). To explore these research questions, this study resorted to functional Magnetic Resonance Imaging (fMRI), a technique that offers an indirect measure of brain activation (Casado-Aranda, Sánchez-Fernández, & Francisco J. Montoro-Ríos 2017; Solnais et al. 2013).

10.4. Method

10.4.1. Participants

Thirty right-handed participants (15 females) averaging 25.04 (SD: 4.32) years of age were selected to participate in the experiment via social networks and the institutional website of XXX University (July - September 2017). The experiment applied standard fMRI exclusion criteria such as claustrophobia, pregnancy and metal implants. Access to private medical information and an ethical commitment consent form were obtained from each participant. Furthermore, the study was approved by a local ethical committee following the Protocol of the World Medical Association Declaration of Helsinki (2013). A total of 29 participants took part in the fMRI analysis as one individual did not adhere to the standards.

Only participants with a high-medium computer expertise were retained as the average expertise level was 5.4 (SD: 1.2) on a seven-point scale (anchored at 1 = low expertise to 7 = high expertise). In addition, 72% spent more than 10 h per week using the Internet, and 85% had purchased books on the Internet at least once, with 67% purchasing at least once each semester. Collectively, the sampling was representative of Spanish online consumers (Statistical National Institute 2017) as 46.66% were female and 53.33% male. All were also keen on reading books, as 89% of them reported reading more than three times a week.

The subjects were also assessed according to the important trait of level of risk (risk propensity) by means of a 7-Likert scale of one item: “I am willing to take substantial risks when online shopping” (adapted from Cho & Lee 2006) with “1 = Totally disagree” and “7 = Totally agree.” The analysis revealed no extreme outliers as the risk propensity of all participants lined up along the medium mean of 3.32, $SD = 0.97$.

10.4.2. Stimuli

The main objective of the experimental design was to simulate the online purchase process of low involvement products, specifically books. Participants viewed six different types of books (four times each) corresponding to a total of 48 trials (in total, 24 books, 18 e-Assurances and 6 controls). The subjects were explained that all books were written by fictitious authors and shared identical page numbers. The color of the books was also uniform (white and black) and they included similar cover page illustrations. In line with previous studies, distinct images of books were selected to avoid monotony during the scanning. The authors purposely simulated the realistic website layout of a fictitious book seller: Bookler.com.

After each book, participants were shown one of the three e-Assurances (rating systems, seals of approval and statements, 18 trials in total) in the fictitious Bookler.com website and were asked to imagine the purchase of the book in function of the e-Assurance. An empty slide in the layout of Bookler.com at times served as a control item and was shown to simulate the absence of e-Assurances during the purchasing process (the remaining 6 trials). fMRI studies require appropriate control variables to "cancel out" spurious brain activation due to visual stimuli, movement, and other sources of noise, and thus isolate brain activation only linked to the experimental stimuli. The set of the e-Assurances was designed in a way that the authors homogenized both the number of words explaining the e-Assurance (between 20 and 24) and their visual complexity. The seal of approval selected was "Confianza Online," the most well-known logo in Spain provided by an independent evaluator firm to businesses that "have decided to make a commitment to promoting good practices on the Internet." The rating system revealed high scores by previous customers regarding privacy disclosure, web security, delivering and return, as well as financial guarantees when doing business with Bookler.com. The assurance statements included the Bookler.com logo together with a description of the returns, privacy and security policies of the seller.

Following previous research (Garbarino & Strahilevitz 2004), books were chosen as the product of study because buyers view them as low involvement. The authors, in an independent sample (n = 80), corroborated the level of involvement of the books by asking participants to express their opinions (7-point Likert scale, 1 = none and 7 = very) of the adjectives included in Zaichkowsky's involvement scale (1986): important, boring, irrelevant, exciting, means much to me, attractive, trivial, worthy or thrilling. After averaging the scores of each adjective of the index, all subjects reported that they considered books as low involvement products (mean = 2.52 and SD = 1.02).

10.4.3. Task

Participants arrived at the laboratory one hour prior to the fMRI task. After receiving instructions and verifying that all the procedures were clear, they completed an informed consent form. They then attended a session to identify the differences between the three e-Assurances. They then began the experiment with a short practice session on a computer to familiarize themselves with the stimuli.

The fMRI experiment consisted of 48 trials (

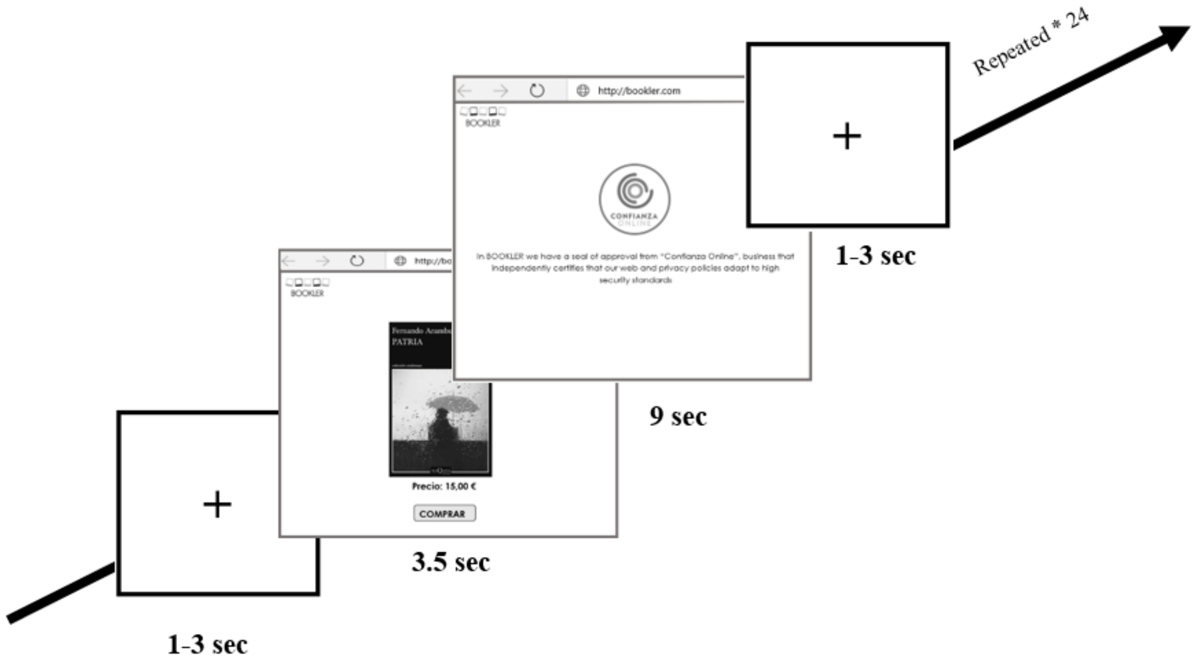

Figure **53**). Each began with the display of a short period of fixation (1-2 s) followed by observation of the layout of Bookler.com including a 3.5 seconds viewing of a randomly selected book. The subjects were then required to reflect on the previous purchase taking into consideration an e-Assurance displayed randomly (9 seconds). This was followed by the display of a fixation cross (1-2 s). The order of the e-Assurances was counterbalanced among the subjects. At the end of the task the subjects received a 30 € payment. The fMRI stimuli were presented via E-Prime Professional 2.0 and lasted about 14 minutes. The timing of each trial was adapted from previous fMRI studies (Dimoka, 2010; Riedl & Javor 2012) and randomization of the books and e-Assurances were implemented by using the "Random" option in the layout of the E-Prime Professional 2.0 software.

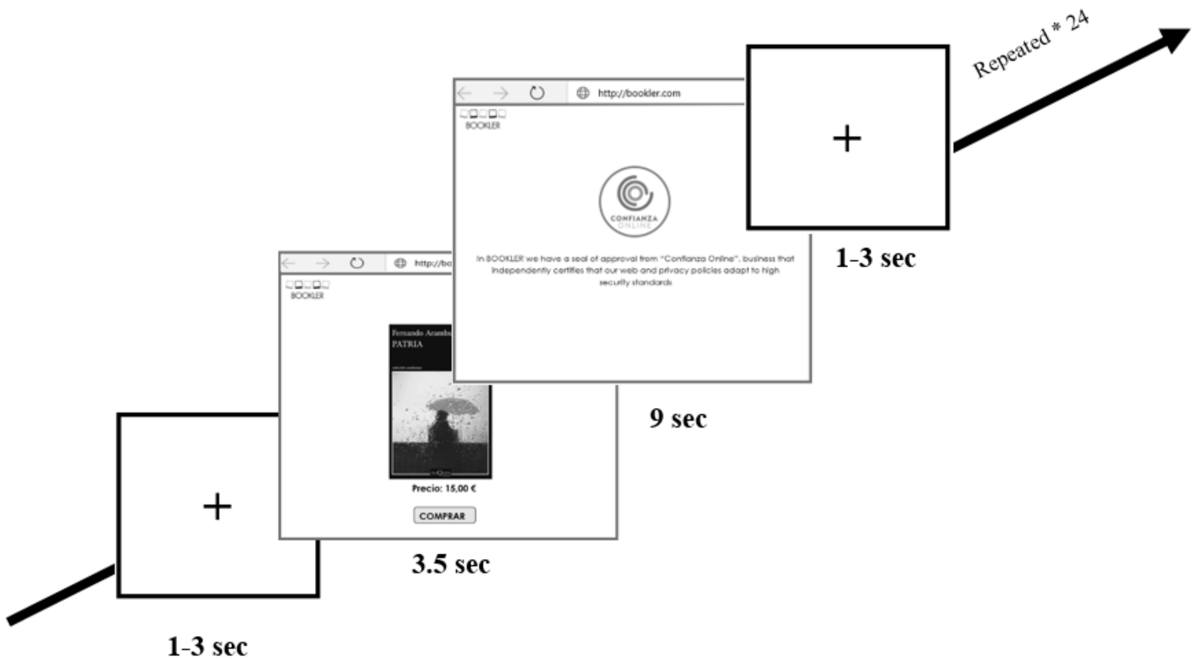

Figure 53. Depiction of the experimental design of the fMRI task. The order corresponds to the first block of trials. The order of the subsequent trials is random and counterbalanced.

10.4.4. Questionnaires

After the scanning, the participants responded to questions regarding trust, risk and intentions gleaned from the purchase of a book in Bookler.com and taking into consideration each e-Assurance. Along the same line, the authors formulated the following inquiries: "After seeing the seal of approval/rating system/assurance statement accompanying the purchase of the book, what is the trust/risk/purchase intention toward the acquisition of this product?" (with 1 = low levels of trust, risk and purchase intentions, and 7 = the highest levels of trust, risk and purchase intentions). The authors also asked the participants the following open question as to the price they would be willing to pay for the book based on its e-Assurances: "After seeing the seal of approval/rating system/assurance statement accompanying the purchase of the book, what is the price you are willing to pay for the book?" The reported price corresponds to a value above and below an average price given to the book during the scanning (i.e. 15 €).

10.4.5. fMRI Participant Level Analyses

Statistical maps were generated for each participant by fitting a boxcar function to the time series convolved with the canonical hemodynamic response function. Data were high-pass filtered with a cutoff of at 128 s. Neuroimaging studies use high-pass filtering with the aim to remove the very low frequencies of the hemodynamic response signal and "pass through" the high frequencies, the latter being the most interesting for the analysis. A general linear model (GLM) was estimated for each participant with the following regressors of interest:

i) Onset picture in the book
ii) Onset picture in the seal of approval
iii) Onset picture in the rating system
iv) Onset picture in the assurance statement
v) Onset picture in the non-assurance slide

Furthermore, each GLM included a constant session term, six covariates to capture residual movement-related artifacts, and fixation crosses as regressors of no interest.

To establish the brain regions that reveal contrasts of responses to seals of approval, the current study carried out a mean subtraction analysis between seals of approval and rating systems together with assurance statements conditions. This resulted in a contrast image of seals of approval minus rating system and assurance statement evaluation periods and a contrast image of the last two e-Assurances as opposed to seals of approval (ii vs. iii + iv, and vice versa). The study also separately contrasted the seals of approval time periods with rating systems and assurance statements (i.e. ii vs. iii and ii vs. iv). To ascertain the brain differences between rating systems and the remaining e-Assurances, four contrasts were calculated: rating systems vs. seals of approval and assurance statements (iii vs. ii + iv) and vice versa, rating systems vs. seals of approval (iii vs. ii), and rating systems vs. assurance statements (iii vs. iv). To test the brain differences between assurance statements and the remaining two e-Assurances, four subtractions were carried out: assurance statements vs. seals of approval and rating systems (iv vs. ii + iii) and vice versa, assurance statements vs. seals of approval (iv vs. ii) and assurance statements vs. rating systems (iv vs. iii).

10.4.6. fMRI Group Level Analyses

To determine the brain regions revealing different types of activations as to seals of approval vs. rating systems vs. assurance statements, the following contrast images were subject to a one-sample t-test analyses. To examine the brain areas that correlate with a likely incremental trust, purchase intention and price toward books accompanied by seals of approval over the same products accompanied by rating systems or assurance statements, the contrast images of seals of approval vs. rating systems and seals of approval vs. assurance statements were subject to one-sample t-tests with as covariate the subtraction of the individual scores of trust, purchase intention and price between the seals of approval, assurance statements and rating systems.

The analyses were carried out by means of a Region of Interest (ROI) approach using small volume correction (SVC) as implemented in SPM, which means that the selected regions of interest were developed based on the coordinates of similar research. Brain activations were labeled according to the automated anatomic labeling tool implemented in the MRIcron and reported using MNI coordinates.

Five reward- and trust-related areas were selected as ROI, namely the striatum, brainstem, septal area and ventral tagmental area. Specifically, the authors applied 10 mm spheres around the coordinates in the striatum (x = 12, y = 6, z = -8) and brainstem (x = 0, y = -20, z = 6) as reported by Bartra, McGuire and Kable (2013) in a metanalysis about the positive effects of stimuli in the reward domain. The authors also applied 10 mm spheres around the coordinates in the septal (x = 1, y = 2, z = -4) and the ventral tagmental areas (x = 2, y= -20, z = -13) as reported by Krueger et al. (2007) in a specific study about the neural correlates of trust. Given the higher value most likely conveyed by the most trustworthy e-Assurances, the authors selected two areas typically linked to value computation as ROI, specifically those reported by Bartra, McGuire and Kable (2013): the ventral striatum (x = 12, y = 10, z = -6) and the pre-SMA (x = -2, y = 16, z = 46).

The e-Assurances subconsciously perceived as less rewarding are likely to elicit an area that Bratra et al. (2013) reported to be associated with a penalty domain, namely the DMPFC (x = 4, y = 22, z = 44). The authors applied 10 mm spheres around those coordinates in the SVC analysis and carried out similar analysis with four ambiguous-related areas which were selected as ROI, namely the middle frontal gyrus (x = 28, y = 2, z = 60), superior frontal gyrus (x = 40, y = 40, z = 30), cingulate gyrus (x = -4, y = 22, z = 37) and inferior parietal gyrus (x = 12, y = -66, z = 61) based on the meta-analysis of mechanisms of risk and ambiguity in decision-making tasks carried out by Krain et al. (2006). Finally, 10 mm spheres were applied around the superior parietal gyrus (x = 30, y = -51, z = 55), precentral gyrus (x = 40, y = 5, z = 36) and anterior cingulate gyrus (x = -20, y = 39, z = 14) that were reported by Krain et al. (2006) to be involved with risky decision making. For regions other than those of *a priori* interest, the study reports the significant clusters at a stricter statistical threshold of $p < 0.001_{\text{uncorrected}}$ and a cluster extent $k > 20$ in line with other research in the field (Casado-Aranda et al., 2018) (see Appendix B for a detailed overview of the preprocessing and image acquisition procedures and see Appendix C for the main regions and functions of interest for risky and security processing).

10.5. Results

10.5.1. Self-report Results

The statistical software IBM Statistical Package for Social Sciences (IBM SPSS Version 20) served to evaluate trust, risk, purchase intentions and prices willing to pay for books accompanied by each type of e-Assurance. Paired-sample t-tests indicate that the trust conferred to books accompanied by seals of approval (mean = 5.03; SD = .95) yielded significantly more positive scores than the remaining e-Assurances (mean = 4.27; SD = 0.98) in general ($t (28) = 4.52$; $p < .001$), and specifically more than those accompanied by rating systems (mean = 4.48; SD = 1.4) and assurance statements (mean = 4.07; SD = 1.16). However, participants showed significantly lower levels of trust toward books accompanied by assurance statements than the joint results of the other e-Assurances ($t (28) = -3.02$; $p = .005$).

Along the same line, Paired-sample t-tests indicate that books accompanied by seals of approval elicited significantly lower levels of perceived risk (mean = 2.25; SD = 0.91) when compared to the joint results of the other e-Assurances (mean = 2.74; SD = 0.92), and specifically when compared to rating systems (mean = 2.63; SD = 1.18).

Following the tendency of perceived trust, participants also revealed significantly higher intentions to purchase books accompanied by seals of approval (mean = 6.00; SD = 0.65) as opposed to the other e-Assurances (mean = 5.13; SD = 1.01) in general ($t (28) = 5.12$; $p < .001$), and specifically, as opposed to rating systems (mean = 5.28; SD = 1.01) and assurance statements (mean = 5.00; SD = 1.22). The subjects also revealed significantly lower levels of purchase intentions toward books accompanied by assurance statements than the joint results of the other e-Assurances ($t (28) = -3.67$; $p < .001$).

Finally, Paired-sample t-tests indicate that participants were willing to pay higher prices for books accompanied by seals of approval (mean = 14.28 €; SD = 2.54 €) as opposed to the remaining e-Assurances conjointly analyzed (mean = 13.38€; SD = 2.40€; $p < .001$), and specifically when compared to assurance statements (mean = 13.01 €; SD = 2.92€).

10.5.2. Functional Imaging Results

- *Seals of Approval vs. Rating Systems and Assurance Statements*

The whole brain analysis ($p_{uncorrected} < .001$, $k > 20$ voxels) indicates that clusters in the Rolandic operculum, calcarine, angular gyrus and SMA were more strongly activated in response to seals of approval vs. the remaining e-Assurances. When restricting this analysis to the ROIs (at an FWE-corrected threshold of $p < .05$) reported by Bartra, McGuire, and Kable (2010), Krueger et al. (2007) and Riedl et al. (2010), the previously hypothesized pre-SMA fell in line with that comparison (Figure 54A). The opposite contrast (rating systems + assurance statements vs. seals of approval) revealed supra-threshold activations in the anterior cingulate (ROI's, Krain et al. 2006) and in the superior parietal and inferior parietal gyri for $p_{uncorrected} < .001$, $k > 20$ voxels. See Table 22 for all peak coordinates.

Table 22. Brain regions revealing different activations in response to the conjoint analysis of seals of approval and the other e-Assurances.

Seals of approval	**Peak MNI coordinates (mm)** x	y	z	**Cluster size**	**T**	**Study**
Seals of approval > Rest						
ROIs [a]						
Pre-SMA	-2	16	46	3	3.72	Bartra, McGuire, & Kable (2013)
Whole brain [c]						
Rolandic operculum	45	-4	9	271	7.89	
Calcarine	10	-88	-6	110	6.59	
Angular gyrus	-36	-63	44	92	6.18	
Superior motor area	-5	0	58	181	5.72	
Rest > Seals of approval						
ROI						
Anterior cingulate	-20	39	14	5	4.14	Krain et al. (2006)
Whole brain [c]						
Superior parietal	-26	-46	72	20	4.57	
Inferior parietal	55	-35	51	21	4.53	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 10$ voxels are reported.

[c] Peaks of clusters significant at $p < .001$ uncorrected, voxel level is reported.

Furthermore, when comparing seals of approval vs. rating systems, the ROIs striatum and septal area (among other regions that survived to the whole-brain analysis) show greater activation (Figure 54B). The contrast seals of approval vs. statements, in turn, yielded more supra-threshold activations in the superior frontal gyrus for $p_{uncorrected} < .001$, $k > 20$ voxels. Table 23 lists all the peak coordinates.

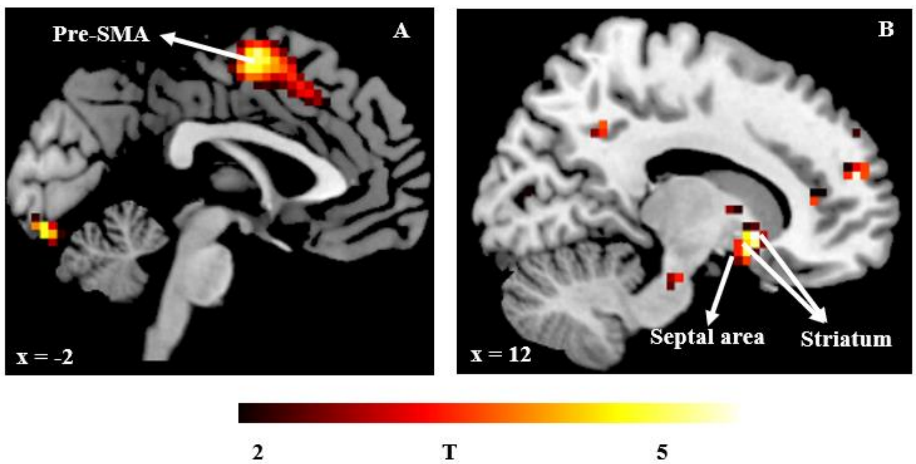

Figure 54. Main effect of the evaluation of book websites accompanied by Seals of Approval. A) view of the increase of activity in the pre-MSA (ROI analysis), the rolandic operculum, calcarine, angular gyrus, superior motor area and inferior parietal gyrus (whole brain analysis) at the moment of Seals of Approval vs. the other e-Assurances; B) view of the increase in activation in the striatum and septal areas (ROI analysis) and middle temporal areas (whole brain analysis). The images are depicted at T-map thresholded at $p < .001_{uncorrected}$, superimposed on the mean anatomical image of all subjects (MNI-space).

Table 23. Brain regions revealing different values of activation in response to seals of approval as opposed to rating systems (as compared to assurance statements).

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Seals of approval > Rating systems						
ROIs [a]						
Striatum	12	6	-8	3	3.94	Bartra, McGuire, & Kable (2013)
Striatum	12	10	-6	4	3.94	Bartra, McGuire, & Kable (2013)
Septal area	1	2	-4	2	3.94	Krueger et al. (2007)
Whole brain [c]						
Middle temporal gyrus	-57	-42	9	185	5.77	
Middle temporal gyrus	59	-11	-13	43	4.45	
Seals of approval > Assurance Statements						
Whole brain [c]						
Superior frontal gyrus	-15	32	58	20	3.89	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 10$ voxels are reported.

[c] Peaks of clusters significant at $p < .001$ uncorrected, voxel level is reported.

- *Assurance Statements vs. Seals of Approval and Rating Systems*

The comparison of the assurance statements with the two remaining e-Assurances, and vice versa, did not yield any supra-threshold activations either at the whole brain or ROI level. Neither did the assurance statement vs. seals of approval contrast (American vs. Spanish products) reveal supra-threshold activations. Nevertheless, clusters in the previously hypothesized ROIs brainstem and ventral tagmental area showed significant activation when confronted with assurance statements, as opposed to rating systems at an FWE-corrected threshold of $p < .05$. The whole brain analysis of that contrast also revealed significant activations of the middle temporal and fusiform regions ($p < .001$ uncorrected, $k > 20$) (See Table 24 for an overview of all the peak coordinates).

Table 24. Brain regions revealing different activations in response to assurance statements vs. rating systems.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Assurance statement > Rating systems						
ROIs [a]						
Brainstem	-2	-22	-12	3	3.81	Bartra, McGuire, & Kable (2013)
Ventral tagmental area	2	-20	-13	3	3.81	Krueger et al. (2007)
Whole brain [c]						
Middle temporal gyrus	59	-11	-13	85	6.04	
Fusiform gyrus	-40	-39	-20	39	5.60	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 10$ voxels are reported.

[c] Peaks of clusters significant at $p < .001$ uncorrected, voxel level is reported.

- *Rating Systems vs. Seals of Approval and Assurance Statements*

Among the other regions activated at the whole brain level, the comparison of ratings vs. seals of approval + assurance statements elicited an increase in activation in the ROIs as reported by Krain et al. (2006) in the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus at an FWE-corrected threshold of $p < .05$ (Figure 55; Table 25). Specifically, at the whole brain level, the contrast rating system vs. seals of approval reflected higher activations in the hypothesized ROIs DMPFC, superior parietal gyrus, precentral gyrus, middle frontal gyrus, cingulate gyrus and inferior parietal gyrus. The contrast rating systems vs. assurance statements also significantly activated the same coordinates of the ROI superior parietal gyrus, as well as other clusters found at the whole brain level. See the remaining peak coordinates in Appendix D and E.

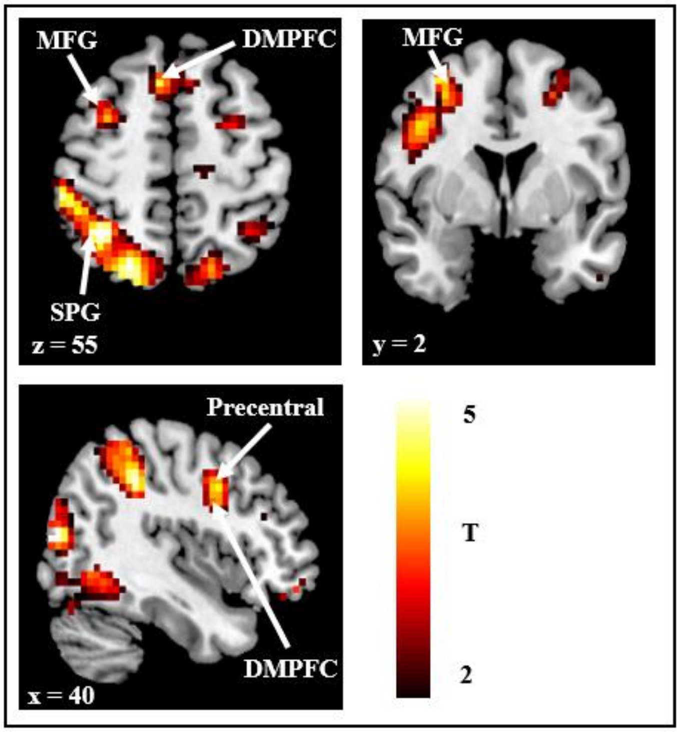

Figure 55. Main effect of the evaluation of book websites accompanied by Rating Systems. An increase of activity is recorded in the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus (ROI analysis) as well as in the middle occipital gyrus, inferior parietal gyrus, precentral and precuneus (whole brain analysis) when rating systems, as opposed to evaluation of the other e-Assurances. The image is depicted at T-map thresholded at $p < .001_{\text{uncorrected}}$, superimposed on the mean anatomical image of all subjects (MNI-space).

Table 25. Brain regions revealing different activations in response to rating systems as opposed to the results of the conjointly analysis of the other e-Assurances.

Seals of approval	**Peak MNI coordinates (mm)** x	y	z	**Cluster size**	**T**	**Study**
Rating systems > Rest						
ROIs [a]						
DMPFC	4	22	44	10	4.04	Bartra, McGuire, & Kable (2013)
Superior parietal gyrus	30	-51	55	55	6.30	Krain et al. (2006)
Precentral gyrus	40	5	36	33	5.27	Krain et al. (2006)
Middle frontal gyrus	28	2	60	11	4.33	Krain et al. (2006)
Whole brain [c]						
Middle occipital gyrus	31	-91	12	1559	8.07	
Inferior parietal gyrus	-33	-46	44	83	6.39	
Precentral	52	11	37	77	5.48	
Precuneus	-19	-70	47	35	4.61	

[a] Peaks reported are significant at p <.05 FWE-corrected on ROI level.

[b] Peaks of clusters significant at p <.001 uncorrected, k > 10 voxels are reported.

[c] Peaks of clusters significant at p <.001 uncorrected, voxel level is reported.

- *Relation between neural responses and trust, risk, purchase intention and price*

Activation in the medial portion of the superior frontal gyrus (x = 3, y = 46, z = 47) during the evaluation of seals of approval minus rating systems covaried significantly (positively) with an incremental trust conferred to books accompanied by seals of approval over the same products with rating systems (r = .361). Along the same line, the incremental intention reported toward the purchase of books accompanied by seals of approval versus rating systems was associated (r = .432) with the activation of the middle frontal gyrus (x = 38, y = 7, z = 61) during the evaluation of seals of approval (vs. rating systems). Similarly, the increased activation of the inferior frontal gyrus (x = -54, y = 35, z = 12) while evaluating seals of approval (vs. assurance statements) was positively (r = .172) related to the incremental trust conferred to books accompanied by seals of approval as opposed to assurance statements.

The higher levels of perceived risk elicited by rating systems when compared to seals of approval were significantly linked (r = .357) with an increase in activation in the thalamus (x = 17, y = -18, z = 2) during the evaluation of books accompanied by ratings as opposed to seals of approval. Finally, activation in the medial superior frontal gyrus (x = -1, y = 46, z = 47) during the evaluation of products accompanied by seals of approval (vs. the remaining e-Assurances) covaried significantly (r = .443) with an higher price conferred to books followed by the seals of approval (vs. the remaining e-Assurances).

A more liberal threshold was applied in this exploratory analysis since it enquires as to the most important brain areas involved in value and reward (e.g. posterior cingulate cortex or cerebellum). In this case the study resorted to a threshold of $p < 0.001$ uncorrected with a cluster extent of minimum 5 voxels. Figure 56 shows the associations of trust and risk scores with brain activations.

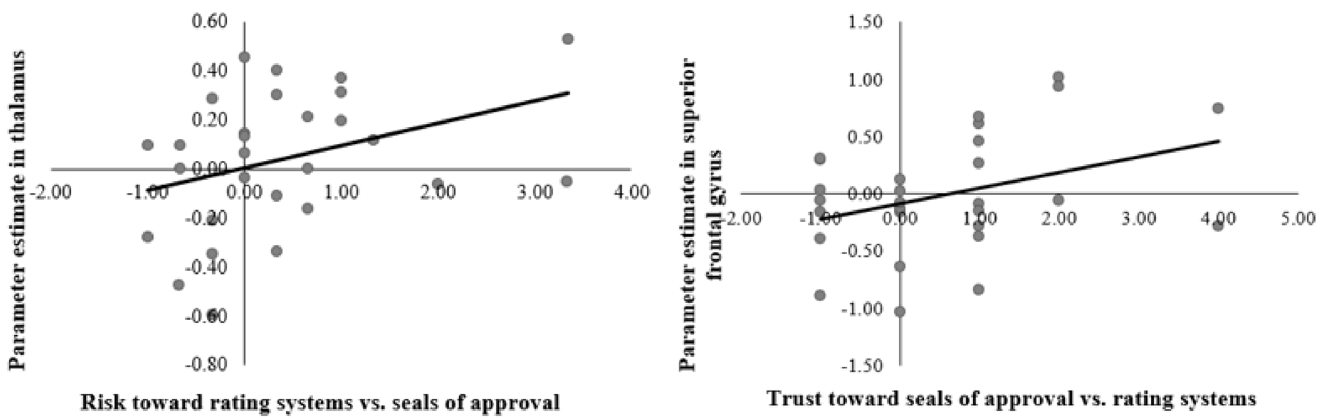

Figure 56. Relation between neural responses and trust and risk scores. **(A)** Plot of the correlation between the parameter estimate of rating systems vs. seals of approval in the thalamus cluster and differences between the levels of perceived risk between rating systems and seals of approval; (B) Plot of the correlation between the parameter estimate of seals of approval vs. rating systems in the superior frontal gyrus cluster and the differences between levels of perceived trust between seals of approval and rating systems.

10.6. Discussion

The growth in online transactions coupled with the worldwide increase in Internet-based information exchange and e-commerce is nowadays accompanied by consumer fear, distrust and high levels of perceived risk (Hille, Walsh, & Mark Cleveland, 2015). As a consequence, online retailers are looking for ways to reduce ambiguity and increase trust, intentions, price willing to pay and actual purchases. E-commerce literature widely concurs on the positive impact that Web services exert on those variables. There is no consensus, however, on the relative effectiveness of different e-Assurances, namely seals of approval, rating systems and assurance statements. This is the first study that resorts to neurological and self-report tools to objectively examine this gap and ascertain the origin by which e-Assurance conveys more trust in a controlled purchase environment (i.e. low involvement environment) and hence lead to involvement of brain regions linked to reward and value computation. This research also assesses whether the corresponding areas elicited by e-Assurances can predict self-reported trust, risk, purchase intention and price willing to pay for products. The behavioral findings unveil that certificates provided by third-party vendors (i.e. seals of approval), as opposed to rating systems and assurance statements, yield a higher perception of trust, purchase intentions and price desiring to pay, as well as lower levels of perceived risk. The later, furthermore, constitute the web assurance that provokes lower perceived trust during the purchase of books. Interestingly, the fMRI scans reveal that: i) seals of approval give rise to stronger activation in value- and reward-related areas when compared to the other e-Assurances, but above all, when compared to rating systems; ii) assurance statements strongly elicit reward- and trust-related areas when compared to rating systems, and iii) rating systems provoke negative and ambiguous-related activations, showing higher levels when compared to seals of approval. This study also brings to light for the first time that higher perceived trust afforded to books accompanied by seals of approval was predicted by value-computation brain areas while evaluation of this e-Assurance, and higher perceived risk provided to rating systems (vs. seals of approval), correlated with areas involved with negative processing.

As regards self-report responses, this study infers that seals of approval yield a significantly more trustworthy online environment than other e-Assurances given the higher scores received in perceived trust. These findings line up with those of the studies of Nöteberg, Christiaanse and Wallage (2003) and Portz, Strong, and Sundby (2001) in that the presence of the web seal increases the perception of website trustworthiness. What is more, the lower levels of perceived risk, as well as the willingness to pay a higher price and purchase intentions afforded to books accompanied by seals of approval, corroborate the key role that the characteristics of the website play as an antecedent of valuation and purchase intentions toward online products (Featherman, & Pavlou 2003; Kim & Peterson, 2017). In addition, participants did not show significant differences between trust, risk, price and purchase intentions toward products accompanied by assurance statements versus rating systems. This could suggest that the trustee sources of the retailer and previous customers may be similarly perceived. Consequently, it could be suggested that not all the external (e.g. customer opinions or seals) or all internal (e.g. privacy or return policies) e-Assurances exert the same impact on e-commerce outcomes, but depend on the source of the e-Assurance (contrary to the reasoning of Bahmanziari et al. 2009). Interestingly, when compared simultaneously to seals of approval and rating systems, assurance statements did provoke significantly lower scores in perceived trust, a notion in line with the findings of Pennington et al. (2003) and Lee and Turban (2001).

The neurological analyses carried out in this study amount to a step in the right direction as they reveal the underlying brain mechanisms that trigger trust and risk toward products accompanied by different e-Assurances. On the one hand, brain regions eliciting stronger activation during evaluation of seals of approval, as opposed to the remaining e-Assurances, include the pre-SMA at the ROI level, and the rolandic operculum, calcarine, angular gyrus and superior motor area at the whole-brain level. The role of the pre-SMA in value computation during decision making is largely evidenced as a great amount of research confirms that this brain area encodes the expected values of outcomes (Bartra, McGuire, & Kable 2013; Pisauro et al. 2017). The rolandic operculum is a part of the frontal lobe involved with preference judgements (Chaudhry et al, 2009). Together with the angular gyrus, the calcarine has been traditionally related to enhancements of endogenous attention to relevant information (Cate et al. 2009). These results are supported by the brain areas elicited by the reverse contrast (rating systems + assurance statements vs. seals of approval), namely the ROI anterior cingulate together with the middle temporal gyrus, as well as the superior and inferior parietal gyri. In the meta-analysis on decision-making, Krain et al (2006) indicate that the anterior cingulate is linked to risky decisions. The same authors also concluded that the inferior parietal gyrus is an ambiguous-related area whereas the superior parietal gyrus is more in line with risky tasks. Overall, these results suggest that the higher trust conferred to products accompanied by seals of approval (vs. the remaining e-

Assurances, see section 4.1.) originates with higher expected values and attention paid to the third-party certificates.

More specifically, the analysis comparing seals of approval with rating systems and assurance statements, when considered individually, reveals that third-party certificates are far more trustworthy than rating systems given the activation in previously hypothesized ventral striatum and septal areas. In line with the findings of Bartra et al. (2013), previous studies exploring product preferences have shown that the ventral striatum is activated during anticipation of a pleasant primary taste reward (O'Doherty et al., 2002), as well as during the visualization of aesthetic packages. Furthermore, it is an area also known to encode the subjective value of a decision (Bartra et al., 2013) and constitutes a key element in trustworthy environments (e.g. Dimoka, 2010). Krueger et al. (2007) resorted to an fMRI study to clarify if the brain regions critically involved in building a trust relationship. Their findings indicate that the septal area satisfies their purposes and is connected to reward and trust (Dimoka, 2010; Reimann et al. 2011). The middle temporal gyrus, furthermore, is found to be activated in secure and safe circumstances (Matthews et al. 2004). Despite the higher scores that participants consciously conferred to products accompanied by seals of approval (when compared to assurance statements), brain data reveal that only one area, the superior frontal gyrus, is more strongly elicited by seals of approval vs. assurance statements. Previous research has also linked the left superior frontal gyrus to rewarding tasks (Rushworth et al. 2004). Taken together, these findings constitute a step forward as they evidence that despite the fact that seals of approval consciously yield more trust than rating systems and assurance statements, neural data reveal that brain activations related to reward and value computation are mostly found when contrasted to rating systems (i.e. to a lower extent when contrasting to assurance statements).

Interestingly, assurance statements only elicited greater brain activations when compared to rating systems. Particularly, the ROIs relate to reward and trust building, namely the brainstem (Bartra, McGuire & Kable 2013) and ventral tagmental (Krueger et al. 2013) respectively showed an increase in activation in response to the above contrast. The middle temporal and fusiform gyri also were strongly elicited at the whole brain level. The former is found to be activated in secure and safe circumstances (Matthews et al. 2004) while the later is a visual area typically involved with endogenous attention (Cate et al., 2009). Accordingly, despite the fact that the self-report findings did not show significant differences between trust, risk, price and purchase intentions conferred to products accompanied by assurance statements versus rating systems, participants did reveal different types of processing of assurance statements and rating systems at the subconscious level. The retailer's statement (vs. rating systems) conveyed a more positive online frame as it led to involvement of the brain regions linked to reward and attention.

Areas previously thought to be involved with the processing of risk, ambiguity and negative feelings (the DMPFC, superior parietal gyrus, precentral gyrus and middle frontal gyrus) show greater activation in response to rating systems as opposed to the other e-Assurances (analyzed conjointly and individually). The DMPFC is widely linked to danger (Liddell et al., 2005) and penalty domains (Bartra, McGuire, & Kable 2013). In their meta-analysis on decision making, Krain et al. (2006) found the middle frontal gyrus and superior parietal gyrus to be strongly related to processing ambiguous stimuli. Similarly, the same authors concluded that the superior parietal gyrus and precentral show greater responses to risky tasks, findings that are bolstered by earlier research (Lin et al. 2015). In our study, the stronger activation in the risk, negative and ambiguity-related areas during rating systems (vs. seals of approval and vs. assurance statements) may be the reflection of a riskier online environment which could negatively affect the trust conferred to the retailer website and, consequently, to purchase intention. These findings are of great interest as neural data bring to light differences inaccessible at the conscious level between trust conveyed by rating systems and assurance statements.

The last goal of this study is to evaluate whether the areas elicited by e-Assurances predict self-reported trust, risk, purchase intention and price willing to pay for products. The findings indicate a consistent tendency: the higher scores of trust, price and purchase intentions afforded to products accompanied by seals of approval (vs. rating systems) were predicted by increases in areas previously involved with value encoding and reward such as the superior frontal gyrus, middle frontal gyrus or inferior frontal gyrus (Bartra, McGuire, & Kable 2013; Casado-Aranda, Martínez-Fiestas and Sánchez-Fernández, 2018). Higher levels of perceived risk elicited by rating systems when compared to seals of approval, in turn, were greatly linked to an increase in activation in the thalamus during the evaluation of books accompanied by ratings (vs. seals of approval). The thalamus is traditionally associated with risky and negative tasks (Aleman, & Swart 2008; Preuschoff, Bossaerts & Quartz 2006). The greater superior, middle and inferior frontal activation during seals of approval among participants who granted a higher level of trust, price and purchase intentions to the books accompanied by seals of approval in the current study may reflect a higher subjective value and preference for online environments which include seals of approval (vs. rating systems). This reasoning is supported by the covariation found between the thalamus and the higher scores of risk conferred to rating systems.

Theoretically, the current findings contribute to the literature challenging the effects of web assurances on trust building in online environments. Earlier studies along these lines focus on the impact of general external and internal e-Assurances on initial trust (Bahmanziari, Odom & Ugrin 2009), the influence of user review volume on consumer willingness-to-pay (Wu, Yinglu, & Jianan Wu 2016) and trust of different modalities of assurance statements such as privacy disclosure (Bansal et al. 2016), return policies (Wang et al. 2004) or ethical performance (Yang et al. 2009). To our knowledge, the study of Pennington et al. 2003 is the only paper that explores the effectiveness of the three most widely used e-Assurances. However, the lack of control of the ~~ir~~ stimuli (colors, shapes, number of letters) and of the type of involvement of the online purchase environment, together with the subconscious nature of the processing of trust and risk associated with e-Assurances, indicate the need of further research to clarify the inconsistencies regarding the differences between the three types of e-Assurances. The current study constitutes a first step in this direction as it resorts to consumer neuroscience tools and controls for the number of letters, colors, type of retailer (fictitious) and involvement of the online marketplace. Unlike preceding studies resorting to self-report tools to generate data about the levels of trust/risk/purchase intentions triggered by different e-Assurances, the neuroscience techniques adopted by this study lead to reflections based on underlying cognitive, emotional, and social processes. Along this line, the current study advances that the higher levels of trust consciously conferred to products accompanied by seals of approval stem from the higher expected values, reward and attention triggered by the e-Assurance. Neurological tools also are known to offer evidence of the implicit processes (Dimoka 2010) present during the receipt of e-Assurances but inaccessible to conscious awareness. In this sense, the current study reveals differences at the brain level in the processing of assurance statements and rating systems, despite participants conferring similar levels of trust, risk and price to both e-Assurances. Finally, this paper constitutes a new step in the application of neurological tools to explore consumer processing of innovation technology constructs such as distrust (Dimoka 2010), usefulness and ease of use (Dimoka et al. 2008). Hence, this study spells out the processing of trust, risk, ambiguity and reward conveyed by e-Assurances accompanying the purchase of low involvement products.

These findings offer remarkable managerial implications as they firstly indicate that the source of trust of web assurance is key to implement rewarding and satisfying online purchase environments (Pennington, Wilcox, & Grover 2003). They also offer evidence based on brain activations related to reward and value computation that assurance signals provided by external evaluators after checking the online retailer websites and related activities (i.e. seals of approval) trigger the highest trust and lowest risk. Hence the findings indicate the importance for e-retailers to make an accurate choice of a well-known and widely renowned website evaluator to act as a trustee (Hu et al. 2010). Secondly, the returns, privacy and security policies included by the retailer on the website (i.e. assurance statements) trigger less self-reported trust during the product evaluation when compared to seals of approval. As its inclusion does not elicit more negative-related brain activations (vs. seals of approval), it will not damage the trust of the online environment. Rating systems, however, not only are consciously perceived as riskier than other e-Assurances, but their inclusion, when compared to others, may elicit brain regions related to ambiguity and negativity during the purchase process. Taken together, professionals interested in selling online products should go to great lengths to discriminate between the assurance they include in their web site. The findings of this study therefore strongly recommend the inclusion of seals of approval in a highly visible place within web site as they may serve as an external reward that can benefit and encourage the overall purchasing process. Furthermore, the inclusion of assurance statements in conjunction with seals of approval will at least not be negative, and may in fact be beneficial to sales, when pertinent marketing strategies are implemented. Finally, more trustworthy signals should be considered by online retailers to include in the website together with e-Assurances. These include a proper e-payment system (Slade, Williams & Dwivedi 2013), personal innovativeness information (Kalinic & Marincovic 2016; Molinillo & Japutra 2017) or efficient seller accessibility (Wells, Joseph, & Hess 2011).

It must be taken into consideration that the current study only measured self-reported intentions and prices desiring to acquire products and not actual purchasing behavior. Although it is widely demonstrated that more positive intentions toward products are linked to an increase in purchase behavior (Ajzen, 1991), future research should link neural responses to product valuation with actual purchasing behaviors. Secondly, and following previous research, this study only resorts to a low involvement purchase environment (i.e. books) to explore the effects of e-Assurances. Further research, in turn, should replicate the findings in high involvement frames and thus corroborate the key role of seals of approval in increasing online trust. Further research exploring the relative trust conveyed by different mechanisms (such as e-payments or website quality) is also needed to advance in the understanding of the effects of the web layout on trust building.

Despite the large amount of literature analyzing the effects of web assurances on trust building in online environments, it is surprising to observe how most studies omit comparing the effectiveness of the three most widely spread e-Assurances in controlled online environments. This is the first study that applies a multimethodological approach to face this research gap and advances that seals of approval are the most trustworthy assurance service due to the increase in expected values and reward they induce during product valuation. By contrast, the other e-Assurances, when compared with rating systems, are perceived as riskier as they subconsciously convey ambiguity and negative processes during the online purchase. Therefore, this exploratory study constitutes an advance in the understanding of the origin of trust and risk induced by e-commerce web sites and marks the first step in revealing the effects of e-Assurances by the use of more objective neurological tools.

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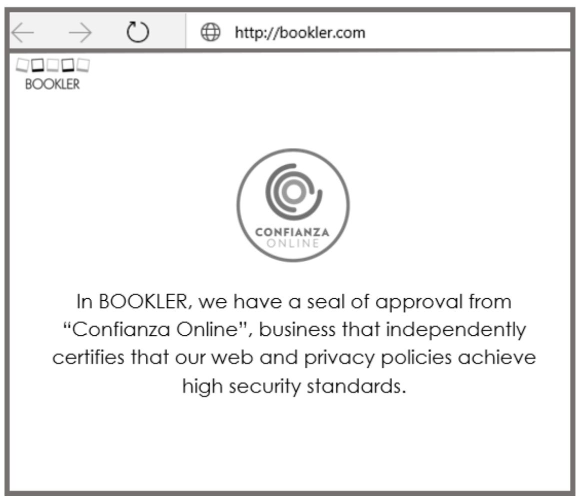
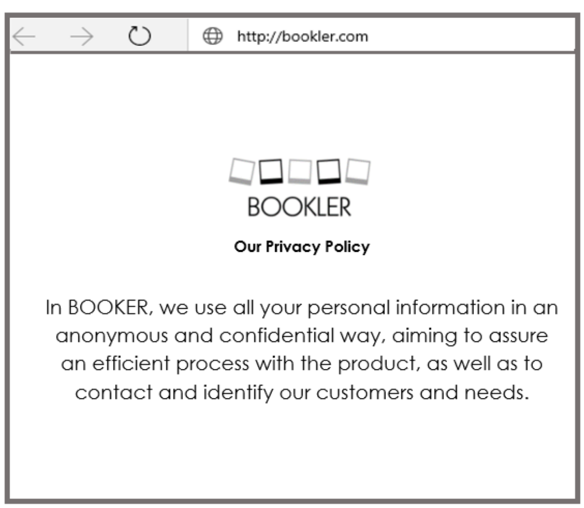
Appendices

Appendix A. e-Assurances

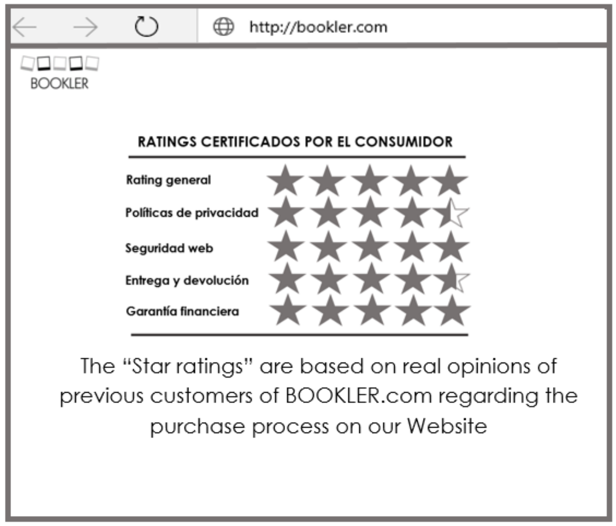
A. Seals of Approval (“Confianza Online”)



B. Assurance statement



C. *Rating systems*

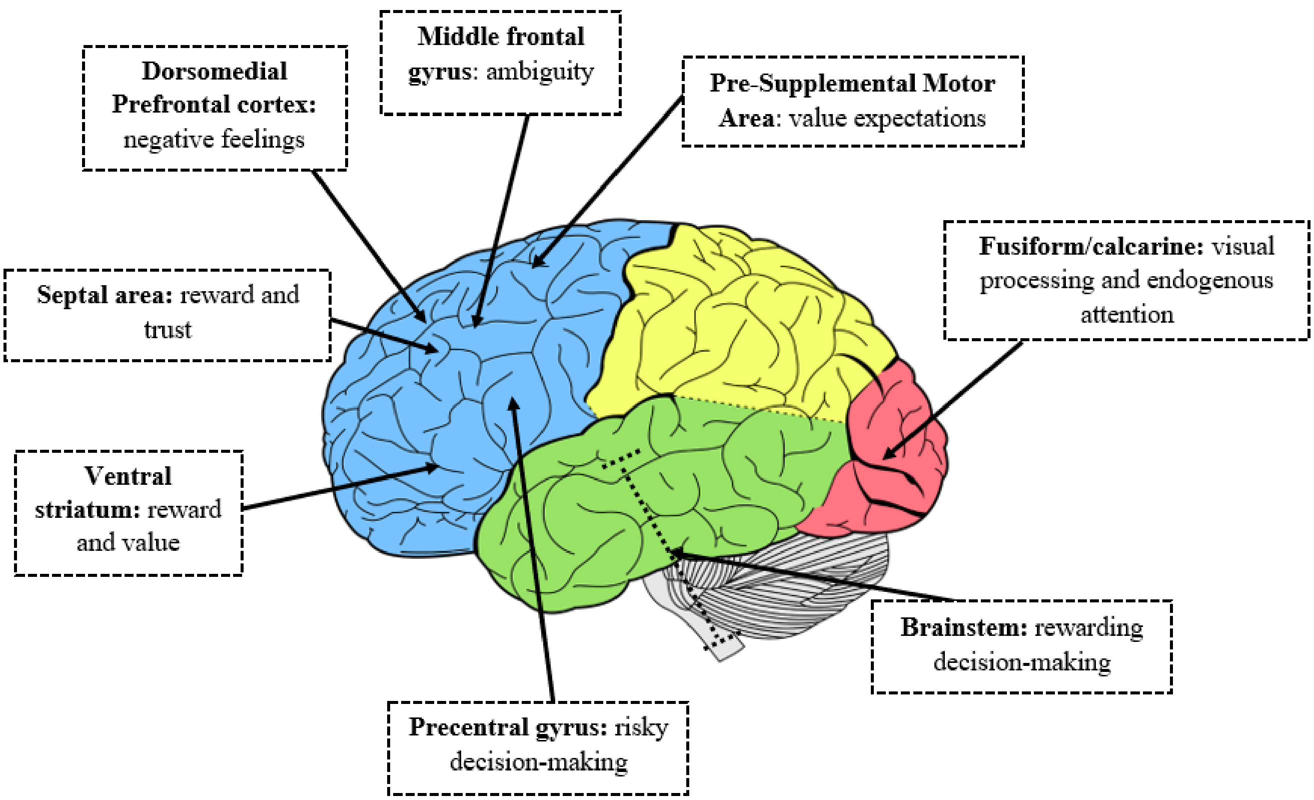


Appendix B. fMRI Data Acquisition and Preprocessing

MRI scanning was carried out in a 3 Tesla Trio Siemens Scanner equipped with a 32-channel head coil. The structural image T1 was acquired by a 3D MP-RAGE sequence with a sagittal orientation and a 1 mm x 1 mm x 1 mm voxel size (TR = 2300 ms, TE = 2.96 ms). Functional scans were acquired with a T2*-weighted echo-planar imaging (EPI) sequence (TR = 2000 ms, TE = 25 ms, flip angle 90° and a plane reduction of 3.5 x 3.5 x 3.5 mm corresponding to the slice thickness, slice order: descending). The distance factor was 20% so as to attain a total of 35 slices, a slice matrix of 64 x 64 mm, and a field of view of 238 mm with an axial orientation. The task resulted in the acquisition of a total of 1090 functional scans.

The data were preprocessed and analyzed using Statistical Parametric Mapping software (SPM12, Wellcome Department of Cognitive Neurology, Institute of Neurology, London, UK, http://www.fil.ion.ucl.ac.uk/spm/software/spm12/) run with MATLAB R2012a (The MathworksInc, Natick, MA). Default settings were used unless stated otherwise. To allow stabilization of the BOLD signal, the first seven volumes (14 seconds with a "cross" on the screen) of each run were discarded prior to analysis. Corrections were then applied by means of interpolation as to the differences in the time of slice acquisition with the initial slice serving as the reference. Functional images were realigned to the first image of the time series. Functional and structural images were co-registered and normalized (retaining 3.5 x 3.5 x 3.5 mm voxels) according to the Montreal Neurological Institute (MNI) template. Finally, functional images were smoothed with the Gaussian kernel (FWHM = 7 mm). The mean functional images were visually inspected for artifacts. Furthermore, the realignment parameters of all subjects were examined.

Appendix C.



Main regions and functions of the brain of interest to the e-Assurances processing. Blue: frontal lobe; green: temporal lobe; yellow: parietal lobe; red: occipital lobe.

Appendix D. Brain regions revealing different activations in response to rating systems as opposed to seals of approval.

Seals of approval	Peak MNI coordinates (mm) x	y	z	Cluster size	T	Study
Rating systems > Seals of approval						
ROIs [a]						
DMPFC	4	22	44	28	5.12	Bartra et al. (2013)
Superior parietal gyrus	30	-51	55	55	6.34	Krain et al. (2006)
Precentral gyrus	40	5	36	53	5.42	Krain et al. (2006)
Middle frontal gyrus	28	2	60	22	4.91	Krain et al. (2006)
Cingulate gyrus	-20	39	14	10	4.10	Krain et al. (2006)
Inferior parietal gyrus	-33	-46	44	58	5.23	Krain et al. (2006)
Whole brain [c]						
Occipital gyrus	24	-95	2	1658	8.07	
Precentral gyrus	45	7	37	184	5.42	
Superior motor area	3	21	47	54	5.12	
Inferior triangulus frontal gyrus	38	32	23	23	4.28	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 10$ voxels are reported.

[c] Peaks of clusters significant at $p < .001$ uncorrected, voxel level is reported.

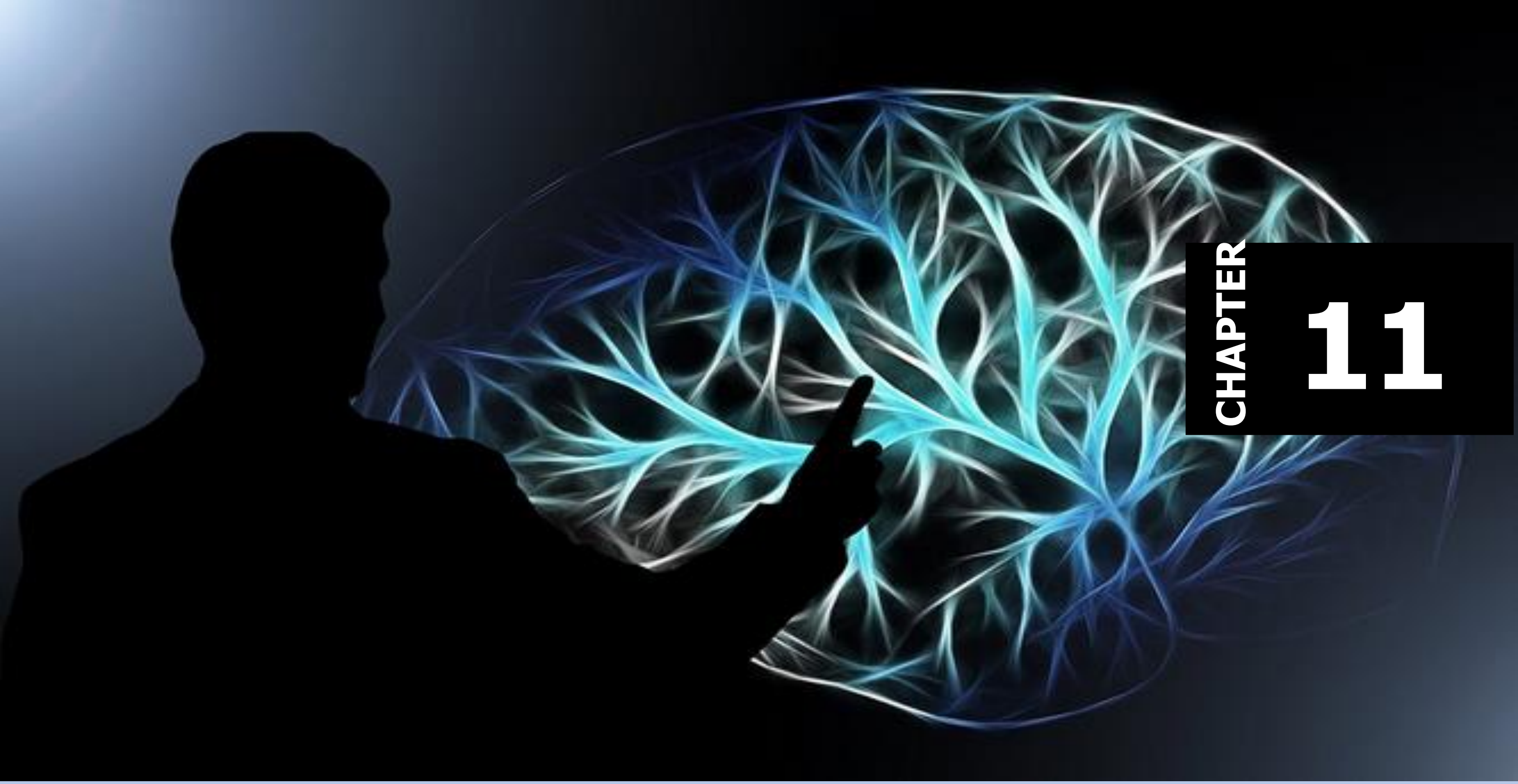
Appendix E. Brain regions revealing different activations in response to rating systems as opposed to assurance statements.

Seals of approval	Peak MNI coordinates (mm)			Cluster size	T	Study
	x	y	z			
Rating systems > Assurance Statements						
ROIs [a]						
Superior parietal gyrus	30	-51	55	38	5.57	Krain et al. (2006)
Whole brain [c]						
Middle occipital gyrus	27	-91	12	464	7.22	
Fusiform	-26	-74	-9	298	6.62	
Inferior parietal	27	-56	44	194	6.15	
Inferior temporal	48	-56	-9	22	4.28	

[a] Peaks reported are significant at $p < .05$ FWE-corrected on ROI level.

[b] Peaks of clusters significant at $p < .001$ uncorrected, $k > 10$ voxels are reported.

[c] Peaks of clusters significant at $p < .001$ uncorrected, voxel level is reported.



CHAPTER 11

CONCLUSIONES

En los primeros capítulos de este trabajo de investigación se justificó el potencial de la neurociencia del consumidor como disciplina emergente, así como los principales dominios del comportamiento del consumidor en los que su aplicación resulta de enorme interés. Precisamente en las páginas posteriores se han presentado seis trabajos empíricos que, utilizando resonancia magnética funcional, esclarecían las reacciones neurológicas del consumidor ante dos grandes campos del marketing: publicidad y e-commerce. En este capítulo se exponen de manera global y unificada las principales conclusiones obtenidas, así como las contribuciones académicas fundamentales generadas. Además, se presentan las implicaciones más importantes para la industria de la publicidad y comercio electrónico, de cara a diseñar mensajes y entornos webs que generen mayor valor inconsciente para los consumidores y, por ende, sean más eficientes. Finalmente, se indican algunas limitaciones de los estudios realizados, así como posibles líneas para futuras investigaciones en el ámbito de la neurociencia del consumidor.

11.1. Principales conclusiones

Los conceptos básicos del consumo son la satisfacción, el valor y la utilidad (Oliver, 2002). En la era digital actual, que cuenta con el comercio electrónico y la publicidad audiovisual como principales aliados, destaca de manera especial el concepto de experiencia. Abbott (1955) se puede considerar un visionario en ese sentido cuando decía que "lo que la gente realmente desea no son los productos, sino las experiencias" que acompañan al consumo de los mismos. Son los sentidos los que moldean las experiencias. En los últimos años, se ha producido un giro desde la psicología cognitiva a la neurociencia y comportamiento del consumidor, consagrándose estas últimas como líneas de trabajo de gran potencial que ponen de nuevo en boga el interés en el análisis de los sentidos que ya proponía Zaltman (2003).

Esta tesis doctoral se presenta como un compendio de investigaciones que muestran el potencial de la neurociencia el potencial de la neurociencia del consumidor como rama de marketing que explora de manera objetiva, subconsciente y precisa las manifestaciones neurológicas de los "sentidos" de los consumidores al exponerse ante estímulos de marketing, tales como los publicitarios y entornos de compra online. Al mismo tiempo, supone un avance en la comprensión de los mecanismos neurales provocados en el consumidor por distintos elementos publicitarios y web no evaluados hasta la fecha, así como su capacidad de predecir actitudes e intenciones hacia dichos elementos del marketing. Conocer estas reacciones neuronales del consumidor implicadas con el valor, la atención endógena, la confianza o la recompensa permitirá desarrollar e implementar campañas publicitarias más eficientes y entornos de compra web menos arriesgados y más confiables.

A continuación, se presentan las principales conclusiones y aportaciones al campo del marketing derivadas de: i) los capítulos 2, 3, y 4, en los que se contextualizó la situación actual de la neurociencia del consumidor, sus principales técnicas y dominios en los que su aplicación sería de interés crucial; ii) los estudios empíricos desarrollados en los capítulos 5, 6 y 7, en los que se presentan diseños experimentales en el campo de la publicidad con metodología de fMRI; y iii) los capítulos 8, 9 y 10, en los que se utiliza la fMRI para esclarecer las respuestas neurológicas ocasionadas por diversos elementos del layout de la web online.

11.1.1. Neurociencia del consumidor: situación actual, metodología y dominios de aplicación

Tras especificar el origen de la neurociencia del consumidor y detallar sus primeros exponentes en el **capítulo 1**, el **segundo** de los capítulos presenta las principales técnicas a las que recurre esta disciplina como metodología de análisis, haciendo especial hincapié en el tipo de medida en la que se basan, su utilidad para el campo del marketing, así como las fortalezas y debilidades derivadas de su empleo. Técnicas biométricas como la tasa cardiaca, la electromiografía o la conductancia han sido cruciales para revelar desde los años 60 el primer tipo de respuesta automática del consumidor ante un estímulo de marketing, a saber, las llamadas respuestas psicofisiológicas (Bradley, Angelini, & Sungkyoung Lee, 2007). No obstante, se ha demostrado que las herramientas que poseen mayor relevancia en el campo de la neurociencia del consumidor son las que miden cambios en la actividad neuronal eléctrica y metabólica, esto es, la fMRI, el EEG y el MEG (Dimoka et al., 2010; Harris, Ciorciari, & Gountas, 2018). Estas tres metodologías resultan ser técnicas no invasivas, pero la alta resolución espacial de la fMRI unida a su capacidad única de detectar cambios neuronales en las estructuras más profundas del cerebro e interesantes para el marketing (tales como la amígdala, insula o corteza cingular anterior), la consagran como la aspirante con mayor potencial en el campo de la neurociencia del consumidor.

Precisamente, el **capítulo 3** presenta un análisis bibliométrico de la investigación llevada a cabo en el campo de la neurociencia del consumidor utilizando sus tres herramientas de mayor relevancia. Se pretendía, así, confirmar el mayor potencial de la fMRI como técnica de análisis y esclarecer los dominios del marketing de mayor interés hasta el momento en la disciplina. Los principales resultados que subyacen de este capítulo se recogen a continuación:

- Desde sus primeras apariciones en 2006, las investigaciones en neurociencia del consumidor que utilizan herramientas neurocientíficas se han incrementado gradualmente a partir del año 2010 hasta llegar a un total de 117 en la actualidad.
- Más de la mitad de estas investigaciones desarrolladas constituyeron trabajos empíricos, de los cuales la mayoría utilizaron la fMRI como herramienta de análisis. El uso de esta técnica en el estudio del comportamiento del consumidor, además, está ganando prevalencia en los últimos cinco años.

- Los dominios del marketing mix que están siendo objeto de los estudios en neurociencia del consumidor son, en orden de importancia: publicidad y producto, e-commerce, marca, entorno social del consumidor y precio. De estas variables, la publicidad y e-commerce son las que muestran mayor consolidación recientemente en detrimento de los estímulos de marca.
- Las investigaciones en neurociencia del consumidor se publican en revistas de marketing (tales como *Journal of Marketing Research* o *European Journal of Marketing*), psicología (como la *Journal of Consumer Psychology*) y neurociencia (*Neuroimage* o *Social Cognitive and Affective Neuroscience*). Se concluye, de esta forma, que su ámbito de publicación es fundamentalmente interdisciplinar.
- Los autores con mayor contribución pertenecen también a disciplinas diversas, como el marketing, economía, neurociencia y psicología. Sus nacionalidades son, principalmente, estadounidenses y europeas.
- Los análisis de diagrama estratégico y temas clave muestran que: i) la investigación en neurociencia del consumidor más inminente se basa en predecir comportamientos y tomas de decisiones del consumidor a través de técnicas neurocientíficas; ii) la neuroeconomía representa una disciplina madre de los estudios en neurociencia del consumidor; iii) el valor y la memoria son constructos transversales en los estudios del campo; y iv) la confianza mostrada en entornos online y nuevos sistemas de información y comunicación están ganando prevalencia en la disciplina de la neurociencia del consumidor.

Dada la importancia atribuida a los campos de la publicidad y comercio electrónico en neurociencia del consumidor, en el **capítulo 4** se presentan los subdominios de estas variables no explorados hasta la fecha y cuyo análisis se vería altamente beneficiado con el uso de técnicas neurocientíficas. Concretamente, este capítulo aconseja desarrollar futuras investigaciones que aborden las reacciones en el consumidor provocadas por: i) distintos enfoques del mensaje (pérdida/ganancia y futuro/pasado), ii) tipos de voz (masculina/femenina y joven/adulta), y iii) combinaciones congruentes/incongruentes de producto y voz. En el campo del comercio electrónico, por último, también se sugiere profundizar en elementos insertados en el entorno web, tales como: i) medios de pago (tarjeta de débito/Paypal), ii) señales de seguridad (sellos de confianza, sistemas de puntuación o políticas de empres), y iii) distintas facetas del riesgo percibido online (riesgo financiero, de privacidad o de entrega del producto).

En su conjunto, estos capítulos introductorios han esclarecido la evolución de la neurociencia del consumidor como disciplina emergente del marketing, el tipo de técnica más utilizada por sus estudios, así como los dominios y subdominios del marketing mix cuya base psicológica podría verse altamente esclarecida mediante la aplicación de técnicas neurocientíficas.

11.1.2. Neurociencia del consumidor y publicidad

Precisamente, los capítulos 5, 6 y 7 constituyen estudios empíricos publicados que, por primera vez, exploran los mecanismos neurológicos subyacentes ante los elementos de la publicidad previamente identificados de gran potencial, esto es, enfoques de pérdida/ganancia y futuro/pasado, tipos de voz masculina/femenina y joven/adulta, así como combinaciones congruentes/incongruentes de producto y voz. A continuación, se ofrece un resumen de dichos trabajos, centrándose en sus objetivos y principales hallazgos.

Tabla 1. Resumen de los tres estudios presentados en el ámbito de la publicidad.

ESTUDIO	OBJETIVO	PRINCIPALES HALLAZGOS
ESTUDIO 1 (E1): Neural Correlates of Gender Congruence in Audiovisual Commercials for Gender-Targeted Products: An fMRI Study	Dilucidar la base neurológica de los efectos inducidos por combinaciones congruentes e incongruentes de producto-voz en la evaluación de publicidad, así como determinar qué regiones cerebrales implicadas en dichas combinaciones audiovisuales covarían con las actitudes conscientes hacia los mensajes	Las actitudes expresadas a nivel consciente son más positivas hacia combinaciones congruentes (versus incongruentes) de producto y voz.
		Áreas cerebrales implicadas con el procesamiento visual y atención endógena se activan más intensamente ante combinaciones congruentes de producto y voz. En cambio, combinaciones audiovisuales incongruentes provocan mayores activaciones en áreas implicadas con el procesamiento del error e inconsistencia.
		Un incremento de la activación en la corteza cingular posterior (área cerebral relacionada con el procesamiento del valor) predijo las mayores actitudes hacia anuncios congruentes.
		Las mayores actitudes expresadas hacia combinaciones congruentes de producto y voz tienen su origen, por tanto, en incrementos en la atención, valor y relevancia que inducen durante su evaluación.
ESTUDIO 2 (E2): Neural Correlates of Voice Gender and Message Framing in Advertising: A Functional MRI Study	Identificar las regiones cerebrales activadas en respuesta a mensajes ecológicos diseñados con un enfoque de ganancia versus pérdida, y presentados con una voz masculina versus femenina. Se pretende, además, evaluar si las activaciones cerebrales en respuesta a dichos elementos predicen las actitudes hacia los anuncios.	Mensajes medioambientales diseñados con un enfoque de pérdida (versus ganancia) provocan mayores activaciones cerebrales en áreas visuales, mientras que los mensajes de ganancia (versus pérdida) activan más significativamente un área implicada con el valor personal, aspiraciones futuras positivas y beneficios sociales.
		La voz masculina induce mayor activación en áreas relacionadas con el procesamiento del tono y percepción visual, a diferencia de la femenina, que provoca un mayor procesamiento neuronal implicado con la integración audiovisual.
		La activación de dos áreas implicadas con el procesamiento del valor (giro frontal inferior y corteza orbitofrontal) durante la evaluación de mensajes presentados por la voz masculina y diseñados con un enfoque de pérdida, respectivamente, predicen las mayores actitudes expresadas hacia dichos mensajes.

		Además de esclarecer el diferente procesamiento neuronal desencadenado por mensajes de pérdida y ganancia, y voces masculinas y femeninas, el estudio sugiere que mensajes que expresan beneficios sociales (tales como los medioambientales) podrían procesarse de manera distinta a aquellos referidos a beneficios individuales (por ejemplo, los saludables).
ESTUDIO 3 (E3): Neural Effects of Environmental Advertising: An fMRI Analysis of Voice Age and Temporal Framing	Evaluar si existen diferentes regiones cerebrales implicadas con el procesamiento de mensajes medioambientales diseñados con un enfoque de futuro versus pasado, y presentados por una voz joven versus adulta. Además, se pretende revelar si alguna de las áreas cerebrales relacionadas con dichos elementos covaría con las actitudes expresadas hacia los mensajes que los incluyen.	Mensajes ecológicos diseñados con un enfoque de futuro provocan mayores activaciones en áreas implicadas con las imaginación, recuerdos prospectivos y eventos episódicos, reflejando así la implicación de comportamientos pasados en acciones ecológicas futuras. Los mensajes referidos al pasado, en cambio, desencadenan activaciones en el sistema cerebral episódico (relacionado con eventos del pasado).
		La voz joven, además de evocar activaciones en áreas implicadas con el procesamiento de un timbre, tono, e intensidad mayores, se percibe como más emocional y motivacional que la adulta. Los mensajes presentados por la voz adulta, en cambio, exhiben mayores activaciones en áreas íntimamente relacionadas con la percepción de tonos bajos.
		Se identifica un link entre respuestas neuronales y conscientes, indicando que ciertas activaciones cerebrales en respuesta a mensajes medioambientales diseñados con un enfoque de futuro y presentados por voces jóvenes, predicen las mayores actitudes hacia mensajes que incluyen dichos elementos.
		En consecuencia, los resultados de este estudio proporcionan información valiosa sobre el origen inconsciente de las actitudes hacia los mensajes ecológicos.

Fuente: Autor

Estos tres trabajos presentados son innovadores, al ser pioneros en:

- Revelar el origen subconsciente de las actitudes expresadas hacia elementos muy comunes en mensajes publicitarios, pero inexplorados o de dudosa efectividad hasta la fecha, tales como combinaciones congruentes e incongruentes de producto y voz (E1). Estudios previos se centraron en los efectos conscientes, y no subconscientes y automáticos, derivados de desarrollar publicidad en smartphones (Martins, Costa, Oliveira, Gonçalves, & Branco, 2018) o incluir combinaciones congruentes de producto y voz (Rodero, Larrea, & Vázquez, 2013).
- Examinar los efectos de elementos incluidos en mensajes que fomentan el consumo de productos responsables (E2) y un cuidado sostenible del planeta (E3), pero que han sido inexplorados en la literatura de la publicidad medioambiental. Más interesantemente, los estudios E2 y E3 se consagran como los primeros en evaluar el origen neurológico de las actitudes expresadas hacia mensajes que incluyen voces masculinas y femeninas (E2), jóvenes y adultas (E3), mensajes de pérdida y ganancia (E2) y otros centrados en el pasado y futuro (E3). Investigaciones precedentes se focalizaron en evaluar elementos de la publicidad que tiene como objetivo reducir el despilfarro de energía residencial (Xu, Arpan, & Chen, 2015) o evitar la compra de comida socialmente irresponsable (Hanss & Böhm, 2013). A nuestro conocimiento, existen escasos estudios que utilizan medidas neurológicas para evaluar el procesamiento de mensajes con fines responsables. Tal es el caso de las investigaciones de Vezich, Gunter, & Lieberman (2017), que compararon los mecanismos neuronales provocados por mensajes medioambientales versus no medioambientales, o el estudio de Vezich, Katzman, Ames, Falk, & Lieberman (2016), que analizaron el procesamiento neuronal de mensajes con enfoque de pérdida y ganancia en un entorno de consumo saludable.

- Utilizar información de origen neuronal para predecir actitudes conscientes expresadas hacia combinaciones congruentes de producto y voz (E1), mensajes de ganancia (E2), voces masculinas (E2), mensajes referidos al futuro (E3), y voces jóvenes (E3).

- Avanzar en la utilización de la fMRI como técnica de evaluación del procesamiento de información audiovisual inserta en publicidad general, y medioambiental en particular.

11.1.3 Neurociencia del consumidor y entorno de compra online

Los capítulos 8, 9 y 10 constituyen trabajos empíricos que evalúan las respuestas neuronales de consumidores expuestos ante distintos elementos del entorno de compra online, a saber, medios de pago, señales de seguridad y diversos tipos de riesgo online. En la Tabla 2 se recoge una síntesis de los tres estudios, haciendo referencia a sus principales objetivos y hallazgos fundamentales.

Tabla 2. Resumen de los tres estudios presentados en el ámbito de la publicidad.

ESTUDIO	OBJETIVO	PRINCIPALES HALLAZGOS
ESTUDIO 4 (E4): A Neuropsychological Study on How Consumers Process risky and Secure E-payments	Dilucidar la base neurológica de sistemas de pago arriesgados y seguros, así como esclarecer los mecanismos neuronales provocados por los dos métodos de pago online de mayor relevancia: tarjeta de débito y Paypal.	Sistemas de pago online arriesgados activan áreas cerebrales implicadas con el procesamiento emocional negativo, mientras que regiones cerebrales involucradas con la predicción de la recompensa están presentes en la evaluación de medios de pago online seguros.
		Paypal no solo recibe mayores intenciones de uso entre los participantes, sino que provoca activaciones cerebrales implicadas con la mayor seguridad, recompensa y afecto. Las tarjetas de débito, en cambio, desencadenan activaciones cerebrales involucradas con eventos negativos y arriesgados.
		Un área implicada con el procesamiento del valor (el cerebelo derecho) predijo las mayores intenciones expresadas por los participantes hacia el uso de Paypal.
		Estos resultados ofrecen información valiosa sobre el origen inconsciente de la elección de los sistemas de pago online entre los consumidores.
ESTUDIO 5 (E5): How Consumers Process Online Privacy, Financial and Performance Risks: An fMRI Study	Evaluar los mecanismos neurológicos inducidos por las facetas del riesgo más estudiadas y de mayor repercusión en el entorno de compra online (a saber, riesgo financiero, de privacidad y de entrega) de productos de baja implicación.	A pesar de que las respuestas conscientes expresadas por los participantes no revelan diferencias entre los tres tipos de riesgo online, su procesamiento neurológico sí que difiere a nivel inconsciente.
		El riesgo financiero es el que confiere en menor medida valores negativos y de aversión durante la compra online de productos de baja implicación. El riesgo de privacidad, en cambio, transmite ambivalencia e incertidumbre, mientras que el riesgo de entrega (de resultados) provoca los niveles más altos de decepción y desconfianza.
		Mediante una técnica neurocientífica, estos datos revelan que el riesgo de entrega es el que provoca mayor desapego a nivel inconsciente en la compra online.

ESTUDIO 6 (E6): Consumer Processing of E-Assurance Signals: A Neuropsychological Study	Dilucidar los efectos neuronales de los tres tipos de servicios de seguridad online más ampliamente extendidos (sellos de confianza, sistemas de puntuaciones y políticas de empresa) en la evaluación de productos online.	Los sellos de confianza constituyen la señal de seguridad online más confiable, ya que provocan activaciones cerebrales implicadas con la recompensa y valores positivos esperados.
		En cambio, productos acompañados por sistemas de puntuaciones de consumidores previos desencadenan activaciones en áreas cerebrales involucradas con la ambigüedad, negatividad y riesgo.
		Las mayores intenciones de compra y confianza otorgadas a los productos acompañados por sellos de confianza se correlacionan con la activación de áreas implicadas con el procesamiento del valor. En cambio, activaciones relacionadas con el dominio negativo predijeron mayores puntuaciones de riesgo asociadas a productos acompañados de sistemas de puntuaciones.
		Estos resultados ofrecen por primera vez información indispensable que aporta conocimiento sobre el origen de la confianza otorgada a diversos tipos de servicios de seguridad online.

Fuente: Autor

Estos tres trabajos presentados suponen un avance en la literatura del comportamiento del consumidor online, por varias razones:

- Investigaciones previas del campo han evaluado los factores que influyen en las actitudes e intenciones del consumidor hacia la compra online, tales como la innovación personal (Kalinic & Marinkovic, 2016), conveniencia (Chiang & Dholakia, 2003) o utilidad percibida (Shin, 2009). Los estudios propuestos exploran elementos poco estudiados hasta la fecha o de cuestionada efectividad, tales como los medios de pago (E4), distintos tipos de riesgo online (E5) y las señales de seguridad (E6).

- Más importante aún, constructos cruciales en el campo del comportamiento del consumidor online como el riesgo, la confianza o la ambigüedad, ocurren de manera inconsciente y automática en los consumidores (Dimoka, 2010), por lo que herramientas más objetivas y precisas, como las neurocientíficas, pueden esclarecer en mayor medida su origen psicológico. Precisamente, los estudios 4, 5 y 6 son pioneros en analizar en un entorno web el procesamiento neurológico de los constructos de riesgo, seguridad y ambigüedad. Previas investigaciones en el campo de la neurociencia del consumidor solo profundizaron en la confianza y desconfianza (Riedl, Hubert, & Kenning, 2010) así como la usabilidad web (Dimoka & Davis, 2008).

- Además, los tres estudios han logrado dilucidar las áreas cerebrales cuya activación está íntimamente relacionada con actitudes e intenciones superiores mostradas a nivel consciente hacia la compra de productos online. Ello supone la validación de una nueva metodología de análisis que, con base en herramientas neurológicas, permite evaluar la capacidad de diferentes elementos de la página web, bien de manera individual o conjunta, de promover la compra de productos online.

En su conjunto, todos los trabajos presentados son innovadores, al ser los primeros en analizar mediante la fMRI el origen psicológico de las actitudes, intenciones y percepciones hacia elementos poco estudiados o de escasa unanimidad en la literatura relacionados con dos de los campos del marketing con mayor potencial para la neurociencia del consumidor, a saber, la publicidad y e-commerce.

11.2. Implicaciones para la gestión

En la era digital actual, en la que la proliferación de las compras online y mensajes publicitarios insertos en dicho medio avanzan de manera muy acelerada, resulta crucial dotar a la web o campañas de comunicación con los elementos audiovisuales que provoquen mayor valor, confianza y seguridad al consumidor, en aras a conseguir mayores ventas y mejorar su experiencia de compra. Las técnicas de investigación tradicionales se han mostrado insuficientes para captar las verdaderas reacciones emocionales y cognitivas del consumidor ante estímulos de publicidad y otros insertos en la web. Herramientas procedentes de la neurociencia permiten complementarlas al proporcionar una vía objetiva de medición del origen psicológico de las evaluaciones, actitudes e intenciones hacia los elementos propuestos.

Utilizando técnicas neurocientíficas, los estudios aquí presentados se han centrado en la evaluación del consumidor de distintas combinaciones de elementos insertos en la publicidad (general y medioambiental) y entornos de compra online. En su conjunto, las investigaciones de esta tesis doctoral proporcionan una serie de recomendaciones e implicaciones relevantes para las empresas interesadas en mejorar el output de su publicidad aplicada a productos de consumo habitual, organizaciones e instituciones medioambientalmente responsables, así como empresas que comercializan sus productos a través de la web.

El primero de los estudios (E1), que analizó el origen neurológico de la evaluación de combinaciones de producto-voz congruentes e incongruentes, revela varias implicaciones para la gestión de especial valor:

- Profesionales de la comunicación que deseen diseñar campañas de publicidad exitosas para la comercialización de productos de conveniencia, deberían utilizar la voz masculina para presentar productos típicamente consumidos por un target masculino, y la voz femenina para referirse a productos de consumo femenino. Según el E1, las combinaciones congruentes no solo incrementan las actitudes hacia los anuncios, sino que alcanzan un grado más alto de atención endógena que las combinaciones incongruentes.
- Este estudio revela, además, que las combinaciones audiovisuales congruentes incrementan el valor y la recompensa proporcionados al consumidor, provocando

mecanismos cerebrales similares a aquellos involucrados con el amor maternal (Noriuchi, Kikuchi, & Senoo, 2008) o comida deseada (Linder et al., 2010).

- A pesar de la escasa unanimidad en la literatura en torno a la combinación audiovisual más adecuada en publicidad (Rodero et al., 2013), este estudio evidencia que las combinaciones incongruentes de producto y voz en publicidad desencadenan mayor ambivalencia y rechazo subconscientes y, por tanto, serían perjudiciales para la evaluación del mensaje, incluso del producto publicitado.
- Por lo tanto, profesionales de la publicidad deberían considerar la importancia de diseñar el mensaje con la combinación adecuada de tipo de producto y género de voz, ya que podrían bien crear expectativas y valores positivos en el consumidor o, por el contrario, provocar reacciones negativas y ambiguas.

Los estudios E2 y E3 utilizaron fMRI para identificar el origen subconsciente de las evaluaciones hacia elementos insertos en publicidad medioambiental, tales como el enfoque de pérdida/ganancia, o de pasado/futuro, voz masculina/femenina y voz joven/adulta. Algunas de sus aplicaciones prácticas de mayor relevancia se recogen a continuación:

- Profesionales, instituciones o gobiernos involucrados con la promoción de hábitos respetuosos con el medio ambiente deberían considerar en sus campañas de concienciación la utilización de la voz masculina en combinación con mensajes que enfaticen lo positivo de ser responsable con el medio ambiente. Estos elementos, en base a los resultados del E2, estimulan áreas cerebrales implicadas con aspiraciones positivas y beneficios sociales, que podrían ser antecedentes de futuras intenciones y comportamientos medioambientalmente responsables.
- Los resultados del E3 complementan estos resultados al revelar que mensajes medioambientales relativos al futuro (y no al pasado) y pronunciados por voces jóvenes (y no adultas) no solo incrementan las actitudes en el consumidor, sino que desencadenan mayor relevancia subconsciente y parecen ser más emocionales.
- Por lo tanto, stakeholders involucrados con la promoción de hábitos respetuosos con el medio ambiente deberían usar la voz de un joven chico para presentar mensajes medioambientales con un enfoque de ganancia referidos al futuro, tal que así: “Si entre

todos cuidamos mejor el planeta, el ecosistema para las generaciones futuras estará garantizado".

Los estudios E4, E5 y E6 se basaron en datos de imágenes funcionales para explorar los mecanismos neuronales provocados por distintos elementos insertos en la web comercial, tales como sistemas de pago, señales de seguridad o tipología de riesgo online. Utilizando una perspectiva conjunta de los resultados encontrados, se proponen las siguientes recomendaciones:

- Los sistemas de pago arriesgados insertos en la web no solo se perciben como inciertos, sino que, en base a los resultados del E4, son subconscientemente procesados como negativos y provocan rechazo. Por tanto, todos los esfuerzos desempeñados por las compañías en ofrecer productos de alta calidad, promover las ventajas de su uso o las inversiones en innovación pueden ser insuficientes si no se incluye un medio de pago seguro en la web de compra.
- Más concretamente, los resultados del E4 aconsejan incluir en la web Paypal como medio de pago principal, ya que, en relación a las tarjetas de débito, promueve mayores intenciones de uso y es percibido como un sistema más seguro, atractivo y afectivo a nivel subconsciente. De esta forma, la inclusión de Paypal podría mejorar la experiencia de compra online, incluso presentar a los consumidores beneficios complementarios a los ofrecidos por el producto.
- Para mejorar la confianza del proceso de compra online, el estudio E5 aconseja el tipo de riesgo online que debe evitarse en mayor medida por las organizaciones que ofrecen productos online de baja implicación (por ejemplo, carcasas de móviles o libros). Concretamente, en nuestro estudio avanzamos que procesos psicológicos como el riesgo, confianza, ambigüedad o decepción no están presentes en todos los tipos de riesgo derivados de la compra online, sino que depende de la faceta del riesgo en cuestión. Más particularmente, los profesionales de ventas online de productos de baja implicación deberían, en primer lugar, focalizar sus esfuerzos en que el producto reúna los requisitos establecidos en la web una vez llegue a manos del consumidor (por ejemplo, condiciones físicas, momento de entrega, etc.). En segundo lugar, sería aconsejable que estas organizaciones definieran adecuadamente todas las políticas de gestión de la información

del consumidor, por ejemplo, a través de sellos de confianza o políticas de privacidad (Bahmanziari, Odom, & Ugrin, 2009).

- Para hacer de la experiencia de compra online un proceso más confiable, el estudio E6 precisamente recomienda incluir en el entorno web sellos de confianza que evalúan de forma independiente los estándares de seguridad de la web de compra. A diferencia de las puntuaciones de consumidores anteriores o políticas de empresa, los sellos de seguridad provocan más activaciones cerebrales implicadas con el valor y la recompensa. Este hecho enfatiza la necesidad de que las empresas de venta online elijan adecuadamente a un evaluador de su web de reconocido prestigio y renombre, ya que actuará como objeto de confianza (Hu, Wu, Wu, & Zhang, 2010).

Si estas consideraciones establecidas en los 6 trabajos empíricos son incorporadas en las estrategias de publicidad general, y medioambiental en particular, así como en el layout de webs comerciales, entonces se estaría estimulando el sistema de recompensa y valor del consumidor, pudiendo ser este un antecedente de futuros comportamientos de consumo medioambientalmente responsables o de compra online.

11.3. Limitaciones y futuras líneas de investigación

Este es el primer trabajo de investigación en utilizar una técnica neurocientífica, la fMRI, en el estudio del origen psicológico de las reacciones del consumidor ante diversos elementos no estudiados hasta el momento de los dominios de la publicidad y el comercio electrónico. No obstante, varias **limitaciones** reducen el alcance de estas conclusiones, abriendo, a su vez, la posibilidad de desarrollar futuras líneas de investigación que vengan a superar y complementar dichas restricciones.

- Las conclusiones de los estudios revelan links entre las activaciones neuronales y respuestas conscientes de los participantes, tales como actitud hacia los anuncios, intención de uso de sistemas de pago o intención de compra de productos online. Sin embargo, para evaluar con mayor grado de precisión la capacidad predictiva de las activaciones neuronales se podría ir más allá y relacionar dichos mecanismos con cambios de comportamiento tras el tratamiento (es decir, sesión experimental) recibido.

- En algunos de los estudios desarrollados (concretamente, E1 y E2), no se solicitaba al sujeto una participación activa durante la tarea, materializada a través de la toma de decisiones. Es interesante, en cambio, de cara a la determinación de los mecanismos cognitivos y afectivos de interés, proponer un entorno de decisión al participante, en aras a aumentar la reproducibilidad de los resultados.
- Se han seleccionado a participantes con un determinado perfil de interés para el estudio. Por ejemplo, solo formaron parte de experimentos participantes de media conciencia medioambiental (E2 y E3) o expertos en la compra de productos online (E4, E5 y E6). Si bien esta homogeneización de las características del participante es un rasgo propio de estudios de la neurociencia del consumidor (Riedl et al., 2010), la reproducibilidad de los resultados debería tomarse con cautela.
- Pudiera parecer que el tamaño de la muestra empleada en los estudios (entre 16 y 30 participantes) es otra de las limitaciones, en tanto en cuanto que pudiera restringir la reproducibilidad de los resultados. Sin embargo, los estudios en neurociencia del consumidor que emplean fMRI generalmente utilizan una muestra similar (Hedgcock & Rao, 2009). De hecho, Solnais y colegas (2013) concluyeron que una muestra de 20 participantes es el número más frecuente usado en estudios en neurociencia del consumidor publicados en revistas de alto impacto (tales como Dietvorst et al., 2009 y Guo, Zhang, Ding, & Wang, 2016). Siguiendo las recomendaciones para la utilización de fMRI en estudios de neurociencia del consumidor desarrolladas por Weber, Mangus, & Huskey (2015), en los trabajos de esta tesis doctoral se han especificado meticulosamente los rasgos sociodemográficos u otros de interés (tales como el grado de experto online y la concienciación ecológica) que han sido la base para la inclusión de los participantes. Además, la mayor parte de los estudios de esta tesis reportan tamaños del efecto (en neurociencia del consumidor, una medida cuantitativa de la fuerza de las activaciones neuronales producidas, Smeets, Kroese, Evers, & de Ridder, 2013,) lo suficientemente elevados como para considerar suficiente la muestra empleada.

Para terminar, considerando tanto los resultados obtenidos como las limitaciones ya descritas, proponemos una serie de **futuras líneas de investigación** sobre la utilización de técnicas neurocientíficas en el estudio del comportamiento del consumidor:

- Dada la importancia atribuida en los estudios de neurociencia del consumidor a los dominios de publicidad y comercio electrónico, futuras investigaciones en la rama deberían evaluar a través de técnicas neurocientíficas nuevos elementos de interés, tales como el sesgo partidista en la evaluación de publicidad política, la base neurológica de distintos grados de privacidad de la información, o las diferencias neurológicas derivadas de comprar en una web nacional versus internacional.
- El carácter complementario de las técnicas neurocientíficas (fMRI, EEG, MEG), y de estas con las herramientas de la psicofisiología (tasa cardiaca, electromiografía o conductancia galvánica), propicia que futuras investigaciones corroboren y añadan información sobre los procesos automáticos experimentados por los consumidores ante los elementos propuestos en esta tesis doctoral.

- Los futuros estudios en neurociencia del consumidor deberían focalizarse, además, en utilizar los mecanismos neurológicos como variables predictivas de cambios en comportamientos reales de los consumidores, tales como modificaciones en la marca seleccionada o frecuencia de compra responsable. De esta forma, se estaría potenciando la validación de una nueva metodología de análisis que, con base en herramientas neurológicas, permite evaluar la capacidad de diferentes elementos del marketing mix de promover comportamientos deseados en el consumidor.

- Por último, estas investigaciones deberían valorar también la inclusión de alguna característica del consumidor sociodemográfica, cultural o de interés para el marketing como variable moduladora de la actividad neuronal desencadenada por determinados estímulos de marketing. En tal caso, se podría determinar el factor neurológico que define, por ejemplo, a dos tipologías de consumidores, facilitando así la estrategia de segmentación de mercados.

La neurociencia del consumidor ha llegado para quedarse. Esta tesis ha demostrado que el crecimiento acelerado de la disciplina en los últimos cinco años ha permitido conocer un poco más las razones por las que los consumidores deciden o valoran en mayor medida una marca, un producto, un anuncio o una web. A diferencia de las técnicas tradicionales que preguntan por el "cuánto" valora el consumidor un estímulo de marketing, la neurociencia del consumidor cuestiona el "cómo" y el "por qué", llegando de esta forma hacia el origen (automático e inconsciente) de las decisiones de consumo. Una vez garantizados los compromisos éticos y morales, en esta tesis queda justificado el potencial de la neurociencia del consumidor para proporcionar información complementaria y, sobre todo, de carácter más objetivo que la ofrecida por las técnicas tradicionales, a medida que se siga avanzando en los próximos años siguiendo las recomendaciones del Marketing Science Institute (2018).

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