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Ph.D. Title:

Consumer Neuroscience: New directions in predicting consumers' behavior and their preferences for product characteristics

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REVIEWER COMMENTS

Reviewer 1

UNIVERSITÀ DEGLI STUDI DEL MOLISE

Revisore: Luiz Moutinho

A. Originalità

Very good piece in terms of originality. Good level of knowledge of neuroscience. Good comments on Neuroeconomics. Good critical reasoning on the history of neuroscience and its dilemmas.

B. Rigore metodologico

Very good structure of the thesis as well as good chapter structure. Good research questions. Good experimental research studies and research designs. Good manipulations and some good measurements. Good overview of neuroscience tools and technical components. Competent statistical analysis. Good experiment guidelines. The research instrument/questionnaire could have been better designed.

C. Impatto potenziale:

Very good potential impact to the food and drink industries. Good applied research context.

D. Giudizio sintetico finale e suggerimenti specifici

A comprehensive piece of research. Good presentation. Good conclusion.

Alla luce della presente valutazione, il Revisore dispone che la tesi:
x - Venga ammessa alla discussione nella prima seduta utile

Data, 21/02/2018

Firma

Reviewer 2

Università degli Studi del Molise

Dottorando:

Titolo Tesi:

Revisore:

A. Originalità

Highly original, creative combination of two fields, namely marketing in economics and neuropsychology.

B. Rigore metodologico

Clear exposition, methodology apt for the interdisciplinary framework investigated, good literature overview and conscientious quoting.

C. Impatto potenziale:

In a sense, the thesis solves a problem in marketing/economics namely that theorists and experimenters could not look into subjects minds when the latter were making actual choices. By figuratively looking into peoples' brains as the researcher does in the thesis, a braoder spectrum of facets can be discovered which might be directing/governing their behavior.

D. Giudizio sintetico finale e suggerimenti specifici

Interesting field, and interesting experiment/method/application which could be used or appropriate variants of it, in other fields of marketing and even economics and game theory.

Alla luce della presente valutazione, il Revisore dispone che la tesi:

X - Venga ammessa alla discussione nella prima seduta utile

Data, 02-03-2018

Firma

CONTENTS

ABSTRACT

This Ph.D. thesis is at the intersection of three domains: Marketing, Psychology and Neuroscience, also known as Consumer Neuroscience. The thesis focuses on consumer behavior and it investigates the existent and potential influences that identifies, defines and affects the decision-making process and buying behavior. This Ph.D. thesis aims at contributing to both theoretical and practical aspects of Consumer Neuroscience research. Firstly, a literature review was conducted in order to establish the realized benefits and potential outcome of Consumer Neuroscience research and to identify potential problems in this field. Moreover, the literature review has clarified how neuroimaging techniques, such as EEG, can help to study and assess individual preferences and perceived quality and the influence of extrinsic cues on individual preferences. Secondly, another goal of the thesis was to investigate the neural mechanisms underlying individual preference during a real product experience. Two studies were carried out using qualitative research methods to analyze the personal preferences and Electroencephalography (EEG) was used to measure the participants' brain activity during product experiences.

- Research Study 1: An experimental approach was developed to investigate individual preferences for wines during a product experience (wine tasting). Performing a conceptual replication of the Boksem and Smidts (2015) experiment, the study aimed at providing evidence that EEG activity in the beta band can predict individual preference for a product.

- Research Study 2: The study aimed at examining how EEG and be-

havioral measures can be used to measure individual choice for product external cues. Individual preferences for the wine labels were investigated testing the effect of aesthetic label components on visual attention mechanisms. Particularly, the PCN (Posterior Controlateral Negativity) component was used to analyze subjects' visual attention for the wine labels.

Overall, the findings presented in this thesis suggest that Consumer Neuroscience improve the study of consumer behavior. The combined use of both psychological and neuroscience methods help to investigate the conscious and unconscious mechanisms that support consumer decision-making process and consumer behavior. The application of Consumer Neuroscience tools and principles can help to overcome the limits that affect traditional marketing research, such as insufficient information and biased results; the numerous individual and social factors involved in buying behavior and the rapid changes in the market. In fact, neuroscience measurements provide unbiased measures of consumer responses and individual preferences as well as the study of the decision-making process and buying behavior at different levels, such as the study of subjective value and quality evaluation; reward mechanisms and the assessment of extrinsic cues. However, the literature review has highlighted several theoretical and practical boundaries that affect predicted versus realized benefits of Consumer Neuroscience. Particularly, the lack of a unified definition and the number of disciplines involved in the field; unclear definition of the goals; the difficulties to reproduce a natural environment and the study of the product experience; no use of Marginal Utility theory and problems of reverse and forward inference can affect Consumer Neuroscience research. The empirical results also showed that tools changes in beta band activity cannot be related directly to individual preferences. However, neuroimaging tools such as EEG allow to measure the influence of extrinsic cues on individual preferences and brain activity as well as to study visual attention mechanisms during the product external cues evaluation.

ACKNOWLEDGMENT

This is unarguably one of the most critical and important parts of my thesis. To quote Winston Churchill (1942), as a researcher is my due to cite someone, this is “the end of the beginning”. In fact, your life as a student ends exactly in this moment. From this point on, there is no turn back. You are no more a student; you are an adult researcher and hopefully you are a better person. As you might know, being a Ph.D. student is not only a job; it is a mission, it is a way of being, think and behave. It helps you to grow professionally but it also teaches you to be humble, patient and at the same time to be confident, brave and determined in order to survive in this jungle called academia.

If you are reading all of this, it means that my journey as a Ph.D. is ending. It means that I am no more the person who started this adventure three years ago and I am ready to be someone else. As trivial as it may seem, trust me when I say that I could have not accomplished it without the help and support of numerous people who have accompanied me thought these three years.

I would like to start with my supervisor at the University of Molise, Prof. Massimo Franco. Thank you for supervising my work and for took me under your wings.

I would like to express my gratitude to my co-supervisor Dr. Efthymios Constantinides who gave me the extraordinary opportunity to work with him at the University of Twente. Thank you for all your kindness, suggestions and pleasant chatting at the University. Thank you for placing confident in me.

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Thanks also to my colleagues at the University of Molise: Aizhan and Barbara. You both inspired me to be a better researcher and a better person. I really miss our "arrosticino" nights and the tea in Glasgow.

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Naturally, a very warm thank to all the secretaries. To Monique, for everything you have arranged for my arrival in Enschede. To Joyce, for smiling all the time even though you are very busy; you really made my working days more pleasant.

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I would like to thank my parents in law for waiting patiently while I was submitting the thesis. Thank you for celebrating with me, I will remember that day forever.

A special thanks to my colleagues but mostly importantly my friends for life: Masha and Isabella. We spent so much time together working on our projects, chatting, laughing and sometimes fighting. We are the living proof that it is not important how much we have changed, we will always be friends everywhere and anyway.

I will not thank you my parents. In fact, there are no words to describe what they did for me. Parents have always a complicated and controversial way to tell you how much they love you. My parents do not always understand me as I do not always understand them. Nevertheless, they have always been there for me. My mother thought me to be optimistic and strong. My dad thought be to be committed to my duty and passionate about my work. My parents do what they do the best, they never stop caring about me.

Finally, (as we say in Italy "Gli ultimi saranno i primi") I thank you, my better half Abhishta. You are the main reason I am standing here (the other one is coffee). Your love released in me strength, courage and even wisdom that I did not know I had. You are the one who gave me back faith in everything. The one person who knows both my good and bad sides and still you chose me. You are both the reasons I can be myself (a little bunny) and at the same time I have to change and be a stronger person. I hope you understand how much you are unique and valuable for me (almost important as chocolate). You are the reason I can enjoy this moment because you gave me something to look ahead: our family.

ACRONYMS

AMA American Marketing Association. 24, 25

CNS Central Nervous System. 16

COO Country of Origin. 107, 115

dlPFC Dorsolateral Prefrontal Cortex. 17, 40

EEG Electroencephalography. 18, 54, 57, 79, 115

EPSP Excitatory Post-Synaptic Potential. 57

ERP Event-Related Potential. 65

FGI Focus Group Interviews. 13

FMCG Fast-Moving Consumer Goods. 94

fMRI Functional Magnetic Resonance Imaging. 18, 55, 71

MEG Magnetoencephalography. 54

MPE Marketing Placebo Effect. 39, 71, 163

MRI Magnetic resonance imaging. 55

NE Neuroeconomics. 18

NM Neuromarketing. 30

OFC Orbitofrontal Cortex. 17

PET Positron Emission Tomography. 55

V Volt. 58

vmPFC Ventromedial Prefrontal Cortex. 40

"L'essentiel est invisible pour les yeux."

"What is essential is invisible to the eye."

Antoine de Saint Exupéry (1943), Le Petit Prince.

CHAPTER

1 INTRODUCTION

1.1 Research Background

Only a few decades ago Marketing was regarded as a marginal activity of relatively little value by organizations and society. However, during the past forty-five years there has been a profound change in Marketing perspective (Hackley 2009; Kotler et al. 2016; Moorman and Rust 1999). Nowadays, knowledge-based organizations recognize the increasing importance of Marketing in our society.

This increased recognition of the importance of Marketing has led to a significant shift in the role of customers for companies. Until the 1960's, companies were production-oriented and sales-driven (MacKenzie 2010). These companies focused on strategies and tactics that pushed or pulled customers to buy products. Hence, these strategies were not aimed at creating a long-term demand by improving the companies' products offerings, instead they were based on the assumption that the product met à priori the need of customers, whether they expressed a need for the product or not. For this reason, companies forced customers to buy standardized product, instead of focusing on satisfying the customer's specific needs (e.g., different model ranges) and preferences (e.g., different color for the same product).

In today's economy, customers are the focal point of the company business activity. Thus, the success of companies depends on their ability to satisfy customers. Companies can achieve customers' satisfaction by studying the decision-making processes that drive consumers' behaviors. Hence, Marketing research studies how to acquire information about consumers and to understand how they choose and behave. However, rapid changes in market conditions, new and improved technologies and, financial crises challenge companies to study the behavior of their customers. Moreover, traditional Marketing techniques such as surveys, focus groups, observation, interviews, and online researching are not able to provide an overall picture of the reason why people buy the things they buy (Plassman et al. 2008; Venkatraman et al. 2012).

Given the number of companies that cannot fulfill customers' expectations and the growing need for a change in Marketing strategies, the last decades have seen an increase in the application of neuroscience tools in Marketing. Even though Marketing research and companies have previously benefited from the use of psychological theories (Armstrong et al. 2017; Kotler et al. 2016), the application of neuroimaging techniques allows researchers to focus on the physiological and neural mechanisms of the consumer rather than only on psychological factors. Hence, the combination of neuroscience, Marketing and Psychology research defines a new field (or sub-field) of study known as Neuromarketing. For reasons clarified at a later moment in this thesis, researchers more frequently indicate this interdisciplinary field as *Consumer Neuroscience*.

Consumer Neuroscience studies the neural mechanisms that support and affect consumer behavior. The main advantage of Consumer Neuroscience research is that it focuses on the entire buying process[i] rather than only on the purchase decision. Consumer Neuroscience studies analyze how consumers evaluate quality and experience product value; it also studies the effect of expectations and rewards on psychophysiological processes. Particularly, an increasing number of studies investigate the neuronal responses and psychological factors (e.g., motivation, attitudes) involved in product evaluation. Many studies focus on understanding individual preferences for products and consequently how and when the human brain processes this information. In fact, some neural mechanisms can be triggered even before the stimulus is presented, e.g., the desire for a cold drink, such as Cola or Sprite, when an individual is thirsty, or immediately after the stimulus is presented ($<$50 ms).

Exploring neuronal mechanisms helps to understand how an individual evaluates the products' extrinsic cues. Consumer Neuroscience provides cognitive and neural information for investigating the influence of

[i]The consumer buying process consists of successive steps the consumer follows to arrive at the final purchase. The buying process starts long before the actual purchase (Armstrong et al. 2017). In fact, it might also result in a decision not to buy.

price, brand and aesthetic on consumers' preferences and perceived quality. For instance, the brain areas involved in brand evaluation (e.g., Toyota, Audi) or preferences for a color. Consumer Neuroscience studies how the brain processes sensory information and where this information originates in the brain. Sensory information can give useful insight for studying and predicts consumer's preferences and improve product quality.

Studying consumer behavior is particularly difficult due to the numerous individual and social factors that influence this process, the rapid changes in the market and the common limits of traditional Marketing research (e.g., insufficient information, biased results). However, the application of Consumer Neuroscience tools and principles can help to overcome the limits that affect traditional Marketing research. Hence, Consumer Neuroscience provides a tool for investigating consumer behavior and improving Marketing research.

1.2 Aim of the thesis

This Ph.D. thesis concerns a topic that is at the intersection of three domains: Marketing, Psychology and Neuroscience, which I prefer to refer to as Consumer Neuroscience (see Chapter 3). The thesis focuses on consumer behavior and it investigates the existent and potential influences that identify, define and affect the decision-making process and buying behavior.

This thesis aims at contributing to both theoretical and practical aspects of Consumer Neuroscience research by:

- Establishing the realized benefits and potential outcome of Consumer Neuroscience research.
- Identifying potential problems in Consumer Neuroscience experiments.
- Clarifying how neuroimaging techniques, such as EEG, can help to study and assess individual preferences and perceived quality.
- Studying the influence of extrinsic cues on individual preferences.

1.3 Research Problem

Initially, I conducted a systematic literature review to assess the current state of affairs in Consumer Neuroscience research. This literature review highlights how consumers' choice and behavior are studied in Consumer Neuroscience research. It provides an overview of the dominant topics of investigation, and describes and discusses the main tools in this field of research. The literature review also focuses on how Consumer Neuroscience differentiates from traditional Marketing research.

The use of both psychological and neuroscience methods enables to study the decision-making process and buying behavior at different levels. Psychology helps to decompose the various components that play a role in human decision making as it studies human cognitive functions (e.g., verbal communication, attention) and emotions which affect the decision-making process and buying behavior. Psychology can account for how customers acquire and process information, subjective factors (e.g., goals, beliefs, motivations) and the effect of emotions on the decision-making process. Psychological methods involve questionnaires and observation. The outcome of these methods are influenced by subject's mental states and interpretations. Frequently, questionnaires and observations cannot determine the reasons underlying consumer's choice, or define the meaning of behavior and measure the effect or intensity of emotions (Whitley et al. 2012). On the other hand, neuroscience can give information on the reasons behind cognitive processes. Neuroscience methods study how cognitive functions are accomplished in the brain and which brain areas play a crucial role in these processes.

Neuroscience methods can explain how psychological findings can be tied back to physiological and neuronal processes. The use of both psychological and neuroscience methods helps Consumer Neuroscience research to investigate the conscious and unconscious psychological and neural mechanisms that support consumer decision-making process and buying behavior. Overall, Consumer Neuroscience can contribute to a systematic understanding of consumer behavior and decision-making process.

Hence, the following overarching research questions were defined in order to achieve the aforementioned aims of the thesis:

1. *Does Consumer Neuroscience research improve Marketing research? If so, how?*
2. *Does Consumer Neuroscience research contribute to Marketing research with regard to consumer behavior and preference?*

Importantly, the literature review revealed that there are several theoretical and practical boundaries that affect predicted versus realized benefits of Consumer Neuroscience.

Hence, the additional overarching research question was defined:

3. *What are the major problems in Consumer Neuroscience experiments?*

The literature review highlights that the general goals and priorities of Consumer Neuroscience research are not well defined. Secondly, Consumer Neuroscience studies mostly seem to provide theoretical contributions. Up to now, a limited number of empirical studies have been published. Thirdly, several methodological problems were classified in the analyzed experiments. Some problems concerned the sample size and the experimental design used to record subjects' brain activity. Other problems refer to reverse and forward inference, thus, the assumption that certain brain areas are necessarily involved in specific cognitive processes and the incorrect or inappropriate use of theories and findings of other experiments (Plassman et al. 2012).

Consumer Neuroscience experiments seem to extremely simplify the complexity of the buying process (Heit 2014; Koschate-Fischer and Schandelmeier 2014). In fact, numerous experiments did not consider individual differences, the psychological (e.g, motivation) or the economical factors that influence the consumer behavior and decision-making process. Consumer Neuroscience studies rarely investigate the neural mechanisms and responses involved in product experiences. In real-life purchase experiences (except for on-line purchase), consumers can interact with the product. For instance, consumer can touch, smell or taste the products. In Consumer Neuroscience experiment, frequently, stimuli (e.g., products) are digitally presented. Thus, there is no contact between the subject and the product. This might excessively simplify the study of consumer behavior. Hence, *it is possible to determine the neural mechanisms and responses involved in product experience*[ii] *?*

Based on the aforementioned considerations, I decided to investigate the neural mechanisms underlying individual preference during a real product experience. I used qualitative research methods to analyze personal preferences and I measured the brain activity during product experiences.

Two studies were carried out using Electroencephalography (EEG). I selected wine as a product for these experiments for two main reasons. Firstly, I wanted to measure the neural activity during the tasting of a product. Recording subjects' brain activity, during drinking or eating, is difficult. In fact, it might create excessive artifacts and noise in the signal. Tools, such as fMRI or MRI, excessively limit the product experience, in fact it can take a significant amount of time, subjects do not have to move, resulting in drift of signals from baseline overtime (Burgess 2016). I wanted to test whether EEG may be more suitable to study neural processes during product experiences. Secondly, I chose wine for its product characteristics. As for other drinking products (e.g., beer), wine quality

[ii] Product experience is "the people's subjective experiences that result from interacting with products" (Schifferstein and Hekkert 2011)

and preferences can be assessed only during consumption. Due to the large amount of different cues that may influence quality perception and consumer preferences (e.g., grape varieties, price, brand), selecting a wine is more complex than the choice of other food or drink products (Sáenz-Navajas et al. 2013). In fact, wine is a complex product with a strong symbolic value based on sensory (intrinsic cue) and no-sensory characteristics (extrinsic cue) (Thornton 2013). Wine sensory characteristics are those related to physical-chemical attributes of wine, usually difficult to interpret for inexpert consumers (Sáenz-Navajas et al. 2013). Defining wine quality can be also complicated due to its low information content (e.g., information on the label) and high customer's knowledge requirement (e.g., classify organoleptic characteristics). Participants selected were not expert wine drinkers. Hence, I investigated how inexpert consumers assess and evaluate wines. I also examined if it is possible to determine a general pattern or a common trend when they choose wines.

- **Research study 1**

  An experimental approach was developed to investigate individual preference for wines during the product experience (wine tasting). The study aimed at providing evidence that EEG activity in the beta band can predict individual preference for a product. The integration of EEG data and behavioral data can additionally provide insight into the effect of Marketing extrinsic cues, such as label on inexpert consumers' preferences and perceived quality.

In the second experiment, I developed the further aim of exploring individual preferences for an important extrinsic cue: the label. Literature review showed that Marketing studies analyzed how the label (e.g., color, design) (Barwich 2017; Mueller and Szolnoki 2010b; Orth and Malkewitz 2008; Szolnoki et al. 2008) can influence consumers' choice and preferences for wine. Several methods have been used to study consumers' preferences and quality assessment for wines (e.g., surveys, questionnaires, simulated choice experiments). However, traditional Marketing methods cannot give an accurate and objective understanding of the consumer behavior during wine selection (Ariely and Berns 2010; Babiloni et al. 2013). Instead, Consumer Neuroscience research provides information on neuronal responses and psychological factors involved in the assessment of product extrinsic cues and how they affect consumer behavior.

Based on previous Consumer Neuroscience studies, I hypothesized that Marketing extrinsic cues, such as label, should impact the product judgment of inexpert wine drinkers.

- **Research study 2**

I implemented a second experiment as a further development of the first study. The study was aimed to examine how EEG and behavioral measures can be used to measure individual choice for product external cues. Individual preferences for the wine labels were investigated testing the effect of aesthetic label components on visual attention mechanisms. Particularly, the PCN (Posterior Controlateral Negativity) component was used to analyze subject's visual attention for wine labels.

The two experiments were designed to improve and avoid the aforementioned flaws and limitations in Consumer Neuroscience research. Hence, the experimental design was set up considering:

- *Product experience.* In the first experiment, products were not digitally displayed, thus the participants could really experience (see and taste) the products.
- *Sample size.* The total sample was 26 participants involved in two measurements (52 tests in total).
- *Sample Characteristics.* Participants of different age (18-40), nationalities (17), wine drinking habits (drinker, non-drinker), wine buying habits and income.
- *Repeated measurements.* A within-subjects design was employed. The experiments were divided in two sessions and two conditions (Label, No Label).
- *Performed a reverse inference.* In order to examine the reverse inference problem, I tried to test the conceptual replication of the Boksem and Smidts (2015) study. In the first study, I examined if beta band can be a useful predictor of individual preferences.

The literature review and the experiments results attempted to answer the following additional research questions:

4. *Does individual preference affect the brain activity during the product experience? If so, is EEG a valid instrument to assess individual preference during the product experience?*
5. *Do extrinsic cues influence individual preference and brain activity? If so, can the influence of extrinsic cues on personal preference be measured using EEG?*

This thesis yields a framework for describing the process through which EEG measurements can assess individual preferences for a product over time. This framework can contribute to the development of future theories in consumers' decision-making and buying behavior. Insights and recommendations from the presented studies might be also valuable for managers and companies, especially within the wine sector.

1.4 Structure of the thesis

This thesis contains in total nine chapters, including this introduction (Chapter 1). The complete thesis structure is described as follows:

Chapter 2 introduces the concept of decision-making. It analyzes the contribution of different disciplines, such as Marketing, Psychology, Neuroscience and Neuroeconomics, to decision-making.

Chapter 3 contains a short description of Marketing evolution and provides a definition of Neuromarketing and Consumer Neuroscience. It also gives an overview of the existing Consumer Neuroscience research on consumer choice and behavior. It first focuses on general benefits of Consumer Neuroscience findings to Marketing research before moving on to the study of reward mechanisms and assessment of quality and value, as main component of consumer behavior.

Chapter 4 describes the most common techniques used in Consumer Neuroscience research; particular attention is given to Electroencephalography, as a research tool of the studies described in Chapter 7 and 8. In order to understand neuroimaging tools better, the human brain and its main functions are illustrated in this Chapter.

Chapter 5 provides an overview of the existing Consumer Neuroscience research on consumer behavior and preference. It describes how external cues such as brand, price and aesthetics can influence consumer behavior and how EEG data have been used in these topics so far. Chapter 5 also contributes to identify the main problems in Consumer Neuroscience experiments and therefore addresses the research questions identified.

Chapter 6 introduces the theoretical background for the two studies described in Chapter 7 and 8. It explores studies in the fast-moving consumer goods (FMCG); specifically, it focuses on wine and previous studies in both Marketing and Consumer Neuroscience research.

Chapter 7 describes the first research study and presents its results.

Chapter 8 describes the second research study and reports the findings.

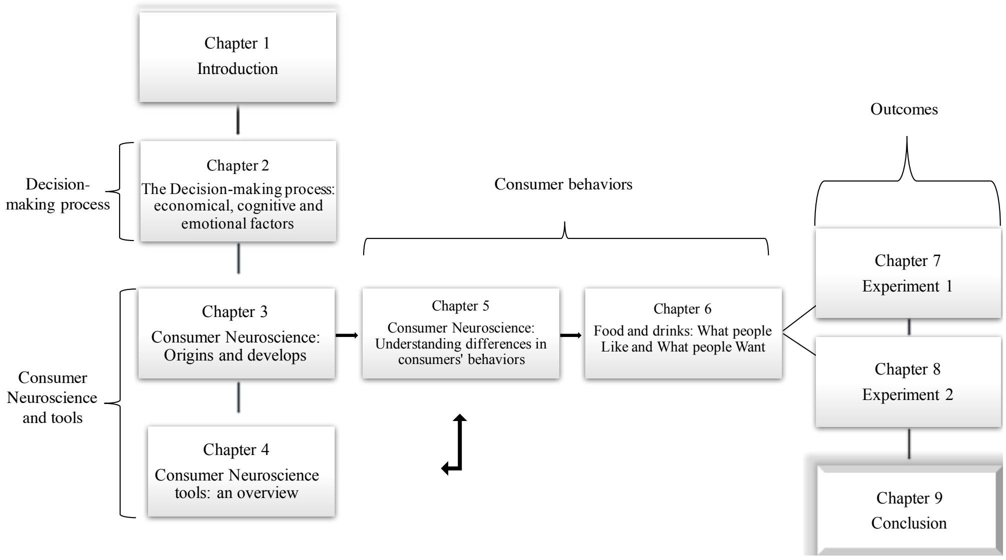

Figure 1.1: *An illustration of the thesis structure.*

Chapter 9 discusses the implication of the findings of this Ph.D. thesis and its contribution to the academic literature and to future experiments. Finally, limitations of the research undertaken are described and suggestions for further future research are proposed.

CHAPTER

2

THE DECISION-MAKING PROCESS: ECONOMICAL, COGNITIVE AND EMOTIONAL FACTORS

2.1 Decision-making: an overview

Decision-making is nothing but a process through which it is possible to make a decision (Padoa-Schioppa 2007). The term decision from the Latin word *"decisio-onis"*, means "to cut off, to end something" and it clearly expresses the will to resolve or to end a problem (March 1994). In fact, decision-making is based on finding and choosing alternative options to get to an ideal situation, which is the solution (Kreitner and Kinicki 2008). The main goal of the decision-making process is generally to improve an individual or organization's condition based on one or more criteria (Caramia and Dell'Olmo 2006).

Everyone, be it individuals or organizations in society, make more or less complex decisions. Making a decision may entail trivial issues, such as choosing what to eat or drink as well as more complex situations like buying a house, accepting or refusing a job, choosing to have a surgery or travel by plane or car.

From this prospective, decision-making is an important process that involves and supports social, economic, psychological and physiological aspects of our lives, either as an individual or as a group. It is not surprising that decision-making mechanisms have been studied in different disciplines and with different finalities. This chapter analyses the contribution of disciplines such as Marketing, Psychology, and Neuroscience to the decision-making process. Finally, the chapter introduces a new discipline, named Neuroeconomics. Neuroeconomics integrates several disciplines, such as economics, Psychology, and Neuroscience to provide better explanation of the decision-making process and economics events.

2.2 The decision-making process in Marketing and Economics

In today's economy, companies are focused on customers' satisfaction. Customers are considered as *"the center of the business universe"* (Keith 1960). Marketing is the business activity that companies can use to attract costumers. In fact, Marketing, more than any other business function, is in contact with customers (Kotler et al. 2016). Marketing researchers study how to acquire information about consumers and understand their behaviors. Specifically, Marketing studies the deep and inner reasons that motivate consumers to buy.

Consumers make decisions when they choose what products to buy or which services to use on a daily basis. Usually, customers try to make the best choice that is also congruent with their values and intentions. In fact, the goal of decision-making is generally to improve an individual or organization's condition by finding and choosing alternative options to get to an ideal situation, which is the solution (Kreitner and Kinicki 2008).

Unlike economic theories, Marketing does not consider decision-making process as a rational process. In economics, decision-making is a rational process that involves three-steps: (1) analyzing the feasibility of the alternatives, then (2) pondering the desirability of the alternatives, and finally (3) choosing the best alternative by combining both desirability and feasibility (Frederiks et al. 2015; Oliveira 2007). Hence, people are objectively able to weigh up the costs and benefits of all alternatives before choosing the optimal course of action. Marketing research, instead, analyzes individual decision-making as a process modulates by no-rational factors such as psychological, socio-cultural factors and especially economic factors.

In Marketing, the decision-making process starts with need recognition or *"growing consciousness of a need"* (Foxall et al. 1998; Lantos

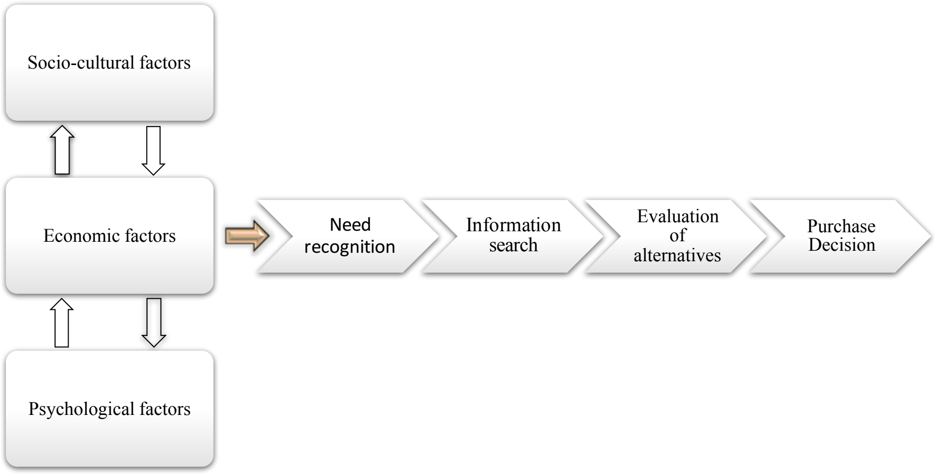

Figure 2.1: *This figure displays the customer's decision-making process according to Marketing research.*

2015). In this stage the potential costumer is aware what he/she wants to satisfy the need. Needs are influenced by psychological (such as motives, beliefs and personality), socio-cultural (such as culture, social class, reference groups, and family) and economic factors. These factors influence every single aspect of a subject life and they can modify their choices. For instance, culture and subculture (nationality, religion and geographic region) determine preferences in life and manifest themselves in how people behave, think, and believe (Oliveira 2007). Social factors can be groups (two or more people who interact to achieve mutual goals), social networks, family, roles and status (Armstrong et al. 2017). Social factors strongly define subject's belief and attitudes (psychological factors). Personal factors such as age, stage in the life cycle, occupation, social class, and personality define subjects' priorities and consequentially how they make choices (ibid.). Finally, a subject's economic situation will strongly affect his or her choice, in terms of shop or product to buy. Particularly important for Marketing research is the trends in spending, personal income, saving and interest rates (Kotler et al. 2016).

The second step is information search (Foxall et al. 1998; Lantos 2015). A customer searches information related to the need that he/she wants to satisfy (Armstrong et al. 2017). A customers search information on the base of internal or external search. Internal search refers to internal processes, such as memory and personal experiences (Jobber 2007). External search are personal sources (e.g., family, friends), commercial sources (e.g., advertising, salespeople) and, public sources (e.g., mass media, social media, online search).

Thirdly, the alternative evaluation is how customers process information to choose among different products or brands (Armstrong et al. 2017). During alternative evaluation, customers do not use a single and linear process (Kotler et al. 2016). Instead, several evaluation processes can be applied according to individual differences, environment and specific buying situations (ibid.).

The information search and the identification of alternatives strongly influence the buying decision-making process. For instance, the absence or lack of information complicate the decision.making process. In fact, the customer will make a decision without a solid foundation. Information overload also hampers decision-making. It generates indecision and stress. Finally, the decision-making process acquires different characteristics depending on (1) the context in which decisions are made (such as a shop or on-line purchase), (2) the role played by the decision maker (e.g., customer or company) and (3) the number of decision makers who are involved in the process (e.g., one or more customers). From this perspective, decision-making process is the results of different influencing factors.

Finally, in the purchase decision the customer decides to buy the product or not (Foxall et al. 1998; Lantos 2015).

In order to implement a successful Marketing strategy, companies need to understand how customer's choice can be interpreted and evaluated. The goal of Marketing research is to study all the decision-making process steps, such as the processes involved when consumers, individuals or groups, select, buy or use a product/service. Marketing research on decision-making process can be implemented at both macro and micro levels. Usually, Marketing researchers use surveys, Focus Group Interviews (FGI), observation, interviews and online researching to support and facilitate the studies (Kotler and Keller 2006).

The macro level determines how companies should target and segment their market (customer's nationality, culture, group and social networks) on the base of forces that shape opportunity and pose threats to the company (Armstrong et al. 2017; Kotler et al. 2016). It enables companies to understand the kind of strategy they want to implement, such as the types of product, distribution channels, price and advertisement policy. In order to define and segment the target, companies need to study how customers identify products, for example how customers recognize and are familiar that specific product, choose the context (local shop, shopping mall or on-line shop) and how customers interpret information. In the micro level, companies determine how to manage customers individual differences on the basis of actors close to the company that can affect positively or negatively their ability to create value for the customers (Armstrong et al. 2017; Kotler et al. 2016). Studying how customers experience products (psychological phenomena, lifestyle, occupation) and how they differ in their choices (Solomon et al. 2013) helps companies to define specific product cues (such as packaging, price, label) and predict purchasing habits.

Nowadays, the study of decision-making has become a key issue for any organization willing to increase its efficiency and the performance perceived by its customers. In Marketing, choice represents the behavior observed when an individual selects one of many available options usually based on subjective preferences, socio-cultural, psychological and economic factors (Padoa-Schioppa 2007). Hence, the study of these factors can help companies to acquire information about consumers and understand their behaviors, and to engage and affect how their clients think and act.

2.3 Psychology and decision-making

As discussed in Section 2.2, the decision-making process has been broadly analyzed in several disciplines. Theories in Psychology[i] tried to explain decision-making process.

Numerous studies have been conducted on subjects with different background to understand the individual, social and emotion factors involved in the decision-making process (Geva and Mintz 1997; Hastie and Dawes 2010; Higgins et al. 2014; Montgomery 1983; Plous 1993). These studies showed that even though people have different expertise (e.g., doctors, financial expert, college students) and they are in very different situations, they frequently think about decisions in the same way (Hastie and Dawes 2010). These findings suggest that human beings have a common set of cognitive skills that are reflected in similar decision habits (ibid.). On the other hand, the outcome of the decision-making process is often dissimilar. Nevertheless the way in which people acquire and process information is not heterogeneous. In fact, Psychology studies both the exogenous and endogenous factors that influence the decision-making process.

Exogenous factors refer to features of the environment, as factor that challenges a subject's existence. In fact, changes in the environment, particularly the appearance of novel stimuli, introduce the possibility of opportunity and/or threat (Weber and Johnson 2009). For instance, constant exposure to a stimulus leads to habituation, i.e., reduced responding,

[i] *"Psychology is what scientists and philosophers of various persuasions have created to . . . understand the minds and behaviors of various organisms from the most primitive to the most complex"* (Reber 1995). The main goal of Psychology is to study the general laws of animal behavior, particularly humans (Henriques 2004).

as things not previously responded to are likely to be neither dangerous nor promising (Weber and Johnson 2009). However, a change in the environment results in dishabituation and an orienting response (ibid.). Task characteristic (e.g., easy, difficult, familiar, unfamiliar) can also modulate how people react or respond to it.

Endogenous factors, instead, refers to the internal state of the decision maker that drives the decision-making process. These factors refer to subject's set of goals, beliefs, motivations, perception and attitude (Geva and Mintz 1997; Hastie and Dawes 2010; Higgins et al. 2014). For instance, a belief is the meaning that a person formulates about something (Grayling 2011). Motivation, instead, refers to factors that activate, direct, and sustain goal-directed behavior (Nevid and McClelland 2013). Motivation drives behaviors as well as choice. Perception is the process by which a subject selects, organizes and interpret information in order to form a meaningful picture of the world (Armstrong et al. 2017). Attitude reflects an subject's evaluative integration of cognitions and affects experienced in relation to an object (Crano and Prislin 2011).

From a psychological perspective, emotions are also considered a dominant driver of decision-making process (Ekman 2007; Keltner and Lerner 2010; Linder et al. 2010). In fact, decision making has both cognitive and emotional components, however, they have different functions (Beresford and Sloper 2008). Cognition refers to a class of higher mental process such as thinking, acting, planning imaging, speaking and perceiving (Ward 2010). Instead, the term emotion means internal experiences, such as feeling that operates without the need for conscious observation or explicit meanings (Koole and Rothermund 2011). Emotions are, indeed, natural reactions. The role of emotions is to alert people to an unexpected situation and providing direction for cognitive processes and behaviors (Beresford and Sloper 2008; Cattarinussi 2006). Emotions help people to prioritize between different options, to reduce the amount of information and to process how to choose or behave in a situation (Beresford and Sloper 2008).

It is possible to identify different types of emotions (fear, sadness, acceptance, diffidence, anticipation and surprise) (Linder et al. 2010). Usually, emotions are reliably associated with particular sets of judgments (Lerner and Keltner 2000; Tiedens and Linton 2001). For instance, anger is associated with unpleasant situations but certainty about what is happening; in contrast fear is also associated with unpleasantness but with uncertainty about what has happened or will happen. However, numerous studies refer simply to positive and negative emotions. For instance, positive emotions signal the presence of promising occasions in the environment (Galati and Sotgiu 2004). Negative emotions, instead, announce the presence of critical situations, judged as negative and unpleasant (Garcia and Saad 2008).

Overall, positive and negative emotions alter people's modes of thinking and consequentially decision-making process. However, negative emotions amplify people's autonomic activity and reduce their attention to support specific choice (e.g., attack, escape), positive emotions, instead, increase people's attention, thinking, and behavioral repertoires (e.g., play, explore) (Fredrickson et al. 2003). For instance, positive emotions produced patterns of choice that are notably unusual, flexible, integrative, open to information and efficient (ibid.). Different studies, instead, found that negative emotions experienced while making a decision involving difficult trade-offs have been shown to impact on strategy selection and decision-making. For instance, Hancock (1989) found that decision-making affected by negative emotion are characterized by increased amounts of processing and avoidance of trade-offs.

Psychological theories are useful to define the cognitive and emotional factors that underlie the decision-making process.

2.4 Neuroscience and decision-making

Neuroscience, also known as Neural Science, studies the human and animal brain and its functions (Purves et al. 2008). Neuroscience describes how the Central Nervous System (CNS) develops, matures, and maintains itself. Neuroscience also studies the functions of nerve cells that comprise the nervous system, how they generate and propagate electrical signals and how the neural circuits are organized (ibid.). In particular, Neuroscience research concerns the study of three systems: the sensory system, the motor system, the associational system (ibid.). The first one produces information about the state of the organism and its environment. The motor system organizes and generates actions, and the associational systems. The associational system connects the two previous systems, providing the basis for *"higher-order"* functions such as attention, cognition, emotions, rational thinking, and other complex brain functions that allow to understanding human beings, their history and their future. Studying the neuronal basis of higher-order functions (e.g. verbal communication, the ability to plan and handle multiple tasks at the same time) is important to address issues such as how humans make decisions and cerebral areas implicated in this process.

Neuroscience literature shows that numerous studies have been conducted on choice making. Unlike Psychology and Marketing research, Neuroscience studies analyze the neural triggers underlying decision-making process. Specifically, these studies focus on the cerebral areas that manifest themselves and their degree of influence over the decision-making process, in particular in patients who can no longer process emotional information. These findings suggest that people make decisions not only by evaluating the consequences and their probability of occurring, but also and even sometimes primarily at a gut or emotional level (Bechara 2004). After damage, they develop complications in planning their workday and future; difficulties in choosing friends, partners, and activities (Bechara et al. 2000, 2002). From a neurological perspective, the result of the decision-making process must be interpreted as the outcome of the neural activity interaction among different subsystems (Juslin and Sloboda 2011). In particular, the Orbitofrontal Cortex (OFC) is involved in the affective system for decision-making, whereas the Dorsolateral Prefrontal Cortex (dlPFC) and the frontal one participate in the deliberative system of the decision-making process (Poletti 2007). More generally, the orbitomedial cortex (see Subsection 4.2) can be considered as a convergence point for multisensory and emotional information, which plays a significant role in social relations and in the evaluation of meanings, as well as in the regulation of emotions (Giusti and Azzi 2013). This brain region, and particularly the right hemisphere, can monitor and regulate the body conditions, and consequently emotional states and socially adaptive behaviors. The orbitomedial cortex can be viewed as the "place" where emotional signals are unconsciously represented (ibid.).

Damasio 1994 studied widely the influence of emotions on the decision-making process. His team has followed studies on patients with lesions in the prefrontal cortex propose a framework called *"Somatic Marker Hypothesis"* (Adolphs et al. 1999). This hypothesis was advanced to provide a valid neurological explanation for everyday-life decision-making processes operated by patients suffering from brain lesions. Based on this theory, it is possible to trace a link between the patients' feelings and emotions anomalies and their inability to make decisions or evaluate real life events (Bechara et al. 2000, 2002). Damasio (1994) describes the process which employs biological information to affect and guide decision making based on previous similar experiences; such processes can bring both positive and negative results. During decision-making, somatic signals are activated, based on an automatic and intuitive emotional elaboration of the available information which helps an individual to choose a given alternative rather than another one (Adolphs et al. 1999; Poletti 2007). In these circumstances, making a decision stimulates a somatic response to mark future events, which are significant for the human being, by attributing to them a sense of danger or advantage. In this way, when a negative somatic marker is linked to a particular future outcome, an alarm signal is activated that tells us to avoid or not to perform that particular course of action (Damasio 1994; Velásquez 1998). Viceversa, when a positive somatic marker is linked, it becomes an incentive to make that particular choice (Velásquez 1998). This hypothesis shows the importance of the sensory mapping of visceral responses not only to understand feelings, but also in the execution of highly complex, goal-oriented behaviors (Naqvi and Bechara 2010). Numerous studies conducted in Neuroscience have tried to demonstrate that emotions and decision making are closely connected.

2.5 Neuroeconomics: the decision-making process between Neuroscience, Psychology and Economics

As discussed in Section 3.2, the last two decades have been characterized by a steady growth in the use of Neuroscience in Economics and Marketing, with the use of Functional Magnetic Resonance Imaging (fMRI) and Electroencephalography (EEG) to study economics-based decision-making processes. In 2000, McCabe coined the term Neuroeconomics (NE), that can be defined as an interdisciplinary field including studies from Neuroscience , Economics and, Psychology (Levallois et al. 2012).

Neuroeconomics research combines Neuroscience , Psychology and Economics tools in order to study the neural mechanisms that drive the decision-making process. This research area deals with the neurobiology of decision making and the way it affects cognitive social interactions between humans and societies/economies. It studies how economic behaviors can pattern our understanding of the brain, and how neuroscientific discoveries can constrain and guide models of economics (Camerer et al. 2005). However, Neuroeconomics research also aims at understanding emotional factors that affect these processes.

The standard economic hypothesis states that the decision-making process is coherent with profit maximization (see Section 2.2), instead Neuroeconomics asserts that the decision-making process is driven by a complex interaction of automatic processes (originated by brain's electrochemical activity) and controlled processes (activated in particular situations, normally when an individual has to face changes or has to make a decision to solve a problem) (Rick and Loewenstein 2008). However, Neuroeconomics does not necessarily take distance from classical economic assumption and theory (Bryan and Lechman 2017). In fact, Neuroeconomics studies the neurobiological and biological microfoundations of economic and value-based decision-making process (Bryan and Lechman 2017; Rangel et al. 2008). Neuroeconomics provides a biologically-based account of human behaviors that can be applied in both economics and social sciences (Rangel et al. 2008).

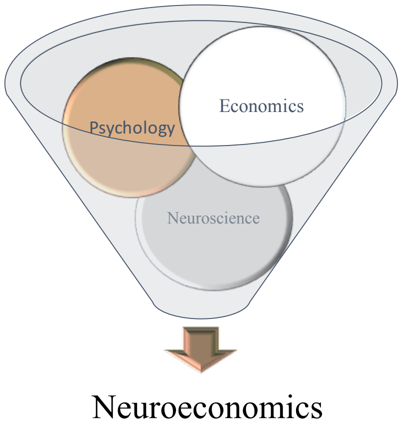

Figure 2.2: *Neuroeconomics as the union of Economics, Psychological and Neuroscientific research.*

Numerous studies in Neuroeconomic research analyze stress. In fact, several studies have shown that stress injures the cerebral areas involved in the decision-making process and consequently affects choices made by an individual. Stress can be defined as the reaction to an unbalanced situation in which a person uses resources and capacities to adjust to the situation. The induction of stress in the human body results in an increase in physiological arousal, in the levels of adrenaline and glucocorticoid release (Glimcher 2014). Stress hormones are known to influence a number of brain regions related to emotions and decisions (ibid.). For instance, Porcelli and Delgado (2009), using the Cold-Pressor Task technique, analyzed the impact of acute stress on a financial decision-making process. Participants were involved in games such as gain or loss domain, where players were supposed to choose between two potential wins or two potential losses (ibid.). The experiment was first conducted under controlled conditions and secondly in a stressful situation (participants were asked to immerse their hands in near-freezing for about 2 minutes) (Porcelli and Delgado 2009). The participants' choices showed a higher degree of reflection in case of stressful situations than under controlled conditions (ibid.). There was a change in the use of the strategies (risky or conservative) employed by stressed participants (Glimcher 2014). In this experiment, subjects who were more stressed became more conservative in the gain domain, and riskier in the loss domain one. In a similar study, psychologists Kahneman et al. (1997) obtained the same results even though this trend was amplified by exposure to stress.

Hall et al. (2010) examined risk propensity under stressful conditions according to the participants' gender. Participants were asked to inflate a series of balloons on the screen. The larger a balloon got, the more points it was worth; but, in case the balloon exploded, the participants would receive no points. During the experiment, men who experienced acute stress were more predisposed to risk taking, while women decreased their risk taking during the stress condition (Glimcher 2014). Another stress-by-gender case was observed in studies, which used the Iowa Gamble Task (IGT). During the task, participants could choose between decks of cards that offered higher payoffs with greater chances of loss (risky) or low-payoff, low-risk (safe) decks (ibid.). Men showed a tendency to pick cards from the risky decks after exposure to a social stressor, but this effect was not found in women (Preston et al. 2007; Van den Bos et al. 2009).

A more recent study, conducted by Hu et al. (2015) investigated how the interaction of emotion and time pressure can effect risk decision-making. The results showed that usually participants are more risk prone when they feel positive emotion rather than negative emotion (Hu et al. 2015). Moreover, time pressure seems to influence the effects of different emotions on risk decision-making. In fact, high time pressure promotes people more risk seeking than no time pressure (ibid.).

Stress and emotions in general trigger great changes to neural processes and consequently they affect human actions, consciousness and perception of the external world. As discussed in Section 2.4, the potential of emotions to affect decision making originates from the fact that it is often the decision-making process itself that can be considered an emotional process. Emotions are also present after we have decided. In fact, after we made a choice and before the outcomes are known, we are often in a state between hope and fear. Sometimes we are eager to learn about the outcomes of our decision, expecting the best. Other times we avoid this information as we fear the worst (Shani et al. 2008; Shani and Zeelenberg 2007). When the outcomes materialize, they may again be a source of emotions, such as elation, happiness, surprise, regret and disappointment (Zeelenberg et al. 1998). These emotions influence the way human beings evaluate their choices and thus their way of behaving.

There are at least two respects in which the emergence of neuroeconomics promises to create a scientific change. The first one concerns the scope of Neuroeconomics' proposed revolution. Economists, psychologists and neuroscientists have separately achieved significant success in modeling and explaining choice and behavior. However, they usually employ dissimilar constructs and pursue different explanatory goals (Glimcher 2014). The pioneers of Neuroeconomics frequently manifest the ambition to develop a single, unified theory of the decision-making process that spans Neuroeconomics's parent disciplines and *"transcends the explanations available to* *neuroscientists, psychologists, and economists working alone"* (Glimcher 2014; Rustichini and Siconolfi 2004). A second peculiarity of Neuroeconomics' intended revolution relates to its purported depth. In fact, Neuroeconomics research is not based on the integration of particular findings from Economics, Psychology and Neuroscience. Instead, the proponents of Neuroeconomics try to create, develop and assess theories that can give a new and innovative academic and practical contributions to all the disciplines involved.

2.6 Summary

Decision-making can be defined as a natural process. Individuals make decisions on a daily basis.

Decisions can have different nature, they can be easy or complex, prudent or instinctive, social or economic, successful or unsuccessful. Even though decisions are different they are driven by the common goal of improving a subject's condition. It means choosing the best solution between the alternatives available.

The outcome of the decision is not originated by a single factor but it is modulated by numerous components such as social, economic, individual, psychological and physiological factors. Numerous disciplines contributed to study and to define scientifically the notion of decision-making process, even though from different perspective. For instance, the notion of decision has been widely debated and analyzed in economics as a rational procedure, which presupposes the attainment of the best result by maximizing the decision maker's utility. In other words, decisions and behaviors are the output of a rationality process that connotes the homo oeconomicus. On the other hand, Marketing distances itself from the notion of rationality. Precisely Marketing looks at the human decision-making process as the result of individuals and emotion factors, thus not-rational. In fact, Marketing analyzes the social, cultural, economic and individual aspects that influence customers during the buying decision-process.

Psychology studies the individual and social aspects of choices. In fact, Psychology focuses on exogenous and endogenous factors of the decision-making mechanism. Particularly important in psychological studies is the relationship between cognitive and emotional functions. In the same way, Neuroscience research evaluates the physiological and neural aspect of decision-making. Neuroscience studies analyze emotions as a direct component of the decision-making process.

Finally, Neuroeconomics and Consumer Neuroscience (see Chaper 3) use tools and theory of these disciplines to analyze economic, emotional, psychological and neural aspects of the decision-making process that drive consumer behaviors. These disciplines promise to develop a single and unified theory of the decision-making process based on findings achieved by economists, psychologists and neuroscientists.

CHAPTER

3

CONSUMER NEUROSCIENCE: ORIGINS AND ITS DEVELOPS

3.1 Marketing history

"*Marketing is everywhere*". According to the *"father of the modern Marketing"*, Philip Kotler, people and organizations are involved, consciously or unconsciously, in an enormous number of activities that could be called Marketing (Jain 2010; Kotler and Keller 2006). In fact, Marketing is a complex activity that involves different actors in many different ways. Marketing is the set of internal and external tasks that a company engages in order to collect information, analyze results, create worth for customers, other companies, the society and stakeholders.

Nowadays, the important role that Marketing plays in our society is unquestionable. However, looking at the Marketing literature and practice, it appears that only during the past twenty-five years there has been a profound change in Marketing perspectives (Hackley 2009; Kotler et al. 2016; Moorman and Rust 1999). Marketing has been just a peripheral activity for long time. Although it has always been used in ancient times, it was only after the Industrial Revolution (surplus in demand) that Marketing became the province of the *"salesman"*, with his specialized skills (Mercer 1996).

According to Hackley (2009), the origin of modern Marketing studies can be dated back to the 1960s. It is common belief that the School of Business at Wharton (University of Pennsylvania) offered the first courses in Product Marketing from 1904 (Hackley 2009). However, according to Jones and Monieson (1990), the first academic Marketing course was offered in Germany (Weitz and Wensley 2006). Although these changes in academia, the management approach strictly focused on the production for a long time (Boone et al. 1974). In fact, the first half of the century was totally production oriented, indeed, it is known as Production Era (Cherubini and Eminente 2015). This Era reached its apex in the middle of the XIX century (Boone et al. 1974). In this period, customer satisfaction was not seen as a dominant perspective. Companies were completely sales-driven. They tried to force consumers *"to fit the products"* (MacKenzie 2010). The famous Henry Ford's slogan *"They (customer) can have any color they want, as long as it is black"* is a good example of Marketing product orientation, since his mass production line was a perfect exemplification of the era (Boone et al. 1974).

In the 1930s, the global economy suffered a quick arrest followed by a sharp decrease in the customer demand for goods and services (the Great Depression) (ibid.). Companies rapidly "dropped" the production orientation and started to be innovative and less sales-driven. Finding new clients, weakened by a low purchasing power and eliminating competitors became essential for good business (Samuel 2013). Organizational survival imposed that managers paid more attention to the market for their products (Boone et al. 1974). During this period, companies focused on the trading function and the role of Marketing changed once again (Cherubini and Eminente 2015). The years 1930-1940 were named the Period of Development, indeed, new principles were developed and consequentially new academic contribution were formulated (Weitz and Wensley 2006). The most famous book of that period was Breyers's *"The Marketing Institution"* that provided the most systematic and theoretical approach in Marketing thought that date (ibid.).

In 1935, the National Association of Marketing Teachers, a predecessor of AMA, coined the first definition of Marketing. This definition was successively adopted by the American Marketing Association (AMA) a slight revision. AMA (1937) defined Marketing as *"those business activities involved in the flow of goods and services from production to consumption"*. This original definition remained valid for 50 years, until it was revised in 1985 (Iyamabo et al. 2013; Ringold and Weitz 2007).

At the end of World War II, industries restarted to produce consumer durable goods, an activity that stopped in early 1942 because industries were converted for war production (Boone et al. 1974). In that period, there was an increase in consumers' purchasing power. Hence, industries were forced to focus more on consumers' needs. Companies shifted from a product-centered (make-and-sell) philosophy to a customer-centered (sense-and-respond) philosophy (Boone et al. 1974; Kotler and Keller 2006).

Between 1940 and 1960, customer behavior became the dominant perspective of the Marketing discipline. Consumer behavior, emotions, reason, and decision-making took on a larger role in Marketing academic discussion and research. In the 1960s, the Journal of Marketing published an article written by Robert Keith (1960), titled *"The Marketing Revolution"*. The author explained the four eras of increasingly sophisticated Marketing applied by the Pillsbury Company (Jones and Richardson 2007). Keith's 4-era theory of the history of Marketing practice became the center of every introductory Marketing textbook (ibid.). According to Keith (1960) *"Our attention has shifted from problem of production to problem of Marketing, from the product we can make to the product the consumer wants us to make, from the company itself to the market place"*.

Through 1960, Marketing definitions appeared to be consistent with a customer oriented philosophy. Marketing finally assumed exactly its modern form (Mercer 1996; Ringold and Weitz 2007). Between 1960 and 1980, different definitions and notions of Marketing emerged. The AMA has provided a list of definition for Marketing in order to standardize the term (Gundlach 2007). In 1967, Kotler, the first recipient of the AMA, published his first text Marketing Management and four years later, he introduced the notion of exchange (the act or process of receiving something from someone by giving something in return) (Jobber 2007). In the period from the beginning of 1960 to the end of 1970, an increasing array of specialty areas of Marketing developed, including Marketing management, Marketing systems, quantitative analysis, internal Marketing and consumer behavior (Weitz and Wensley 2006). Moreover, numerous consumer/buying behavior models were developed (ibid.). Two famous books were published Consumer Behavior (Engel et al. 1968) and Theory of Buying Behavior (Howard and Jagdish 1969; Weitz and Wensley 2006). In the 1970s, several dedicated journals were initiated, including the Journal of Consumer Research (Weitz and Wensley 2006).

In the 1990s, successful companies were completely market driven, adapting their products to customers' strategies. These companies modified their strategies according to customer's preferences. Marketing finally was oriented towards creating rather than controlling a market (MacKenzie 2010). Developmental education, incremental development and constant growth became companies' Marketing strategies rather than on simple market-share tactics, raw sales, and one-time events (ibid.). Companies were finally aware that market knowledge, experience and consumer orientation are the key elements of success, far away from selling-product and expert-driven approaches. In other words, customer-oriented companies do not ask *"what is wrong with these people, why won't they understand?"*, but *"what is wrong with us? What don't we understand about our target audience?"* (MacFadyen et al. 1999).

The early 2000s have been characterized by technological advances (mobile, social media), deep economic, social, demographic and environment challenges (Moutinho 2014). Hence, companies increased their focus on customers and changed their Marketing strategies (Social digital Marketing) and tactics (web contents and relationship-building on the web such as on-line communities, direct emails) (Borges 2009). In 2004, the AMA announced a new definition of Marketing: *"Marketing is an organizational function and a set of processes for creating, communicating and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders*[i] (Gundlach 2007). In fact, building a strong relationship with customers is the only way to create value[ii]. Hence, companies' goal is built a strong relationship with customer in order to create value. However, the created value has to be beneficial also for larger institutions, actors, and processes; perspectives that embrace viewpoints beyond the firm (ibid.).

Over the centuries the concept of Marketing has drastically changed. Numerous factors as war, industrial revolutions and technology forced companies and the academic world to change the way Marketing was perceived and applied. According to Armstrong et al. (2017), we are far away from the old concept of Marketing as a sale (*"telling and selling"*) and definitely in the new sense of satisfying customer needs. This satisfaction refers not only to buying process but also at the connection and relationship that companies can possibly build with the customers. It refers to the constant and continuous exchange of information and customer's engagement in the

[i] A company, which sells a good or service for more than it costs to produce, generates profit. It is a common belief that price is a good indicator of profit. However, the term price usually connotes something temporary. In fact, prices usually increase or decrease based on temporary shifts of demand. Hence, economists prefer to use the concept of value (Wood 1996).

[ii] Value can be defined as something that is amenable to measurement (ibid.). The value of a commodity is *"the power of purchasing other goods"* (Smith 1776). In fact, the value of a specific good (X) is equal to the quantity of other goods (e.g. A, B) that X can purchase in the market (Wood 1996). It can be determined in terms of any other good that can be exchanged (ibid.). However, it is unrealistic to determine a common and real standard by which the value of all commodities can always and at any condition be estimated and compared. Hence, Smith (1776) proposed that labor should be considered as the *"the real measure of the exchangeable value of all commodities"*. Thus due to the fact that the value of the goods which varies and not the labor in itself (ibid.).

process of the product/service creation (Kotler et al. 2016). In fact, the new AMA (2013) stated that: *"Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large"*. Hence, Marketing has to exchange value in order to capture it. This *"process in the process"* has to be applied to all companies' stakeholders and particularly to customers. Integrating the customers in the process assure the companies to satisfy them and create value (Armstrong et al. 2017).

3.2 Marketing evolution

As discussed in Section 2.2 Marketing, thought the study of decision-making process, can understand consumer's preferences and buying behaviors. Companies that are customer oriented try to find customers, interpret their needs and expectations and study their perceptions (Stenberg 1997). However, understanding customers and discovering their current needs is a complex process. Moreover, rapidly changing market conditions challenge companies to find new and fast solutions for customers.

Globalization, the Internet, mobile and social media transformed the way customers select and buy products, in particular how they experience purchases. In fact, customer's need and expectations are changing rapidly as well as their quality standards and their ability to compare product features (Moutinho 2014). This has generated a *"hyper-competitive"* environment, which force companies to produce more goods than they could sell (Lindström 2010). On the other hand, customers have to choose between thousands of products in a shop and outside. It is not surprising that the mortality of new products is about 8 out of 10 (ibid.). For instance, in 1965, the ordinary consumer was able to remember a significant percentage (34 %) of products and/or advertising presented; in 1990, the percentage dropped to 8%; in 2007. ACNielsen survey on 1000 consumers concluded that a person could cite a small amount (2.21 %) of advertising on those he had seen throughout his life (ibid.).

Moreover, the increasing demand for highly differentiated products has strengthened the competitiveness between small firms and larger firms (Escalante et al. 2006). The consequence is a downward pressure on prices and an upward pressure on product differentiation (Kotler and Keller 2006). To overcome these difficulties, the companies invest in market research. In 2015, U.S. companies spent more than 44 billion dollars for market research industry. Interestingly, the Top 10 companies are decreasing total spending year over year (2.7 % less). In this chaotic environment, a need for change is world wide perceived, so new lines of research are

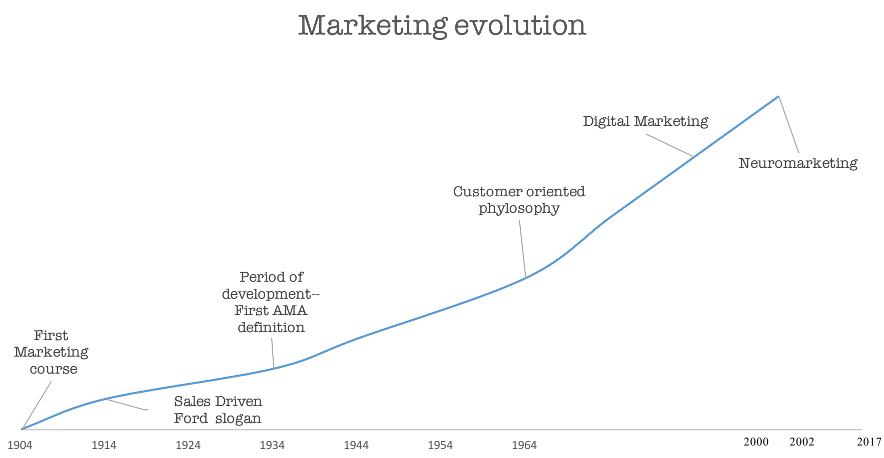

Figure 3.1: *The graphs shows the evolution of Marketing, from 1904 to 2002.*

coming out.

According to AMA (2016) the market research industry, as we have known it for decades, is radically changing. In order to satisfy customers' wishes and needs, traditional Marketing (a canon of principles, concepts and methodologies that Marketing academicians, practitioners have developed throughout this century) (Schmitt 1999) has to evolve and renovate itself. Marketing is being absorbed into a rapidly transforming collection of market intelligence sub-disciplines. It is not surprising that there has been an exponential growth in the application of Neuroscience theories and tools to different kinds of business.

Neuroscience studies can be translated into clear application for Marketing theory and practice, offering scientific explanation on consumer's preferences and behaviors (Levallois et al. 2012; Plassman et al. 2015; Russo 2015). Particularly, Neuroscience offers an accurate insight into the emotional component of the decision-making and buying process (Kumar and Singh 2016). The use of Neuroscience tools in Marketing research is known as Neuromarketing.

3.3 Neuromarketing: the contribution of Neuroscience

Recent years have seen an explosion in the use of neuroimaging techniques (Section 2.5, 3.2) to market research. Medical diagnostic devices that allow real-time measurements of brain activity, such as fMRI and EEG, are often used in Marketing research. These tools provide information of the brain activity based *"on changes in ion polarity, temperature, and electronic impulses"* (Fugate 2008). In addition, neurotransmitters and hormones play a major role in the generation and modulation of various cognitive and behavioral functions that can influence customer satisfaction and loyalty (Koc and Boz 2014). Measuring biological factors, such as photoperiod and circadian rhythm, or changes in the secretion or discharge of neurotransmitters and hormones (such as serotonin, dopamine and melatonin) has significant and interesting implications for Marketing, especially for the tourism and hospitality sectors (ibid.).

The reason why Neuroscience can help Marketing research is based on the assumption that people cannot completely and consciously explain their preferences when explicitly asked (Vecchiato et al. 2011). Moreover, the increasing non-response rates to survey, the limitation of Internet panels, the increased realization of biased nature of findings in focus groups challenge Marketing research (Moutinho 2014). From this prospective, traditional Marketing methods (see Section 2.2) are not sufficient to deeply understand the mechanisms of the consumer's decision-making (Babiloni et al. 2013). Instead, Neuroscience uses a decisional model that integrates the emotional and affective dimension with unconscious process, without resorting to the subjective reports that have long been the mainstay of Marketing studies (Miljkovic and Alcakovic 2010; Russo 2015). For this reason, Neuroscience data remain insensitive to the types of biases that often characterized traditional Marketing research (Ariely and Berns 2010). Neuroscience theories can give a more accurate and objective indication of the underlying preferences of consumers (ibid.). The application of Neuroscience methods to Marketing research aims at understanding brain areas and physiological responses involved in the processing of Marketing stimuli (Fortunato et al. 2014; Lee et al. 2006). Once that these areas are identified, it is possible to associate them with cognitive, psychological and emotional processing that are the dominant aspect of the consumption process (Fortunato et al. 2014; Russo 2015).

The use of neuroimaging techniques for Marketing purposes is usually labeled as Neuromarketing. However, the term Neuromarketing has different uses and implications. The lack of a unified definition of Neuromarketing is partially due to its unclear origin. In fact, it is still not clear when and how the term originated. Apparently, Neuromarketing emerged in the early 2000s as a new and popular topic in academic studies. The term is believed to be coined by Prof. Ale Smidts of "Erasmus Research Institute of Management" (RSM). However, Fisher et al. (2010) reported that the term Neuromarketing was coined by Professors Gerald Zaltman

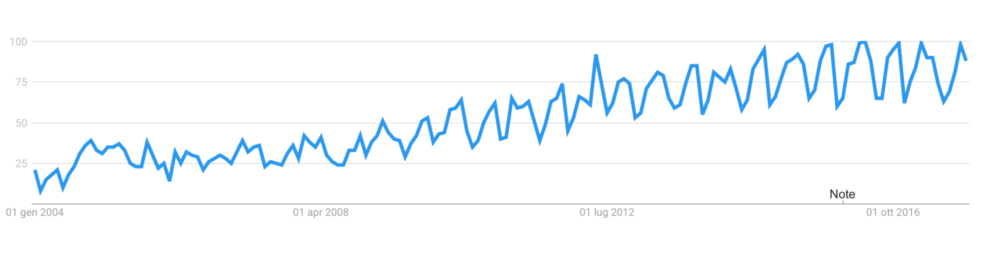

Figure 3.2: *The figure shows the Web search trends of the occurrence of the word "Neuromarketing" from 2004 to 2017. From Google Trends.*

and Stephen Kosslyn of Harvard University. To be thorough, it seems to be unrealistic since Zaltman quickly focused his attention on another type of research that did not employ imaging technology, and Kosslyn appeared not to have been involved in Neuromarketing until 2008. According to Fortunato et al. (2014), the first reports of the use of Neuromarketing techniques can be dated back to June 2002. In that period, Brighthouse, an American advertising company, announced the creation of a Department for the use of functional magnetic resonance images (fMRI) to conduct marketing research (Fisher et al. 2010). The following year, Forbes magazine published an article titled *"In Search of the Buy Button"*, which highlighted the increasing attention from the scientific literature and to the new branch of Economics. In academia, Levallois et al. (2012) reported that the first mentions of *"decision" + "Neuroscience "* in academic studies appeared in year 2003. Since then, Neuromarketing-related academic papers have increased, showing a pick in 2012 (Plassman et al. 2012). In the first six month of 2014, the number of paper is estimated to be 800 per year (Ramsøy 2014). Nowadays, Neuromarketing is a research topics in several journals and fields such as Neuroscience, Psychology, Economics, Marketing and other disciplines (Constantinides and Roth 2015).

3.4 Neuromarketing or Consumer Neuroscience?

Several definitions of Neuromarketings (NMs) can be found in the scientific literature. Excluding only specific cases, Neuromarketing can be classified as a scientific field rather than as a business (Fisher et al. 2010). In fact, Neuromarketing has been described as a field of study (Lee et al. 2006); a research field (Murphy et al. 2008), scientific approach (Senior and Lee 2008), a sub-field of Neuroeconomics (Hubert and Kenning 2008), a strand of behavioral Economics s (Lindstrom 2008); a distinct discipline (Garcia and Saad 2008), a part of Marketing (Fisher et al. 2010) and interdisciplinary research field (Constensen 2011). However, some authors argued

Table 3.1: *List of Journal in which Neuromarketing is a research topic.*

Research field	Name of Journal
Neuroscience	Nature Reviews Neuroscience
	Social Cognitive and Affective Neuroscience
	Journal of Neuroscience
	Journal of Neuroimaging
	NeuroReport
	NeuroImage
	Frontiers in Human Neuroscience
	Brain Research Bulletin
Marketing	Journal of Marketing Research
	Journal of Marketing Management
	Journal of Retailing
	Journal of Product and Brand Management
	Journal of Consumer Marketing
	Journal of Consumer Behavior
	Journal of Services Marketing
Psychology	Journal of Consumer Psychology
	Annual Review of Psychology
	Journal of Economic Psychology
	Trends in Cognitive Sciences
	Harvard Review of Psychiatry
	International Journal of Psychophysiology
	Swiss Journal of Psychology
Economics and Management	Journal of Economic Literature
	Journal of Management
	Journal of Management Research
	International Journal of Business and Management
	Tourism Management
	Journal of Economic Psychology
Food	Journal of Consumer Protection and Food Safety
	Food Quality and Preferences
	Agricultural Economics
	International Journal of Wine Business Research
Conference papers	NeuroPsychoEconomics Conference Proceedings
	European Marketing Academy (EMAC)
	International Academy Conference Proceedings (WEI)
Others	Current Biology
	Procedia-Social and Behavioral Sciences
	Journal of Mechanical Design

that Neuromarketing can be considered as a potential tool for commercial purposes, such as a standard tool or procedure (Lee et al. 2006); a business activities (Hubert and Kenning 2008); a process (Georges and Badoc 2010), a method (Morin 2011), a research instrument (Armstrong et al. 2017; Kotler et al. 2016), others (Plassman et al. 2008) stated that the use of Neuromarketing cannot be delimited to research purposes.

According to Plassman et al. (2012), most of the major Marketing companies such as Nielsen, Ipsos, Millward Brown and advertising agencies have established a Neuromarketing division. Several emerging companies located in 42 different countries offer services and tests on neural and physiological consumer responses to ads, commercials, flyers (Ramsøy 2014; NMSBA, 2017). These companies serve as clients, companies that represent an impressive list of brands across a variety of product categories (e.g., Google, Campbell's, Estée Lauder, Fox News) (Plassman et al. 2012). According to Ramsøy (2014) the effect of commercial overselling and the erroneous use of Neuroscience methods for business purposes have affected the reputation of the term Neuromarketing in the academic world. In fact, from the critical literature review is clear that some scholars prefer the alternative term *"Consumer Neuroscience "*. Consumer Neuroscience describes better *"the academic approach of employing Neuroscience methods and insights to study and understand consumer psychology and behavior"* (Ramsøy 2014).

In literature, researchers have different opinions regarding the classification of Neuromarketing and Consumer Neuroscience. According to Lee et al. (2006), Neuromarketing as a field of study can be simply defined as the application of neuroscientific methods to analyze and understand human behaviors in relation to markets and marketing exchanges. On the other hand, Hubert and Kenning (2008) argued that the consumer Neuroscience (what Lee et al. refer to as Neuromarketing) concerns the scientific proceeding of this research approach, instead Neuromarketing is the application of Neuroscience findings for managerial purposes. The two definitions seem contradictory, in fact, for the latter authors (Hubert and Kenning 2008) consumer Neuroscience is a scientific approach, while Neuromarketing is the application of Neuroscience methods to sell products. Instead, Lee et al. (2006) considers Neuromarketing simply an academic field. Kotler and Keller (2016; 2012) argued that Neuromarketing is *"a research instrument"*, researchers use neuromarketing to measure brain activity to understand how consumers feel and respond (Armstrong et al. 2017; Kotler et al. 2016). Neuromarketing can be also defined as the process that supports the knowledge and understanding of the mechanisms used by the human brain to process information (Georges and Badoc 2010). As reported to Dooley (2011), also Consumer Neuroscience uses the di-

Table 3.2: *Definition of Neuromarketing and Consumer Neuroscience.*

Background	Neuromarketing	Consumer Neuroscience
Definition	field of study (Lee et al. 2006), business activities (Hubert and Kenning 2008), research instrument (Kotler et al. 2016).	academic approach (Ramsøy 2014), research approach (Hubert and Kenning 2008), sub-field of study (Smidts et al. 2014).
Combination of disciplines	Neuroscience, Genetics, Economics, and Psychology (Levallois et al. 2012).	Neuroscience, Psychology, Economics, Decision Theory and, Marketing (Plassman et al. 2010).
Techniques	MRI, EEG, fMRI and other brain wave tools (Hammou et al. 2013).	Neuroscience insights and techniques (Smidts et al. 2014).
Mission	The goal of Neuromarketing is the improvement of marketing strategies, through the study of the cerebral mechanism underling consumer's behavior (Lindström 2010).	Consumer Neuroscience aims at understanding the neural systems supporting and affecting marketing-relevant behavior (Hedgcock and Rao 2009).

rect measurement of brain activity in order to avoid the limits imposed by a marketing-only focus. The author argued that Neuromarketing and Consumer Neuroscience approach involves the study of brain as a tool to improve marketing techniques and understanding of the biological bases of human behavior.

Some authors define Neuromarketing and Consumer Neuroscience as the combination of different disciplines. For instance, Smidts et al. (2003) and Lindstrom (2008) defined Neuromarketing as the union of Neuroscience and Marketing to explain how consumer make their buying decision. According to Levallois et al. (2012), Neuromarketing combines Neuroscience, Genetics, Economics, and Psychology to understand how specific neuron activation may lead to a larger scale market behavior. According to Plassman et al. (2010) also Consumer Neuroscience can be defined as the field that lies in the intersection of different disciplines such as Neuroscience, Psychology, Economics, Decision Theory, and Marketing. The above mentioned authors defined both fields as interdisciplinary. However, some authors (Lindström 2010; Smidts 2003) considered Neuromarketing as the combination of two disciplines: Marketing and Neuroscience . On the other hand, some authors (Levallois et al. 2012; Plassman et al. 2008) broaden the definitions of Neuromarketing and Consumer Neuroscience, including other disciplines such as genetics, Economics, Psychology, decision theory.

Other definitions underlined the use of Neuroscience techniques in Neuromarketing or Consumer Neuroscience research. According to Hammou et al. (2013) Neuromarketing is the science that uses MRI, EEG, fMRI and other brain wave tools to measure customers' brain responses to marketing stimuli. Moreover, Smidts et al. (2014) argue that the subfield of Consumer Neuroscience applies Neuroscience insights and techniques to Consumer Behavior and Marketing problems. Similarly, Karmarkar and Plassmann (2015) define Consumer Neuroscience as the nascent field that applies tools and theories from Neuroscience to better understand decision-making and related processes. The above definitions state that the use of Neuroscience techniques and theories is a prerequisite for Neuromarketing and Consumer Neuroscience research.

In literature, some definitions refer to the mission and how this new field can help Marketing. According to Lindström (2010) the goal of Neuromarketing is the improvement of Marketing strategies, through the study of the cerebral mechanism underlying consumer behavior. Madan (2010) simply claims that the goal of Neuromarketing is to understand brain responses to marketing stimuli. Hedgcock and Rao (2009) argue that Consumer Neuroscience aims at understanding the neural systems supporting and affecting marketing-relevant behavior. According to Plassman et al. (2010) this field tries to answer basic questions of consumer behavior by combining traditional, experimental, and statistical research techniques with those developed by neuroscientists.

Ariely and Berns (2010) proposed that marketers use Neuromarketing for two main reasons. Firstly, they hope that neuroimaging tools can become cheaper and faster than other traditional marketing methods. Secondly, marketers expect to obtain information that is not obtainable through conventional marketing methods. According to Karmarkar and Plassmann (2015), Consumer Neuroscience is *"useful to integrate the "black box" of the consumer's brain into Marketing research"*. It is clear that the goal of Neuromarketing and Consumer Neuroscience is the study of neurobiological mechanisms that support and lead consumer decision making and behavior. According to (Pop and Iorga 2012) the classical model that considers the human's decision center as a *"black box"* is losing its appeal. Nowadays, Neuromarketing and Consumer Neuroscience offer a different prospective. The study of human brain is seen as the solution to unsolved Marketing problems. Neuromarketing and Consumer Neuroscience methods offer faster and more accurate answers to marketers' questions.

Regardless differences in the authors' views, some definitions about

Neuromarketing and Consumer Neuroscience are confluent and interrelated. In literature, the relationship between the research on consumers' behavior and the study of cerebral mechanisms and cognitive processes can be found for both terms (Dooley 2011; Hubert and Kenning 2008; Kotler and Keller 2012; Lee et al. 2006; Morin 2011; Senior and Lee 2008). Moreover, both terminologies are used to describe the application of Neuroscience insight and tools to Marketing problems (Ariely and Berns 2010; Hammou et al. 2013; Karmarkar and Plassmann 2015; Smidts et al. 2014). It is also clear that Neuromarketing and Consumer Neuroscience use Neuroscience tools to shed light on consumer behavior in order to check the validity of different Marketing strategies. Neuromarketing and Consumer Neuroscience are also defined as fields resulting from the association between two or even more disciplines (Levallois et al. 2012; Plassman et al. 2010; Senior and Lee 2008).

Excluding those cases in which (Hubert and Kenning 2008; Lee et al. 2006; Lindström 2010; Perrachione and Perrachione 2008; Plassman et al. 2012) Neuromarketing and Consumer Neuroscience are analyzed as two different disciplines, the vast majority of authors defined the terms as two sides of the same coin. In fact, if we exclude the implications of the use of Neuroscience methods for business purposes, Neuromarketing and Consumer Neuroscience could be examined as the same field of study. Both terminologies could be summarized as a nascent interdisciplinary field that combines Neuroscience , Marketing and Psychology techniques and tools to better understand consumer's behaviors and improve Marketing theories and strategies (Ariely and Berns 2010; Karmarkar and Plassmann 2015; Levallois et al. 2012; Lindström 2010; Ramsøy 2014; Smidts 2003).

This thesis has taken in account academic papers that refer both to Neuromarketing and Consumer Neuroscience. The two terms are considered interchangeable however, the term Consumer Neuroscience is preferred.

3.5 Use of Neuromarketing and Consumer Neuroscience

Consumer Neuroscience covers a broad range of topics. However, in literature, the most promising contribution that Consumer Neuroscience can offer is a deep understanding of behavioral phenomena relevant for Marketing (see Section 3.5.1 and 3.5.2) (Ariely and Berns 2010; Fugate 2008). Consumer Neuroscience can improve existing Marketing theories by providing insights into cognitive and neurological processes (e.g., attention, memory) underlying marketing-relevant behavior (Plassman et al. 2015). As discussed in Section 3.2, traditional methods, such as focus groups and surveys, cannot adapt easily to new situations, for instance if the choice environment differs significantly (e.g., time, location). However, a biological model that is based on understanding of behavior and underlying neural mechanisms, which likely will not change from one decision environment to the next, might be less effected by new situations (Bernheim 2009; Clithero et al. 2008). Particularly, Consumer Neuroscience research can help to explain implicit processes that are usually difficult to study due to unwillingness or inability of consumers to explain them. Moreover, Consumer Neuroscience research focuses on the study of individual differences to marketing stimuli. Understanding individual differences can help to define the heterogeneity in consumer behavior as well as the common factors that can influence and modify consumer behavior and preferences (Plassman et al. 2015). In addition, Consumer Neuroscience research studies neuronal and cognitive process not only during actual marketing-relevant behavior but also in the periods that directly precede or follow such behaviors (ibid.). Hence, Consumer Neuroscience can help also to build models that improve the predictions of marketing-relevant behavior (ibid.).

The study of customers' cognitive and neurological processes can also be helpful for companies in order to apply the optimal strategy for the four elements of marketing-mix such as product, price, promotion (advertisement), and place (distribution). For instance, Consumer Neuroscience approach might help researchers to understand how costumers experience an advertisement stimulus (positively or negatively). Understanding how the human brain processes, learns, and stores advertisement can help to overcome the existing lack of theory in advertisement research (Kenning and Linzmajer 2010). In distribution policy, the use of emotional reinforces as positive experiences (see Subsection 3.5.1) might help to understand how to built long-term relationship with customers. Moreover, understanding how customers assess and experience value (see Subsection 3.5.2) might help to personalize customers' buying experience. Regarding the other elements of marketing-mix, Consumer Neuroscience research also helps to determine the optimal price of a product. For instance, Knutson et al. (2007) examine the brain area correlated with the negative price effect. The activation of the insula corresponds to excessive prices, and the activation of the medial prefrontal cortex is correlated with reduced prices. Bizer and Schindler (2005) propose that consumers pay less attention to later numbers in a sequence, for example when the prices end in 0.99 rather than a whole number. These findings can be used to determine how much a customer is willing to pay for a product. Most importantly, Consumer Neuroscience research can be used to improve products. In fact, studying consumers' brain responses to aesthetic (e.g., color, shape) characteristics can help to define the optimal product design (see also Chapter 5). Studying how people react to aesthetic characteristics helps to link individual preferences to specific product traits. For instance, Consumer Neuroscience studies how color or shape of a product affects consumer preferences and brain responses (see Chapter 5). However, studies on product design usually analyze the post-design application (Ariely and Berns 2010). Instead, it could be useful to use neuroimaging tools to test the effectiveness and attractiveness of product design in production phase. For instance, Venkatraman et al. (2012) identified five different stages of Marketing that can use Neuroscience to improve product design, such as: testing prototypic ideas and concepts; developing the physical product; communicating product information; understanding user experience; segmenting consumers for effective Marketing. Defining how aesthetic characteristics influence consumer preferences can help to produce more attractive and ad-hoc product, nevertheless it helps the segmentation and distribution due to the ability to study individual differences and preferences.

Finally, Consumer Neuroscience research tries to explain and describe the neurobiological substrate of choice in consumers (Ariely and Berns 2010; Vlasceanu 2014). However, some authors argue that Consumer Neuroscience research could be considerably broader than the study of consumers' satisfaction and decision-making process. Consumer Neuroscience can also be used to assess problems in organizations, like trust, negotiations and pricing (Butler et al. 2016; Hannah et al. 2013; Knutson et al. 2008; Lee et al. 2006, 2012). Understanding how trust is assessed in the brain can help companies to understand and build strong relationships with other stakeholders in the organization. Similarly, Consumer Neuroscience can study how to negotiate and to deal with conflicts caused by the actual or perceived opposition of needs, values and interests between people working together. The use of neuroimaging tools to study organizational behavior has so much grown in popularity, that some authors prefer to use the term Organizational Cognitive Neuroscience (OCN). Organizational Cognitive Neuroscience can be defined as a a multidisciplinary and multi-method approach to the conceptualization of management and organizations (Butler et al. 2016; Hannah et al. 2013). Organizational Cognitive Neuroscience focuses on studying the neuronal mechanisms that regulates trust, leadership, reward and loss in financial risks at the individual, group, organizational, inter-organizational and societal levels (Butler et al. 2016; Hannah et al. 2013; Knutson et al. 2008; Lee et al. 2012). Organizational Cognitive Neuroscience should address problems that are related to the fields of Economics, Marketing and, Organizational Behavior. However, the issues covered are too often related to organizational theory and Economics s, not focusing on problems relevant to Marketing. Frequently, Organizational Cognitive Neuroscience appears to be more related Neuroeconomics that Consumer Neuroscience. Hence, authors should carefully try to study organizational problems more related to the Marketing disciplines.

3.5.1 Reward mechanisms

Neuroscience research spaces from the study of single cells to different brain areas or complex brain systems and how they interact (Plassman et al. 2012). Neuroscience theories can be used to understand how consumers behave during positive stimuli (e.g., food or money), and which are the reward mechanisms involved during the exposition to such stimuli. In fact, rewards[iii] are biological or cognitive stimuli that produce and reinforce approach behaviors (Naranjo et al. 2001). In particular, the brain reward system (BRS) has a major role in mediating reward or reinforcing behaviors such as pleasure and motivation (ibid.). The BRS involves a circuit including the striatum, the orbito-frontal cortex and the amygdala but also the medial prefrontal cortex, in particular the anterior paracingulate cortex (Walter et al. 2005).

Even though our knowledge about reward processing was mainly based on animal research (ibid.), literature shows that the study of the brain reward system (BRS) has a major role in Consumer Neuroscience research. In fact, studying how our brain assesses rewards and how positive and negative reinforcement[iv] manifest themselves, and their degree of influence on psychological mechanisms can help to better control or influence our behaviors (ibid.). The study of the reward system is usually engaged in economic decision-making, however rewards can be used to explain emotions, moods, and feelings evoked by a product. Based on these theoretical assessments, the theory of reward can be used to predict and influence consumers' preferences and behaviors.

For instance, Erk et al. (2002) carried out an experiment to determine the level of attractiveness of sports cars compared to small cars. The results showed a significant higher activation in area of the BRS, such as the right ventral striatum and the medial orbito-frontal gyrus, as well as in the left anterior cingulate cortex, bilateral dorsolateral prefrontal cortex, right fusiform gyrus and the left occipital cortex (Erk et al. 2002). Similarly, Breiter et al. (2014) studied the model of choice, which is focused on how consumers assess reward/aversion and how their choices can be shifted or influenced. According to the authors, the process of influence is determined by internal (e.g., individual) and external (e.g., group, price) gradients of preference. The combination of intrinsic and extrinsic motivations, can help to define the gradients of individual preferences based on the experienced utility (Breiter et al. 2014). The authors argue that often,

[iii]Reward can be defined as *"any pleasurable or satisfying event or thing that is obtained when some requisite task has been carried out"* (Reber 1995).

[iv]Reinforcement can be defined as *"the operation of strengthening, supporting or solidifying something, or the event that so strengthens or supports it"* (ibid.).

in Consumer Neuroscience research, there is no clear correlation between internal and external motivation, their effects on behavior and how they can shift the distributions of choices. However, I found that some studies focused on how individual expectancies shape consumption experiences and how these experience influence the BRS. Plassmann and Weber (2015) tested brain processes, during consumption, on the base of marketing-based expectancy, also defined as Marketing Placebo Effect (MPE). Authors tried to determine how personality traits moderate the placebo effects of price in behavioral experiments of wine tasting. Based on existing evidence that links each of these brain areas with personality traits (i.e., the striatum with reward seeking, the posterior insula with somatosensory awareness, and the dmPFC with need for cognition), they found that higher gray matter volume in the striatum was linked to higher MPE responsiveness and also that striatal activity has been linked in overlapping regions to reward-seeking (Beaver et al. 2006; Schweinhardt et al. 2009).

Another experiment on the Ultimatum game showed that punishment is altruistic from an evolutionary point of view, because it involves costs for the punisher (Sanfey et al. 2003). The data showed that cooperative interaction activated the main structures of the reward system while non-cooperative behavior did not activate them (ibid.). Three main results emerged from these studies. Firstly, the anterior insula was active when people experience negative social events, like being treated unfairly, being frustrated, being socially excluded, or seeing other people suffer. From a neurological point of view, mental pain appears to be related to bodily pain. Secondly, the prefrontal cortex influences and controls these emotional reactions. Finally, executing punishment measures is related to experiencing reward.

Finally, Plassmann and Weber (2015) provide evidence that participants high in reward seeking and need for cognitive processing, were more responsive to MPEs, whereas people high in somatosensory awareness were less responsive to MPEs. Authors examined if reward responsiveness, somatosensory awareness, and need for cognition moderate the effects of the perceived expertise of artists on subjective aesthetic experiences. They tested the effect of a different cognitive cue (if an art piece was generated by an artist or the experimenter on a computer) on a consumption experience in a different sensory domain (experienced aesthetic pleasantness). The results show that reward-seeking and motivational behavior play an important role in MPEs. Furthermore, the authors proved that MPEs effects hold for different types of expectancy effects (such an artist's expertise) and sensory domains (aesthetic consumption) and it is not only related to pricing or health claim effects on food consumption.

Expectations and reward have such a powerful influence on consumers that they can modify consumption choices and behaviors. However, it is not easy to determine how consumers assess reward and aversion. Overall, these findings suggest that the evaluation process of rewards has been broadly studied in Consumer Neuroscience research. For these reasons, neuroscientific methods can provide information about consumer preferences or, eventually, buying behaviors in real life (Walter et al. 2005).

3.5.2 Consumers' satisfaction: analyzing value and quality

As discussed in Section 3.2, customers' satisfaction has received great attention by organizations and researchers alike. Customer-centric oriented companies try to provide superior value to customers in order to differentiate themselves from competitors and to create and maintain long-term customer relationships. However, customer satisfaction involves perception of the quality received as well the customers' need of quality improvements and their willingness to pay for it (Raval and Gronroos 1996). To establish and maintain mutually beneficial customer relationships, there are several questions that researchers have to address *"How can value and quality be defined? Is it possible to measure these components?"*. Consumer Neuroscience research provides useful information on how we predict, experience and remember quality and value of products or brands.

According to Plassman et al. (2012) the predicted value symbolizes the future consumer's belief about the experienced value of one brand. In other words, it is the consumer's idea about how much enjoyment he/she will derive from consuming a product of that specific brand. Plassman et al. (2012) suggested that at least three brain structures are involved when consumers evaluate predicted values: the striatum, the Ventromedial Prefrontal Cortex (vmPFC), and the dlPFC (Plassman et al. 2012). Two studies investigated how favorableness of brand associations affects predicted value signals in the striatum. In the first one, Schaefer and Rotte (2007) found a correlation between imagining a pleasant experience, such as driving a car of a brand that is linked to favorable brand associations, and activity changes in the striatum. The second study, Plassman et al. (2007), found that customers who are loyal to a brand (e.g., H&M vs. Zara) show more activation in the striatum compared to customers who are less loyal, even if they are buying identical clothes.

Experienced value is defined as the pleasure derived from the consumption of a product or a brand (ibid.). According to Plassman et al. (2012) previous fMRI studies suggest that the OFC (in particular its medial part), the ventral striatum and the pregenual cingulate cortex are correlated with positive experienced values. For instance, the OFC is correlated with individual preferences and experienced pleasantness for olfactory experiences, musical rewards, touch, secondary rewards such as money. Finally, memory is an important predictor of consumers' choices (Plassman et al. 2012). How we encode, consolidate, and retrieve brands define the remembered value. The remembered value consists of both explicit memory and implicit memory of prior consumption experience. It is possible to link explicit memories, or declarative memories to specific brain regions such as the hippocampus and the medial temporal lobe (MTL) and the dlPFC[v] (ibid.). Moreover, the researchers found a more direct activation of the dlPFC and the parahippocampal cortex. According to Plassman et al. (2012), the use of neuroimaging data, it is possible to track neural processes that predict conscious choice, such advances improve our understanding of implicit brand memory and studying the consumer psychology of branding. Bartra et al. (2013) suggested that the study subjective value (SV) is an important factor in value-maximizing choice. SV allows comparing complex and qualitatively different alternatives on a common scale. In fact, stable assessments of SV can support consistency in decisions and behaviors over time and across contexts. Numerous experiments have tried to identify neural signals associated with the subjective value (SV) of choice alternatives. Bartra et al. (2013) investigated if there are brain regions correlated positively or negatively with SV. The results showed that SV trigged two general patterns in the brain. Some brain regions, such as the dmPFC and the bilateral anterior insula, showed both positively and negatively signed effects of SV on BOLD across studies, while other regions showed positive effects only (vmPFC and PCC) (Bartra et al. 2013). The authors also tried to determine the neural correlates of SV during decision-making are similar or different from SV responses during the receipt of an outcome (decision utility vs. experienced utility) (Kahneman et al. 1997). A set of brain areas, including vmPFC and anterior VS, showed positively signed effects with SV responses both during decision-making and outcome delivery. These results suggest that vmPFC and VS form the core of a "valuation system" believed to play a critical role in value-based learning and decision-making.

A more recent study by Wang and Han (2014) showed that EEG data could be used to guide attribute configuration of products to fit consumers' expectations (perceived quality) on the basis of individual preferences. Based on the assumption that product feature evaluation is a cognitive process that modulates attention, EEG can be used to analyze neural processes that occur during product judgment. Particularly, authors found that stimuli that were perceptually similar produced higher

[v] As suggested by Klucharev et al. (2008), these areas are related to successful encoding and subsequent recall.

P300 amplitudes than other stimuli (Wang and Han 2014).

Value and quality are important factors in the study of the decision-making process. Differentiating the types of subjective experience helps to define how value and quality are perceived and experienced. As discussed in this Section, Consumer Neuroscience research can use cognitive and neurological processes to explain how consumers assess value and quality consequentially improve consumer behavior.

3.6 Summary

Over the centuries the concept of Marketing has radically changed. Marketing has been evolving from a marginal activity to one of the most important business. Marketing helps companies to define strategies that satisfy and attract customers. In order to achieve customers' satisfaction, Marketing focuses on the study of *the decision-making process that drives consumers' behavior*.

Even though Marketing strategies have been often successful, traditional Marketing tools are no longer efficient to study consumer behavior. In fact, rapid and repeated changes in market conditions, new and improved technologies and financial crises challenge Marketing research on consumer behavior and preferences.

With the turn of the century, there has been a growth in the application of Neuroscience theories and tools to Marketing research. The use of neuroimaging techniques for Marketing purposes is labeled as Neuromarketing. However, the erroneous use of Neuroscience methods for business purposes have affected the reputation of the term Neuromarketing in the academic world. In fact, researchers more frequently use the alternative term *"Consumer Neuroscience"*. In literature, it is possible to find numerous definition and classifications (e.g., field, sub-field, activity) of Neuromarketing and Consumer Neuroscience. Some authors identify Neuromarketing and Consumer Neuroscience as separate disciplines, however, the vast majority of authors analyzed it as the same discipline. In this thesis the term Consumer Neuroscience is preferred and it is defined as *"the academic approach of employing Neuroscience methods and insights to study and understand consumer psychology and behavior"* (Ramsøy 2014).

Literature shows that Consumer Neuroscience supports Marketing research in several ways. In particular, it can be used to study the emotional, conscious and unconscious processes that support decision-making process and consumer behavior (Levallois et al. 2012; Plassman et al. 2015; Russo 2015). It helps to understand how consumer experience marketing stimuli, and to identify the factors that influence and modify consumers' preferences. Consumer Neuroscience tools provides numerous benefits for studying consumer behavior, such as the use of unbiased moment-by-moment measures of consumer response and decision-making process and extensive analysis of the cognitive and affective triggers of marketing stimuli based on inner psychophysiological processes.

Consumer Neuroscience in particular focuses on the study of reward. Reward mechanisms are neural and biological mechanisms that can produce or reinforce a behavior motivated by events commonly associated with pleasure (Esch and Stefano 2010). The study of these mechanisms helps to locate the brain areas involved and to understand the assessment of reward and aversion for Marketing stimuli. Moreover, it can help to study repetitive behaviors, for instance brand loyalty.

Consumer Neuroscience also studies how consumers assess product value and quality by investigating the neural and psychological mechanisms underlying expectancy and valuation during consumption.

CHAPTER

4

CONSUMER NEUROSCIENCE TOOLS: AN OVERVIEW

4.1 Behavioral, physiological measurements and neuroimaging techniques

Numerous tools are used in Consumer Neuroscience experiments to study consumer's decision-making and behavior.

This section examines neuroscience methods that provide the driving force for Consumer Neuroscience studies. Table 4.1 reports a list of all instruments and tools used in Consumer Neuroscience.

According to Ramsøy (2014) 4 different classes of tools can be distinguished: Self-reports, Behavioral Measurement, Physiological Measurement and Neuroimaging. Postma (2013), instead, categorizes tools in 3 main groups: External Reflexes, Input-Output Models and Internal Reflexes. The two classifications are quite similar. However, Ramsøy (2014) added Self-reports, as good protocol for understanding people and their personality better. Neuroimaging techniques (Internal Reflexes) are described in details in Subsection 4.2.1, after a brief explanation of the human brain (see Subsection 4.2).

- Self-reports, Behavioral measurement and Physiological measurement

Table 4.1: *Consumer Neuroscience tools.*

Tools	Class	Output
Self-reports	Self-reports	individual health status, feelings, attitudes and beliefs information
Survey and Questionnaire	Behavioral Measurement	individual habits, preferences, beliefs information
Facial Expression recognition	Physiological Measurement and External Reflexes	emotions associated to facial expression
Eye tracking	Physiological Measurement and External Reflexes	attention, visual behavior, pupil dilatation
Galvanic Skin	Physiological Measurement and External Reflexes	skin temperature, electric conductance, heart rate
Electroencephalogram	Neuroimaging and Internal Reflexes	electrical brain activity
Magnetoencephalography	Neuroimaging and Internal Reflexes	magnetic field produced by brain electrical activity
Functional magnetic resonance imaging	Neuroimaging and Internal Reflexes	brain activity by detecting changes associated with blood flow

together correspond to External reflexes.

Self-report is a type of survey, questionnaire. Self-report[i] is one of the most widely used methods of collecting information regarding individual health status, feelings, attitudes and beliefs (Short et al. 2009). These tools have easy interpretability, richness of information, motivation to report, causal force, and sheer practicality (Paulhus and Vazire 2007). However, self-report output usually reflects the product of *"higher-order thought processes"*, for instance attitude[ii]. Hence, the response does not reflect a lot of the actual computation that produces them (Wittenbrink and Schwarz 2007).

- Behavioral Measurements reveal information about consumer behaviors, impressions, and concern particular mental states or responses (Ramsøy 2014). In Behavioral Measurements people are observed and recorded when they perform a task, the opposite of self-report, which focuses on what people say they do (Whitley et al. 2012).

[i]There are several kinds of self-report. For instance, in the direct self-report people are asked to report directly on their own personalities (Paulhus and Vazire 2007). Indirect self-reports, instead, ask questions about the subject's personality (ibid.). The main difference is that in indirect self-reports respondents may not be aware about the purpose of the test (ibid.).

[ii]The term attitude refers to the positive or negative predisposition to respond toward a stimulus or different stimuli. (Wittenbrink and Schwarz 2007).

Through Behavioral Measurements is possible to understand the frequency and speed at which a behavior occurs, its duration-intensity; moreover it is possible to measure the accuracy and persistence of the behavior (Whitley et al. 2012). The major advantage of these tools is that people are not always aware that they are under observation (ibid.). However, it is not always possible to determine the reason underlying consumer's choice or the meaning of a specific behavior (ibid.). Moreover, behaviors can be highly *"situation-specific"* (ibid.). Hence, one behavior can be observed in one situation but it might be not represented in another similar situation (ibid.).

- Physiological Measurements (External Reflex) are useful to evaluate people's biological responses to stimuli (Short et al. 2009). These measurements are used to assess implicit process (Whitley et al. 2012). In fact, Physiological Measurements are usually not under consumer's voluntary control, therefore they cannot be easily influenced, as Self-reports and Behavioral Measurements[iii] (ibid.). Physiological Measurements depend on sophisticated and usually expensive equipment (ibid.). These measurements produce a great number of information (e.g., number of fixations, duration of a fixation, heart rate) means that often the desired information has to be differentiated from undesirable information (ibid.). In the same way, external reflexes measure human reactions that originate in the unconscious brain and can be observed using specialized equipment or techniques (Postma 2013). In particular, these techniques reveal information about consumer behavior, impressions and reactions when exposed to marketing stimuli. Even if they have their origin in the brain, these measurements do not directly reflect the brain activity (Constantinides and Roth 2015). The most important of these External Reflexes are: body language, facial expression, eye movement and pupil dilatation, palm sweating, respiration and pulse (ibid.).

  The contraction and relaxation of muscles produce a non-verbal communication that can be called body language. It manifests itself in conscious or unconscious ways, specifically in gestures, mimic, posture and other body movements (Postma 2013). Studying body language helps to understand how people react in a specific situation, as well, how they interpret information and emotions conveyed through another person's body (Hinzman and Kelly 2013). It can be used to predict personal choices. For instance, when people are positively engaged in something they tend to lean forward, instead when they are disgusted or appealed they tend to move away (Ramsøy 2014).

[iii] Physiological Measurement are independent from participant's subjective awareness of the attitude (Short et al. 2009).

Usually, emotional expressions of the whole body play a significant role in how people perceive a stimulus or the immediate impact of a specific situation (Hinzman and Kelly 2013). However, the face is also a powerful cue for such categorizations (ibid.). Hence, researchers use special software to match the consumer's facial expression with emotions while people are confronted with a stimulus (e.g., product, person, movie or website) (Constantinides and Roth 2015; Russo 2015). Changes in facial expression can be divided in observable changes of expressions (e.g., smile) and unobservable changes of mimic muscles (e.g., muscle contractions imperceptible to the human eye) (Fortunato et al. 2014; Horska and Bervcik 2017). Facial expressions are important indicators of positive and negative emotional reactions (Horska and Bervcik 2017).

An eye tracker is an instrument for measuring eye positions and eye movement, in particular, the focus of customers' attention, visual behavior of fixation of the gaze, pupil dilatations (Fortunato et al. 2014). The speed and sight direction changes provide information of consumers' attention, interest and attraction (Horska and Bervcik 2017). Pupil dilatation instead can give information about strong excitement, fear and pain (ibid.). The outputs of this measurement are heat maps, colored maps that determine areas that receives more attention (according to the duration and numerous of fixation), qualitative analysis like focus maps (areas that are not observed) and the scan path (Russo 2015). The scan path is the ocular track of a person. It is traced with lines and circles. The circles represent the fixation points, the focus of the person on a specific point. The lines are linked between circles. Unlike focus maps, it offers a quantitative analysis. In fact, it reports also the numbers and the duration of each fixation in one analysis (ibid.).

Galvanic Skin Response, or skin conductance, is another important tool. It is used to measure the temperature of the skin and its electrical conductance and to identify and measure psychological and physiological arousal (Kumar and Singh 2016). Its most common use is in lie detecting technology (ibid.). The hart rate could also be measured through galvanic skin response (ibid.). The fluctuations in the pulse reveal the level of excitement or stress that the person experiences as a response to certain triggers (ibid.).

For instance, empathic design is used to observe people (physically or by means of cameras) in order to identify reactions or usage patterns of products in their daily routine (Postma 2013).

Physiological Processes (External reflex) form the basis of implicit

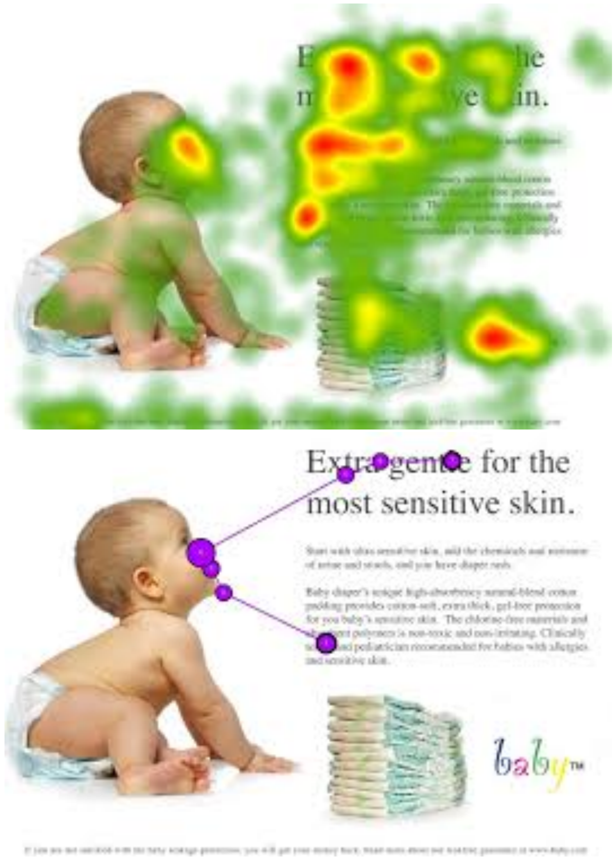

Figure 4.1: *Using an eye-tracker is possible to monitor subject's eye positions and movements. The images show eye-tracking data on a baby advertisement using a heat map (top image) and gaze plot (bottom image). From https://blog.kissmetrics.com/eye-tracking-studies/*

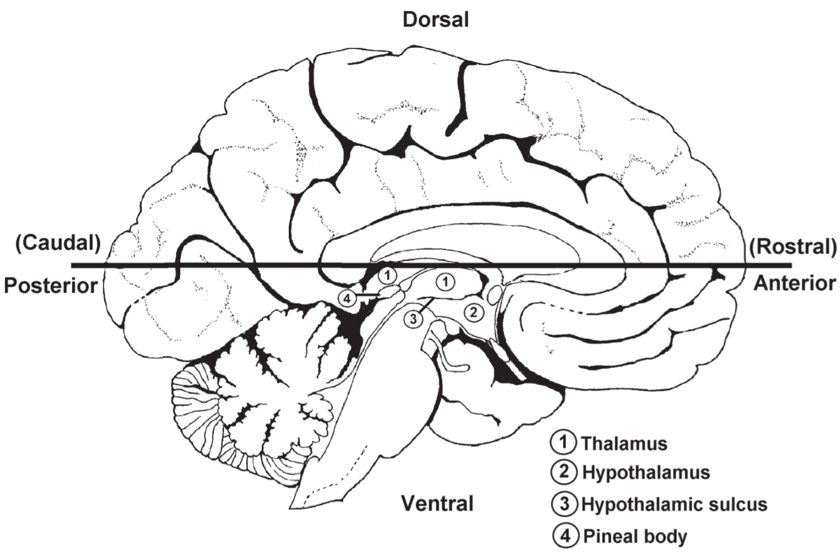

Figure 4.2: *Brain structures.*

processes that are attitudes that people are not willing or able to verbalize (Short et al. 2009). These processes originate in the brain but do not reflex directly the brain activity.

Neuroimaging techniques are explained in Subsection 4.2.1.

4.2 The human brain

As described in Chapter 2, Neuroscience studies the nervous systems of humans and tries to interpret the complex biological, neurological and cognitive aspects that support the brain of all living creatures. However, comparing humans to other primate groups, it is not surprising that there are substantial differences, humans *"think differently"*.

The human brain acts as a control center that receives, interprets, and directs sensory information throughout the body. While defining some basic terms and understanding the anatomy of the brain, it is useful to interpret the complexity of human behavior. There are different ways to illustrate the internal structure of the brain. An easy way is to use conventional directions for navigating around the brain, just like north, south, east and west are used to navigate around maps (Ward 2015). If we image brain be divided by three imaginary intersecting planes, orthogonal to each other based on the Cartesian coordinate system, it will appear divided in: (1) Anterior-Posterior (Rostal- Caudal); (2) Dorsal-Ventral (Superior-Inferior), (3) Medial-Lateral (Siegel and Sapru 2015).

The brain, specifically the cerebrum, is divided into two hemispheres (left and right). The two hemispheres[iv] are connected, in the middle, by the corpus callosum (Stark-Vance and Dubay 2010). Each cerebral hemisphere is divided into five lobes: frontal lobe, temporal lobe, parietal lobe, occipital lobe and the insula (Patestas and Gartner 2016). Moreover, the cortical constituents of the limbic system are also considered a region of the cerebral hemisphere and some consider it the sixth lobe, called the limbic lobe (ibid.). Different functions are located in each lobe (Freberg 2016). The functions areas of the cortex are divided into three categories: sensory cortex, motor cortex and association cortex (ibid.).

- The frontal lobe is the most anterior and largest part of the human cortex (one-third of the cerebral cortex) (ibid.). The frontal lobe is the part of the brain involved in emotions, reasoning, thought and all walks of decision making (Ramsøy 2014; Stark-Vance and Dubay 2010). In fact, this lobe has an important role in behavioral control, initiation and inhibition, and it regulates social behavior (Ramsøy 2014). It is also involved in attention and consciousness. The frontal lobes can be subdivided into three regions: the prefrontal cortex, the inferior frontal cortex and the posterior (back) frontal lobe (Patestas and Gartner 2016).

- The parietal lobe is located between the frontal and occipital lobes and is situated above the temporal lobe (ibid.). This lobe controls sensory and motor information (Stark-Vance and Dubay 2010). It is also implicated in different mental functions: including self-awareness, special processing and body sense and representations (Ramsøy 2014). Other regions of the parietal lobe control aspects of language and attention (Purves et al. 2008).

- The occipital lobe extends from the occipital pole to the parieto-occipital sulcus (Patestas and Gartner 2016). The primary visual cortex is located in the occipital lobe. For this reason (Purves et al. 2008), this area of the brain interprets visual images and written words, it allows us to recognize what we see (Stark-Vance and Dubay 2010). Damage in this area can lead to blindness, colorblindness, even if optic nerves of the person are perfectly intact.

- The temporal lobe is placed between the occipital lobe and the frontal lobe but below them (Purves et al. 2008). This part of the brain is involved in sound, vision and spoken language (Stark-Vance and Dubay

[iv]The outer surface of the hemispheres, the cortex, is composed of gray matter. The gray matter contains neuronal cell bodies (Ward 2015). Deep to the cortex, in the central, there is a core of white matter that forms the bulk of the cerebrum (Patestas and Gartner 2016). The white matter consists of nerve fibers (axons) and support cells (Ward 2015).

2010). The highest part of the temporal lobe participates in audition, instead the inferior is related to high-order visual information (Purves et al. 2008). The right temporal lobe is involved in visual memory and musical abilities; the left temporal lobe is concerned with specific language functions, such as the comprehension of words, and verbal memory.

- The insula is located below the frontal and temporal lobes (ibid.). This lobe is completely surrounded by the circular sulcus, that why it is called insula, that in Latin means literally "island" (Patestas and Gartner 2016; Ward 2010). The insula has been implicated in numerous functions, however, It is mainly concerned with visceral and automatic functions, including consciousness, taste and its relationship to emotional responses, as well as to value-based decision making (Purves et al. 2008).

- The limbic lobe is part of the limbic system; it refers to the cortical area of the mentioned system (Hendelman, 2006). The limbic lobe is the part of the cerebral cortex that forms a rim (limbus is Latin for rim) (Purves et al. 2001). Two important parts of this region are the cingulate gyrus and the hippocampus (ibid.). For many years, the limbic lobe has been primarily related to the olfactory apparatus (Isaacson 1974). It is known as the "smell brain" because most of its structures receive projections from the olfactory system in the brain (ibid.). However, some researchers, like Papez (1937), argued that the function of the limbic lobe might be more related to the emotions than to olfactory functions (Purves et al. 2001).

- The hippocampus is located in the medial aspect of the temporal lobe (Swenson 2006). The hippocampus has several functions: controlling the corticosteroid production and understanding spatial relations within the environment (ibid.). It is especially important in the formation and/or retrieval of some forms of memory (Purves et al. 2008). In humans, functional resonance imaging shows that the human hippocampus is activated during certain kinds of memory tasks, especially short-term memory (Purves et al. 2001; Swenson 2006). Damage to the hippocampus results in an inability to form certain types of new memories but do not affect old, established memories (Purves et al. 2001; Swenson 2006).

Numerous Consumer Neuroscience studies showed that other regions of the brain such as thalamus, hypothalamus and amygdala are involved in consumers' choices and preferences. These brain areas are described as follows:

Table 4.2: *Brain regions and their functions.*

Brain region	Important Subdivisions	Information	Functions
Frontal lobe	Prefrontal cortex (OFC, dlPFC, vmPFC, etc.), Inferior frontal cortex, Posterior frontal lobe	Sensory information	Behavioral control, Emotions, Reasoning, Attention and Consciousness
Parietal lobe	group of nuclei and cortical regions	Sensory and Motor information	Self-awareness, Special Processing, Body Sense and representations
Occipital lobe	group of nuclei and cortical regions	Visual information	interpreting Visual Images and Written Words
Temporal lobe	Left lobe and Right lobe	Auditory and Visual Information	Right = visual memory and musical abilities, Left = specific language functions
Limbic lobe	Cingulate gyrus, Hippocampus	Olfactory Information	receive plentiful projections from the olfactory system
Hippocampus	part of the MTL	Sensory information	Memory, Short-Memory, Relations within the environment
Insula	Anterior, Posterior	Emotional information	Visceral and automatic function, Consciousness, Taste, Emotional responses, value-based Decision Making
Thalamus	different nuclei (LGN, pulvinar, etc.)	Sensory and and Homeostatic Information	processing station for all Senses (except smell) distributing information across the brain, Consciousness
Hypothalamus	different nuclei	Sensory information	Automatic and basic functions, Reproductive behaviors, Gender identity, Sexual orientation, regulation of Stress hormones, Control of blood flow, Energy metabolism, Circadian rhythms
Amygdala	group of nuclei and cortical regions	Visual, Auditory, Somatic, Visceral, Gustatory, and Olfactory information	Behavioral, Autonomic and Endocrine responses, Emotion (Fear and Anxiety)

- The thalamus operates as one of the most central gateways of information in the brain (Ramsøy 2014). In fact, one function of the thalamus is to distribute information across the brain, especially sensory information (although it has many other functions as well) (Purves et al. 2001). It can be considered as a processing station for all senses (except smell) between all the sensory organs (eyes, ears, etc.) (Ward 2015). It also plays an important role for consciousness in behavioral flexibility, including in disorder/distortions of consciousness (Ramsøy 2014).

- The hypothalamus is located below the thalamus (Ward 2015). The hypothalamus consists of different nuclei that are specialized in different functions. Thanks to its central position in the brain, the hypothalamus integrates information from the different brain parts, such as brainstem, frontal lobes (Purves et al. 2001). The hypothalamus is involved in the regulation of automatic functions, in the control of reproductive behaviors. In fact, it influences gender identity, sexual orientation and mating behavior and, in females, menstrual cycles, pregnancy, and lactation) and coordinates responses to threatening conditions (regulation of the release of stress hormones, modulating the balance between sympathetic and parasympathetic tone, and influencing the regional distribution) (ibid.). In particular, it strongly influences many functions including autonomics, endocrine functions and behaviors thought the control of blood flow (by promoting adjustments in cardiac output, vasomotor tone, and by motivating drinking and salt consumption); the regulation of energy metabolism (by monitoring blood glucose levels and regulating feeding behavior, digestive functions, metabolic rate, and temperature) and entraining circadian rhythms to the day-night cycle (Purves et al. 2001; Swenson 2006).

- The amygdala is a heterogeneous group of nuclei and cortical regions situated in the anterior-medial portion of the temporal lobe (Whalen and Phelps 2009). The amygdala has a unique set of connections with other parts of the brain, such as hypothalamus, brainstem and thalamus (Purves et al. 2001; Swenson 2006). It is a critical center for coordinating behavioral, autonomic and endocrine responses to environmental stimuli, especially those with emotional content (Swenson 2006). In fact, it is considered an emotion-related brain region (Friston et al. 2004) and responds to different emotional stimuli, but mostly those related to fear and anxiety (ibid.). However, many neurons in the amygdala respond to visual, auditory, somatic sensory, visceral sensory, gustatory, and olfactory stimuli (Purves et al. 2001).

4.2.1 Neuroimaging techniques

Physiological processes and internal reflex both result from brain activity. However, internal reflexes are automatic, subconscious responses to various stimuli like products, advertising, packaging, brands etc. that reflect directly the brain activity (Constantinides and Roth 2015). Neuroimaging tools refer to different tools that are used to identify and analyze the brain internal reflexes (ibid.). Researchers use neuroimaging tools to create images of the structure and function of the nervous system in the human brain (Man et al. 2015). Through these images, researchers can determine when and where neural activity in the brain is associated with the ability to perform a particular cognitive task (Bunge and Kahn 2009). Neuroimaging helps to study differential involvement of both normal and abnormal parts of the brain in humans (Man et al. 2015). It is possible to classify functional neuroimaging techniques in two main classes (Bunge and Kahn 2009).

- The first class entails methods, such as EEG and Magnetoencephalography (MEG), which directly measure the electrical activity associated with neuronal firing (ibid.). In fact, EEG and MEG are non-invasive techniques that have outstanding temporal resolution and they are the primary clinical techniques used to capture the dynamics of neuronal connections (Zhang et al. 2014). EEG measures the electrophysiological signals resulting from brain activity (ibid.). The electroencephalogram is defined as electrical activity of an alternating type recorded from the scalp (Teplan 2002). Instead, MEG measures the magnetic fields resulted by naturally occurring electrical currents from the brain (Bunge and Kahn 2009; Ramsøy 2014). According to Bunge and Kahn (2009) *"EEG records the electrical activity associated with neuronal depolarization, the newer technique of MEG records the magnetic field produced by this electrical activity"*. The electrical activity recorded by EEG is oriented perpendicular to the surface of the brain, instead those recorded by MEG is oriented parallel to the surface of the brain (Bunge and Kahn 2009). Both techniques have an excellent temporal resolution. However, MEG has a better spacial resolution than EEG (Fortunato et al. 2014). In fact, the different structures of the head (brain, cerebrospinal fluid, skull and scalp) influence the magnetic fields less than the volume current flow that affects EEG (Zhang et al. 2014). Additionally, MEG is reference free, so localizing sources at a given level of precision is more easily done with MEG data than it is with EEG data (ibid.). EEG is explained in more details in Section 4.3.
- The second class comprises methods that measure neuronal activity

indirectly. Methods such as Positron Emission Tomography (PET), Magnetic resonance imaging (MRI) and fMRI can measure the neural activity through the increasing of blood flow and metabolic activity in a specific area of the brain (Bunge and Kahn 2009). Instead, PET, MRI and fMRI have a high spacial resolution. In particular, PET and fMRI have significantly contributed to a better understanding of biological and neurological processes (Talavage et al. 2014). In fact, these tools allow to obtain functional (dynamic, time-varying) information simultaneous with localization (within the brain) of signal sources (ibid.). The products of PET and fMRI are images. Changes in the image intensity reflect changes in cognitive state as well as neuronal and neurological mechanisms (ibid.). In particular, PET provides tomographic images of quantitative parameters describing various features of brain hemodynamics, including cerebral blood flow (CBF), cerebral blood volume (CBV), oxygen extraction fraction (OEF), and cerebral metabolic rate of oxygen (CMRO2).

PET is based on radio-active particles imaging, it uses positron-emitting radionuclides to visualize organs and tissues of the body (Tietze et al. 2012). In fact, a small amount of a radioactive tracer is injected into a vein. After approximately 30 s the tracer enters the brain, and in the following 30 s, radiation in the brain rises to its maximal value; a picture of the rCBF is detected by a special camera during this time frame (Bunge and Kahn 2009; Tietze et al. 2012). PET is extremely important for understanding the role of various neurotransmitters in cognition. Instead, MRI is a non-invasive technology used to produce three-dimensional detailed anatomical images of human body without the use of damaging radiation (Ramsøy 2014). It is based on *"sophisticated technology that excites and detects the absorption and emission of the electromagnetic spectrum"* (ibid.). MRI provides excellent detailed structural information (Bunge and Kahn 2009). It is used to track gray matter (neuronal cell bodies) and white matter (myelinated tracts) (ibid.). It can be used to track the normal and abnormal development of neural pathways in childhood (ibid.).

The last technique, fMRI, is currently one of the most popular brain imaging technique used (Ramsøy 2014). Even if this tool is relatively new, it has revolutionized the study of brain function (Buxton 2013). fMRI finds is used in both clinical and neuroscience studies (Gore 2003). fMRI is easily available and at a relatively low cost per scan compared to MRI scanners (one hour MRI search costs \$ 500 or more) (Bunge and Kahn 2009). However, it is more expensive and the procedure takes longer than EEG. The fMRI detects changes in brain activity through the increasing of blood flow (Buxton 2013). The blood oxygenation level-dependent (BOLD)

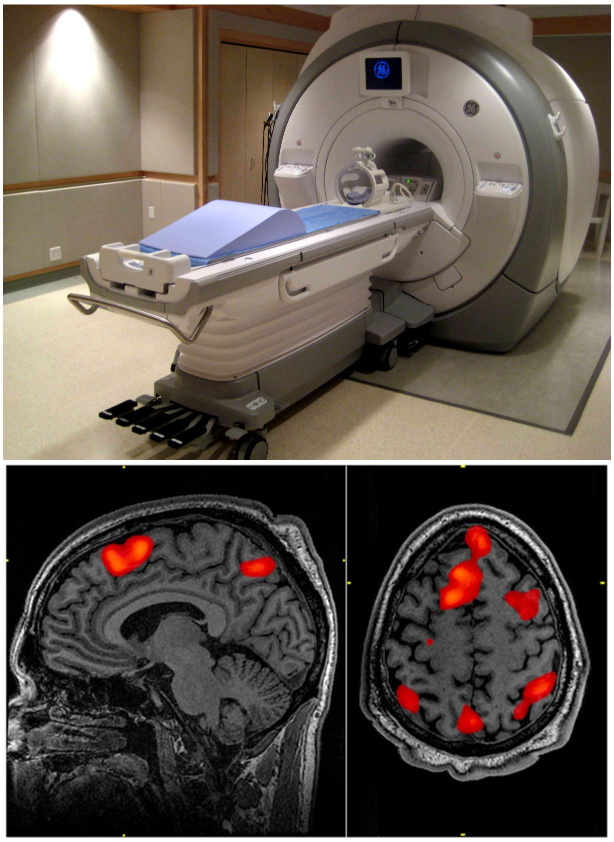

Figure 4.3: *The fMRI detects changes in brain activity through the increasing of blood flow. fMRI scanner is showed in the top image. fMRI scan is performed while a subject is lying in the scanner. The bottom image shows a sample of fMRI data. fMRI shows which regions of the brain appear to be activating (lighting up).*

rises when changes in neuronal activity occur following a change in brain state. The blood oxygen level–dependent (BOLD) changes in the MRI signal may be produced, for example, by a stimulus or task (Gore 2003).

Physiological measurement and Neuroimaging together correspond to Internal Reflex and Input-Output models.

4.3 EEG

EEG is a non-invasive medical imaging technique that records the extracellular electrical activity of the brain, generated by the action potentials of neurons (Abhang et al. 2016; Alix et al. 2017). In the brain, an action potential travels down the axon to the nerve terminal, where a neurotransmitter is released (Marcuse et al. 2015). The neurotransmitter produces, at the post-synaptic membrane level, a change in membrane conductance and transmembrane potential (ibid.). If the signal has an excitatory effect on the neuron it leads to excitation of these postsynaptic neurons[v], and it creates a local reduction of the transmembrane potential (depolarization) and an extracellular voltage near the dendrites[vi] (Jackson and Bolger 2014; Marcuse et al. 2015).

During an EPSP, the inside of the neuronal membrane becomes more positive while the extracellular matrix becomes more negative (Marcuse et al. 2015). The combination of EPSPs and IPSPs induces currents that flow within and around the neuron (ibid.). This situation is named *dipole*, when an object has two ends oppositely charged, in this case a neuron[vii] (Theodosiadou et al. 2017). Dipoles have both a positive and negative side, therefore, they can produce both a positive and a negative deflection at different regions of the scalp (Jackson and Bolger 2014).

The signal that can be recorded on the scalp is the sum of dipoles from multiple neurons arranged in a parallel fashion and synchronously active[viii] (ibid.).

EEG signal *"rises from synchronized synaptic activity in populations of cortical neurons (pyramidal cells organized along cortical columns)"*

[v]Excitatory Post-Synaptic Potential (EPSP)

[vi]The dendrite acts to propagate the electrochemical stimulation received.

[vii]The region of positive charge is named source, while the region of negative charge is referred to as a sink (Jackson and Bolger 2014).

[viii]In order to produce a measurable dipole, the parallel arrangement is necessary (ibid.). In fact, if the neurons are all arrayed in the same orientation, then their signals can produce a measurable, nonzero, signal. In any other configuration, the individual dipoles' positive and negative ends will measure a net neutral (canceling each other out). The synchronization of activity is necessary in order to produce a net charge on the scalp-facing side of the dipole sheet. Moreover, it is necessary to produce a signal large enough to be measured (ibid.).

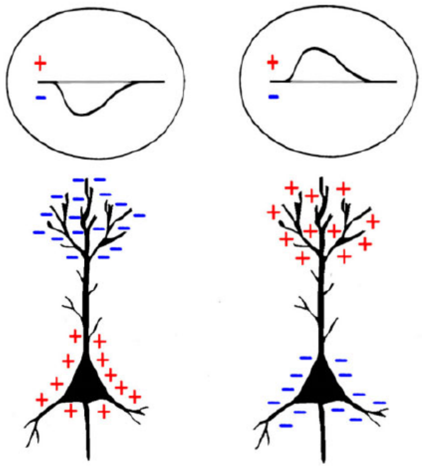

Figure 4.4: *Dipole measurement. The neuron on the left is receiving an IPSP (which produces an extracellular positivity) near the soma, and an EPSP (which produces an extracellular negativity) at the apical dendrites. These signals will be measured as a negative deflection in the EEG. The neuron on the right is receiving an EPSP near the soma and an IPSP at the apical dendrites. These signals will be measured as a positive deflection in the EEG (Jackson and Bolger 2014).*

(Jackson and Bolger 2014). The EEG is essentially the measurement of these voltage changes in the extracellular matrix (Marcuse et al. 2015).

4.3.1 Frequency bands

The electrical-voltage changes result in a *wave* of charge that travels through the extracellular space (Jackson and Bolger 2014). Hence, brain waves are oscillating electrical voltages measuring just a few millionths of a Volt (V) (Abhang et al. 2016). The EEG signal consists of many waves with different characteristics (ibid.). In fact, the various regions of the brain emit different brain waves frequency simultaneously (ibid.). These brain wave patterns are unique for every individual. However, brain waves and the main frequencies of human EEG waves, have been classified in five groups (Abhang et al. 2016; Rahman et al. 2015).

1. Delta (0.5 to 4 Hz)
2. Theta (4 to 8 Hz)
3. Apha (8 to 13 Hz)
4. Beta (13 to 30 Hz)

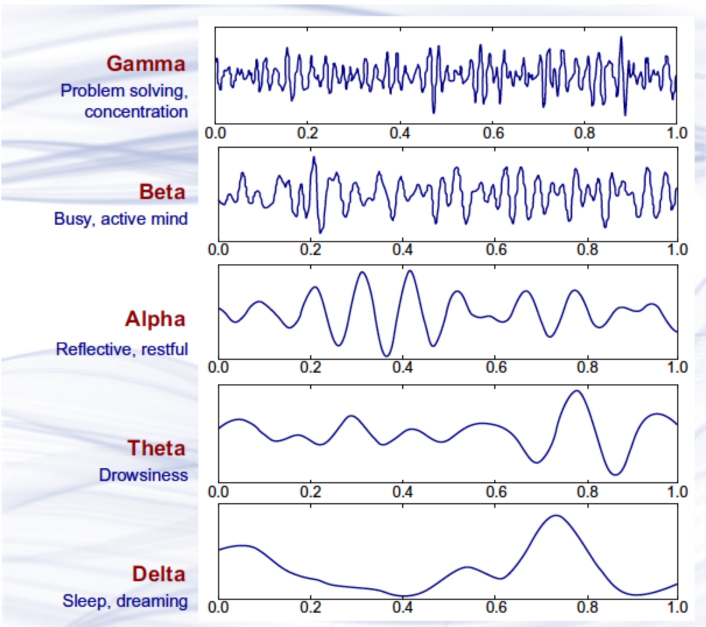

Figure 4.5: *Frequency Bands in EEG (Abhang et al. 2016).*

5. Gamma (31 to 100 Hz)

Oscillations of different frequencies reflect global state changes of the brain (Engel and Fries 2010). However, it might be difficult to associate cognitive functions, in a unique and direct way, with oscillatory activity in a single frequency band (ibid.). On the other hand, it is unlikely that a given frequency band subserves a single cognitive function in the brain (Abhang et al. 2016; Engel and Fries 2010; Rahman et al. 2015). For instance, delta band appear to be implicated in many cognitive processes. Delta band is the predominant frequency during deep sleep but it is also associated with learning, motivational processes and the brain reward system (Engel and Fries 2010). Delta band is involved in the synchronization of brain activity with autonomic functions, in higher emotional involvement, and in cognitive processes related to attention and the detection of motivationally salient stimuli in the environment (Harmony 2013; Knyazev 2007), in motivational processes associated with both reward and atavistic defensive mechanisms. Delta band has also been related to behavioral inhibition (Harmony 2013; Knyazev 2007).

Theta is considered to be a relatively "slow" brain rhythm, but for our conscious experience of the world, theta is quite fast (Cohen 2014). In fact, if you clap your hands as fast as you possibly can. That is around the lower edge of theta (4-5 times per second, or Hz) (ibid.). Theta band is implicated in several cognitive functions, such as working memory functions, emotional arousal and fear conditioning (Cohen 2014; Engel and Fries 2010). In particular, theta band is activated at the time of a choice that requires episodic memory (Klimesch et al. 1994; Young et al. 2017). For instance, theta band activity in the frontal cortical regions has been found to be higher for well-remembered advertisements (Wang and Doong 2017).

The alpha band has usually been identified as a cortical idling rhythm (or unoccupied cortex) (Tenke et al. 2015). In fact, alpha band oscillatory activity is classically observed in the resting state (MacLean et al. 2012). Specifically, alpha band activity increases during periods of rest with eyes closed compared to periods of rest with eyes open (Babiloni et al. 2014; MacLean et al. 2012; Tenke et al. 2015). This effect is attributed to the desynchronizing effect of visual stimulation on the cortex (MacLean et al. 2012). Moreover, alpha band has been frequently used as a neurophysiological measure of activation (Tenke et al. 2015). In fact, alpha band reductions might accompany an increase in vigilance (MacLean et al. 2012). Indeed, alpha reduction has been observed to be correlated with an increase in metabolic activity in frontal–parietal cortical areas, where is located the attention network (ibid.). Alpha band is also used in the prediction of positive emotional responses. For example, the frontal asymmetry in alpha oscillations reflects emotional experience during TV ad exposure or brand preferences (Lee et al. 2014; Lucchiari and Pravettoni 2012).

Beta band (12-30 Hz)[ix] is usually linked to cortical excitability during sensory and motor tasks (Engel and Fries 2010; Hasler et al. 2016). However, recent studies showed that beta band might also be associated with active wakefulness and alert state (Spironelli et al. 2013). In particular, some studies showed that increased beta activity, in posterior brain regions, can be related to attentional processing of visual information (Engel and Fries 2010; Hasler et al. 2016). Moreover, beta band has been shown to be correlated with various perceptual benefits, including faster and better detection in tactile and visual tasks and language processing (Buchholz et al. 2014; Spironelli et al. 2013). Beta band (see also Chapter 7) is also associated with reward processing and consumer preferences for a product (Boksem and Smidts 2015; HajiHosseini et al. 2012). In fact, these oscillations might originate from brain areas involved in reward processing, such as the vmPFC (Boksem and Smidts 2015). For instance, beta band activity has been observed to increase 200-400 ms after positive feedback informing about monetary gains using EEG (HajiHosseini et al. 2012). Moroever,

[ix]Beta frequency bands can be divided in three sub-bands (Spironelli et al. 2013). Low beta band (12-15 Hz) associates mostly with quiet, focused, introverted concentration (Abhang et al. 2016). Mid-range beta band (15-20 Hz) relates to increase in energy, anxiety, and performance (ibid.). Finally, high beta band (18-30 Hz) associates with significant stress, anxiety, paranoia, high energy, and high arousal (ibid.).

beta band activity seems to be modulated by the experience of pleasure associated with a favorite brand (Boksem and Smidts 2015; Lucchiari and Pravettoni 2012).

Finally, gamma band can be considered one of the fastest bands. However, the skull, scalp layers, the muscular and ocular artifacts heavily attenuate these frequencies and make them difficult to study (Cohen 2014). Gamma band activity has frequently been related to states of enhanced arousal and focused attention (Boksem and Smidts 2015). Specifically, studies showed that gamma band could be enhanced during attentive listening and visual attention (Boksem and Smidts 2015; Musch et al. 2017). In fact, gamma band activity has been related to increase in task situations involving object recognition, such as faces or movie trailer (Boksem and Smidts 2015; Musch et al. 2017).

4.3.2 EEG system: electrodes and amplifier

The electrical signal generated by neural firing travels from the brain, through the skull layers, through the scalp (Jackson and Bolger 2014; Shih et al. 2012). In order to measure these signals, electrodes[x] are attached to the scalp, through a cap. The electrodes are usually filled in with conductive gel (Jackson and Bolger 2014). This gel is used to create a conductive path from scalp to electrode[xi] (ibid.). The positions of the EEG electrodes is not random, instead it is based on the International 10/20 system, recommended by the American EEG Society (Alix et al. 2017; Tsuzuki et al. 2016). This system is an international recognized method to describe and apply the location of electrodes in EEG test or experiment (Tsuzuki et al. 2016). In fact, the standard numbering system places odd-numbered electrodes on the left and those with even numbers are on the right side of the scalp (Abhang et al. 2016; Marcuse et al. 2015).

1. nasion (the depression at the top of the nose)
2. inion (the prominence in the midline at the base of the occiput)
3. preauricular point (right and left)

[x]Electrodes are the means by which the electro cortical potentials are conducted to the amplification apparatus (Marcuse et al. 2015). Standard EEG electrodes are small, non-reactive metal discs or cups applied to the scalp with a conductive paste (ibid.).

[xi]Cerebral spinal fluids and various ion-filled substances in the brain are very good conductors, however, they are separated from the electrode by several layers of poor conductors, including the skull, dead skin cells, hair, and air in the interstices of hair. The conductive gel is used to saturate the space beneath an electrode, filling in the air pockets between hairs and thus providing a conductive path from scalp to electrode (Jackson and Bolger 2014).

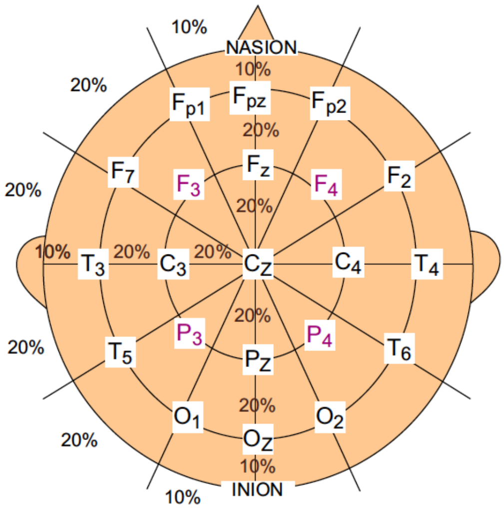

Figure 4.6: *The International 10/20 electrode placement system (Abhang et al. 2016).*

The use of the numbers 10 and 20 refers to distances between adjacent electrodes, indeed placed at either 10% or 20% distance on the skull (Abhang et al. 2016). Electrode locations are determined by dividing these perimeters into 10% and 20% intervals (ibid.). For the corporal landmarks four standard points are taken in consideration (Cheryl and Kieffaber 2014; Marcuse et al. 2015; Rahman et al. 2015):

Different brain areas are related to different functions of the brain (Rahman et al. 2015). Hence, each electrode is located near a particular brain center (Abhang et al. 2016). Letters are used to describe the brain regions where the electrodes are located. In fact, Z refers to electrodes placed on the midline and C is for the central region. Symbol A represents the anterior region, instead, F describes frontal region; P the parietal region and T is for temporal.

Important component of the EEG system is the amplifier. In fact, the amplifier maximizes the minuscule voltage generated by the brain. Increasing the size these voltage allows to translate it into digital values (Cheryl and Kieffaber 2014; Jackson and Bolger 2014). One particular characteristic of the amplifier is the input impedance. Impedance is vital to EEG collection (Jackson and Bolger 2014). Input impedance determines how well the amplifier can tolerate a poor connection to the scalp[xii] (ibid.).

In order to measure the neural response to discrete experiment events, two computers (control and acquisition) and two monitor screens

[xii]The same amplifier should be used thought out the experiment

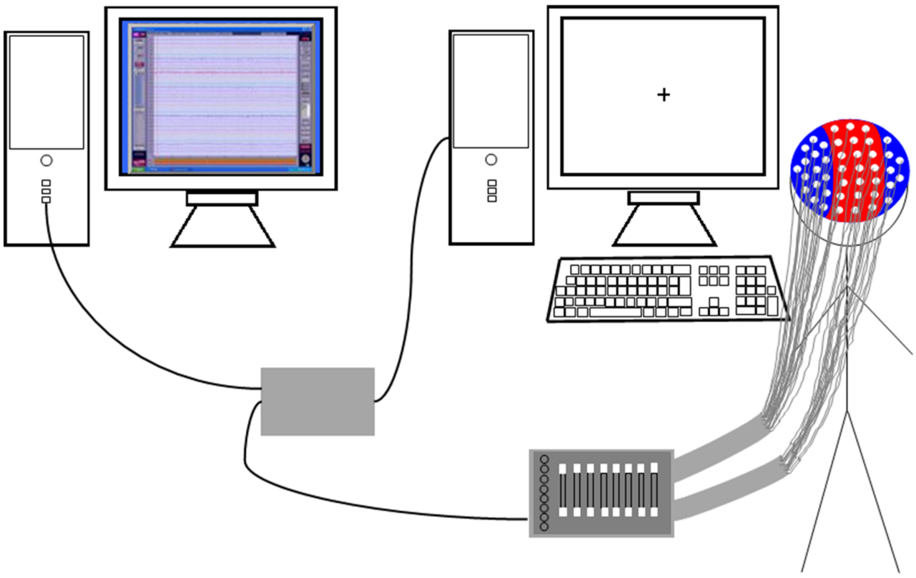

Figure 4.7: *The major components of EEG system From http://cass.lancs.ac.uk/?p=1818*

are usually needed (Cheryl and Kieffaber 2014). The acquisition computer is used to control the experimental protocol (ibid.). The control computer, and one monitor screen, is used for presenting the stimuli to the participant. In order to mark the occurrence of significant events (g.e. stimulus appearing on the monitor), this computer is also linked to the amplifier and the acquisition computer (ibid.). This communication is particularly essential in case of ERP measuring (ibid.). For more details read the Section 4.3.4.

4.3.3 Why EEG?

There are several advantages in the use of EEG as tools for studying neurocognitive processes. Firstly, EEG has a high-temporal-resolution (Abhang et al. 2016; Cohen 2014; Lakshmi et al. 2014; Michel and Murray 2012; Ramsøy 2014). It means that EEG can capture the dynamics of brain processes in the time frame in which they occur (Cohen 2014; Freeman and Quiroga 2012). Moreover, cognitive, perceptual, linguistic, emotional, and motor processes are fast (Cohen 2014). In fact, most cognitive processes occur within tens to hundreds of milliseconds (Cohen 2014; Freeman and Quiroga 2012). EEG is also well suited to capture these fast, dynamic, time sequenced cognitive events cognitive events (Cohen 2014). On the other hand, EEG has a low-spatial-resolution (Michel and Murray 2012; Ramsøy 2014). Hence, EEG is not well suited for studies in which precise functional localization is important (Cohen 2014). Moreover, EEG might not be a suboptimal technique for recording and analyzing slow cognitive processes that have an uncertain and variable time course (Cohen 2014). In this case, the extremely high temporal precision of EEG might be a drawback. In fact, many EEG analyses become unreliable when the cross-trial variations in timing are longer than a few tens or hundreds of milliseconds (ibid.).

In addition to its high temporal resolution, using EEG allows to recreate a relatively naturalistic viewing conditions (Boksem and Smidts 2015). In fact, participants can be seated in a comfortable chair, viewing a relatively large screen with surround-sound cinematic acoustics (ibid.). However, wires of electrodes restrict the mobility of the subject (Abhang et al. 2016). In fact, connection wiring is usually complicated, with a large number of cables between the electrodes and the acquisition machine (ibid.).

Another advantage of EEG is the signal multidimensionality (Cohen 2014). In fact, EEG data comprise at least four dimensions: time, space, frequency, and power[xiii] and phase[xiv](Cohen 2014; Michel and Murray 2012). This multidimensionality allows analyses in both neurophysiology and in psychology (Cohen 2014). In fact, the multidimensionality of EEG provides many possibilities for understanding of brain functioning and variations of these functions during sleep, drug intake, neuropathology, psychiatric diseases or maturation (Cohen 2014; Michel and Murray 2012). However, EEG signal is non-stationary in nature (Lakshmi et al. 2014). EEG signal is easily susceptible to artefacts caused by eye blinks, eye movements, heartbeat, muscular activities and the power line interferences.

Finally, the EEG is relatively not expensive (Boksem and Smidts 2015; Freeman and Quiroga 2012). In fact, the cost of a complete EEG setup is approximately 5% of that of an fMRI machine ($1.3 to $2.6 millions) (Hammou et al. 2013). The costs per-hour are also much lower compared to other techniques (Miljkovic and Alcakovic 2010). In fact, the equipment cost of running a one hour MRI research, in USA, is generally $500 or more.

For these reasons EEG is useful tool in neurophysiology, psychology and marketing research.

4.3.4 ERP

The oscillations measured by EEG can be analyzed in two domains: time and frequency domain (Cohen 2014). Research in the frequency-domain

[xiii]The strength of frequency-band-specific activity (Cohen 2014).
[xiv]The timing of the activity (ibid.).

studies neural activity via its spectral properties; studies in the time-domain usually involve the study of potentials.

An *evoked potential* (or evoked response) is an electrical potential that can be recorded from the nervous following the presentation of a stimulus, as distinct from spontaneous potentials (Abhang et al. 2016). The standard approach to study event-related processes (e.g., related to a stimulus or a response), is to align the time-domain EEG to the time = 0 event and average activity to certain events (belonging to the same category) at each time point (Cohen 2014; Van der Lubbe et al. 2016). It is also known as Event-Related Potential (ERP)[xv]. Event-related potentials are scalp-recorded voltage fluctuations that are time-locked to a certain event and small in magnitude, whereas the irrelevant activity is temporally unrelated to this event and is thought to be very large (Kropotov 2016; Van der Lubbe et al. 2016). All ERP are examples of phase-locked activities[xvi] (Cohen 2014).

ERP are used to investigate the brain responses to attention, emotion, memory, language processing, and other cognitive process (Oh 2015). In ERP experiment, the event is usually a stimulus presentation followed by different operations, such as sensory-related operations (estimation of color, shape, or category of the visual stimulus), by cognitive control operations (e.g., selection of appropriate response or suppression of prepared action), by affective operations (associations with positive or negative emotions) or memory-related operations (recalling an item or remembering a new item) and motor or other type of subject responses (Kropotov 2016).

There are several advantages of event-related potentials. In fact, ERP have a high temporal precision and accuracy (Cohen 2014). Moreover, ERP are simple and fast to compute and require few analysis assumptions or parameters (ibid.). Hence, they provide a quick and useful data quality check of single subject data (ibid.).

Unfortunately, ERP are far from being a unique physiological marker for a given cognitive process. In fact, despite the clear resulting peaks and troughs after the averaging procedure, the exact origin of the ERP is not that clear (Van der Lubbe et al. 2016). Hence, ERP provide limited opportunities for linking results to physiological mechanisms (Cohen 2014). In fact, the neurophysiological mechanisms that produce ERP are less well understood compared to those mechanisms that produce oscillations (ibid.).

[xv] "The mathematical basis of an ERP is simple: sum the voltage at each time point over trials and then divide by the number of trials" (Cohen 2014).

[xvi] Activity is phase-locked when its phase is the same or very similar on each trial, whereas activity is nonphase-locked when its phase is different on each trial, even if it is still time-locked to the trial (ibid.).

4.4 Summary

Consumer Neuroscience research uses different tools to study consumer's decision-making and behavior. Consumer Neuroscience tools can be classified according to the output and the type of measurement.

Firstly, Self-report and Behavioral measurement tools give information about higher-order functions and behaviors. These tools reveal information about consumers' habit, feelings, personality, preference and belief. The output of these measurements is usually under individual voluntary control, therefore these measurements can be easily biased.

Secondly, Consumer Neuroscience research uses Physiological measurements (external reflex) to evaluate people' biological responses to stimuli (Short et al. 2009). These measurements are used to the assessing of implicit processes and they are independent from participant' subjective awareness (Short et al. 2009; Whitley et al. 2012). In fact, physiological processes, such as body language, empathic design, facial expression, eye movement, originate from the brain. However, physiological processes do not directly reflect the brain activity. Tools such as facial expression recognition, eye tracking, galvanic skin are used in Consumer Neuroscience research to measure physiological processes.

Finally, internal reflexes are automatic, subconscious responses to various stimuli like products, advertising, packaging, brands that reflect directly the consumer's brain activity (Constantinides and Roth 2015). Researchers use neuroimaging tools to identify and analyze the brain internal reflexes (ibid.). There are several neuroimaging tools such as fMRI, EEG, MRI and PET.

In particular, an EEG records the extracellular electrical activity of the brain. The use of this tool has several advantages, such as high-temporal resolution (Abhang et al. 2016; Cohen 2014; Lakshmi et al. 2014; Michel and Murray 2012), signal multidimensionality (Cohen 2014) and low-cost compared to other neuroimaging tools.

CHAPTER

5

CONSUMER NEUROSCIENCE: UNDERSTANDING INDIVIDUAL DIFFERENCES IN CONSUMER BEHAVIOR

5.1 Consumer behavior and preferences

As discussed in Chapter 2, companies' success depends on their ability to deeply understand customer's decision-making and be prepared for small shifts in consumer behavior (Jobber 2007). In order to attract customers, create and deliver value-added products and services, companies need to comprehend how individuals interact with the marketing system (Solomon et al. 2013). Marketing can help companies to acquire information about consumers and understand their choices and behaviors, engage and affect how they think and act (Armstrong et al. 2017; Kotler et al. 2016). In fact, marketing researchers study the processes involved when consumers buy or use a product, service, idea, experience and how they differ in their choices (Solomon et al. 2013). Ideally, marketing researchers try to answer the following questions: *How do consumers select products? Which factors influence consumers' preferences and behaviors? Why are people attracted to some products and not to others?*. Studying why and how customers select and buy a specific product (or brand) is important for different reasons. It helps marketers to identify potential customers (Kotler et al. 2016). It improves the use of market segmentation strategies (Solomon et al. 2013). In fact, defining customers' characteristics means targeting a particular brand or product only to specific groups of consumers and not to everybody (ibid.). Moreover, it may increase brand loyalty (ibid.). If people get passionate about a product or brand, it is possible that they will buy it one more time. Studying people's behaviors generally helps big companies, nevertheless, it can also improve small businesses, for instance determining where to locate an additional store (ibid.). However, in order to understand the *how* of consumer behavior, researchers have to acquire a large amount of information (Jobber 2007). Consumers' preferences for a specific product or brand result from the mix of many different factors (Venkatraman et al. 2012). Some factors arise from the state of the individuals, whereas others depend on the properties of the product itself (Plassman et al. 2008; Venkatraman et al. 2012).

The attributes of consumers themselves refer to those factors which can influence a person's desire and behavior (Kotler et al. 2016; Moutinho and Chien 2007; Tanner and Raymond 2012; Venkatraman et al. 2012). For instance, culture, subculture, family, social classes and status are particularly important influences on consumer buying behavior. Culture and subculture (nationality, religion and geographic region) determine the person's values, rituals and relationship to others (Jobber 2007; Kotler and Keller 2006, 2012). It means that cultural factors influence every single aspect of a person's life. Specifically, culture impacts the product and service that individuals need or they are willing to buy (e.g., food, garments, insurances). Family can be considered the most important consumer buying organization in society, and the most influential group on family members (Kotler and Keller 2012). In the USA almost 40 percent of families have car insurance with the same company as the husband's parents (ibid.). Consumption is also shaped by personal factors such as age, stage in the life cycle, occupation, social class, economic circumstances and personality define individual preferences (Armstrong et al. 2017). For instance, people from middle and upper classes (higher spendable incomes) show distinct product and brand preferences in many areas compared to lower class. Moreover, the needs and preferences of customers cannot be considered as stable and static factors. In fact, critical life events or transitions can strongly influence and modify people's choices. For instance, marriage, childbirth, illness, divorce, first job symbolize critical events that positively or negatively alter people's life and consequentially influence needs and buying behaviors (Kotler and Keller 2012; Moutinho and Chien 2007).

The properties of a product have been dichotomized into intrinsic and extrinsic cues (Aaker and Bie 1993). Intrinsic attributes (e.g., ingredients, durability, taste) refer to those specific and physical properties that cannot be changed without altering the nature of the product itself (Aaker and Bie 1977). Instead, extrinsic attributes (e.g., price, brand name, country of origin) are *"product related"* but external to the product itself (Aaker and Bie 1993; Inscha and McBride 2004; Moutinho 2011; Zeithaml 1988). Hence, changing the extrinsic cues does not alter the physical product (Aaker and Bie 1993). Intrinsic and extrinsic cues provide a basis for developing different impressions of the product itself. The combination of intrinsic and extrinsic cues has strong effects on perceived quality[i] of the product (Olson and Jacoby 1972). The perceived quality, in turn, influences the assessment of a product and therefore consumers' buying behaviors. Marketing research often studies the functional relationship between levels of a cue and degrees of perceived quality (ibid.). However, it is not easy to determine which cue has the strongest influence on product choices and perceptions of quality (ibid.).

Researchers have also to take into consideration the product symbolism. In fact, shopping[ii] enables consumers to maintain, express, and enhance their personal and social identities (Allen 2002). For example, an expensive car may symbolize achievement; the owner feels to be self-confidence and successful when driving it (Kujala and Nurkka 2012). These considerations led Kujala and Nurkka (2012) to conclude that the meanings that the customer attach to products play an essential role in how they feel and evaluate them. In fact, the image of a product is shaped according to the abstract ideas/associations related to it and the beliefs about the kinds of people who use it (Allen 2002). A person may attach almost any meaning to any object, as human thinking is associative by nature (Kujala and Nurkka 2012). These associations can be defined as product symbolism (Allen 2002).

The product symbolism is the image of the product, encompassing abstract ideas and associations with the product as well as beliefs about

[i] Quality is a synonymous for innate excellence (Oude Ophuis and Van Trijp 1995). Quality usually refers to the superior characteristics of a product or service. However, low quality refers to the poor or inferior characteristics of a product. Consumer's judgment of quality is named perceived quality. According to Aaker and Bie (1993) perceived quality is *"the customer's perception of the overall quality or superiority of a product or or service with respect to its intended purpose, relative to alternatives"*. Olson and Jacoby (1972) argued that the quality perception process has two stages. In the first stage, a subject chooses surrogate indicators of product quality, (i.e., quality cues) from an array of product-related attributes. In the second stage, the subject combines the evaluations of these individual cues into an overall judgment of product quality.

[ii] The shopping experience and the act of buying serves needs like amusement, self-gratification, sensory stimulation, physical activity, or appearance enjoyment (Friese 2001).

the kinds of people who use the product (Allen 2002). Product symbolism is a psychological concept that elicit in the consumer's mind is the results of attributes found in the product, the consumer's perceptual mode, and the context in which the perceptual process takes place (Friedmann and Lessig 1986). Hence, symbolic meaning is not a one-dimensional concept because symbols are capable of holding complex meanings for individuals (Kujala and Nurkka 2012). If a product serves a symbol, psychology studies how products are evaluated, purchased and consumed based on their symbolic content (Friedmann 1986). Psychological and consumer researchers focused on the factors which influence the formation and change of product symbolism such as product-related factors (Belk 1981; Wright et al. 1992) individual difference factors (Belk 1981; Belk et al. 1982), and social system factors (Hirschman 1986; Wright et al. 1992). However, the multidimensionality of meanings attributed to a product makes the symbolic meaning not easy definable. Psychological methods can help to understand how consumers' attributes influence product symbolism, the multiple symbolic contents that can be attached to a product, how social factors, such as culture or family, impact product symbolism. However, psychological methods cannot explain how these processes are generated, which are the unconscious process that influence product symbolism and all the possible combinations of individual differences and symbolic contents.

Since there are numerous factors involved in the study of consumer behavior, traditional methods of study will not do justice to all the factors. The limitations of traditional marketing methods account for the growth in applications of neuroscience tools to marketing research. In fact, monitoring and recording brain activity helps researchers to measure simultaneously consumers' attitudes, influence of product cues and how symbolic contents are processed in the brain. Neuroscience methods investigate how these processes are accomplished. Neuroscience can provide information on the brain areas that manifest themselves and their degree of influence over the decision-making process and behavior. Neuroscience methods can help marketing to study cognitive processes that influence individual preferences and product symbolism. Studying extrinsic cues can help researchers to understand how product value and quality are assessed. Hence, neuroscience methods can help to understand the *how* of consumer behavior.

Neuroscience methods and findings in marketing are commonly grouped under the terms of Consumer Neuroscience or Neuromarketing.

5.2 Analyzing the influence of extrinsic cues on consumer behavior using eye-tracking and fMRI

Consumer Neuroscience research investigates neural mechanisms involved in the evaluation of products or services and the factors that influences the decision-making process and consumer behavior.

Multidisciplinary evidence suggests that the customers' images of a product influence how they evaluate or enjoy the goods before and during consumption (Plassman et al. 2015). Hence, Consumer Neuroscience research focuses on the influence of extrinsic cues, such as price, brand and appearance on consumer's preferences and behaviors by using different tools, such as fMRI, EEG and eye-tracking. Studying how external cues are processed in the brain can help researchers to study consumer behavior in several ways. In fact, it helps to understand how consumers assess product quality and value (e.g., the relation between price and quality), the influence of these cues on different consumer attributes (e.g., effect of color in different cultures) and influence of emotions on product symbolism (e.g., positive and negative).

This section discusses experiments on consumer behavior and extrinsic cues conducted using fMRI and eye-tracking. Studies conducted using EEG are separately discussed in Section 5.3 and Subsection 5.3.1.

5.2.1 Price

As discussed in Section 5.1, products have several different external attributes or cues that characterized the product even though they are exterior to the product itself. One important external cue that influences consumption is price (Aaker and Bie 1977).

Consumer Neuroscience researchers have given most attention to price as external cue. However, Consumer Neuroscience literature shows that few studies investigate directly how price can influence neural mechanisms. Studies focused mostly on the effect of marketing-based expectancy, also known as MPEs, based on price (Plassman et al. 2015). Mostly, researchers investigated the effect of price on experienced quality of consumers, particularly how price enhances or subverts these experiences, misleading consumers by creating an environment of positive or negative expectations. Usually, price and perceived quality are positively related (Acebron and Dopico 2000). The greater the price, the greater the expected quality (Acebron and Dopico 2000; Gerstner 1985; Huber and McCann 1982; Rao and Monroe 1988). Recent studies have shown that people enjoy consuming identical products (e.g., wines, underwear) more when they have a higher price (Geuter et al. 2013; Knutson et al. 2007; Plassman et al. 2008, 2015). For instance, Knutson et al. (2007) found that price-based expectancies not only change product preferences, they also activate distinct neural circuits related to anticipatory effects that precede and support consumers' purchasing decisions. Using fMRI, authors showed that individual preference for a pice or product found to be positively correlated with activation in the nucleus accumbens (NAcc). In particular, the price differential (i.e., the difference between what the subject was willing to pay and the displayed price of the product) was correlated with activation in the medial prefrontal cortex (mPFC) (Knutson et al. 2007). Instead, in case of excessive prices there was an activation in the insula and a deactivation the mPFC prior to the purchase decision(ibid.).

Similarly, Plassman et al. (2008), using fMRI, studied how a price differential for wine is perceived. The author found that higher price change consumers' preferences for wines, flavor pleasantness perceived and increase or decrease activity in several brain areas. Plassman et al. showed that higher prices change neural measures of consumption enjoyment, such as increase activity in the left mOFC and the left ventromedial prefrontal cortex (vmPFC) for the case of experienced flavor pleasantness. In fact, activity in the mOFC is correlated with behavioral pleasantness ratings for odors, tastes and music (Plassman et al. 2008). The results suggested that increased activity in the mOFC, due to changes in the price of a wine, leading to a change in the actual experienced pleasantness derived from its consumption (ibid.).

fMRI can also be used to determine how price fairness affects brain activity. Price fairness refers to the outcome or the process that leads consumers to define if a price is reasonable or not (Xia et al. 2004). Price fairness judgment involves a comparison of two or more prices and also influences quality judgment (ibid.). Usually, people want to pay less for products, however, quality can be also defined on the base of price. In fact, prices below a lower price-threshold usually may signal poor product quality, prices above an upper threshold may be considered as too high. Hence, companies have to take in account that consumers are willing to pay less only if they believe that the quality of a product is still the same than if the price were high. Neuroimaging techniques show differences in brain activity during the view of optimal versus lower/higher prices of a product. Linzmajer et al. tested how customers perceive price fairness in two experiments. In their first experiment, Linzmajer et al. (2011) tried to determine whether there are neural activation patterns that correspond to a lower, optimal, and upper price-threshold. Results showed that prices below the lower threshold were significantly more accepted than prices within the op-

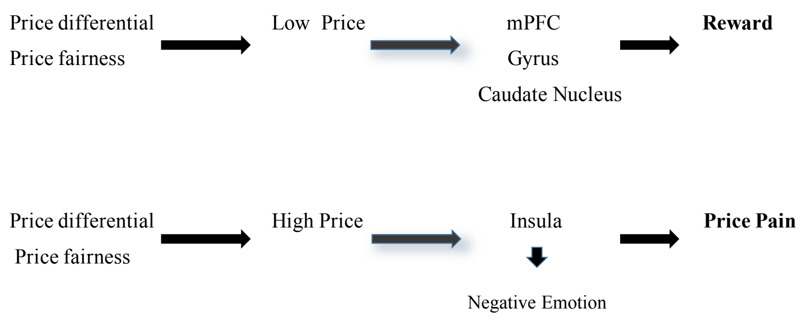

Figure 5.1: *The influence of low and high price on brain activity in Consumer Neuroscience research.*

timal range. Moreover, higher activity in the middle temporal gyrus, and the caudate nucleus suggested that lower prices are perceived as more rewarding than optimal price. Increased activity in the insula, in the dlPFC, the superior frontal cortex and the anterior and posterior cingulate were found during the comparison of high prices versus the optimal price range. Activity in the insula is usually associated with *"price pain"* and negative emotions (e.g., uncertainty, anger) (Linzmajer et al. 2011). Instead, prefrontal areas and the ACC/PCC are frequently associated with reflective processes, decision-making and conflict monitoring, it indicates that the decision becomes more complex for prices above the upper-price-threshold. However, there is also no linear relationship between higher prices and activity changes in the insula (ibid.). In a following experiment, authors tried to determine customers perceived product prices as having greater fairness after glucose intake, thus identifying a biological driver of customer price fairness perception (Linzmajer et al. 2014). However, author did not find linear effect of glucose consumption on customer price fairness perception. Moreover, glucose intake did not lead to significant differences in the mood states of participants.

5.2.2 Brand

Consumer Neuroscience research also studies cognitive and neural processes involved with brand decisions (Plassman et al. 2012). Neuroscience tools and theory can provide information on how consumers predict[iii] brand value, experience[iv] and remember[v] brand value and, brand loyalty[vi] (Plassman et al. 2012, 2015; Schaefer and Rotte 2007).

Several brain areas have been related to the psychology of brands, such as the anterior and the paracingulate cortex, the orbifrontal cortex (OFC) the striatum, the hippocampus, the ventral medial prefrontal cortex (vmPFC) and the dorsolateral prefrontal cortex (dlPFC) (McClure et al. 2004; Plassman et al. 2007, 2012, 2015; Santos et al. 2011, 2012; Schaefer and Rotte 2007). The hippocampus and dlPFC have been related to changes in behaviors based on emotions (McClure et al. 2004). The hippocampus has often been related to emotional memory. Researchers investigated the role of hippocampus in anticipatory processes during the memorization of aversive events and, sex differences in emotional memory (The effect of anticipation and the specificity of sex differences for amygdala and hippocampus function in emotional memory). The dlPFC is often thought to be involved in cognitive control, including working memory and reward-motivated behavior (ibid.). The vmPFC has been related to preference judgments, processing emotions after the decision-making process (Santos et al. 2011). The OFC is correlated with subjective reports about the pleasantness for olfactory experiences, musical rewards, touch, secondary rewards such as money and in response to a specific aroma (Plassman et al. 2012).

McClure et al. (2004), using functional magnetic resonance imaging (fMRI), measured people's preferences for two famous drinks: Coke and Pepsi. The study revealed a significant influence of brand knowledge for Coke label on subjects' behavioral preference and brain activity (McClure et al. 2004). Specifically, authors found greater brain activity in the dlPFC, the hippocampus, and the midbrain to Coke delivery compared to Pepsi.

Moreover, Yoon et al. (2006) conducted a peculiar study to determine whether participants' judgments about attributes of brand and par-

[iii] *The predicted value of a brand is defined as the consumer's belief about the experienced value of that brand at some time in the future* (Plassman et al. 2012). The predicted value involves the consumer's evaluation of how much enjoyment he/she will derive from consuming a specific brand (ibid.).

[iv] *Experienced value is defined as the pleasure derived from consuming a brand* (ibid.).

[v] Memory is an important predictor of consumers' choices (ibid.). *How we encoded, consolidated, and retrieved brands define the remembered value* (ibid.). The remembered value consists of both explicit memory and implicit memory of prior consumption experience. It is possible to rely explicit memories, or declarative memories, on specific brain regions such as the hippocampus and surrounding medial temporal lobe (MTL) and dlPFC (ibid.).

[vi] *Brand loyalty is a positive attitude towards a brand* (Ferrell and Hartline 2012). Hence, customers that are loyal to a brand have a consistent preference for that brand over all other competing brands (ibid.).

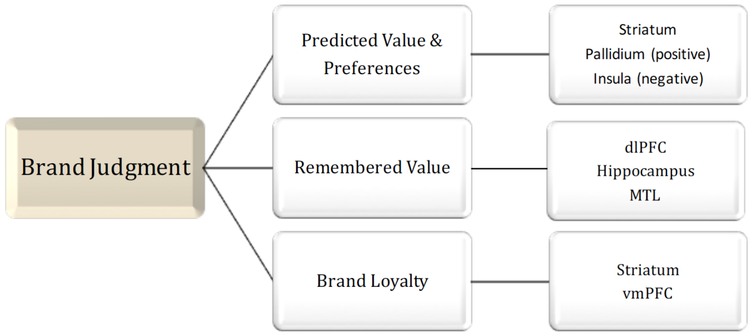

Figure 5.2: *The brain areas that have been related to different processes of brand judgment.*

ticipants' judgments about attributes of people are processed equally. In particular, authors investigated if regions responsible for processing brand features are opposed or similar to those regions that processes human traits. Results showed that distinct neural processes cause judgments about people and they are not involved in brand judgments (Yoon et al. 2006). In fact, judgments for persons indicated greater activation in the medial prefrontal cortex regions, instead, for products the activation was greater in the left inferior prefrontal cortex, an area known to be involved in object processing (ibid.). These findings imply that processing a brand is similar to processing an object but it is opposed to processing a person (ibid.). It suggests that customers might identify and memorize brands in the same way they process products. Hence, customers might associate brands with personalities and, people establish relationships with brands in the same way they form relationships with other human beings.

Two studies investigated how favorableness of brand associations affects predicted value signals in the striatum. In the first one, Schaefer and Rotte (2007) found a correlation between imagining a pleasant experience, such as driving a car of a brand that is linked to favorable brand associations, and activity changes in the striatum. In the second one, Plassman et al. (2007) investigated differences in neural activations between loyal and disloyal customers of a store during fictitious purchasing decisions. Based on psychological theories, authors assumed that for loyal customers the exposure to the store brand would modulate their decision via an emotion-based path. Plassman et al. 2007 (2007) found that customers who are loyal to a brand, such as H&M vs. Zara, show a stronger activation in the striatum, in the vmPFC and the ACC, compared to customers who are less loyal, even though both buy identical clothes. The results also suggest that loyal customers have established affective bonds to the store, which might be the underlying psychological driver of their repurchases.

However, Santos et al. (2011) investigated the effect of the vmPFC in brand preferences. Authors used fMRI to study how individuals assessed preferences for brands (positive, indefinite and fictitious). Santos et al. recorded subjects' brain activities during and after the brand evaluation (decision-making process). Authors found that there was activation of the vmPFC when comparing positive with indifferent or fictitious brands. However, the vmPFC was more active after the choice than during the decision-making process itself. These findings challenge some of the existing literature that has related the activation of the vmPFC to brand preferences during the decision-making process (Santos et al. 2011).

Nakamura et al. (2016) investigated how individuals memorize and recognize brands, and the brain areas involved in the recognition process. During the experiment, two kinds of product were used: sport drinks and music players (Nakamura et al. 2016). The products were divided in two categories according to the "level of recognition" of the brand: high (easy to recognize), low (difficult to recognize) (ibid.). Authors used fMRI data to determine the level of recognition of branded product. Results showed that the frontal lobe activity was higher during the view of sport drinks brands than music players (ibid.). Results showed that the frontal lobe activity was higher during the view of sport drinks brand than music players (ibid.). It suggests that sport drinks are easier to recall. However, it is not clear when the authors determined participant's knowledge and familiarity of the products.

5.2.3 Aesthetic properties

Aesthetic properties are considered important aspects when a company designs a new product (Veryzer and Hutchinson 1998). Usually, aesthetic properties derive from the visual, tactile and formal attributes of a product, such as color, shape, proportions (e.g., the golden ratio), materials, and craftsmanship (Rindova and Petkova 2007). According to Veryzer (1995) *"aesthetic considerations (e.g., shape, symmetry, texture) usually pertain to the external surface(s), which house or protect the inner workings (e.g., mechanical or electrical components) of a product, these considerations are not entirely independent of other design concerns"*. However, aesthetic properties have a more recondite meaning that a *meaningless exercise in styling and... an isolated exploration of technology* (Ashby and Johnson 2014). The word aesthetic comes from the Greek word "aisthesis" that means perception from the senses, feeling, hearing, and seeing (Reimann et al. 2010). The aesthetic characteristics are meant to give products *a personality that fits its owner*. The goal of marketing is to create products that are significant and attractive to people, give them characteristics that affect, thrill and trigger aesthetic responses in consumers (Ashby and Johnson 2014; Veryzer and Hutchinson 1998). The use of these visual and tactile properties can help marketers to influences consumers' perception and evaluation of products. Hence, Consumer Neuroscience researchers focus on the aesthetic component as an essential key element to attract customers. In particular, Consumer Neuroscience studies changes in consumer's neuronal activity that arise from product evaluation or preferences of design, and aesthetic properties.

Literature review shows that studies investigated the impact of external cues, such as appearance and luxury, on neural processes. For instance, using fMRI, Erk et al. (2002) investigated whether the different designs of cultural objects, such as cars, can act as strong social reinforcers and can modulate the dopaminergic reward circuitry (Section 3.5.1 in Chapter 3). Reward mechanisms are often involved in the regulation of social relations like dominance and social rank (Erk et al. 2002). Based on evolutionary theories, authors hypothesized that sport cars, compared to other cars (e.g., limousines and small cars) would modulate the reward circuitry because they act as strong social reinforces. Results confirmed that, during the presentation of sports cars vs small cars, there was a significant activation for sports cars in brain regions associated with reward and reinforcement, such as the right ventral striatum, left orbito-frontal cortex, left anterior cingulate and the bilateral prefrontal cortex (ibid.). Given these results, author suggested that the reward circuity can be activated by the degree of attractiveness[vii]. It might be possible that the attractiveness of sport cars functions as predictor of potential social reward and consequentially as highly reliable predictors for social dominance and high social rank (ibid.).

Reimann et al. (2010) used fMRI to examine the differences in consumers' brain activity during the view of decorated packaging compared to standardized packaging. Authors studied the effect of aesthetic in affective processing[viii]. The results showed that intense emotional responses, such as

[vii] Aesthetics also refers to the visual attractiveness of a product. In the case at hand, the brain regions associated with reward and reinforcement were found more active during the view of product with strong visual appearance characteristics.

[viii] Later internal and external stimuli are translated into the brain's language, the actual information processing can begin (Davis et al. 2017). Here, two types of information can be distinguished: affective and cognitive (Eder et al. 2007). Cognitive information highlight semantic features (*what something is*), instead affective information is evaluative leading (*how something is*). Hence, affecting processing is a first mecha-

the view of decorated packages elicited affective processes the most. In fact, specific affective brain areas of the reward system, such as the nucleus accumbens and the ventromedial prefrontal cortex were activated during the view of decorated packaging (Reimann et al. 2010). According to the authors, these results suggest that measure of effective product engagement can be positively related to aesthetic product experiences in the brain. However, the view of decorated packaging resulted in the increased Reaction Times (RT)[ix] (ibid.). It means that participants took considerably longer to choose decorated products than standardized ones. The authors considered increased RT as a positive factor. However, it suggests that the visual complexity of decorated packaging results in an increased effort in processing the visual information. Even though, decorated packaging elicited specific affective brain areas of the reward system, it might also suggest that process these information requires more visual and cognitive effort.

As described in Section 4.1, the eye tracker measures eye positions and eye movement. Thus, eye tracking can be used to analyze how people evaluate product design on the base of their visual attention. For instance, eye tracking helps to determine how long a person focuses on a product. In addition, eye tracking helps to determine which product features are more attractive on the base of their visual saliency[x]. Rojas-Lopez et al. (2014) investigated differences in the participants' visual attention for the same product (beer bottle) when they saw the real picture or a virtual one (rendering). Results showed that participants' evaluation (behavioral data) of the virtual and real picture were similar (Rojas-Lopez et al. 2014). However, eye-tracking measurements indicated that there were differences between the way participants looked at the two pictures, specifically in the gaze patterns (ibid.). People spent more time to analyze the virtual picture, specifically the upper label. In fact, the representation in the real picture was excessively simplifying, meanwhile the virtual bottle showed a more visible text label (ibid.). This study suggests that people take long to analyze the image with a better quality, which is reflected in the heat map capturing more attention from the observer. These results suggest that using rendering for advertisement might capture better consumers' visual

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nism (precede cognitive processing) to adapt behavior according to evaluative decisions (Davis et al. 2017). Affecting processing and cognitive processing together contribute to the decision-making process and thus modify human behaviors (ibid.). Some authors consider emotion as a behavioral output of affective processing (Davis et al. 2017; Eder et al. 2007).

[ix]Reaction time is the length of time taken for a person to respond to a given stimulus or event.

[x]Visual salience (or visual saliency) is the distinct subjective perceptual quality which makes some items in the world stand out from their neighbors and immediately grab our attention (Itti 2011)

attention.

A more recent study by Goucher-Lambert et al. (2016) investigated how consumers' preferences and product features evaluation can be altered if sustainability is added as a variable. The authors, used fMRI to measure participants' preferences for various water bottles, according to different parameters like forms (high utility, medium utility, low utility), function (material: aluminum, hard plastic, soft plastic), and price ($9.99, $14.99, $19.99). Two different conditions were used in the experiment: control and environmental. In the control condition participants were asked to rank the water bottles on the base of forms, function and price. In the environmental condition, sustainability factors were included for each parameters (Goucher-Lambert et al. 2016). Behavioral results showed that, during the environmental condition, the importance for form attributes and price decreased. However, the importance of functional product attributes increased under these same conditions (ibid.). The fMRI data showed a different brain activation during the two conditions, especially in the brain regions involved in the vision and visual processing. The inferior occipital gyrus, precuneus and the cuneus were more active during the control condition compared to the environmental condition (ibid.). It supports the hypothesis that the participants' mental effort during product evaluation was higher in the control condition than in the environmental condition. This hypothesis is also supported by Reaction time data. In fact, participants spend significantly less time in evaluating products where environmental impact was a factor. This indicates that there are some aspects of the decision-making process that may have required less mental effort for participants during the environmental condition (ibid.). These results suggest that sustainability might be a more important factor in product evaluation than aesthetic or price components due to social and moral judgments.

5.3 Measuring extrinsic cues effect on consumer behavior by using EEG

The present Section emphasizes the use of EEG in Consumer Neuroscience research. The electrical activity of the brain can be measured using EEG oscillations (regular cyclic voltage changes) in different frequency bands or changes in ERP amplitudes. The use of EEG techniques in marketing research began several decades ago (Boksem and Smidts 2015). Initially, this tool was used to investigate attention and memory of commercial messages (ibid.). However, EEG can be used for detecting the effect of other marketing stimuli on consumer' preferences and choices. EEG data help to measure the level of attention, memory, preference, pleasantness or unpleasantness that an individual has for a product or its peculiar characteristic.

For instance, Ohme et al. (2010) showed that EEG data can provide information that can be very hard to obtain via traditional consumer research methods.

For instance, EEG can be used to examine how physical characteristics and appearances influence people's brain activity. Rocha et al. (2013) investigated customers' satisfaction for dermatological treatments. Authors recorded females' brain activities during the evaluation of the dermatological treatment received. Authors investigated if the level of satisfaction (unsatisfied=1; very satisfied=5) for each facial component (e.g., nose, eye) was supported by diverse set of neurons. Results showed that there was a linear correlation between positive evaluation (high score=5) and increase in brain activity recorded from the central and right electrodes. In contrast, the activity recorded for the left and right anterior frontal electrodes were inversely correlated with this self-evaluation (Rocha et al. 2013). This study suggests that Consumer Neuroscience research not only can address problems regarding consumers' preference for product and services but it can be a useful instrument to understand how people act in a self-evaluation and how they judge physical appearances.

As discussed in Subsection 5.2.3, aesthetic properties of a product derive from different attributes, namely visual appeal such as color, shape, proportions. However, aesthetic properties can also refer to tactile attributes. In fact, tactile components play also an important role in product evaluation. For instance, Park et al. (2015) used EEG to evaluate participants' satisfaction for tactile attributes with a haptic prototyping system. Authors investigated if changes in delta, theta, alpha and high beta bands reflect changes in the level of tactile satisfaction (Park et al. 2015). Results showed a linear correlation between bands power and satisfaction score. However, there was a negative correlation with satisfaction scores (ibid.). Therefore, the authors could not define which brain regions were related to level of satisfaction. These findings suggest that a correlation between band power and level of satisfaction could be found, however defining and measure satisfaction is challenging.

Rakshit and Lahiri (2016) investigated the effect of color on brain activity. The participants' brain activity was recorded from Frontal, Temporal, Occipital and Parietal area, during the view of four different colors (red, green, yellow and blue). Studies showed that each color has different mental arousal state and evokes different emotions (Zhang and Tang 2011). Hence, authors hypothesized that the view of each color activated different brain areas. Results confirmed that different color elicited different brain area. However, red color was identified most accurately compared to other colors (Rakshit and Lahiri 2016). It suggests that the color red is the most responsible for mental arousal and cognitive activity followed by green, blue and yellow color (Rakshit and Lahiri 2016).

Regarding brands, Balconi et al. (2014) investigated the implicit and explicit individual responses to different goods of famous Italian brands. Correlating cerebral responses with consumers' explicit preferences, authors found an increasing brain activity in response to goods, which were evaluated as preferred, linked to rewarding conditions. They found an increase in the theta frequency band. Theta bands are thought to engage the customer through a social reward. Moreover, this increase was found in the dlPFC, the brain area that supports reward mechanisms. These findings shed light on the role of the reward system in brand evaluation. Also Murugappan et al. (2014) used EEG to identify the preferred brand on automotive in Malaysia. Four famous brands, such as Toyota, Audi, Proton and Suzuki, were selected for the experiment. Authors recorded brain activity of 12 subjects, during the view of advertisement video for each brand. The authors used FFT to analyze alpha band. Results showed that subjects were mostly inspired on Toyota brand vehicles compared to other brands (Murugappan et al. 2014).

As discussed, Consumer Neuroscience can be used also to predict the success of intangible assets as for in the lance of a movie trailer. Boksem and Smidts (2015) used EEG to investigate how neuroscientific data can be useful to predict individual choice behavior and population-wide commercial success. The high-frequency components of the EEG (beta and gamma oscillations), beyond stated preference measures, provided information about the participants' preferences. Authors found that a high ranking of a particular movie was related to increase in the amplitude of EEG oscillations in the beta frequency range during viewing of the same movie trailer (Boksem and Smidts 2015). Moreover, they found a relationship between commercial success of the viewed movies and very high frequency oscillations in the gamma range, with a frontal and a somewhat bilateral distribution. Gamma bands were related to population preference independent of stated preference measures (ibid.). The results provided the first evidence that EEG measures are related to real-world outcomes. Neural measurements can help in predicting choice behavior, and thus can significantly implement models based on stated preference measures (ibid.).

Finally, Aprilianty et al. (2016) examined the influence of price on consumer's perception and evaluation. Authors measured changes in consumers' brain activity while they were touching underwear of different prices (low, medium, high). Authors found that there was an increase in beta band (13-30 Hz) when participants indicated their attentiveness towards each price level stimulus. Moreover, the EEG data showed an increase in beta band for high price stimulus, whether in parietal lobe (touching sensations), temporal lobe (consumer price perception) (Aprilianty et al. 2016). These findings suggest that price might be an indicator of perceived quality of underwear (Aprilianty et al. 2016).

5.3.1 ERP and LRP

As discussed in Section 4.3.4, the electrical activity of the brain or its temporal reaction (from 1 ms to 1000 ms) to stimuli can be measured in Event-Related Potential (ERP) experiments. *evoked potentials* (EP) and *event-related potential*(ERP) are components of the EEG that arise in response to different kinds of stimuli, such as auditory, gustatory, olfactory, somatosensory and visual input (Ramsøy 2014). Event-Related Potential can be used to measure the consumers' preferences for brand, product or aesthetic properties, as the following experiment show. For instance, Wang et al. 2012 (2012) used ERP to investigate the participants' responses to aesthetic features of jewelries. In particular, authors recorded P2 component on the participants' frontal, central and parietal areas during the view of two types of jewelry pictures: beautiful and less beautiful[xi]. Results showed that less beautiful jewelries evoked greater amplitudes of P2 than the beautiful ones. This suggests that at the early stage of an aesthetic experience, negative emotional experiences are automatically aroused for less beautiful (less selling) objects (Oh 2015). It also indicates that event-related potential methodology may be a sensitive measure of attention for aesthetic components (Wang et al. 2012). However, the study did not investigate participants' preferences for the jewelries. It might also imply that greater amplitudes of P2 for less beautiful is related to greater attention for less beautiful jewelries and not necessarily imply negative emotions for them.

ERP can be also used to investigate the influence of implicit and explicit cues, specifically brand, in a product. For instance, Thomas et al. (2013) used a Go/No-go Association Task (GNAT)[xii] to determine if branded products as opposed to no-branded products are associated with positive attitudes. Results showed that ERP to branded products had a more positive waveform in LPC component than no-branded products. Moreover, the amplitude of the late positive component (LPC) was found to be enhanced for brand as opposed to no-branded stimuli. These findings suggest that ERP and LPC are sensitive to explicit attitudes.

Similarly,Nazari (2014) investigated if N1 component of ERP can be used to measure consumers' preferences of familiar (e.g., Coca Cola)

[xi] It was determined on the base of sales ranking of the jewelries

[xii] The Go/No-go Association Task (GNAT) can be used to measure associations between categories (e.g., faces of elderly or young people/- assuming that elderly faces are associated with negative attitudes) and adding an evaluative dimension such as e.g., positive or negative words (Thomas et al. 2013)

and unfamiliar (e.g., Ayda Cola) brand beverages. The results of the experiments showed that a significant increase in N1 component amplitude was found in occipital lobe for familiar logos than for unfamiliar ones which might refer to a pre-comprehension brain activity (Nazari 2014). It suggests that familiar brands are processed faster in the brain. However, the study did not report participants' previous knowledge of the stimuli.

Finally, a more recent study by Pozharliev et al. (2015) used ERP to investigated differences in neural processes during participants' view of picture of luxury product versus basic branded products. Next, authors investigated the differences in neural processes when the participants were viewing the picture alone (Alone condition) or with another person (Together condition). First, the authors tested the changes in P2, P3, and LPP component of ERP for luxury product versus basic branded products. Then, they tested the changes in these component for both the conditions. Results showed that there was no significant difference in ERP component between luxury and basic brand products. However, authors found that dissimilar brain responses occurred between the two conditions for the P2 and P3 components. Results also showed that LPP amplitude was significantly higher for luxury product in the Together condition but not in the Alone condition. These results suggest that LPP amplitude was enhanced by the presence of another person (Pozharliev et al. 2015). It suggests that the presence of a person, or social influence can effect consumer preferences and brain activity.

5.4 Limits and challenges in Consumer Neuroscience research

As discussed in the present Chapter and Chapter 3, Consumer Neuroscience investigates the neuronal and psychological processes that characterize and lead consumer's buying behaviors. In particular, Consumer Neuroscience provides insights into the neural mechanisms that support and influence consumer preferences and the decision-making process. Consumer Neuroscience research allows an in-depth analysis of the cognitive and affective processes that regulates reward mechanisms, perceived quality and value judgment. Literature review showed that the use of unbiased measures (e.g., neuroscientific data) of consumer response can explain the emotional attachment and preferences of individuals to brands or particular product design better. Moreover, previous studies explored individual reactions to price fairness as well as the effect of price on product quality and pleasantness. From a marketing prospective, Consumer Neuroscience helps researchers to define the gradient of influence of each of the four elements of marketing-mix and consequently support companies to create optimal strategies for their customer segments.

Overall, the current state of the art suggests that Consumer Neuroscience not only can improve our understanding of the decision-making process but also promises to revolutionize how researchers investigate, analyze and explain consumer's behavior in marketing research. However, Consumer Neuroscience studies present several issues and limitations that researchers should carefully address. This section discusses both minor and major problems in Consumer Neuroscience studies. Initially, three minor problems were identified.

1. A clear definition of Neuromarketing and Consumer Neuroscience is missing. It creates misconceptions regarding the difference of disciplines involved in Consumer Neuroscience studies and consequently the theoretical foundations used for the experiments. Researchers usually refer to Consumer Neuroscience or Neuromarketing as the union of three disciplines such as Marketing, Psychology and Neuroscience. However, there is no clear identification of the psychological theories and methods used in Consumer Neuroscience research. Psychology encompasses a vast domain comprised of several different yet complementary areas of specialization. Hence, the use of the term Psychology might be too generic and imprecise.

   Identifying a specific sub-field of Psychology can be useful for developing new theories and guide researchers during experimental design. Some authors, such as Plassman et al. (2007), Weber and Johnson (2009), Plassman et al. (2012) and Ramsøy (2014), used Consumer Psychology methods to better understand psychological processes underlying consumer decision making process and buying behavior. Consumer Psychology or Consumer research can be defined as *"a branch of applied psychology that explores the principles that underlie the consumption of goods and services in a society"* (Reber 1995). Consumer Psychology studies *why and how individuals and groups engaged in consumer activities, as well as how they are affected by them* (Jansson-Boyd 2010). Mostly, Consumer Psychology focuses on the cognitive processes and behavior involved when people purchase and use products and services (ibid.). However, the subfield of Cognitive Psychology might also successfully be applied in Consumer Neuroscience research. Cognitive Psychology can be defined as the *"general approach to psychology emphasizing the internal mental processes"* (Reber 1995) or the *"scientific study of the mind"* (Braisby and Gellatly 2012). Cognitive Psychology studies mental events, beliefs, intentions and cognitive processes, such as the how people think, perceive, learn, remember information, thought the use of neuropsychological, neuroimaging tools and computational models (Braisby and Gellatly 2012; Reber 1995; Sternberg and Sternberg 2016). Cognitive psychology studies how people acquire and apply knowledge or information, in normal and abnormal conditions, and where and when this information is processed in the brain.

2. The main goals of Consumer Neuroscience reserach are not clear. Defying goals and priorities of Consumer Neuroscience research helps (1) to better understand valuable contributions and limits in this field; (2) researchers to set priorities in their research; (3) to limit the number of biased results, especially results spread by Neuromarketing companies. In particular, Neuromarketing companies, in order to sell their services, spread misleading or inflated information regarding archived results and growth potential.

3. The use of neuroimaging tools limits the product experience and designs field experiments.

   Firstly, neuroimaging tools can constraint the study of food products. The use of tools, such as fMRI or MRI, make the analysis of consumers' preferences for these products during tasting procedures difficult. In fact, the administration route (how to supply the product) can be problematic. Additionally, facial and body movements during food supply might produce an excessive number of artifacts that reduce data quality.

   Secondly, Consumer Neuroscience research is that neuroscientific methods demand highly artificial contexts and thus cannot provide useful data or theories about classroom contexts (Varma et al. 2008). In fact, experiments are often carried out in laboratories, consequently these experiments take place in aseptic and artificially created environment. Unlike field experiments, laboratory experiments restrict and circumscribe data and theories. They extremely simplify the complexity of the real world, such as choosing between thousands of other products in a real shop, hence they are less suitable to generalize the real situation (Koschate-Fischer and Schandelmeier 2014). The concerns is that neuroscience methods do not provide access to important issues such as context (Varma et al. 2008). However, in order to achieve high internal validity[xiii], laboratory experiments are generally more suitable than field experiments (Aaker et al. 2011; Koschate-Fischer and Schandelmeier 2014). In fact, laboratory ex-

[xiii]Internal validity is assumed when the manipulation of the independent variable is the only reason that can change the measured values of the dependent variable. Thus, there are no complementary reasons for changes in the dependent variable (Shadish et al. 2002)

periments allow extensive control of extraneous variables, which in turn positively influences internal validity. In contrast, field experiments are considered to possess limited internal validity due to the uncontrolled and complex environment (Aaker et al. 2011; Koschate-Fischer and Schandelmeier 2014). To solve this problem, laboratory experiments can be designed and implemented in more natural and "warm" environments (e.g., light effect) that make the experience more realistic and less artificial for the test subjects. The increasing use of wearable tools, such as eye-tracking or Emotiv cap can partially reduce this problem. Wearable tools allow to design field experiments and not only laboratory experiment, hence experiment in a real environment. However, these tools also reduce data quality (e.g., excessive noise and artifacts) due to less control of disturbing environmental factors (e.g., lightning conditions, auditory noise).

From a review of the current literature, it is possible to identify five major limitations.

1. Consumer Neuroscience studies use neuroimaging tools in order to determine which brain area(s) are activated when a specific marketing stimulus is presented and relate this activation to a cognitive or emotional process. Neuroimaging data allow researchers to infer the role that a particular brain region plays in a specific cognitive function (Poldrack 2006, 2011). However, researchers might also use neuroimaging data to make the opposite inference; thus to infer the engagement of particular cognitive functions based on activation of specific brain regions (Henson 2006; Poldrack 2006, 2011). This practice is named reverse inference (Poldrack 2006). Reverse inference is *"the (probabilistic) assumption that a particular cognitive process is inferred from the activation of a particular brain region"* (Henson 2006; Poldrack 2006). Hence, *"if the cognitive process X (e.g., reward) is engaged then the brain area Z (e.g., striatum) is active"* (Plassman et al. 2012; Poldrack 2006). This is a type of reasoning that links the activity of a specific brain area to a particular cognitive process not directly tested, but perhaps linked to the task used, drawing on other research implicating that brain area with that cognitive process. Using reverse inferencing implies that:

    - In study n.1, when the task comparison A was presented (e.g., comparison famous vs. unknown brands), the brain area Z was active (e.g. striatum) (Plassman et al. 2012; Poldrack 2006).
    - In study n.2, when the cognitive process X (e.g., reward) was engaged, then brain area Z (e.g., striatum) was active (Poldrack 2006).

- Thus, the activity of area Z (e.g., striatum) in the study n. 1 demonstrates engagement of cognitive process X (e.g., reward) by task comparison A (e.g., comparison famous vs unknown brands) (Poldrack 2006).

Reverse inference can be defined as a case of logical error of *affirming the consequent* (Luck and Kappenman 2011). If the presence of the cognitive process X leads to the activity of brain area Z, it does not imply that the activity in that brain area (e.g., striatum) necessarily involves the presence of the process X (ibid.). Obviously, a specific brain region can be activated by more than one mental process (e.g., the amygdala can be active in both aversive responses and memory process) (Ariely and Berns 2010). Hence, reverse inference may lead to false conclusions and it can be problematic if the central findings and contributions of the paper are built on reverse inference (Plassman et al. 2012). For instance, Schaefer and Rotte (2007), using fMRI, investigated whether favorableness for a brand affects predicted value signals in the striatum. They hypothesized an increased activity in reward-related areas for favorite brand, specifically for sport or luxury that were associated, in previous studies (Erk et al. 2002), with wealth and social dominance modulate the reward circuitry. Results showed that activity in the striatum for favorite brands that positively correlated with sports and luxury characteristics (high social status), but negatively with other brands car, such as small cars (low social status). Authors argued that exposure to favorite branded car associated with high social status induces increased activity in the striatum. In the case at hand, authors used reverse inference because they asserted that the increased brain activity in the striatum for favorite brands (brand association for high social vs low social status) infer a mental process (a pleasurable experience) associated with reward mechanisms.

On the other hand, few researchers in Neuroeconomics and Consumer Neuroscience have argued that reverse inference is a fundamentally important research tool, especially in these fields where the underlying mental processes may be less well understood (Ariely and Berns 2010; Poldrack 2011; Young and Saxe 2009). In fact, reverse inference can be very useful in specific experimental task setting in consideration and discarding unsupported mental processes (Ariely and Berns 2010). For instance, when the number of interpretations and uncertainty remain too high. Reverse reference can be used to generate useful hypotheses for future studies (ibid.). However, according to Poldrack (2011) reverse inference is practiced too often in the literature.

2. Consumer Neuroscience studies apply psychological methods and neuroimaging tools in order to prove that a given physiological measure or neural process (e.g., ERP component) reflects a specific psychological process. The problem indeed arises from the fact that researchers investigate the neural measure of a given process precisely because they do not totally understand the process (Luck and Kappenman 2011). Researchers try to use the neural measure to study the process itself (ibid.). This method is defined as forward inference. Forward inference can be defined as the use of different patterns of brain activity to distinguish between competing cognitive theories (Henson 2006). Hence if the designed experimental conditions differ in the manifestation of a cognitive process according to one theory, but not according to another, then the observation of distinct patterns of brain activity associated with those conditions establishes evidence in favor of the first theory (ibid.).

   The main idea is that if Theory 1 assumes that the same cognitive process can underlie two different experimental conditions, instead Theory 2 assumes that the conditions differ in terms of at least one cognitive process; then Theory 2 will be supported if patterns of brain activity differ between the two conditions (Heit 2014). Forward inference depends on the assumption that there is at least one connection between cognitive processes and brain areas. Hence, the same cognitive process cannot be supported by different brain regions within the experimental comparison of interest (ibid.). However, Theory 1 can be supported by null results, while Theory 2 could potentially be supported numerous differences (ibid.). Also, forward inferences are Theory-dependent (Henson 2006). Theories 1 and 2 may both be incorrect, and some alternative accounts such as Theory 3 may be correct. If that alternative is not considered by the researcher, then forward inferences based on theories 1 and 2 will be misleading (ibid.). For instance, Henson explained forward inference with a neuroimaging test of "single-process" versus "dual-process" theories of recognition memory (Zubicaray 2012). Overall, multiple brain regions are likely to contribute different types of information during memory retrieval. Henson et al. (1999) used fMRI to compare brain activity for items that subjects said they remembered with that for items that subjects said they just knew. According to single-process models, the two judgments (Remember and Know) differ in regards to the strength of memory for an item. Instead, in dual-process models, the two judgments differ due to two distinct forms of memory (e.g., recollection and familiarity). Henson et al. (1999) found an increased activity in the posterior cingulate for Remember than Know judgments, while the right lateral frontal cortex was more active for

Know than Remember judgments. However, authors did not report in the paper that there was a significant interaction between the two regions and the two types of judgment (Henson 2006). In fact, both regions were active for either Remember or Know judgments relative to the new unstudied words (ibid.). These findings match the criteria for a qualitative difference in brain activity (ibid.). This observation of a qualitative, rather than simply quantitative, difference in brain activity for Remember versus Know judgments would appear to favor dual-process over single-process models of recognition memory and hence constitutes a forward inference (ibid.).

3. Consumer Neuroscience experiments are usually characterized by a small sample size. According to Plassman et al. (2012), the majority of neuroscience experiments includes a sample of 20–30 participants. Moreover, neuroscience experiments often use within-subject designs to study the same questions. Hence, Plassman et al. argued that the number of participants is not necessarily small if we consider that neuroscience data involve repeated designs and are often aggregated across multiple repetitions of the stimuli. In addition, it is becoming increasingly common to replicate findings from fMRI studies using follow-up studies (Plassman et al. 2012). However, most of the Consumer Neuroscience experiments do not follow these criteria. In fact, experiments published in less important Journals, had even a smaller sample (e.g., eight participants). The average number of participants in these studies was less than 20. Moreover, most of the experiments analyzed did not use within-subject design.

   Experiments that employ within-subject design usually results in greater effectiveness and efficiency compared to experiment that employ one condition (Koschate-Fischer and Schandelmeier 2014). In fact, within-subject design requires fewer participants (efficiency bonus), and second, the influence of participants' characteristics (e.g., age) on the dependent variable is completely eliminated.

   Moreover, small sample (e.g., underpowered) studies can increase the number of Type I and Type II errors (Aarts et al. 2014; Plassman et al. 2012; Rumsey 2015). In fact, a small sample can be more subjects to different problems such as bias of the results, overestimates of effect size and low reproducibility of results (Button et al. 2013; Plassman et al. 2012). However, data aggregation across investigators and multiple studies might be an effective way to enhance sample size and power and address the issue of false positives (Plassman et al. 2012).

4. The use of statistic methods is essential in numerous disciplines.

Hence, statistical methods are applied also in Consumer Neuroscience research. Mostly, Consumer Neuroscience research usually relies on *null hypothesis significance testing* (NHST)[xiv] (Cumming 2013). The hypothesis-testing is a conjecture that allows researchers to evaluate claims[xv] about a population (e.g., regular customers) (Bluman 2007). Hypothesis tests are used to test the validity of a claim that is made about a population (Rumsey 2015). Once the hypothesis is defined, it is possible to compute the test value.

In the hypothesis-testing situation, there are four possible outcomes (Bluman 2007). There are two possibilities for a correct decision (e.g., reject the null hypothesis when it is false) and two possibilities for an incorrect decision (e.g., Type I and Type II errors) (ibid.). The incorrect decisions occur if researchers inappropriately accept or reject the null hypothesis. A Type I error (e.g., false alarms) occurs if the null hypothesis is rejected when it is true, hence researchers conclude that there is a difference when there is none (Beukelman and Brunner 2016; Rumsey 2015). For instance, music is known to influence brain activity, thus a researcher wants to test if playing fast music during shopping increase the number of purchase. It is possible that listening to music might not significantly change the number of purchases of all the users in the population but it might change the purchase, by change, of the subjects in the sample. In this case, if the researcher rejects the null hypothesis when it is true, thus he/she will commit a Type I error. Type I error can be reduced by setting a low cut-off probability (significant level) to reject the null hypothesis, by convention, this is typically set to 5% or 1% (Beukelman and Brunner 2016; Rumsey 2015).

Type II errors is the probability of not rejecting the null hypothesis when it is false, hence researchers conclude that there is no difference when there is a difference (Beukelman and Brunner 2016; Bluman 2007). For instance, using fMRI, a researcher wants to test if the view of famous brands (e.g, Coca Cola) changes individual preferences and the brain activity (e.g., in the dlPFC). The famous brand might not change the brain activity of the subjects in the sample, however it might cause a significant increase or decrease in the brain activity of observers for a more general population. Type II errors can be

[xiv]The null hypothesis significance testing remains the standard inferential tool in numerous disciplines of cognitive science (Cumming 2013; Masson 2011). However, the last decade has seen an increase in the use of the Bayesian approach to model comparison and estimation (Masson 2011; Nathoo and Masson 2016).

[xv]This claim is called the null hypothesis. *"The null hypothesis (H0), is a statistical hypothesis that states that there is no difference between a parameter and a specific value, or there is no difference between a parameter and a specific value"* (Bluman 2007)

reduced by selecting a large sample size (e.g., >30) to ensure that any differences or departures that really exist cannot be missed (Rumsey 2015). Type I and II errors are considered to be mutually exclusive (DePoy and Gitlin 2016). However, decreasing the risk of a Type I error, it might increase the chances of a Type II error (ibid.).

Overall, a Type I error is considered to be more serious as the researcher is claiming a significant relationship or outcome when there is none (ibid.). In fact, it implies that other researchers may act on that finding. However, failure to recognize a positive effect from an intervention, a Type II error, can also have serious consequences for professional practice (ibid.). For instance, on the basis of an inaccurate finding, a valuable and productive intervention may be discarded (ibid.).

Testing the hypothesis implies to find the p-value, a number between 0 and 1 that can be interpreted in three ways (Rumsey 2015). However, Consumer Neuroscience literature review points out that a small number of studies did not report the p-value. Reporting p-values help researchers to determine the statistically significance of the results of an experiment. Small p-values add to the conviction that there is an effect. Even though p-values do not measure the probability that the studied hypothesis is true, it helps to determine the significance of an experiment results and its validity (Rumsey 2015; Wasserstein and Lazar 2016). Moreover, p-values can indicate how incompatible the data are with a specified statistical model (Wasserstein and Lazar 2016).

5. Marginal Utility (MU) theory[xvi] plays an important factor in the marketing research, and in particular, in predicting consumer's choices and satisfaction, similar to temperature for the predictions in physical phenomena. However, literature review shows that there is no use of Marginal Utility theory in Consumer Neuroscience research. Using marginal utility theory in Consumer Neuroscience can help researchers in several ways. Marginal Utility is an essential economic parameter that measures satisfaction, one of the most important elements of the consumer decision. In fact, customers' satisfaction is often seen as the key to a company's success and long-term competitiveness (Higgins et al. 2014). For instance, it is one of the strong determinants of consumers repurchase intention (ibid.). Consumer repurchase can be defined as the individual judgment about buying

[xvi]The Marginal Utility can be defined as the change in utility associated with a small change for one of the goods consumed when keeping the quantity of the other good fixed (Levin and Milgrom 2004).

again a designated service from the same company, taking into accounts his or her current situation and likely circumstances (Higgins et al. 2014). Measuring MU benefits researchers to understand if products and services meet or exceed customers' expectations. Moreover, it can also be used to reduce customer churn (Gustafsson et al. 2005). It gives us an indication of how likely a customer will make a purchase in the future. Measuring and tracking customer's satisfaction aids companies in improving their business strategy and increasing the overall quality of customer service. From an academic perspective, it can be used to improve and extend previous marketing theories and Neuromarketing studies, such as Plassman et al. (2007), on customer's loyalty. It is also a good parameter that allows to analyze how the consumers react to changes in the price. In fact, researchers might measure changes in customer total satisfaction, reducing the quantity of a specific product, when the MU of the product is less than its price. Moreover, if we consider that MU measures the rate of change in utility when the quantity of a good consumed varies (Karaivanov 2012). This parameter can be used in Consumer Neuroscience research to understand and evaluate how customers compare product.

Overall, Consumer neuroscience contributes to a systematic understanding of consumer behavior and decision-making process. The number of Neuromarketing studies has rapidly grown in the past decade, and consequentially the number of methodological developments and innovations that represent significant markers of advancement. However, the above said limitations can reduce the quality work and scientific knowledge in this field. Researchers should address issues such as reverse and forward inference, lack of reliability due to the small sample sizes, p-values and use of Marginal Utility theory. Consumer Neuroscience should focus on an interdisciplinary approach for providing a general overview of consumers' decision-making processes and behaviors.

5.5 Summary

Consumer Neuroscience research studies the brain areas involved during various stages of product quality evaluation. Specifically, studies investigate how individuals evaluate product extrinsic cues and how these cues influence and effect consumer behavior and decision making process. Three important extrinsic cues, such as price, brand and aesthetic have been studied in Consumer Neuroscience research.

Firstly, Consumer Neuroscience studies investigate the effect of price on experienced quality of consumers, particularly how price enhance or subvert these experience, misleading consumers by creating an environment of positive or negative expectations. Studies showed that usually low price active brain areas involved in reward mechanisms. On the other hand, high price active brain areas are usually associated with negative emotions.

Secondly, Consumer Neuroscience studies neural processes involved with brand decisions. Consumer Neuroscience investigates how consumers predict, experience and remember brands. Studies found a correlation between the specific brain areas (e.g., striatum, dlPFC) and the level of predicted brand value, experienced brand value, brand loyalty.

Thirdly, Consumer Neuroscience studies the effect of appearance on individual preferences and product quality. Numerous studies examined how color, shape, proportions can influence participants' perception of the same product. Other studies investigated the differences in the brain areas involved during product evaluation with different aesthetics components (e.g., luxury, eco-friendly labels)

Different tools, such as fMRI, EEG, eye-tracking, are used to analyze the effect of extrinsic cues on product evaluation. In particular, EEG is a useful tool for detecting the effect of external cues on consumer' preferences and choices. Measuring the electrical brain activity of consumers help to determine the level of attention, preference, familiarity, pleasantness or unpleasantness that an individual has for a product or its peculiar characteristic.

These findings suggest that Consumer Neuroscience can improve our understanding of decision-making process and consumer behavior during product evaluation. Moreover, Consumer Neuroscience can help researchers to define the gradient of influence of product external cues and consequentially support companies to create optimal strategies for their customer segments. However, Consumer Neuroscience studies present few problems and limitations that researchers should carefully address. Five major limitations were identified. Firstly, two limitations concern the use of reverse inference and forward inference. The size sample and the report of statistical findings are also major issue in this field of study. Finally, the use of Marginal Utility as a parameter in Consumer Neuroscience research.

CHAPTER

6

FOOD AND DRINKS: WHAT PEOPLE LIKE AND WHAT PEOPLE WANT

6.1 Brain reactions to food

Understanding the influential forces in consumer behavior requires to address how consumers perceive and/or interpret quality and pleasantness. According to previous studies (Aaker and Bie 1993; Inscha and McBride 2004; Jobber 2007; Kotler and Keller 2006, 2012; Zeithaml 1988), pleasure (predicted and experienced value, see Section 3.5.2) and perceived quality associated with a particular product depend both on its attributes and the attributes of the consumers themselves (Plassman et al. 2008; Venkatraman et al. 2012). Factors such as culture, age, social class or simply the mood of the person generate different buying behaviors. Certainly, this applies to all kinds of product. However, the Fast-Moving Consumer Goods (FMCG) is a particularly prolific area for researching the influence of subjective experiences and product cues on quality and pleasantness. In fact, the consumption of food or drinks is a psychical need (see Maslow piramid in Section 2.1) that triggers a barrage of stimuli (Witt 2001; Zurawicki 2010). For instance, eating a chocolate bar stimulates different senses such as taste (flavor: sweet or bitter), vision (related to the product itself, brand

and packaging), touch (the texture) but also the auditory sensation (the sound of biting, or opening the packaging) (Zurawicki 2010). Moreover, effects of price, nutritional information on food packaging can modify and, in extreme cases, even override the mere physical sensory consumption experience (Plassmann and Weber 2015). Altering a product information or the way a product is presented influences consumer's expectations and level of enjoyment experienced (Lucchiari and Pravettoni 2012; Plassmann and Weber 2015; Zurawicki 2010).

Traditional introspection and questionnaire seem not well suited to detect unconscious reactions or attitudes (Zurawicki 2010). Neuroimaging tools can add significant predictive and explanatory power to traditional measurements in marketing research (Lusk et al. 2015).

Hence, a growing area of Consumer Neuroscience research relates to the study of food and drink consumption. Numerous experiments have been conducted in order to uncover brain mechanisms corresponding to consumer's choice, olfactory and gustatory sensation during food and drink consumption. Precisely, researchers study:

1. the physiological aspects of consumption experience (e.g., craving, time choice) and preferences
2. the effect of brand, aesthetic and nutritional information on consumer choices
3. the effect of price, label and packaging on smell and taste

6.1.1 Consumption experience and preferences

Studies tried to determine the main physiological aspects of the consumption experience, the psychological associations that preface or follow the consumption, how these associations modulate consumer's preference and the neural mechanisms underlying the associations and preferences.

One of the first experiments in O'Doherty et al. (2006) illustrated how food choice results from a predictive representation of the subjective value of the associated food stimulus. The goal was to investigating learning associations between arbitrary visual stimuli and subsequent delivery of one food flavor (O'Doherty et al. 2006; Zurawicki 2010). On the basis of individual preferences for four different food "flavors" (black- currant juice, melon juice, grapefruit juice, carrot juice) and a tasteless and odorless control solution, authors determined overall preference ranks for each flavor. Successively, authors used fMRI to scan subjects during which the presentation of five different visual cues, each of which was reliably associated with the subsequent presentation (500 ms later) of one of the five specific foods. The results showed that during the experiment visual cues became the predictors of the participants' drink preferences (O'Doherty et al. 2006; Zurawicki 2010). This was also confirmed through fMRI data. In fact, the greater the activity in the amygdala and the OFC (related to reward and reward-related learning) in response to a predictive cues, the more the associated beverage was preferred (O'Doherty et al. 2006; Zurawicki 2010).

Another study conducted by Hutcherson et al. (2012) investigated how people can influence their craving for food using "cognitive regulation". During the experiment three different conditions (Distance, Natural and Indulge) were used (Hutcherson et al. 2012). Each condition was indicated before the food appeared. In one condition (Distance), participants were asked to use any strategy they needed to decrease their craving for the food (ibid.). Instead, on Indulge condition, they were asked to increase their craving for food. In Natural condition, they were asked to allow whatever thoughts and feelings came naturally (ibid.). Using fMRI, authors found that cognitive regulation affected two regions: vmPFC and dlPFC. Neuroimaging data showed that two distinct regulatory mechanisms were used: value modulation, which operates by changing the values assigned to foods in the vmPFC and the dlPFC at the time of choice, and behavioral control modulation, which operates by changing the relative influence of the vmPFC and dlPFC value signals on the action selection process used during the decision-making process (ibid.). However, during value modulation, dlPFC and vmPFC were sensitive in a different way. In fact, in value modulation there was a decrease in the dlPFC activity and an increase in the vmPFC activity (ibid.). During behavioral control modulation, the vmPFC contribution to behavior decreased over time to near zero in Distance condition, while dlPFC contribution increased (ibid.).

Finally, a more recent study by Horska and Bercik (2014) examined the effect of lighting on the purchasing decisions of consumers and the perception of lighting on food consumption. Using EEG, authors were able to establish consumer preferences for different lighting conditions (color temperature, color rendering index) for the selected type of food. The results showed that various types of lighting change alpha and beta activity, for conscious and subconscious reactions (Horska and Bercik 2014). In fact, the right hemisphere of the human brain is more involved (ibid.). These findings show that light is an essential marketing tool that can positively influence and encourage consumers purchases and preferences.

These studies suggest that value and individual preferences play an important role in cognitive and behavioral mechanisms. Value and pleasure associated with food raises the issue of how a food image and its actual consumption reinforce the experience (Zurawicki 2010). Furthermore,

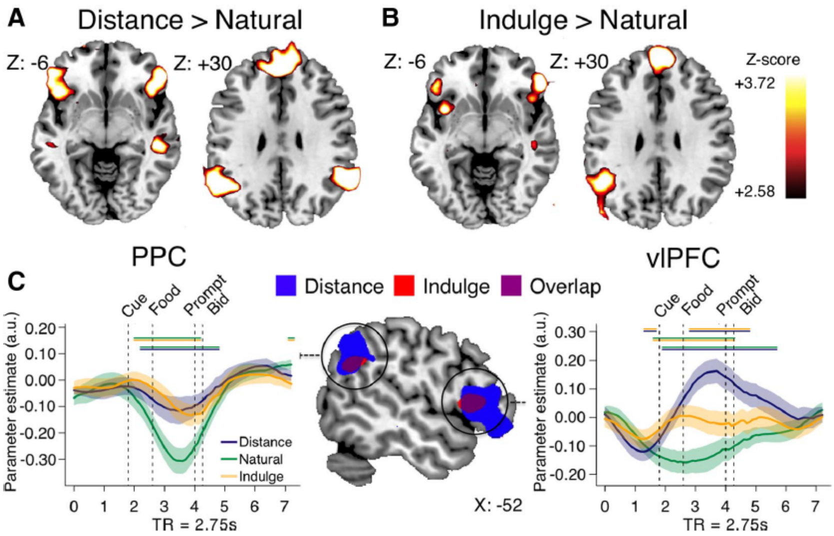


Figure 6.1: *Regions implementing cognitive regulation. From Hutcherson et al. (2012)*

environment and product display can influence consumer choice and preferences.

6.1.2 Food choice and extrinsic cues

Every day customers choose between a variety of different food items (Linder et al. 2010). Mostly, when we buy, we quickly manage to make choices that appear best for us. Individuals are able to integrate all item-related information and properties into an apparently *"plausible decision"* (ibid.). However, *Can we be really sure that what we buy is what we want? Are we absolutely sure that our choices are not biased?*. Making a choice is a difficult process, especially when numerous factors can influence it. As studies have proved our food choices and preferences can be influenced by external product cues, such as label, price, brand, nutritional information (Bruce et al. 2012). For instance, comparing identical food and beverage, one labeled McDonald's and the other one unbranded, children significantly preferred the first one (Robinson et al. 2007). However, it is still unclear how external cues influence consumer decision-making.

The key approach to study of the consumer's choices, in the food sector, is to reveal the brain mechanisms engaged during the judgment of product features. Recent contributions have investigated the neural antecedents of such choice, particularly as they relate to price, brand and aesthetics (label and packaging) (Khushaba et al. 2013; Linder et al. 2010; Lusk et al. 2015; Plassmann and Weber 2015; Van der Laan et al. 2012;

Wolfe et al. 2016; Zurawicki 2010).

In particular, fMRI studies showed that preferences for drinks and/or anticipation of a food reward result in an increased neural activity in different brain regions (Linder et al. 2010). For instance, the ventral striatum, as part of the reward system (see Section 4.2 and 3.5.1), has been found active during the exposure to high-calorie foods compared to low-calorie foods (Linder et al. 2010; Stoeckel et al. 2008), anticipation of a sweet food (O'Doherty et al. 2003), and perception of appetizing food (Beaver et al. 2006). These findings suggest that activation in this brain region shows preferences for rerwarding food stimuli. Similarly, a Consumer Neuroscience study conducted by Linder et al. (2010) showed increased activity in the ventral striatum for organic label food compared to conventionally labeled food. These findings suggest that organic labels are associated with positive anticipations leading to food affection which is processed at the same rewarding level as for high-calorie foods (Linder et al. 2010; Stoeckel et al. 2008). Authors found also activation in the dlPFC in the comparison between organic and conventional food. Similarly Laan et al. (2011) found that activation in the bilateral striatum respond to preferred food packages. In fact, comparison between chosen abd not-chosen packages activated several regions in response to chosen packages, among which the bilateral striatum (Laan et al. 2011). Moreover, results showed that food choices could be predicted with an accuracy of up to 61.2 per cent by activation patterns in brain regions previously found to be involved in healthy food choices (superior frontal gyrus) and visual processing (middle occipital gyrus) (ibid.). Plassmann and Weber (2015) collected data from three experiments to investigate neural correlates of MPE in food using fMRI. Authors investigated how the price of wines (Plassman et al. 2008), willingness to pay (Plassman et al. 2008; Plassmann et al. 2010; Plassmann and Weber 2015) and different types of labels (Lee et al. 2013) influenced behavioral and neural measures of experienced utility and pleasantness. Authors found increased gray matter volume in the striatum and prefrontal structures (i.e., the lateral orbitofrontal, the lateral prefrontal, and, the dmPFC), the more responsive participants are to MPEs (Plassmann and Weber 2015).

Activation in dlPFC is related to different cognitive functions such as working memory (Lusk et al. 2015), two famous brands (McClure et al. 2004), comparison between organic and conventional food (Linder et al. 2010), weighing the cost and benefits of alternative choices (Hutcherson et al. 2012), cognitive regulation and craving for food (ibid.), preferences to logos[i] (Plassman et al. 2012), MPE (Plassmann and Weber 2015). Several

[i]However, Bruce et al. (2012) found that preferences for logos food (e.g., McDonald's, Lucky CharmsTM leprechaun, Rice KrispiesTM) in children were associated with

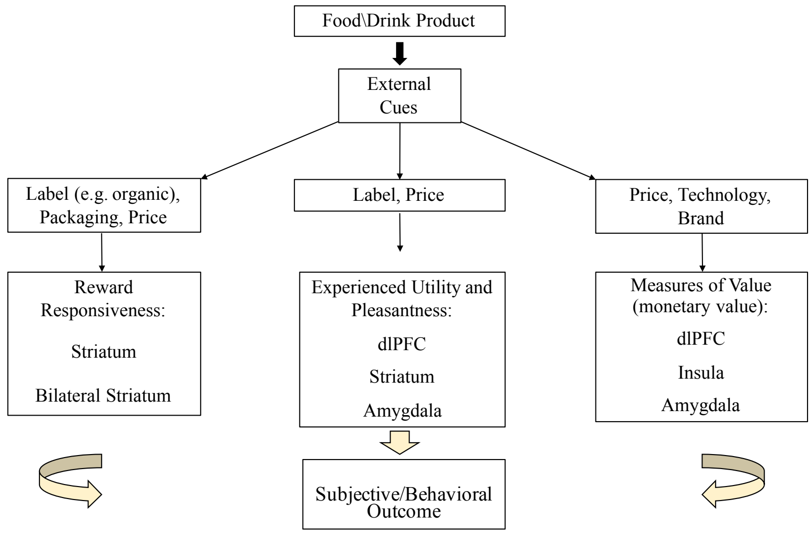


Figure 6.2: *The image shows how external product cues inflence cognitive processes and brain region involved.*

studies have also shown that activity in some parts of dlPFC is correlated with various measures of value during perceptual and economic decision-making tasks (Plassmann et al. 2010). In fact, Lusk et al. (2015) found evidence that the dlPFC is involved in resolving tradeoffs among competing choices in the decision-making process. Authors found a greater activation in this region during the comparison between two milk jugs in price condition (products differenced only with respect to price) and technology condition (products differenced in use of controversial food technology such as cloning or growth hormones) (Lusk et al. 2015). The experiment results showed that the dlPFC is also involved in predicted choice. Subjects who showed a greater activation in the dlPFC in the technology condition, were less likely to choose the higher-price for non-hormone and non-cloned option (ibid.). Results suggest that also activation in the amygdala and the insula might predict food choices involving money and controversial technology (ibid.).

The activation of the amygdala is associated with preferences for brands (Dalli et al. 2006) and evaluation of a particular product and experience associated with it (Hubert and Kenning 2008). Grabenhorst et al. (2013) found also increased activation in the amygdala during the choice of health-related food properties, the strength of this bias predicted behavioral shifts towards healthier choices. These findings suggest that such

increased activation in orbitofrontal cortex and inferior prefrontal cortex. These brain regions in children are associated with motivation (Bruce et al. 2012).

labels engaged an "emotional" brain area that is connect to taste pleasantness (Grabenhorst et al. 2013).

Insula activity is usually associated with monetary value (FitzGerald et al. 2009; Lusk et al. 2015).

Finally, EEG and eye tracking can also be useful tools to investigated of food preferences. Numerous Consumer Neuroscience studies examine changes in frequency bands activity in response to prefabricated marketing stimuli (Apriliaanty et al. 2016; Balconi et al. 2014; Boksem and Smidts 2015; Khushaba et al. 2013; Park et al. 2015; Rakshit and Lahiri 2016; Rocha et al. 2013). Khushaba et al. (2013) investigated (1) how participants choose their preferred crackers described by shape, flavor and topping; (2) how the importance of measuring different cracker features in order to improve the product design. Results illustrate a clear phase synchronization between the left and right frontal and occipital regions indicating interhemispheric communications during the chosen task (Khushaba et al. 2013). Moreover, there was a clear and significant change in the EEG power spectral activities taking a place mainly in the frontal (delta, alpha and, beta), temporal (alpha, beta, gamma), and occipital (theta, alpha and, beta) regions when participants chose their preferred crackers (ibid.). Results showed that cracker's flavors and toppings were considered really important factor in the buying decision process compared to the crackers' shapes (ibid.).

Consumer Neuroscience research and neuroimaging data offer a valid and scientific method to understand food choice and preferences better. In particular, experiments in this field can help to explain brain region and cognitive processes involved in the assessment and evaluation of different food product cues.

6.1.3 Taste and smell

Taste and olfaction are both very important senses in separating the undesirable, even toxic, substances from those which are healthy and useful (Moio 2016; Peng et al. 2015; Zurawicki 2010). Hence, taste and olfaction help humans to find food (proteins, fat and salts) that are necessary to survive as well as to avoid harmful substances (Moio 2016).

The sense of smell is the oldest and most important of human senses (Zurawicki 2010). The process of smelling is an interpretation of the chemical information of the environment through our sensory system (Barwich 2017; Dey and Stowers 2016). Humans are poor at odor object identification compared to other animals (Krusemark et al. 2013). For instance, dogs are 10.000 times more sensitive to odors than humans (Zurawicki 2010). However, humans have 40 million odorant receptors and each individual has a unique set of genetic variations that lead to variation in olfactory perception (Mainland et al. 2014). In general humans can recognize up to 10.000 different odors (Zurawicki 2010). Unlike with other senses, olfactory neuroanatomy is related, through extensive reciprocal axonal connections, with primary emotion brain areas such as the amygdala, the hippocampus, and the orbitofrontal cortex (OFC) (Krusemark et al. 2013). Indeed, the central organ of olfactory experience is not the nose but the brain (Barwich 2017). Bypassing the primary olfactory cortex, olfactory stimulation can directly activate amygdala neurons and arriving at the secondary olfactory cortex situated in the middle of the OFC (Krusemark et al. 2013). The process of smelling has been associated with primitive needs concerning reward, threat, homeostasis and emotions for a long time (ibid.). For instance, Raudenbush et al. (2009) found that peppermint and cinnamon scent can make drivers more focused and less stressed.

The olfaction and taste are both involved in the detection of chemicals in the environment (Zurawicki 2010). Specifically, the perception of taste, and interpretation of chemical substances, takes place through the taste receptors that are distributed on the tongue and throughout the palate epithelium and soft palate within several specialized structures called taste buds (Beauchamp and Bartoshuk 1997; Zurawicki 2010). Taste buds are located in papillae (tiny projection that justify the tongue appearance) (Yucel et al. 2015; Zurawicki 2010). Taste buds consist of three separate developments of the same cell line: taste cell (Zurawicki 2010). When the food enters in contact with the tongue, tastants[ii] dissolve in the saliva and contact the taste cell (Yucel et al. 2015; Zurawicki 2010). The interaction between proteins and taste receptors produces electrical changes in the taste cells which send chemicals signals and consequentially the impulses to the brain (Zurawicki 2010). The impulse is carried to the brain by the activity in peripheral taste nerves (Beauchamp and Bartoshuk 1997). This impulse is extremely fast: only 15 milliseconds (Moio 2016). The neural coding of taste information is usually related to knowledge chemical sensitivities and how they are distributed and organized among peripheral and central gustatory neurons (Beauchamp and Bartoshuk 1997). The chemical stimulation of taste receptors produces taste sensations, however, it also provides critical input for diverse somatic and visceral responses related to food ingestion and rejection (ibid.).

The chemical signals sent from the taste cell and buds to the brain are interpreted in different ways. Precisely the brain interprets five basic tastes: salty, sour, sweet, bitter and umami (*fifth taste*) (De Araujo et al. 2003; Jacquin-Piques et al. 2016; Moio 2016; Zurawicki 2010). Salty taste is produced by the ionic salt, a critical cation necessary for survival and an

[ii] Any chemical that stimulates the sensory cells in a taste bud.

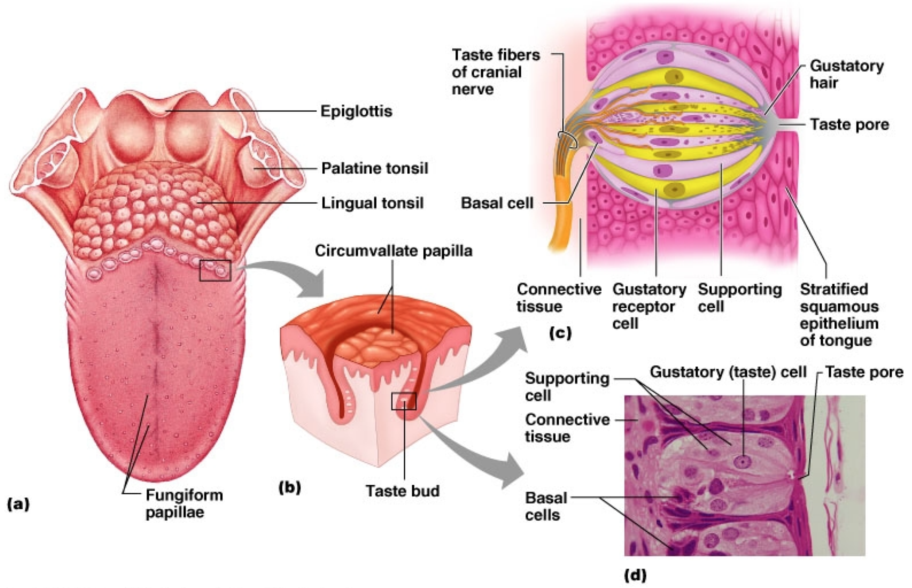


Figure 6.3: *The image shows the anatomy of the tongue. From Benjamin Cummings (2004)*

appetitive taste stimulus that adds to the flavor of many foods, including meats, vegetables and snacks (Lemon 2015; Zurawicki 2010). Sweet, bitter and umami represent the most salient sensory percepts (Peng et al. 2015). In fact, sweet and amino acid (umami) receptors allow the identification of nutritionally rich food sources, while bitter receptors warn against the intake of potentially noxious and toxic chemicals (Moio 2016; Peng et al. 2015; Zhang et al. 2003). In particular, umami taste stimuli, that means "flavorful" in Japanese, is produced by the glutamate ion and also by some ribonucleotides (including inosine and guanosine nucleotides) (De Araujo et al. 2003; Moio 2016). It can be found in a diversity of food like fish, meats, milk and, some vegetables that contain numerous proteins (Moio 2016). Acid taste is generated by hydrogen ions (Zurawicki 2010). The more a food contains hydrogen ions, the sourer and more intense the sensation will be (e.g., lemon) (ibid.).

The food desire and choice result primarily from our senses such as vision, smell and taste. Nevertheless, taste preferences in humans are influenced by conscious (e.g., learning) and unconscious factors (Lemon 2015; O'Doherty et al. 2006; Zurawicki 2010). Hence, food preferences are jointly determined by reflect characteristics of the stimulus impinging on the perceiver's sensory organs (bottom-up processes), and people's beliefs, desires, and expectations (top-down processes) (Lee et al. 2006). In fact, the sense of taste can be developed with experience and it varies widely according to cultures, lifestyle, habits, etc. (Yucel et al. 2015). In the same way, taste can be easily manipulated to make food more desirable. Studies showed that taste is extremely influenced by personal expectations and external marketing cues (brand, label) (Aaker and Bie 1977; Lee et al. 2006; Olson and Jacoby 1972; Robinson et al. 2007). Hence, the domain of food and drinks provides a particularly fertile testing ground for marketing research (Lee et al. 2006). In fact, managers are more frequently focusing on experiential and sensory aspects (Biswas et al. 2014). However, little is known about the neural mechanisms related to food perception in marketing research. Consumer Neuroscience literature offers a good understanding of taste perception and brain responses.

The framework of some of the taste studies can be illustrated with reference to one of most famous experiments by McClure et al. (2004). Using fMRI, authors demonstrated a different modulation of the dlPFC during the evaluation of a famous brand drink (Coca-Cola) in comparison to a drink without any label. In fact, Coke was rated higher when consumed from a cup bearing the brand logo rather than from an unmarked cup (McClure et al. 2004). The results showed the influence of brand on subjective experiences and taste.

As previous studies demonstrated EEG can be used to study the human sense of taste (Crouzet et al. 2015; Iannilli et al. 2015; Iannilli et al. 2014; Jacquin-Piques et al. 2016). In fact, a high time resolution is required to measure the latency of neuronal activity in the primary and secondary gustatory cortex, in response to a taste stimulus reliably (Gemousakakis et al. 2013; Jacquin-Piques et al. 2016; Onoda et al. 2005). Using EEG, Lucchiari and Pravettoni (2012) examined the influence of mineral water brands on taste. Results showed that tasting the favorite water brand modulated brain activity in a very different ways compared to tasting the same water labeled with another brand (Lucchiari and Pravettoni 2012). Results showed that testing a well-known brand caused changes in beta band activity, instead less known brand were associated with increased theta band activity. The results suggest that beta activity is modulated by the experience of pleasure associated to a favorite brand (ibid.). Instead, theta activity seems to reflect the lack of this experience. Changes in theta band activity was associated with unknown brands (ibid.). However, it is not clear how authors associated both theta and beta bands to reward processing. Hence, it is not clear how it possible to relate increased theta band activity to lack of pleasantness during the taste of an unknown water brands.

A more recent Neuromarketing experiment studied the influence of coffee brand on taste. In Yucel et al. (2015) five different coffee brands were tasted (blind-taste) meanwhile subjects' brain activity was recorded by EEG. Firstly, individual preferences for the coffee brands were also de-

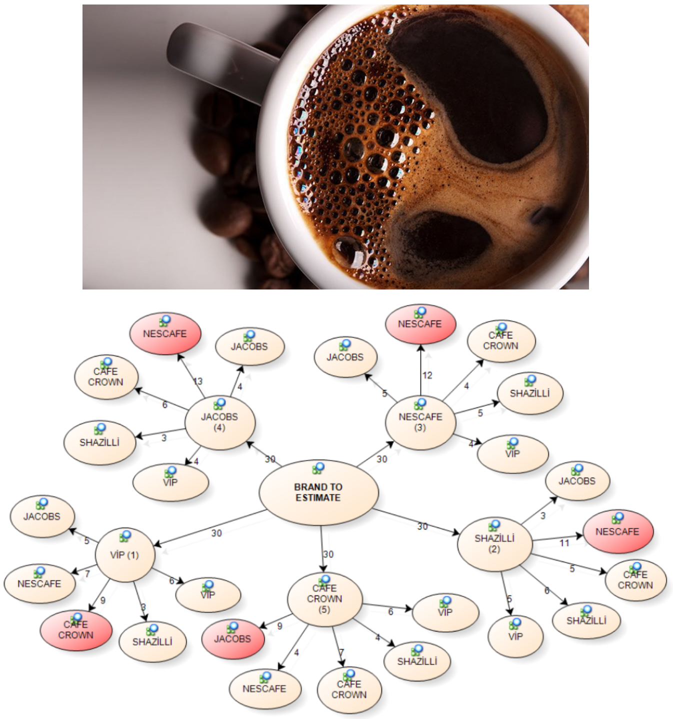


Figure 6.4: *The image shows the coffee brand selected in Yucel et al. experiment.*

termined by questionnaire and association task (the first brand associated with the word "Coffee"). Secondly, subjects' preferences were compared with EEG output. Results showed that theta band activity was related to subjects' preference for a brand. In fact, the intake of the preferred coffee brand had a relaxing effect on subjects. Instead, tasting the least preferred coffee generated stress and increase in alpha band activity.

These experiments show that decoding neural mechanisms for taste has implications for understanding how sensory factors are involved with intake behavior and guide nutritional status in humans (Lemon 2015). Consumer Neuroscience research can help to understand how brains process food tasting as form of fundamental physiological needs but also as source of pleasure.

6.2 Wine

The wine trends analysis 2016 show that world wine production is estimated between 260 and 267 million hectoliters (*The Wine Institute* 2017). The European Union is the world's leader in wine production. In particular, Italy (48.8 mhl) confirms its place as the leading world producer, followed by France (41.9 mhl) and Spain (37.8 mhl) (*International Organisation of Vine and Wine (OIV* 2016). USA production figures in 2015 (22.1 mhl) and reached an estimated retail value of $34.1 billion in 2016 (*International Organisation of Vine and Wine (OIV* 2016; *The Wine Institute* 2017). However, China has recently contributed most to trade growth and it is expected to replace the USA as the world's largest economy by 2030 in market exchange rate terms (*International Organisation of Vine and Wine (OIV* 2016). South Africa can be considered the 8th largest wine producer globally (ibid.).

Overall, wine sector is a profitable business. However, the competition is high and selling and promoting wine is a difficult task for wine companies. In fact, wine itself is a peculiar and complex product. Unlike other products, wine cannot be standardized. Wine is a "cultural good" (Moio 2016). In fact, wine essence and characteristics are strictly related to traditions, territory and production methods (ibid.). These characteristics lend a strong symbolic meaning to the wine.

The symbolic value of the wine depends on many different, although correlated, factors. In fact, this symbolic content is related to the sensory and non-sensory characteristics that a wine possesses, also known as quality (Thornton 2013). However, these characteristics are also strictly related to the territory where the wine is produced. Hence, each wine has a particular appearance, smell and taste that results from grape variety, vineyard location, vinicultural practice and possibly regional attributes

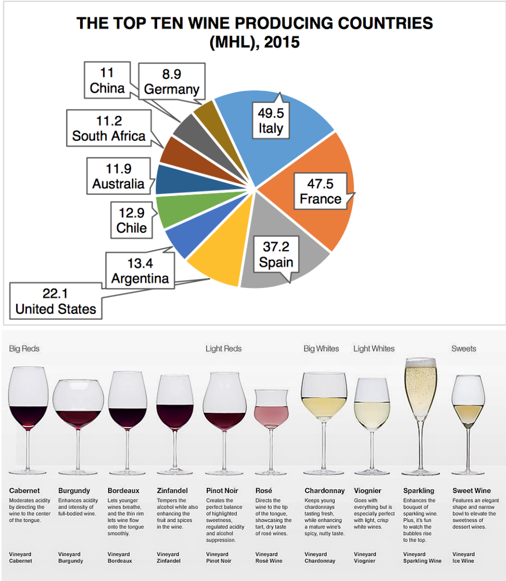


Figure 6.5: *The first image shows a pie chart of the top ten wine producing country in the world. From* International Organisation of Vine and Wine (OIV *2016. The second picture shows some different types of wine and their main organoleptic characteristics. From* Wine Blog Roll Italia *2014*

(Jackson 2017; Thornton 2013).

The controversial nature of wine quality makes it difficult to assess. As Maynard Amerine[iii] (1980) once said, wine quality is easier to detect than define (Jackson 2017). This is partially due to consumers' expertise and preference (subjective factor). On the other hand, wine quality, as well as food products, can only be assessed during consumption (experience attributes) (Louviere et al. 2015). Therefore, the ability of consumers to assess quality prior to purchase is severely impaired (ibid.). Consumers' buying behaviors, especially for inexperienced consumers, rely mostly on extrinsic cues in the assessment of wine quality.

Hence, in order to be successful, wine producers and companies need to address two major problems. First, these companies need to transfer both sensory (such as physiochemical, organoleptic characteristics) and no-sensory (prestige, context, regional attributes) wine knowledge to customers. For instance, information about wine, such as brand or producer name, region and country of origin, grape variety (mandatory for the old-

[iii]Maynard Amerine (1911–1998) was a pioneering researcher in the cultivation, fermentation, and sensory evaluation of wine.

world countries[iv]) and the alcoholic level, which is required by law[v], are usually displayed on the wine bottle. Second, they need to understand the changeable nature of what constitutes wine quality (Jackson 2017) studying how customers assess intrinsic and extrinsic wine characteristics.

6.2.1 Marketing of Wine: the effect of extrinsic cues

A growing body of Marketing research focuses on the influence of external attributes on quality perception during the wine tasting or the selection process (Festa et al. 2016; Jackson 2017; Mueller and Szolnoki 2010a,b; Russo 2015; Thornton 2013). Precisely, marketing studies analyzed how price (Chen and McCluskey 2016; Goldstein et al. 2008; Hollebeek et al. 2007; Mueller and Szolnoki 2010b), label (e.g., color, design) (Barwich 2017; Mueller and Szolnoki 2010b; Orth and Malkewitz 2008; Szolnoki et al. 2008), Country of Origin (COO) (Dean 2002; Skuras and Vakrou 2002), and producer characteristics/brand (Beverland 2000; Johnson and Bruwer 2007; Lockshin et al. 2000) influence consumer's choice and preferences.

However, other factors such as recommendations (e.g., friends, family, experts) can play an important role in consumer behavior (Dodd et al. 2005; Higgins et al. 2014; Jones and Dewald 2006). Frequently, wine consumption is a social statement, for instance, wine consumers in the U.S. are more likely to employ technology in their wine purchase decision, such as apps (Higgins et al. 2014). In restaurants, sommeliers influence wine sales (Jones and Dewald 2006). On average, customers ask a sommelier to provide wine recommendations 38 per cent of the time and they choose the sommeliers wine recommendations 42 per cent of the time (ibid.). Organic labels are also considered an influential factor in consumer's choice (Apaolaza et al. 2017; Bonn et al. 2016). In fact, consumers associate health benefits with organic wine (Apaolaza et al. 2017). It might explain the increasing success of "bio" wines in U.S. and especially Europe.

General trends in wine literature shows that it is possible to distinguish two different strategies to examine the effect of extrinsic cues (Mueller and Szolnoki 2010a). Firstly, some studies examined the impact of one single extrinsic cue on wine evaluation (ibid.). These studies have mostly focused on the positive or negative effect of the single attribute on perceived quality or buying behavior. Secondly, other studies focus on how consumers use extrinsic cues to form an opinion about product quality over the time, e.g. comparing "blind setting" (the information is not disclosed) and normal setting (the information is disclosed before the test) (Almen-

[iv] World countries of wine are Italy, France, Spain, and other European nations (Festa et al. 2016)

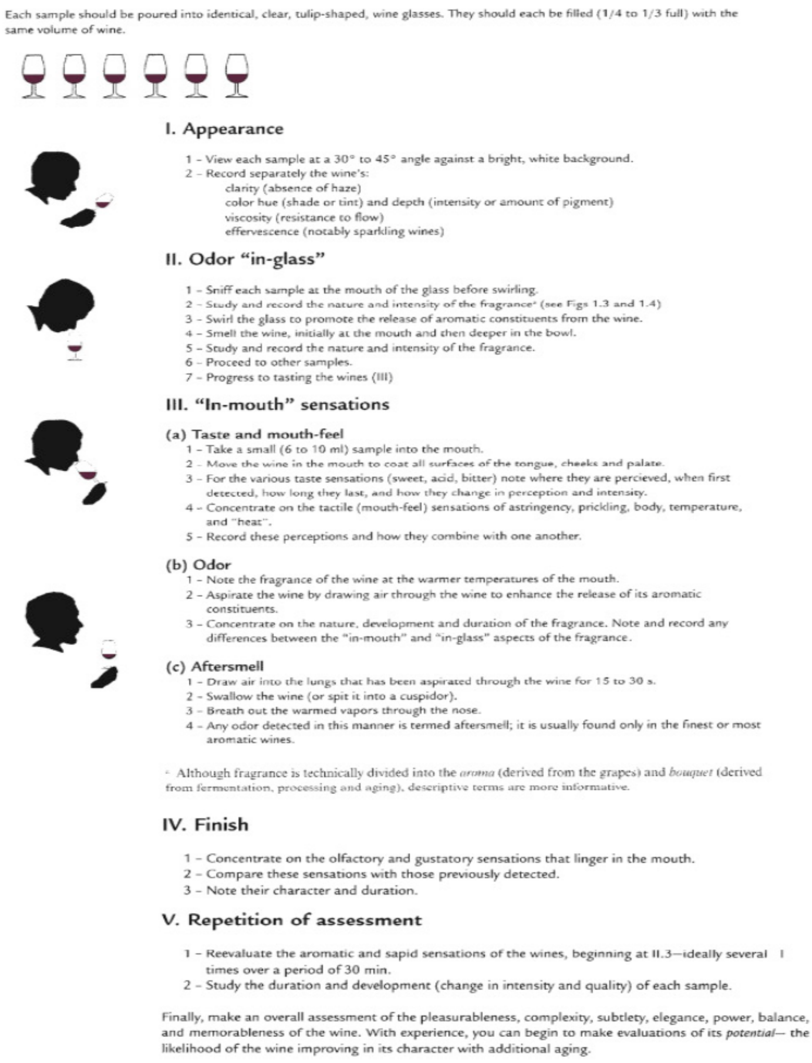
[v] New-world countries are USA, Chile, Argentina, South Africa, Australia and, New Zealand, to name a few (ibid.)

berg and Dreber 2009). For instance, revealing a high price before tasting the wine produces considerably higher ratings (Almenberg and Dreber 2009). Mostly, these studies showed the positive correlation between price and quality (Almenberg and Dreber 2009; Heffetz and Shaya 2009; Mastrobuoni et al. 2014). Hence, consumer perceive higher price as a signal of higher quality. However, Goldstein et al. (2008) results suggested that it can be applied only to non-expert wine consumers. In fact, author results showed that unless they are experts, individuals on average enjoy more expensive wines slightly less (Goldstein et al. 2008). Despite the promising results of these studies, it is unrealistic to expect that only one cue can influence product evaluation. In fact, in real life, consumers are exposed to multiple extrinsic factors.

Wine tasting refers to a range of procedures that enhance to rank wines, according to their quality, or/and describe wine sensory attributes in relatively objective terms (Jackson 2017). "Deguster" or tasting means to evaluate with one or more senses the flavor and quality of wine. In fact, the wine tasting involves three of our senses: sight, smell and taste. There are differing opinions on how to taste and evaluate wines. A brief explanation of wine tasting is described as follows. Wine tasting has three main steps. It starts with a visual examination. The visual observation needs to analyze wine appearance and color, specifically, the hue and depth. Hue denotes its shade or tint, whereas depth refers to intensity (ibid.). Wine color should be examined under neutral lighting and a white background.

The second step of wine tasting is an olfactory examination. Usually, this examination starts sticking the nose just above the mouth of the glass and prior to swirling (McCarthy and Ewing-Mulligan 2015; Moio 2016). This permits initial assessment of the wine's most volatile aromatics (Jackson 2017). Then, the glass can be rotate few seconds (swirling enhances volatilization) and sniff the wine again. This step is needed to understand aroma (fruity, spicy, earth, etc.), intensity, bouquet or fragrance of the wine (Skelton 2013).

Finally, the wine can be tasted. As with odor, several attributes are evaluated such as quality, intensity, duration. However, the first modalities that can be detected are sweetness, acidity, saltiness and bitterness (McCarthy and Ewing-Mulligan 2015; Skelton 2013). Moreover, tannin (a substance that exists naturally in the skin, seed of grapes) can be tasted, usually more in red wines. Taste examination is used to define the flavors, structure (combination of mouth touch and taste), balance (a fusion of all the above in mouth sensation) and state



Each sample should be poured into identical, clear, tulip-shaped, wine glasses. They should each be filled (1/4 to 1/3 full) with the same volume of wine.

I. Appearance

1 – View each sample at a 30° to 45° angle against a bright, white background.
2 – Record separately the wine's:
  clarity (absence of haze)
  color hue (shade or tint) and depth (intensity or amount of pigment)
  viscosity (resistance to flow)
  effervescence (notably sparkling wines)

II. Odor "in-glass"

1 – Sniff each sample at the mouth of the glass before swirling.
2 – Study and record the nature and intensity of the fragrance* (see Figs 1.3 and 1.4)
3 – Swirl the glass to promote the release of aromatic constituents from the wine.
4 – Smell the wine, initially at the mouth and then deeper in the bowl.
5 – Study and record the nature and intensity of the fragrance.
6 – Proceed to other samples.
7 – Progress to tasting the wines (III)

III. "In-mouth" sensations

(a) Taste and mouth-feel

1 – Take a small (6 to 10 ml) sample into the mouth.
2 – Move the wine in the mouth to coat all surfaces of the tongue, cheeks and palate.
3 – For the various taste sensations (sweet, acid, bitter) note where they are percieved, when first detected, how long they last, and how they change in perception and intensity.
4 – Concentrate on the tactile (mouth-feel) sensations of astringency, prickling, body, temperature, and "heat".
5 – Record these perceptions and how they combine with one another.

(b) Odor

1 – Note the fragrance of the wine at the warmer temperatures of the mouth.
2 – Aspirate the wine by drawing air through the wine to enhance the release of its aromatic constituents.
3 – Concentrate on the nature, development and duration of the fragrance. Note and record any differences between the "in-mouth" and "in-glass" aspects of the fragrance.

(c) Aftersmell

1 – Draw air into the lungs that has been aspirated through the wine for 15 to 30 s.
2 – Swallow the wine (or spit it into a cuspidor).
3 – Breath out the warmed vapors through the nose.
4 – Any odor detected in this manner is termed aftersmell; it is usually found only in the finest or most aromatic wines.

* Although fragrance is technically divided into the *aroma* (derived from the grapes) and *bouquet* (derived from fermentation, processing and aging), descriptive terms are more informative.

IV. Finish

1 – Concentrate on the olfactory and gustatory sensations that linger in the mouth.
2 – Compare these sensations with those previously detected.
3 – Note their character and duration.

V. Repetition of assessment

1 – Reevaluate the aromatic and sapid sensations of the wines, beginning at II.3—ideally several times over a period of 30 min.
2 – Study the duration and development (change in intensity and quality) of each sample.

Finally, make an overall assessment of the pleasurableness, complexity, subtlety, elegance, power, balance, and memorableness of the wine. With experience, you can begin to make evaluations of its *potential*— the likelihood of the wine improving in its character with additional aging.

Figure 6.6: *All the step of wine tasting. From Jackson (2017).*

of evolution of the wine (Skelton 2013). Usually a retro-nasal (mouth-derived) examination is also required to better evaluate the wine.

Hence, several studies measured the combined effect of multiple extrinsic cues on product evaluation, without aiming to disentangle their relative impact (Mueller and Szolnoki 2010a). For instance, Lockshin et al. (2006) analyzed the effect of four different attributes such as brand name, region of origin, price, and award (gold medal or not). Instead, D'Alessandro and Pecotich (2013) investigated the influence of brand and country of origin (COO) on perceived quality according to different level of consumer expertise. However, the complexity caused by the interaction of several cues can negatively affect these kinds of experiment. Moreover, most of these experiments do not consider the impact of these cues on their buying behaviors. Hence, research in marketing could not confirm liking as valid predictor for consumers' true purchase behavior (ibid.).

6.2.2 Measuring consumer sensitivity to extrinsic cues in wine choice: a Consumer Neuroscience approach

As discussed in Section (6.2) wine, more than any other consumer goods, has a strong symbolic value. Hence, the wine quality is particularly difficult to define and analyze. On the other hand, the effect of extrinsic cues on consumers' perceived quality can be measured. Consumer Neuroscience research promises to identify and analyze neural mechanisms involved in wine selection and perceived quality. In the last decade, many experiments have been conducted to study the influence of extrinsic cues on wine selection and preference.

In particular, the renowned experiment conducted by Plassman et al. (2008) illustrated how price influences individual choice and the brain reward system (pleasantness). Using fMRI, authors showed that the more the price increases the more individual perception of flavor pleasantness rises. Results also showed increased activity in the medial orbito-frontal cortex, an area that is widely thought to encode for experienced pleasantness (Plassman et al. 2008) .

Other Consumer Neuroscience tools, such as Emotiv cap and eye-tracking, can be used to measure brain responses during wine tasting. Russo (2015) compared wine experts' brain activity (sommelier) with non-experts' brain activity (student), during a wine tasting. Moreover, authors measured and compared number of fixation, time and heat map for the two groups during wine labels view. Results showed that there was

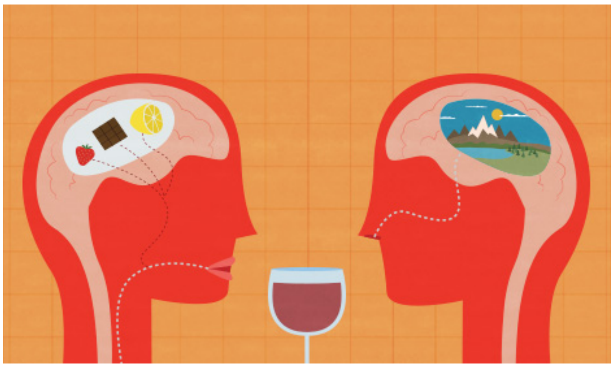


Figure 6.7: *Consumer Neuroscience research and wine sector: investigating brain responses to external cues. From vivino.com*

Figure 6.8: *Using eye-tracking and Emotiv cap to measure individual physiological responses for wines. From IULM University*

a significant difference between the two groups for both Emotiv data and eye-tracking data. Emotiv data showed that the level of "frustration" (how much the subject is stressed) of sommeliers was significantly less than students (Russo 2015). Regarding eye-tracking, sommeliers' average fixation time and heat map was significantly more accurate and quick compared to students (ibid.). Results suggest that wine customers that are not expert can be more influenced by information (ibid.).

Similarly, a more recent study conducted by Horska et al. (2016) measured participants' physiological responses, using Emotiv epoc and facial expression recognition, during the tasting of eight wines. The experiment showed how facial expressions (happiness, sadness, disgust, neutral emotions, anger and surprise) and live metrics can be used to study and define consumer's preference for wines (Horska et al. 2016). However, Horska et al. (2016) and Russo (2015) studies did not analyze electrical brain activity of participants. It is not clear how preferences for a wine can be related to a specific brain activity or area.

Finally, eye-tracker can be used to evaluate how individuals judge wine labels and which aesthetic features are usually most attractive. In Laeng et al. (2016), authors showed that pupil dilatation, number of fixations and the amount of time participants spent on a specific label, is related to individual attention and preferences. In particular, number of fixation can be indicative of willingness to pay and predict choices (Laeng et al. 2016).

As discussed in Section 6.2, wine product possesses a powerful symbolic meaning that make it significantly different form other manufactured or agricultural goods. Traditional marketing studies (see Subsection 6.2.1), tried to explain how external cues can influence individual choice for wine. However, Consumer Neuroscience techniques appear more suitable for studying consumer's preferences and perceived quality, especially during the wine tasting process (Horska et al. 2016; Plassman et al. 2008; Russo 2015). Consumer Neuroscience can investigate how consumers evaluate organoleptic characteristics of wines as well as how they evaluate wine quality. These findings might help wine companies to increase sales nevertheless in the production process (Horska et al. 2016).

6.3 Summary

Consumer Neuroscience research and neuroimaging data offer a valid and scientific method to understand food choice and preferences better. In fact, Consumer Neuroscience research can provide information regarding brain regions and cognitive processes involved during product consumption. In particular, studies investigated whether neuroimaging data can be used to predict individual preferences or craving for food (Hutcherson et al. 2012; O'Doherty et al. 2006).

Consumer Neuroscience research also focuses on how consumers assess product quality for food and drinks. In particular, studies focused on the brain mechanisms engaged during product quality evaluation in relation to marketing extrinsic cues. In fact, studies proved that extrinsic cues can affect cognitive processes (e.g., reward) and brain area (e.g., dlPFC, striatum) and consequentially modify consumer preferences and behaviors (Khushaba et al. 2013; Linder et al. 2010; Lusk et al. 2015; Plassmann and Weber 2015; Van der Laan et al. 2012; Wolfe et al. 2016). Most importantly, Consumer Neuroscience investigates the effect of extrinsic cues such as price, label and packaging on smell and taste perception (Lucchiari and Pravettoni 2012; McClure et al. 2004; Yucel et al. 2015).

Finally, several Consumer Neuroscience studies investigated neuronal and physiological processes involved in wine evaluation (Horska et al. 2016; Plassman et al. 2008; Russo 2015). In particular, studies examined the effect of price and label on experienced pleasantness during wine consumption. Consumer Neuroscience research seems to provide detailed insights on psychophysiological mechanisms that drive consumer behavior and preferences for wines.

CHAPTER

7

EXPERIMENT 1

7.1 Introduction

Recent years have seen an explosion in the use of psychological and neuroscientific methods to help marketing research. The use of these methods for marketing purposes is labeled as Consumer Neuroscience (see Chapter 3). Consumer Neuroscience research uses a decisional model that integrates conscious and unconscious processes, without resorting to the subjective reports that have been the mainstay of marketing studies for ages (Miljkovic and Alcakovic 2010; Russo 2015). In fact, the subjective reports are based on the assumption that people cannot completely and consciously explain their preferences when explicitly asked (Vecchiato et al. 2011). Consumer Neuroscience research can add value to marketing research providing information that is not accessible through conventional methods.

Consumer Neuroscience studies investigate human neural mechanisms and cognitive functions in order to verify and improve existing marketing theories on consumer decision-making and behavior (see Chapter 3 and 5). Firstly, the application of neuroscience methods aims at showing the brain areas and physiological responses involved in the processing of marketing stimuli (Fortunato et al. 2014; Lee et al. 2006). Secondly, it is possible to associate the brain area identified with cognitive and emotional processing that are the dominant aspect of consumer behavior (Fortunato et al. 2014; Russo 2015).

In particular, Consumer Neuroscience research can help researchers to identify and analyze the neural mechanisms involved in product experiences. In fact, product experiences rely on a set of brain mechanisms, psychological processes (e.g., expectation, valence) and subjective factors (e.g., culture, economic status) (Plassman et al. 2008; Ramsøy 2014). Several methods have been used in marketing to study consumers' preferences during the product experience (e.g., surveys, questionnaires, simulated choice experiments). However, the combination of neural data and traditional measure to study the consumer behavior during product experiences can provide unique added value to conscious and unconscious mechanisms that drive consumer behavior. Relating brain activity to choice and preferences can also be useful to predict consumer's behavior (Boksem and Smidts 2015; Ohme et al. 2010).

Hence, a Consumer Neuroscience approach was used to investigate individual preferences and brain responses during the product experience. The present experimental study is aimed at investigating whether EEG data gives a valuable and substantial contribution to the prediction of individuals' preferences and behaviors.

Of particular relevance is in the case of wine the identification of consumers preferences and the product experience. Wine quality and preferences can be assessed only during consumption. Due to the large amount of different cues that may influence quality perception and consumer preferences, choosing a wine is more complex than choosing many other products (Moio 2016; Sáenz-Navajas et al. 2013). In fact, wine is a complex product with a strong symbolic value based on sensory (intrinsic cues) and non-sensory characteristics (extrinsic cues) (Thornton 2013). Wine sensory characteristics are those related to physical-chemical attributes of wine, usually difficult to define for inexpert consumers (Sáenz-Navajas et al. 2013). Instead, extrinsic cues, such as label, price, COO and producer characteristics/brand do not always reflect wine quality or are difficult to be interpreted (Mueller and Szolnoki 2010a).

The experiment was designed trying to recreate a real wine tasting experience. Using EEG, the participant's brain activities were recorded during wine tasting, and behavioral responses were measured during the process. Individual preferences for wines were also measured based on self-reported preferences. Studies showed that the frontal cortex (FC) is anatomically and functionally connected to structures that process emotional activity (Davidson and Irwin 1999; Maglione et al. 2017). Thus, the role that the frontal cortex plays in the generation of the emotions is well recognized (Davidson and Irwin 1999; Maglione et al. 2017). EEG oscillations in the beta band range (12-30 Hz), particularly in the frontal and central area, are associated with reward and pleasantness (Boksem and

Smidts 2015; HajiHosseini et al. 2012; Khushaba et al. 2013; Lucchiari and Pravettoni 2012; Park et al. 2015; Rakshit and Lahiri 2016; Vecchiato et al. 2013). Based on these findings (see Subsection 5.3 and **??**), I performed a reverse inference (conceptual replication of the Boksem and Smidts (2015) study) in order to examine whether beta band oscillations in the fronto-central cortex would be related to individual preferences for wines, and whether beta band could add predictive power to self-reported preferences.

Consumer Neuroscience studies also investigated the effects of extrinsic cues, such as label and price on quality assessment and individual preferences. Studies showed that extrinsic cues can influence people's product experiences and preferences (Balconi et al. 2014; Park et al. 2015; Plassman et al. 2008; Plassmann and Weber 2015; Rocha et al. 2013). Thus, I also hypothesized that the view of the label can influence EEG oscillations in the beta band range associated with the product experience. Finally, marketing studies showed that people's preferences can influence people's willingness to pay (Chen and McCluskey 2016; Goldstein et al. 2008; Hollebeek et al. 2007; Mueller and Szolnoki 2010b). Hence, I tested whether individual preferences for wine and label can affect the participants' price perception of wines.

A within-subjects design was employed and the experiment was divided in two sessions. All participants took part in a blind taste session (No Label condition), in which information about the wine was not disclosed, and a normal taste session (Label condition), the bottle was presented during the experiment. This was based on the assumption that the pleasure derived from consuming a good, in the case at hand wine, depends on intrinsic and extrinsic product cues.

Overall, the present study tries to test the following hypotheses:

1. Wines influence participants' preferences and brain activity (beta band) differently.

2. Preference for a wine is related to increased beta band activity (>0).

3. Participants have strong preferences for more expensive wines.

4. Labels influence participants' preferences and brain activity (beta band).

5. Preference for a wine influences the participant's perception of price.

In summary, the aim of this study is to investigate whether neural measure can provide a substantial contribution to the prediction of consumers' preferences and behaviors. In particular, this study has the goal of investigating individual preferences (self-reported preferences) and brain responses during the product experience. I predict that high beta band activity in the prefrontal cortex would be related to preferences for a wine. Moreover, this study also investigated the effect of the label on individual preferences. I predict that the view of the label can increase beta band activity and individual preferences. Finally, I predict that individual preference for a wine influence the perceived price.

7.2 Methods

7.2.1 Participants

Thirty-one participants, all volunteers, were recruited from the University of Twente. All volunteers were asked to participate in two sessions.

Participants had no history of neurological illness or damage, were not using drugs or psychiatric medication, and had normal or corrected-to-normal vision and no color-blindness. Non-smoker volunteers were preferred; smokers were required not to smoke 12 hours before the experiment. Participants were also instructed to abstain from alcohol and caffeine-containing substances 12 h before the experiment. Questionnaires (see Appendix C) and Alcohol Use Disorders Identification Test (AUDIT)[i] were sent by email and were used to check whether volunteers could participate in our experiment. Subjects with a score higher that 19 in the AUDIT were excluded as they can be considered to display hazardous (or risky) drinking behavior, harmful drinking or alcohol dependence.

In the questionnaire, four categories were used to classify wine knowledge of the participants: amateur, basic knowledge, expert, or professional. The results showed that 13 participants could be considered as amateur; while 17 participants displayed basic knowledge.

I excluded five participants in total for different reasons. For two participants, a different amplifier was used in the first and the second session, due to EEG equipment failure. One participant was not able to take part in the second session. Two other participants were excluded because of excessive artifacts in their EEG recordings. The final sample consisted of 26 participants (16 men) between 18 and 40 years of age (Female: Mage = 27.3, SD = 4.6, ranging from 23 to 39 years; Male: Mage = 26.2, SD = 3.4, ranging from 19 to 33 years) that participated in two full sessions. Par-

[i] According to the World Health Organization (WHO) (2001) the AUDIT is a simple method of screening for excessive drinking and to assist in brief assessment. It can help in identifying excessive drinking as the cause of presenting illness. It also provides a framework for intervention to help hazardous and harmful drinkers reduce or cease alcohol consumption and thereby avoid the harmful consequences of their drinking.

ticipants originated from 17 different countries (Austria, Belarus, China, Cuba, France, Germany, Great Britain, Honduras, India, Italy, Lithuania, Mexico, the Netherlands, Pakistan, Poland, Spain, and Turkey).

The local ethics committee at the Faculty of Behavioral Sciences of the University of Twente approved the employed procedures, which were all in line with the declaration of Helsinki.

7.2.2 Procedure

Once participants arrived at the laboratory, I asked them to sign the Informed Consent form. Then, participants received detailed written and verbal instructions on all the tasks they were going to perform in the experiment. In particular, they had to read a small guideline on how to evaluate the wine.

I invited the participants to sit on a comfortable chair in a sound-attenuated and illuminated room. I applied EEG electrodes and participants were placed at a distance of approximately 100 (cm) at the eye level in front of a 24-inch AOC G2460P LED computer screen. Volunteers were instructed to relax and reduce blinking. I asked them to reduce sudden movements during the tasks and follow the instructions displayed on the computer screen.

The experiment consisted of two tasks, during the performance of both the tasks, EEG was measured. In the first task, several wines had to be tasted and evaluated. In the second task, the participants had to select the preferred label out of two displayed labels. The tasks consisted of a sequence of programmed steps to be completed by each volunteer within a given time window. In this chapter, only the first task will be discussed.

7.2.3 Task

In the wine tasting task four different wines had to be judged (see Subsection 7.2.4). The procedure consisted of four steps that were repeated for each wine (see Figure 7.1)[ii].

1. Volunteers started with rinsing their mouth with water after which they had to wait for 10 seconds.
2. A glass containing red wine was presented in front of the participant for 20 seconds.

[ii]The procedure used refers to the FISAR procedure for wine tasting (Italian Federation of Sommeliers Hoteliers Restaurateurs) (see also Appendix F).

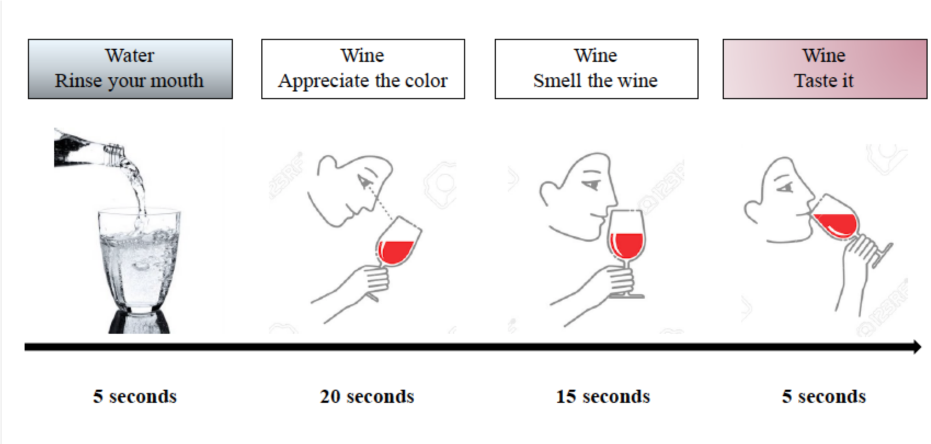


Figure 7.1: *Steps of the wine tasting procedure. Participants repeated these steps for each wine.*

3. Volunteers had to smell the wine twice; once with a stationary glass and the second time after swirling the wine in the glass for three seconds.

4. Volunteers subsequently tasted the wine by taking a small sip, and swirling the wine in their mouth, to appreciate the full taste.

After these four steps, participants were asked to rate each wine.

The wine tasting task was performed in two sessions, which were separated by two weeks. In one session (Label session) the wines were presented together with their corresponding labels as the relevant bottles were presented in front of the volunteers. In the other session (No Label session), the wines were presented without any label. A time frame of two weeks was chosen in order to reduce the possibility that volunteers would remember the wines. In both sessions, the volunteers were also asked to give an overall rating of the wine (Wine preferences), and to indicate in which price category the wine should be located. In the session with the labels, the volunteers were additionally asked to rate the labels.

The participants were randomly assigned to one of the two conditions for the first session (Order of sessions). The order of sessions (No Label/Label; Label/No Label) was counterbalanced between participants, as showed in Figure 7.2.

7.2.4 Materials and Stimuli

I selected the wines based on the type of grape, the price, and the country of origin. In order to reduce the number of variables, I decided to select

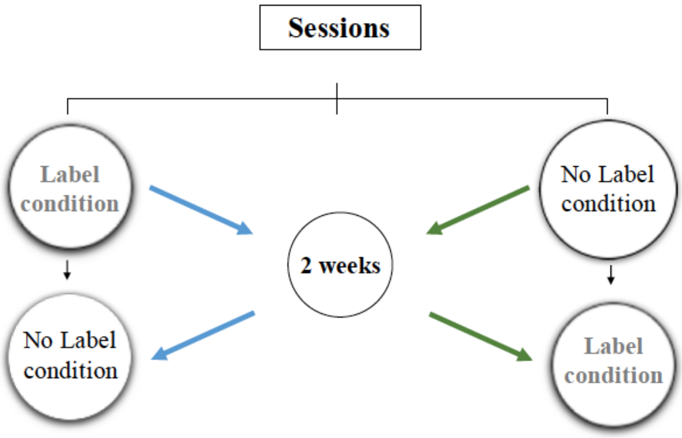


Figure 7.2: *The figure shows the order of sessions and conditions.*

wines that were based on the same type of grape (Cabernet Sauvignon, 100 %). Furthermore, I decided to examine only wine producers from Italy and Chili.

I selected two wines per country from two different price ranges. In order to have a realistic evaluation of the prices, they were compared on the same website. Moreover, all the wines can be bought easily online. The two selected Italian wines were Camelot and Alturis. The two selected Chilean wines were Los Boldos and Cimarosa.

The Chilean Los Boldos (*Chilean Expensive (CE)*) and the Italian Camelot (*Italian Expensive (IE)*) were expensive wines (price category: 24-27 €), while the two other wines, the Chilean Cimarosa (*Chilean Cheap (CC)*) and the Italian Alturis (*Italian Cheap (IC)*) were cheap wines (price category: 3-5 €). The wine order was counterbalanced for all the participants. Precisely, the order was changed according to the nationality (Italian, Chilean) and the price (Cheap, Expensive).

During the experiment, the wine temperature was constantly monitored and kept at room temperature. Once the bottles were opened, the wine was kept for no more than 4 days. Four wine saviors[iii] were used to close the wine bottles and preserve the wines. For more details about wine characteristics see Chapter 6.

[iii]The Wine Saver is a vacuum pump, which extracts the air from the opened bottle and re-seals it with a reusable rubber stopper (https://vacuvin.com/products/wine-saver/).

7.2.5 Behavioral Measures

- *Drinking behaviors.* In order to participate in the experiment, I asked the volunteers to complete a questionnaire. I used the questionnaires to classify volunteers according to their age, nationality, gender, drinking habits, and wine knowledge. Moreover, the questionnaires highlighted participants' criteria for choosing wine, such as Price, Quality, Grape variety, Wine type, Bottle Design, Label and country of origin (CO).

- *Wine preference.* The volunteers were asked to give an overall rating of the wine, according to their preferences (6-points Likert scale, the greater the preference the higher the value).

- *Perceived price.* The volunteer freely chose the corresponding price category of each wine (3-5, 6-8, 9-11, 12-15, 16-21, 22-27 €).

- *Label preference.* For the label condition only, the volunteers rated the labels of the wines (6-points Likert scale, the greater the preference the higher the value).

7.2.6 Electroencephalographic (EEG) Measures

The EEG was recorded continuously from 32 active Ag/AgCl electrode sites using an EasyCap-62 channel cap (standard international 10–20 system layout) connected to an ActiChamp amplifier, with BrainVision Recorder software (version 1.21.0102).

The electrodes were located at the following sites: AFz, AF3, AF4, AF7, AF8, F1, F2, F5, F6, FCz, FC3, FC4, FT7, FT8, C3, C4, C5, C6, CPz, CP3, CP4, TP7, TP8, P1, P2, P5, P6, POz, PO3, PO4, PO7, and PO8. The horizontal and vertical electro-oculogram (hEOG and vEOG) were recorded. Two electrodes were placed at the side of both eyes to measure the electrical activity generated by horizontal eye movements. Electrodes located on the infraorbital and supraorbital regions of the left eye placed in line with the pupil enabled to measure vertical eye movements and blinks. The resistance of the electrodes was kept below 10 kΩ by using electrode gel and standard procedures to improve conductivity.

Presentation® software[iv] (Neurobehavioral Systems, Inc., 2012)

[iv]Presentation® is a stimulus delivery and experiment control program for neuroscience. It runs on any Windows PC, and delivers auditory, visual and multimodal stimuli with sub-millisecond temporal precision. Presentation is powerful enough to handle almost any behavioral, psychological or physiological experiment using fMRI, ERP, MEG, psychophysics, eye movements, single neuron recording, reaction time measures, other performance measures, and more.

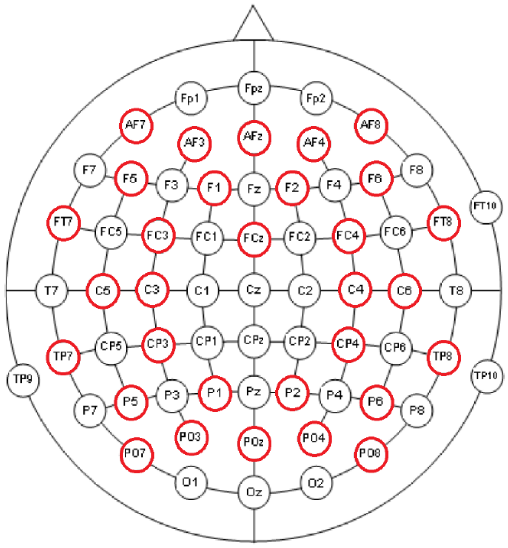


Figure 7.3: *The figure shows the position of the electrodes.*

installed on a separate computer (DELL), was used to present instructions to the participants and send appropriate markers signaling relevant events to be picked up by BrainVision Recorder Version 1.21. A QWERTY keyboard was used where the keys 1, 2, 3, 4, 5, 6, on the top left, and the space bar registered answers and controlled the sequence of events during the experiment.

7.2.7 EEG Data Analysis

I processed data using the BrainVision Analyzer v. 2.1.1 software.

Firstly, I applied Formula Evaluator on the raw data with respect to noisy channels. Formula Evaluator enables to correct a noisy channel and to calculate it as functions of two or three existing channels, located close to the noisy channel. It was applied on a total number of 12 participants.

Secondly, the continuous data (between 130 and 165 s) were segmented (0 to 165000 ms) and then divided into 4 segments (one for each wine), each segment (0 to 40000 ms) started at the beginning of each testing and lasted the duration of the whole procedure.

I then further separated each segment (wine) into 4 segments of 19500 ms (2500 to 22000 ms) for the color, smell, taste and water. Each segment (color, smell, taste and water) was in turn partitioned in sized segments of 5000 ms. Then, Baseline correction transformation was applied (0 to 100 ms). Standard artifact detection and rejection procedures were applied to the five data point segments, rejecting channels within segments containing jumps larger than 30 μV/ms, segments with amplitude differences that exceeded 150m V/200ms, and segments with amplitude differences that did not exceed 0.5m V/200ms. I performed a Fast Fourier Transformations (FFTs) analysis on taste and water data for each wine, using a standard Hanning window. A log10 transformation was applied[v] on the preprocessed data for wine. Next, the resulting spectral EEG data per wine and water were averaged for all participants individually.

In order to obtain a baseline, a subtraction was performed between wine and water log10 transformed data.

Finally, data were organized and imported to be used with SPSS.

7.2.8 Statistical Analysis

Three different statistical analysis were used to test the alternative hypothesis.

A repeated measures ANOVA[vi] was used to analyze changes in the beta bands (log10 transformed data) over different conditions, such as different types of wine, electrodes, frequencies and sessions (Label, No Label). The repeated measured ANOVA was used to establish the relation between the dependent variable (beta band 12-30 Hz) and the multiple independent variables (wine, electrodes, frequencies and sessions).

In order to perform the statistical analysis:

- six different electrodes located over the frontal and central cortex were selected: AFz, F1,F2, FCz, FC3, FC4. The electrodes were chosen on the basis of data analysis used in other studies (Boksem and Smidts 2015; Khushaba et al. 2013; Lucchiari and Pravettoni 2012; Rakshit and Lahiri 2016).
- beta bands (12-30 Hz) were analyzed in three different frequency ranges: low-beta band (12-16 Hz), mid-beta band (16-20 Hz) and high-beta band (20-30 Hz). As described in other studies, the beta

[v]The log10 transformation allows to normalize the EEG data (see Figures B.2 and B.1 in Appendix B.

[vi]The repeated measures ANOVA is a parametric test that allows to compare the means across one or more variables that are based on repeated observations. The repeated measures ANOVA *" allows to determine whether the means of three or more measures from the same person are similar or different"* (Plichta and Garzon 2009). Specifically, the same people are being measured more than once on the same dependent variable or within-subjects factor (LaerdStatistics 2013). Repeated measures ANOVA can be used to investigate either (1) changes in mean scores over three or more time points, or (2) differences in mean scores under three or more different conditions (ibid.). The independent variable has categories called levels or related groups (ibid.).

bands can be divided in different ranges (Abhang et al. 2016; Boksem and Smidts 2015; Engel and Fries 2010; Spironelli et al. 2013).

- two different sessions were analyzed: Label and No Label. In the Label session, the wines were presented with the label. In the No Label session, the wines were presented without any label.
- participants were divided in two groups according to the order of sessions attended (Group 1=No Label/Label; Group 2= Label/No Label). The order of sessions was used as between-subject variable in the repeated measurement ANOVA.

For the ANOVA analysis, associated *Degree of freedom*, *F-values*, *p-values*, *Means* and *Partial Eta Squared* were reported. In order to report the correct degree of freedom for the averaged tests of significant, associated Mauchly's Test of Sphericity was analyzed. Corrected results (Greenhouse-Geisser or Huynh-Feldt corrections)[vii] were reported when the sphericity[viii] assumption was violated.

For the behavioral data, a Friedman test[ix] was used to analyze changes in participants responses for wines rating (*Wine preferences*), price perception (*Perceived price*) and label rating (Label preferences) for the different wines and sessions (Label/No Label). A Wilcoxon signed-rank test[x] was used as post-hoc test to analyze differences in the different combinations of related groups (wines and sessions).

Finally, a correlation analysis was performed for the behavioral data in order to determine the relationship between *Wine preferences* and *Perceived price* for all the wine and the two different sessions (Bluman 2007).

7.3 Results

This section described the results obtained for both behavioral and EEG data.

[vii] Generally, the recommendation is to use the Greenhouse-Geisser correction if ε <0.75 and the Huynd-Feldt correction if ε >0.75.

[viii] Sphericity refers to the condition where the variances of the differences between all possible combinations of related groups are equal (LaerdStatistics 2013). The assumption of sphericity is violated when the variances of differences scores among related groups are unequal (Acee et al. 2003).

[ix] The Friedman test is the non-parametric alternative to the repeated measures ANOVA (LaerdStatistics 2013). It is used to test differences between groups when the dependent variable is ordinal (ibid.).

[x] The Wilcoxon signed-rank test is the nonparametric test equivalent to the dependent t-test (ibid.).

Behavioral Results

Statistical analysis was performed in order to analyze if there were differences in the means of the participants' responses for wine rating (*Wine preferences*), price perception (*Perceived price*) and label rating (*Label preferences*) among the different wines and sessions (Label/No Label).

Table 7.1: *Means of the participants' responses (Wine preferences) for each of the four wines that the participants tasted in both sessions (Label/No Label).*

Wine	Session	Mean
Los Boldos	Label	5.56
Los Boldos	No Label	5.27
Camelot	Label	5.17
Camelot	No Label	1.04
Cimarosa	Label	5.08
Cimarosa	No Label	4.77
Alturis	Label	4.71
Alturis	No Label	4.4

Firstly, the results show that there was a significant difference in the means of the participants' responses (6-points Likert scale, the greater the preferences the highest the value) for Wine preferences ($\tilde{\chi}^2(7)=73.444$ $p=0.000$) among wines and sessions, as described in Table 7.1.

Next, post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied ($p<0.0031$) in order to determine where there was significant differences among the wines and conditions. As presented in Table 7.2, the results show that there was a significant difference in the participants' responses for the wine Camelot (IE) between the two sessions ($Z=-4.492$ $p=0.000$). Similarly, there was a significant difference between Camelot (IE) and Los Boldos (CE) ($Z=-4.527$ $p=0.000$), Camelot (IE) and Cimarosa (CC) ($Z=-4.508$ $p=0.000$), Los Boldos (CE) and Altruris (IC) ($Z=-4.527$ $p=0.000$) in the No Label condition. As shown in Table 7.2, no significant difference was observed between the other wines for the different sessions.

Secondly, the results show that there was no significant difference in the means of the participants' responses (6-points Likert scale, the greater the preferences the highest the value) for Perceived Price ($\tilde{\chi}^2(6)=11.189$ $p=0.083$) among wines and sessions.

Thirdly, a significant effect was found in the means of the participants' responses (6-points Likert scale, the greater the preferences the highest the value) for Label preferences ($\tilde{\chi}^2(3)=13.396$ $p=0.004$) among

Table 7.2: *Results of the comparison between the different wine labels in respect to participants' responses.*

Wine 1	Session	Wine 2	Session	Z	p value
Los Boldos	No Label	Los Boldos	Label	-1.292	0.196
Camelot	No Label	Los Boldos	No Label	-4.527	0.0000
Camelot	Label	Camelot	No Label	-4.492	0.0000
Camelot	Label	Los Boldos	Label	-1.211	0.226
Cimarosa	Label	Los Boldos	Label	-0.769	0.442
Cimarosa	No Label	Los Boldos	No Label	-0.538	0.59
Cimarosa	Label	Camelot	Label	-0.336	0.737
Cimarosa	No Label	Camelot	No Label	-4.508	0.0000
Cimarosa	No Label	Cimarosa	Label	-0.613	0.54
Alturis	No Label	Alturis	Label	-0.371	0.71
Alturis	Label	Cimarosa	Label	-0.926	0.355
Alturis	No Label	Cimarosa	No Label	-0.532	0.594
Alturis	Label	Los Boldos	Label	-1.536	0.125
Alturis	No Label	Los Boldos	No Label	-1.186	0.235
Alturis	Label	Camelot	Label	-0.580	0.562
Alturis	No Label	Camelot	No Label	-4.527	0.0000

wines and sessions. Post hoc analysis with Wilcoxon signed-rank tests was conducted with a Bonferroni correction applied (p<0.0083) in order to determine where there was significant difference among the wines and the conditions for the label. The results show that there was a significant difference in the participants' responses between the Camelot (IE) label and the Cimarosa (IC) label (Z=-3.128 p=0.002). No significant difference was observed comparing the other labels: Camelot (IE) and Los Boldos (CE) (Z=-2.034 p=0.042); Camelot (IE) and Alturis (IC) (Z=-0.202 p=0.840); Los Boldos (CE) and Cimarosa (CC) (Z=-1.479 p=0.139); Los Boldos (CE) and Altruris (IC) (Z=-2.137 p=0.033); Cimarosa (CC) and Altruris (IC) (Z=-1.263 p=0.207).

Finally, behavioral data were also used to determine whether there was a positive or negative relationship between Wine preference and Perceived price. The Pearson correlation coefficient[xi] (Vetterling et al. 1992) was obtained for all the participants, wines and conditions. Overall, the analysis showed that there was a positive correlation between the participant's preferences and perceived price. In fact, the Wine preference can be explained 55 per cent by the assessment of price.

[xi]Correlation determine the strength of a linear relationship between two variables. When there is no correlation between two variables, then there is no tendency for the values of the variables to increase or decrease in tandem (Bluman 2007).

Table 7.3: *Correlation between individual preferences for each wine and perceived price.*

Data	Variable 1	Variable 2	Results
All data	Ordered preferences	Price	0.5529
No Label	Ordered preferences	Price	0.5408
Label	Ordered preferences	Price	0.5724
Los Boldos	Ordered preferences	Price	0.4172
Camelot	Ordered preferences	Price	0.6167
Cimarosa	Ordered preferences	Price	0.621
Alturis	Ordered preferences	Price	0.4907
No Label-Los Boldos	Ordered preferences	Price	0.3474
Label-Los Boldos	Ordered preferences	Price	0.4665
No Label-Camelot	Ordered preferences	Price	0.6345
Label-Camelot	Ordered preferences	Price	0.5909
No Label-Cimarosa	Ordered preferences	Price	0.6942
Label-Wine Cimarosa	Ordered preferences	Price	0.5734
No Label-Wine Alturis	Ordered preferences	Price	0.3481
Label-Wine Alturis	Ordered preferences	Price	0.6157

The correlation coefficient suggests also a moderate uphill relationship between the preference and the price for both conditions. However, the correlation coefficient was slightly higher for the Label condition (0.5724) than the No Label condition (0.5408). The analysis also showed a positive relationship between preferences and price for all the wines. However, the test revealed some differences between the two conditions for each wine. In fact, the correlation coefficient for the wines Camelot (IE) and Cimarosa (CC) is higher in the No label condition (Camelot:0.6345; Cimarosa:0.6942) compared to the Label condition (Camelot:0.5909; Cimarosa:0.5734). Instead for wines Los Boldos (CE) and Alturis (IC) the correlation coefficient was significantly higher in the Label Condition. Los Boldos (CE) showed a correlation of 0.3474 in the No Label condition and a correlation of 0.4665 in the Label condition; Alturis (IC) showed a correlation of 0.3481 in the No Label condition and a correlation of 0.6157 in the Label condition.

EEG Results

In order to verify whether there were differences in the mean of beta bands (log10 transformed data) among the conditions, a repeated measures ANOVA was performed to compare the difference between the beta band on the base of the different electrodes, frequencies, sessions (Label/No Label) and wines.

Table 7.4: *The table shows the results of the repeated measures ANOVA analysis for the different conditions.*

Conditions	Correction	df	Mean Square	F	p value	η^2
Electrodes	Greenhouse-Geisser	2.3	3.39	0.669	0.536	0.027
Frequency	Sphericity Assumed	2	1.24	0.542	0.585	0.022
Wine	Huynh-Feldt	2.5	13.18	2.93	0.049	0.109
Label	Huynh-Feldt	1	1.44	0.22	0.641	0.009

Firstly, as described in Table 7.4, the results show that the different electrodes (F (2.3,3.39)>0.66 p=0.536), frequency ranges (F(2,1.24)>0.54 p=0.585) and sessions (F(1,1.44)>0.22 p=0.641) did not have an effect on the mean of beta bands activity of the participants. However, the results suggest that difference in the wine tasted influenced the mean beta bands activity (F(2.5,13.18)>2.9 p=0.049).

Next, a comparison between wines was performed in order to further explore the impact of each wine on beta bands activity. These results suggest that there was a main effect of the wine Los Boldos compared to the other wines. Specifically, there was a significant effect of Los Boldos wine (CE) compared to Camelot (IE) (F(1,58.04)>5.635 p=0.026), Cimarosa (CC) (F(1,12.17)>5.61 p=0.026) and Altruris (IC) (F(1,37.43)>4.532 p=.044). However, no significant differences was found between Camelot (IE) and Cimarosa (CC) (F(1,17.05)>1.99 p=0.171) or Altruris (IC) (F(1,2.24)>0.29 p=0.592). Similarly, no difference was observed between Cimarosa (CC) and Altruris (IC) (F(1,6.91)>0.79 p=0.592).

As a further examination, the means of the wines were analyzed in order to determine whether there was an increase or decrease of beta bands activity. As shown in Table 7.6, the mean of the expensive wines Los Boldos (CE) and Camelot (IE) and the Alturis had a negative value. Instead for Cimarosa (CC) wine the mean had a positive value. These results suggest that there was a decrease in the beta bands activity for the wine Los Boldos (CE), Camelot (IE) and the Alturis. Instead, for the wine Cimarosa there was an increased beta band activity.

Finally, the interaction effect between all the conditions was tested. The results show that there was no significant interaction effect between electrode and the frequency (F(4.4,0.76)>.68 p=0.616). In addition, no interaction was observed between the electrodes and both the sessions (F(2.8,12.13)>1.5 p=0.218) and the wine (F(2.5,.55)>0.16 p=0.89). Hence, the effect of electrodes did not depend on any of the other conditions.

Table 7.5: *The table shows the comparison between the different wines in respect to beta bands activity.*

Wine	Wine	df	Mean Square	F	p value	η^2
Los Boldos	Camelot	1	58.04	5.635	0.026	0.19
Los Boldos	Cimarosa	1	12.17	5.61	0.026	0.189
Los Boldos	Alturis	1	37.43	4.532	0.044	0.159
Camelot	Cimarosa	1	17.05	1.99	0.171	0.077
Camelot	Alturis	1	2.24	0.295	0.592	0.012
Cimarosa	Alturis	1	6.915	0.791	0.383	0.032

Table 7.6: *Mean of beta bands for each of the four wines that the participants tasted. The expensive Chilean wine Los Boldos (CE) and the two Italian wines the Camelot (IE) and the Alturis have negatives means (decrease in beta bands). Instead for the Chilean cheap wine Cimarosa (CC) the mean is positive (increase in beta bands).*

Wine	Mean	Std. Error
Los Boldos	-0.247	0.072
Camelot	-0.133	0.065
Cimarosa	0.002	0.085
Alturis	-0.047	0.08

Similarly, no significant interaction was observed between frequency and wine (F(5.4,0.83)>.95 p=0.451); frequency and sessions (F(1.8,.14)>0.08 p=0.898); wine and sessions (F(3,2.17)>0.92 p=0.434). Finally, no meaningful interaction effects was observed for all the conditions combined frequency*electrodes*wine (F(8.6,1.47)>1.35 p=0.215), electrodes*wine*session (F(2.7,5.73)>0.74 p=0.517), electrodes*frequency*sessions(F(10,0.63)>1.14 p=0.329), frequency*wine*sessions (F(6,.75)>1.34 p=0.243), electrodes* frequency*wine*sessions (F(5.6,1.98)>1.16 p=0.328).

The results also show that there was no significant effect of the order of sessions, as between-subjects effect on the beta bands (F(1,28.77)>2.8 p=0.104).

7.4 Discussion

The present study aimed at investigating the contribution of neural measures to the prediction of people's preference and behavior. In particular, I attempted to show that neural measures could be used to assess individual preference during the product experience (wine tasting). EEG measures and individual preferences were obtained from a sample of 26 volunteers, during the tasting of four different wines. All volunteers participated in two different sessions (Label, No Label), thus the volunteers' brain activity and preferences were measured twice. In the No Label session, the wines were presented without any labels. In the Label session, the subjects saw the bottles and thus the labels.

Next, I tested whether beta band oscillations can be used to assess individual preferences for wines. In Consumer Neuroscience studies, beta band oscillations are often associated with reward processes and pleasantness (see Chapter 5). Beta band oscillations are related to preferences for water brands (Lucchiari and Pravettoni 2012), crackers (Khushaba et al. 2013), movies (Boksem and Smidts 2015) and, underwear (Aprilianty et al. 2016), as well as tactile attributes (Park et al. 2015).

Firstly, I hypothesized that tasting different wines can affect the participants' brain activity in the beta bands frequency diversely. Performing a reverse inference, I also tested the conceptual replication of the Boksem and Smidts (2015) study. Hence, I examined whether beta band oscillations in the fronto-central cortex would be related to the participants' preferences for wines (H2).

The difference in price range among the four wines was very wide: 2 cheap wines (3-5 €) and 2 expensive (24-27 €). I assumed that the more expensive wines are of a higher quality (see Chapter 6). Hence, I predicted that participants would prefer more expensive wines (H3), as high quality wine.

In addition, marketing and Consumer Neuroscience literature show that extrinsic cues have a strong effect in wine evaluation (see Chapter 6) (Almenberg and Dreber 2009; Lusk et al. 2015; Mueller and Szolnoki 2010a,b; Plassman et al. 2008; Russo 2015). Hence, I used a Consumer Neuroscience approach to investigate the effect of the external cue on personal choice and behavior. I assumed that the label would influence the participants' preferences and brain activity (H4). Finally, my hypothesis is that preferences for a wine would influence the participants' perception of price (H5).

On evaluating the first hypothesis (H1), the results show that there was a significant difference in the participants' brain activity after the tasting of the four different wines. In particular, beta band oscillations in three different frequency ranges (12-16, 16-20, 20-30 Hz) and for six different electrodes (AFz, F1, F2, FCz, FC3, FC4) in the fronto-central cortex were different among wines. Behavioral data also confirmed differences in participants' preferences among wines. The participants' judgment of wines (1 to 6) showed that there was a significant difference in the score that participants attributed to the four wines after the tasting. It suggests that changes in participants' perception of the wine reflect changes in neural measures. Hence, tasting different wines might influence people's preferences and cognitive process as well as more internal processes such beta band oscillations.

Similarly, results show that personal preferences influenced the participants' perceived price, as hypothesized (H5). These findings are highly consistent with the literature (Almenberg and Dreber 2009; Heffetz and Shaya 2009; Mastrobuoni et al. 2014), in fact a positive correlation was found between price and individual preferences. Additionally, there correlation was slightly stronger during the Label session, hence when participants could see the label compared to the blind session (No Label session). It suggests that people's preference for a wine strongly influence their perception of the price. It might also influence their willingness to pay.

According to the third hypothesis, I assumed that the participants would prefer more expensive wines (H3). The behavioral data confirmed the alternative hypothesis (H3) that participants preferred the expensive wines (Los Boldos and Camelot) rather than cheaper wines (Cimarosa and Alturis). In order to test if the EEG data confirmed the alternative hypothesis (H3), in the second hypothesis (H2) I assumed that participants' preferences for a wine would be related to increased beta band activity (>0). Results for EEG data did not confirm the second and the third hypothesis. Unlike Boksem and Smidts (2015) study, participants' preferences for a wine were not connected to increased beta band activity. Boksem and Smidts found that the higher participants ranked a movie, the higher the amplitude of beta band oscillations. In the present study, results did not confirm this hypothesis. Results show that there was an opposite trend, higher preferences for a wine corresponded to a stronger decrease in beta band oscillations. In fact, a decrease in beta band oscillation was observed for the most preferred wines (Los Boldos, Camelot), instead a higher beta band oscillation was observed for the least preferred wines (Cimarosa and Alturis). These results suggest that it is not possible to relate neural activation to individual choice for wines. However, it might also suggest that different products (e.g., wine, movie) influence consumers' experience and neural processes in several ways. In fact, beta band oscillations are often related to reward processes or product pleasantness, however they are also associated to vigilance and visual attention (Abhang et al. 2016; Hernandez-Gonzalez et al. 2012; Minami et al. 2014; Spironelli et al. 2013; Wrobel 2000). It suggests that watching a movie might involve different cognitive and neuronal processes (e.g, visual attention) that are different from those that arouse from a wine tasting (e.g, processing of olfactory and gustatory signals). Several studies found that a higher beta band activity can be associated with an increase in attentional processing (Abhang et al. 2016; HajiHosseini et al. 2012; Spironelli et al. 2013). Hence, results in Boksem and Smidts study might be interpreted assuming that increased beta band oscillation reflect the consumer preferences for the movie on the base of an arousal of the visual system during increased visual attention. Instead, wine tasting do not imply visual attention process but processing of olfactory and gustatory signals that might have a different impact on beta bands oscillations. Hence, it is not possible to infer the findings of Boksem and Smidts study for the wine product.

It is the same for the fourth hypothesis. In fact, EEG data revealed that there was not any significant difference in the beta band oscillations between the Label and No Label sessions (H4). Hence, no important effect of the extrinsic cue label was observed for the neural measures. It was also partially confirmed by the behavioral data. In fact, not significant differences were observed among wines in participants' preferences in the two sessions, except for the Italian expensive wine Camelot. Behavioral data show that participants assigned significant higher scores to the wine during the Label session, hence when the label was displayed. It suggests that the participants' preferences for the wine was strongly influenced by the label and that their scores did not match with their real preferences for wine quality.

Overall these results suggest that:

- People reveal what they really like when they are free to choose it. Hence, when they are not aware about the product characteristics are not influenced by price, label or brand. In this study, participants freely indicated their preferences for the wines whether they were cheap or expensive for the No Label session. Results show a clear trend, in fact participants clearly preferred the expensive Chilean wine Los Boldos, as well they dislike the cheap Italian wine Alturis. It suggests that it might be possible to find similarities in consumers' preferences for a wine (e.g., preferences for sweet taste). However, these preferences might be related to product characteristics that matched the participants' preferences rather than the higher product quality itself.

- The results also suggest that selecting a wine for inexpert and not regular wine drinkers is difficult. Hence, unexperienced consumers are more easily persuadable by marketing manipulations. Participants' ranking for all the wines were slightly higher in the Label session compared to the No Label session. However, this difference was highly significant for one of the expensive wines (Camelot) in the Label session compared to the No Label session. It suggests that the view of the label influenced participants' preferences for the wine. It is also confirmed from the participant questionnaires, in fact mostly all the participants (17) indicated that label and/or bottle design represent an important or a very important factor when they choose the wine.

- Finally, the results show differences in the tasting of four different wines can be related to beta bands oscillations. However, unlike Boksem and Smidts 2015 study, it is not possible to link increased beta band activity to the participants' preferences for a wine. The results of the present study suggest that it is not possible to infer the findings of Boksem and Smidts (2015) study for consumers' preferences during product experiences, in the case at hand wine tasting.

Taken together, these findings bring evidence that it is possible to link some properties of the collected EEG data (beta activity) during the product experiences (wine tasting) with the individual preferences. As discussed, these results confirm, challenge and develop previous findings in Consumer Neuroscience literature. However, the present study has few research constraints that can be addressed in future studies. For instance, investigating the effect of multiple external cues, such as price and brand, on consumers' preferences. A final issue to be addressed concerns the effect of this cues on consumer's willingness to pay. Future studies can also investigate gender differences, regarding wine taste and the reactions to product external cues, or differences between professional and no expert consumers.

CHAPTER

8

EXPERIMENT 2

8.1 Introduction

Consumers interpret product quality and establish product preferences on the base of many different factors. Some factors arise from the state of the individuals (e.g., culture, economic status), whereas others depend on the properties of the product itself (Plassman et al. 2008; Venkatraman et al. 2012). The properties of a product can be defined as *intrinsic* when they are part of the physical object or *extrinsic* (e.g., price, design, brand name, country of origin) when are *"product related"* although external to the product itself (Aaker and Bie 1993; Inscha and McBride 2004; Moutinho 2011; Zeithaml 1988).

Consumer Neuroscience research investigates cognitive and neural processes that support consumer decision making and behavior during the evaluation of intrinsic and extrinsic cues. Studying emotional responses and cognitive processes such as memory, attention, consciousness can help to understand how individuals process and memorize product cues (e.g., brand, design, color) and to predict consumer behavior. For instance, neuroimaging tools can be used to understand how consumers allocate their attention, how external cues catch consumers' attention and influence consumers preferences.

Attention refers to the selective aspect of perception (Reber 1995). It is a process though an individual, at any moment, focuses on certain aspects of the environment, thus excluding other components (Reber 1995). Attention may be a conscious process; in fact, it is possible that an individual actively select some elements out of the total input (ibid.). However, mostly individuals are not aware of the factors that guide and lead them to focus only on one stimulus or on some small parts of it (ibid.). Hence, identifying the physiological and neural mechanisms that drive attention helps to understand how consumers' attention is allocated in space and time and which are the product extrinsic cues that affect the most consumers' attention and choice. Precisely, Consumer Neuroscience studies focus on visual attention.

Visual attention is a key component in consumers' decision-making processes since information must be visually noticed to influence choice (Gidlöf et al. 2017). Consumers' preferences for a product appear to be strongly influenced by brain processes of visual stimuli (Karmarkar and Plassmann 2015; Milosavljevic et al. 2011). In fact, consumers' visual attention is often guided towards those products whose appearance fit consumers preferences (Gidlöf et al. 2017). Studies showed that product value assessment depends on the amount of attention that they receive during the decision making process (Glimcher and Fehr 2013; Krajbich et al. 2010). For instance, food products receive higher liking ratings and are more likely to be chosen when attention focuses on them longer (Krajbich et al. 2010). Product aesthetic characteristics (e.g., brightness or color) also influence visual attention. In fact, aesthetic characteristics determine the visual saliency[i] of a product. The visual saliency of a product can strongly influence consumers' preferences.

Consumer Neuroscience research used different tools to measure visual attentional mechanisms. For instance, numerous studies used the eye-tracker to study the visual allocation of attention. Though the measurement of eye positions and eye movement (e.g., duration and number of fixations, shifts of the gaze, pupil dilatations), researchers study changes in consumers' visual attention due to differences in product aesthetic characteristics (e.g., attractive or unattractive), consumers inclination to sustainability (e.g., eco-label, production methods) (Behe et al. 2014; Dawling et al. 2011; Khachatryan et al. 2017; Van Loo et al. 2015). However, the measurement of eye movements is not always sufficient to understand how consumers process visual attention, and thus if a product or brand is able to catch their attention. Firstly, eye movements are relatively slow compared to other mechanisms (Luck and Kappenman 2011). Secondly, eye movements are supported by other mechanisms for focusing processing and

[i] Visual salience (or visual saliency) is the distinct subjective perceptual quality which makes some items in the world stand out from their neighbors and immediately grab our attention (Itti 2011)

perceptual processing, for instance process one word without interference from other words during reading (Luck and Kappenman 2011). Finally, a customer who faces with many simultaneous objects can simply look at one of the product but it does not necessarily mean that he/she is interested in that specific product.

A tool such as EEG, due to its high temporal resolution, can be more suitable to measure visual attention. Consumer Neuroscience research investigated the influence of external cues on visual attention processes by using EEG. In particular, studies used Event-Related Potential (ERP) component in order to determine which cognitive or neural processes differ during consumers' evaluation of different brand or aesthetic properties. In fact, ERP allow to see processing that occur before, during and after the execution of a specific behavioral responses (ibid.). For instance, studies investigated differences in ERP to evaluate consumers' neural responses to aesthetic features of jewelries (Wang et al. 2012); to measure consumers' preferences for familiar/unfamiliar or branded/ no-branded product (Nazari 2014; Thomas et al. 2013); and to examined the influence of social factors (e.g., presence of a person) and exposure to luxury versus basic branded products (Pozharliev et al. 2015). These studies showed that EEG is a useful tool to investigate the relation between cognitive function (e.g., attention) and brain activity during the exposure to product external cues. In fact, EEG data provide additional insight that cannot be gained with behavioral measurement alone. Consequently, it allows to understand the attention-allocation behavior of consumers for external cues better.

Similarly, in the current study participants' visual attention was analyzed using EEG, with particular focus on whether specific preferences for a product, in the case at hand wine label, are reflected by changes in the participants' brain activity. Parameters of the Posterior-Contralateral-Negativity (PCN)[ii] were analyzed in order to assess if a certain label caught visual participants' attention. In fact, PCN are parameters have been considered to reflect the dynamics of visuospatial attention processes and that allow to examine attentional effects with the EEG (Tollner et al. 2011a,b; Vossel et al. 2015; Zehetleitner and Muller 2010) were analyzed in order to assess whether a certain label caught participants' attention. Hence, the PCN expresses an increased negativity in the visual area (posterior electrodes) contralateral to the stimulus position in a time window of approximately 175 and 300 ms (or even less) after the stimulus presentation. This parameter can be used as a marker that traces the transition from when the stimulus (e.g., label) reaches a receptor (e.g., retinal cell) to the focal

[ii]Some studies also use the term N2-posterior contralateral (N2pc), however in this study the term PCN is preferred.

attentional stage to target selection, thus when the stimulus is perceived and successively selected (Tollner et al. 2011a). Numerous psychological and neuroscientific studies investigated the PCN parameter in order to trace the timing and the allocation of visuospatial attention is modulated by stimulus intensity, stimulus saliency and set size (Tollner et al. 2011a,b; Van der Lubbe and Abrahamse 2011; Van der Lubbe et al. 2014; Vossel et al. 2015; Zehetleitner and Muller 2010). However, there is no evidence that the PCN parameter has been used in Consumer Neuroscience research.

Based on the assumption that PCN reflects the visual allocation of attention based on perceptual stimulus properties; the present study aims at showing that PCN parameters can be used to assess and predict consumers' preferences for a specific product on the base of external cues, in the case at hand four different wine labels. The hypothesis is that individual visual attention for a specific label are reflected by EEG lateralization in the parieto-occipital area (PO8/PO7 electrode pair). In fact, lateralized EEG potentials as a function of the to-be-attended side were analyzed on the PO7/PO8 electrode pair, using the following procedures: attend left (PO8-PO7)[iii] and attend right (PO7-PO8/2)[iv]. Hence, negativity on the right hemisphere implies that the brain activity was more negative on the PO8 electrode (attend right), instead positivity on the right hemisphere implies that the brain activity was more negative on the PO7 electrode (attend left). As discussed above, changes in PCN components can be measured in a really short time window (175 and 300 ms post stimulus). Hence, PCN components can be used to assess individual preferences for a specific label compared to another even before the actual selection of the label. In addition, changes in PCN component can also reveal that individual visual attention is oriented towards a target, in the case at hand label, different then the preferred choice. In fact, consumers' visual attention might be driven by labels with great saliency, however their final choice might be based on more high-level information or cognitive processes. This suggests that consumers' visual attention might differ from their choice. Hence, linking the Posterior Contralateral Negativity (PCN) component to behavioral data (Wine Preference), it might be possible to determine whether visual attention mechanisms confirm participants' preferences for a specific label.

Overall, the present study tries to test the following hypotheses:

1. The view of the four wine labels results in different PCN latencies
2. Participants' preference for a wine label would be indicated by a more

[iii]In the case at hand, the left hemisphere reflects ipsi vs. controlateral power (Van der Lubbe et al. 2014).

[iv]In the case at hand, the right hemisphere reflects contra vs. ipsilateral power (ibid.).

negative-going deflection (PCN).

3. PCN latencies in the two sessions (Label, No Label) for each wine are different.

8.2 Methods

8.2.1 Participants

The data sample consisted of thirty-one participants, students and co-workers of the University of Twente. All volunteers participated in two sessions. Questionnaires and Alcohol Use Disorders Identification Test (AUDIT) were sent by email and were used to check whether volunteers could participate in our experiment. Subjects with a score higher that 19 in the AUDIT were excluded as they can be considered to display hazardous (or risky) drinking behavior, harmful drinking or alcohol dependence.

Participants had normal or corrected-to-normal vision and no history of neurological disease or damage, were not using drugs or psychiatric medication. Handedness, with use of Annett's Handedness Inventory (Annett 1970), and color-blindness were tested. For the color-blindness test participants reported the colored numbers in the figures, if the participants reported the current numbers the test was passed (Ishihara, 1976). The handedness test revealed that twenty-eight participants were right handed and three participants were left handed.

Five participants in total had to be excluded for different reasons. For two participants, a different amplifier was used between the first and the second session, due to EEG equipment failure. One participant was not able to take part in the second session. Two other participants were excluded because of excessive artifacts in their EEG recordings. Twenty-six participants were used for the final sample. In total, 10 participants were female (Mage = 27.3, SD = 4.6, ranging from 23 to 39 years) and 16 participants were male (Mage = 26.2, SD = 3.4, ranging from 19 to 33 years). The experiment received the approval of the local ethics committee at the Faculty of Behavioural Sciences of the University of Twente.

8.2.2 Procedures

Upon arrival at the laboratory, all volunteers gave written informed consent prior to their participation (Informed Consent form). Then, the participants received detailed written and verbal instructions on all the tasks they were going to perform in the experiment. Participants were tested individually in a sound-attenuated and dimly lit room. The volunteers were invited to sit in a comfortable chair and EEG electrodes were applied. Participants were placed at a distance of approximately 100 (cm) at the eye level in front of a 24-inch AOC G2460P LED computer screen. Participants were instructed to relax and to reduce sudden movements and blinking in order to prevent distortion of the EEG signal. An experimenter sat nearby throughout the experiment to check the procedure and to answer any questions.

This experiment follows the experiment described in Chapter 7. A within-subjects design was employed and the experiment has been divided in two sessions (Label, No Labels) as described in the experiment 1 in Chapter 7. Participants were randomly assigned to one of the two conditions for the first session. The order of sessions (No Label, Label) was counterbalanced between participants. In the second task, participants were asked to select the preferred label out of two displayed labels. The wine labels used for this experiment are the same of the wine tasted in the experiment 1. The tasks consisted of a sequence of programmed steps to be completed by each volunteer within a given time window. In this Chapter, only the second task will be discussed.

8.2.3 Task

The study employed a *"Stimulus Discrimination"* task that required a right-hand or left-hand button-press in response to the presentation of different pictures of wine labels. Responses were made on a standard QWERTY keyboard, with the left index finger positioned on the "left Ctrl" key, and the right index finger on the "right Ctrl" key.

The task was performed with the simultaneous presentation of two pictures displayed on the left and right side of the computer screen. Stimuli presentation was controlled by Presentation® software (Neurobehavioral Systems, Inc., 2012).

Volunteers were asked to choose the most preferred wine label. Participant could freely decide:

1. when press one of the two buttons, however, they were instructed to answer as fast as possible.
2. whether they wanted to press the right or the left button.

The task started with ten practice trials to check if the volunteers comprehended the task.

Each trial started with a white fixation point in the center of the computer screen. Volunteers had to wait for an interval of 3000 ms before

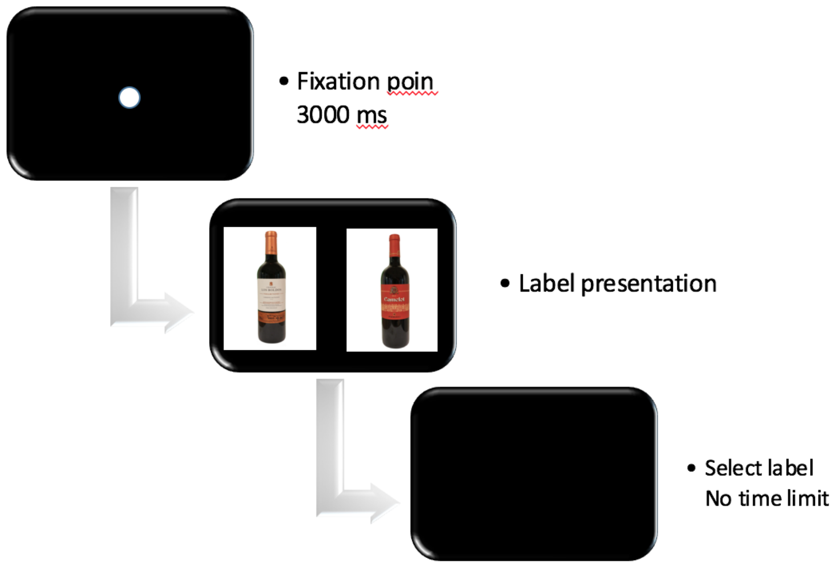


Figure 8.1: *The figures shows the label presentations on the monitor screen.*

the white fixation point turned red. After 200 ms, a short presentation of a pair of labels (800 ms) was presented on the screen. The volunteers could choose the preferred label, pressing the left or right bottom.

The stimulus discrimination task was divided in four blocks, the participants had one minute of rest at the end of each block. The blocks contained 96 stimuli each. Overall, the participants saw a succession of 384 set of pictures of four different wine labels. The duration of the task was between 42 and 47 minutes.

8.2.4 Materials and Stimuli

The stimuli consisted of pictures of labels chosen from the four different wines that the participants tasted in the first task (see Chapter 7). Stimuli were digitally presented on a 24-inch monitor at a distance of 100 (cm) in front of the participant.

The wine bottles were photographed using a NIKON D3300 camera. The bottles were positioned on a white backdrop and they were illuminated with different daylight bulbs to balance the pictures. Successively, Adobe Photoshop CC (2015) software was used to erase the background and regulate the size and luminance. The four pictures were stored as 300-pixel JPEG files. Images were displayed aligned vertically in the center of the screen.

Figure 8.2: *The left picture shows the Chilean expensive wine Los Boldos (CE). The right picture shows the Italian expensive wine Camelot (IE). The wine Los Boldos has a traditional white label with a simple design and gold drawings. Instead, the wine Camelot has a particular red label with gold drawings.*

The wine bottles were selected per country and from two different price ranges. Two of the wines selected were Chilean (Los Boldos and Cimarosa) and two were Italian (Camelot and Alturis). The Italian Camelot (*Italian Expensive (IE)*) and Chilean Los Boldos (*Chilean Expensive (CE)*) were expensive wines (price category: 24-27 euros), while the two other wines, the Italian Alturis (*Italian Cheap (IC)*) and the Chilean Cimarosa (*Chilean Cheap (CC)*) were cheap wines (price category: 3-5 euros).

The labels were selected according to specific patterns: traditional or particular, hue (light or dark) and brightness (shiny or opaque), size (small or big), different writings (white, black or gold) and overall design (simple or complex) (Batt and Dean 2000; Sáenz-Navajas et al. 2013). The two Chilean wines had a classic label and, for both wines, the type of wine and the production year was clearly written in the middle of the label.

Overall, the Los Boldos's label (CE) was more elegant and refined then Cimarosa's label (CC). The Los Boldos's label was white and bronzed, a wine company with vineyards was drawn at the bottom of the label. The country of origin was written in small characters. The Cimarosa's label was white with blue sides; the name of the wine was written in gold characters and the bottle had a plastic cork. However, the country of origin was clearly visible.

The two Italian wines had an unconventional and particular label.

Figure 8.3: *The left picture shows the Chilean cheap wine Cimarosa (CC). The wine has a traditional black and white label with gold writings. The right picture shows the Italian cheap wine Alturis (IC). The wine has a particular label and bottle shape with a colored drawing.*

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The country of origin and type of wine was shown only for the Alturis (IC), however, only the Camelot's label (IE) reported the production year. The Camelot's label was red with gold and white characters. The name of the wine, the name of the producer was clearly visible. The peculiarity of the label was a golden drown of warriors to revoke the name of the wine. The label did not show the country of origin. The Alturis's label was white and red, small red patters were presented. However, the bottle had a peculiar shape, different from the other wines.

8.2.5 Behavioral Measures

Label Preferences. Responses for the label were recorded from one of the Ctrl buttons (left or right) that had to be pressed by the participants. The responses were used in order to determine the preferred label for each participant.

8.2.6 Electroencephalographic (EEG) Measures

The EEG was recorded continuously from 32 active Ag/AgCl electrode sites using an EasyCap-62 channel cap (standard international 10–20 system layout) connected to an ActiChamp amplifier, with BrainVision Recorder software (version 1.21.0102).

The electrodes were located at the following sites: AFz, AF3,

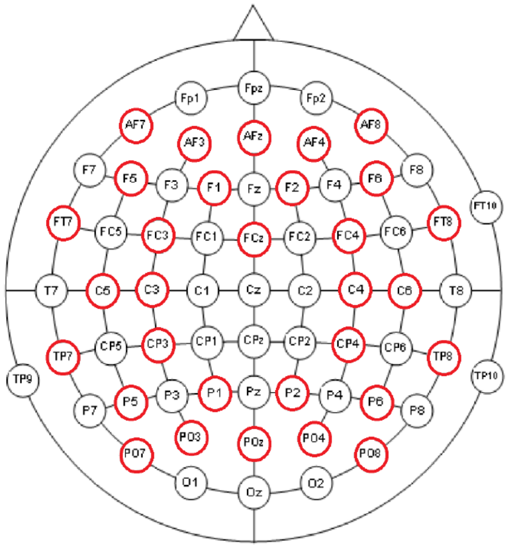

Figure 8.4: *The figure shows the position of the electrodes.*

AF4, AF7, AF8, F1, F2, F5, F6, FCz, FC3, FC4, FT7, FT8, C3, C4, C5, C6, CPz, CP3, CP4, TP7, TP8, P1, P2, P5, P6, POz, PO3, PO4, PO7, and PO8. The horizontal and vertical electro-oculogram (hEOG and vEOG) were recorded. Two electrodes were placed at the side of both eyes to measure the electrical activity generated by horizontal eye movements. Electrodes located on the infraorbital and supraorbital regions of the left eye placed in line with the pupil enabled to measure vertical eye movements and blinks. The resistance of the electrodes was kept below 10 kΩ by using electrode gel and standard procedures to improve conductivity.

8.2.7 EEG Data Analysis

The EOG, EEG and behavioral responses were measured with BrainVision Analyzer v. 2.1.1 software. The continuous data were epoched from of 1000 ms prior up to 1000 ms after the stimulus. An initial baseline was set from -1000 to o ms before the stimulus. Only trials without artifacts were selected. Hence, trials with amplitude differences exceeding $\pm$ 150 μV was marked to remove segments with horizontal eye movement from 200 ms before and after the stimulus. After the automatic artifact rejection all trials were visually inspected and rejected if eye movement artifacts or electrode drifts were visible. A criterion of at least 166 valid trials was set per condition for data analysis.

Finally, lateralized EEG potentials as a function of the to-be-attended side was carried out for all homologue electrode pairs and for each label. Lateralized potentials were analyzed on the PO7/PO8 electrode pair, using the following procedures: attend left (PO8-PO7) and attend right (PO7-PO8/2).

The data were exported in time frequency domain (from 0 to 280 ms) in time windows of 40 ms each. The data were organized and analyzed in SPSS.

8.2.8 Statistical Analysis

A repeated measured ANOVA (see Section 7.2.8) was used to analyze both EEG and behavioral data.

Firstly, the repeated measures ANOVA was used to analyzed the participants' responses to each wine label (Label preferences) and preferences. Precisely, the ANOVA was used to investigate the participants' preferences for the wine labels on the base of stimulus presentation (Left or Right side) for each wine label during the task. Differences in the participants' responses were analyzed across different conditions such as the labels, the sessions (Label, No Label) and the label presentations (Left or Right side).

Secondly, changes in PCN latencies were analyzed for the labels, the time windows and the sessions (Label, No Label). For the analysis, seven different time windows (from 0 to 280 ms) were analyzed.

For both EEG and behavioral data, associated *Degree of freedom*, *F-values*, *p-values*, *Means* and *Partial Eta Squared* were reported. First, associated Mauchly's Test of Sphericity was analyzed. Corrected results (Greenhouse-Geisser or Huynh-Feldt correction)[v] were reported when the assumption of sphericity (see Section 7.2.8) was violated.

8.3 Results

8.3.1 Behavioral Results

The repeated measures ANOVA was performed in order to compare differences between the participants' responses for the wine labels on the base of the four labels, label presentation (Left or Right side) and sessions (Label/No Label). The results show that there was no significant effect of label presentation (Left or Right side) on participants' responses (F(1,7.53)>0.1 p=0.749). Similarly, there was no significant effect of Label or No Label session on participants' responses (F(1,0.001)>2.18 p=0.153). However, results showed that there was an effect of the wine label on participants'

[v]The Greenhouse-Geisser correction was used for $\varepsilon \prec 0.75$ and the Huynd-Feldt correction was used for $\varepsilon > 0.75$.

Table 8.1: *Results of the repeated measures ANOVA analysis for the participants' responses to wine labels.*

Conditions	Correction	df	Mean Square	F	p value	η^2
Label presentation	Sphericity Assumed	1	7.538	0.105	0.749	0.004
Session	Sphericity Assumed	1	0.01	2.182	0.153	0.083
Label	Sphericity Assumed	3	44270.901	11.976	0.000	0.333

responses (F(3,44270)>11.97 p=.000).

Next, the interaction effect between all the conditions was tested. The interaction effect was used to determine whether the effect of the label preferences was consistent across labels, label presentations and sessions. No significant interaction was observed between the label presentation and both the sessions (F(1,61.53)>0.99 p=0.329) and the labels (F(2.22, 9.55)>1.44 p=0.244). Similarly, there was a slightly tendency interaction effect between the sessions and the labels (F(3,1708)>2.32 p=0.082). No effect was found for all the conditions combined (Label presentation*Label*Session F(3,0.353)>0.17 p=0.917).

The results also show that there was a small tendency effect of the order of sessions, as between-subjects effect on the participants' brain activity (F(0.01,2.18)>0.153 p=0.083).

Finally, a comparison between wine labels was performed in order to define the impact of each wine on the participants' responses. As shown in Table 8.2, there was a main effect of Los Boldos label (CE) compared to the other wine labels. Specifically, there was a significant effect of Los Boldos label (CE) compared to Camelot (IE) (F(1,81536)>12.06 p=0.002), Cimarosa (CC) (F(1,225525)>28.48 p=0.000) and Altruris (IC) (F(1,168567)>23.98 p=0.000). Similarly, there was a strong effect of Camelot label compared to Cimarosa (F(1,24707)>4.05 p=0.05). However, no significant differences were found between Camelot (IE) compared to Altruris (IC) (F(1,15613)>2.22 p=0.149). No differences were found between Cimarosa (CC) and Altruris (IC) (F(1,4137) >0.58 p=0.453).

These results suggest that there was a main effect of the Los Boldos (CE) wine label compared to the other labels (see Figure 8.5). As shown in Table 8.3, the results suggest that Los Boldos was the most preferred label. Therefore, the second preferred label was Camelot (IE). There was no significant difference between Cimarosa (CC) and Alturis (IC) wine label, however Alturis label was slightly preferred compared to Cimarosa.

Table 8.2: *The comparison between the different wine labels .*

Wine 1	Wine 2	df	Mean Square	F	p value
Los Boldos	Camelot	1	81536	12.069	0.002
Los Boldos	Cimarosa	1	225525.5	28.481	0.000
Los Boldos	Alturis	1	168567	23.985	0.000
Camelot	Cimarosa	1	24707.78	4.058	0.05
Camelot	Alturis	1	15613.01	2.222	0.149
Cimarosa	Alturis	1	4137.846	0.581	0.453

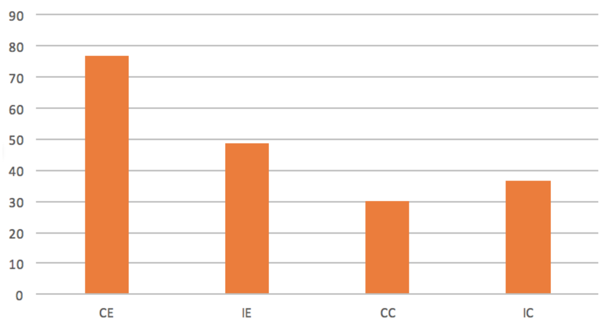

Figure 8.5: *Participants' preferences for wine labels on the base of the participants' responses during the "Stimulus Discrimination task". The figure shows that the Los Boldos and Camelot wine labels were the most preferred. Cimarosa label was the least preferred*

Table 8.3: *The overall mean of participants' responses for each label. The results show that the label of the Los Boldos wine was the most preferred, the label of Camelot was the second most preferred and third the label of the Italian cheap wine Alturis. The label of the Chilean cheap wine Cimarosa was the least preferred.*

Order	Wine	Mean	Std. Error
1	Los Boldos (CE)	76.701	5.023
2	Camelot (IE)	48.701	5.208
3	Alturis (IC)	36.442	5.092
4	Cimarosa (CC)	30.134	5.599

8.3.2 EEG results

In order to verify whether there were changes in the PCN latencies and deflections among the conditions, a repeated measures ANOVA was performed to compare the difference in the brain activity on the base of the different time windows (seven) after the stimulus presentation, sessions (Label/No Label) and labels (four).

The results showed that there was no significant difference in the brain activity between the two sessions (F(1,0.348)>2.44 p=0.130). As shown in Table 8.4, there was a significant effect in the brain activity between the seven time windows (F(3.32,0.368)>4.97 p=0.002). In addition, the results revealed that there was a significant differences in the brain activity among the four labels (F(2.74,19.88)>6.13 p=0.001). The results suggest that different wine labels had an impact on participants' brain activity.

The results also showed that there was no significant effect of the order of sessions, as between-subjects effect on the beta bands (F(1,0.00)>0.09 p=0.76).

As further examination, a comparison between wine labels was performed in order to determine the impact of each label on participants' brain activity as displayed in Table 8.5. The analysis showed that there was no significant difference between Los Boldos and Alturis (IC) (F(1,6.94)>1.18 p=0.287). A slight difference was observed between Los Boldos (CE) and Camelot (IE) (F(1,19.54)>3.74 p=0.06). A significant difference was found between Los Boldos and Cimarosa (CC) (F(1,48.19)>5.92 p=0.023), Camelot and Alturis (F(1,49.79)>6.14 p=0.021); Cimarosa and Alturis (F(1,91.72)>14. 85 p=0.001). Finally, no significant difference was found between Camelot and Cimarosa (F(1,6.35)>1.65 p=0.21).

As shown in Table 8.6, the ANOVA results also revealed that there was no significant interaction effect between time window and session (F(2.70, .10)>1.25 p=0.297). An interaction effect was observed between time window and label (F(6.97,23.02)>13.8 p=0.000). Similarly, there was a significant effect between all the conditions (Time window*Label*Session) (F(6.29,2.91)> 2.4 p=0.028). No significant effect was observed between label and sessions (F(2.66, 0.005)>0.03 p=0.986). The results suggest that there was a changed of participants' brain activity over time and for different sessions and wine labels.

In order to analyze changes in participants' brain activity over time and whether there was presence of a PCN component, a separate analysis for each time window was performed on the base of the wine labels and the sessions.

Table 8.4: *Results of the repeated measures ANOVA analysis of participants' brain activity for the different conditions.*

Conditions	Correction	df	Mean Square	F	p value	η^2
Time window	Greenhouse-Geisser	3.324	368	4.97	0.002	0.166
Session	Sphericity Assumed	1	0.31	2.283	0.144	0.087
Label	Huynh-Feldt	2.758	20.177	6.131	0.001	0.197

Table 8.5: *Results of the comparison between the different wine labels in respect to participants' brain activity.*

Wine 1	Wine 2	df	Mean Square	F	p value
Los Boldos	Camelot	1	19.544	3.747	0.06
Los Boldos	Cimarosa	1	48.19	5.925	0.023
Los Boldos	Alturis	1	6.946	1.188	0.287
Camelot	Cimarosa	1	6.356	1.658	0.210
Camelot	Alturis	1	49.793	6.148	0.021
Cimarosa	Alturis	1	91.728	14.85	0.001

Table 8.6: *Results of the repeated measures ANOVA analysis for the participants' responses to wine labels.*

Conditions	Correction	df	Mean Square	F	p value	η^2
Time window*Session	Greenhouse-Geisser	2.702	0.108	1.253	0.297	0.048
Time window*Label	Greenhouse-Geisser	6.979	26.305	13.809	0.000	0.356
Time window*Label*Session	Greenhouse-Geisser	6.293	2.912	2.407	0.028	0.088
Label*Sessions	Huynh-Feldt	2.669	0.053	0.035	0.986	0.001

1. The statistical analysis shows that in the first time window (from 0 to 40 ms) after the stimulus presentation, there was significant difference in the participants' brain activity between the sessions (F(1,0.00)>0.30 p=0.588), the labels (F(2.361,0.63)>1.19 p=0.315); interaction effect between the sessions and the labels (F(2.22,.82)>1.67 p=0.195).

2. The statistical analysis shows that in the second time window (from 40 to 80 ms) there was no significant interaction effect between session and label (F(2.57,0.07)>1.63 p=0.897) and between the labels (F(3,0.96)>2.04 p=0.115) and between the sessions (F(1,0.01)>0.386 p=0.54).

3. In the third time window (from 80 to 120 ms), no significant effect was found for the labels (F(3,0.62)>1.13 p=0.34) and the sessions (F(1,0.31)>1.94 p=0.17). However, a major interaction effect was observed for session and label (F(2.68,4.06)>4.62 p=.007). Separate t-tests confirmed (see Table 8.7) that there was a significant difference in participants' brain activity between Label and No Label sessions for Camelot (t(25)=-2.731, p=0.011) and Alturis (t(25)=3.191, p=0.004). A slightly significant effect was observed for the label of Los Boldos wine (t(25)= -1.973, p=0.06). No significant effect was found for Cimarosa label (t(25)=0.091, p=0.928). The Table 8.8 shows the mean of the participants' brain activity for the four labels in the Label and No Label sessions. The Table shows the deviation of mean activity from the baseline. Indeed, there was more negativity for the wine label Los Boldos and Camelot in the No Label Session that in the Label session. It suggests that attention was oriented towards two labels early in the No Label session compared to the Label session. It also suggests that participants attended the wine label Los Boldos the most in the No Label session. Instead, the effect was the opposite for the two cheap wines (Cimarosa and Alturis), participants attended the two labels early in the Label session compared to the No Label session.

4. In the fourth time window (from 120 ms to 160 ms), no significant effect was found for sessions (F(1,0.00)>0.10 p=0.747) or interaction effect between session and label (F(1.89,1.45)>1.522 p=0.229). The statistical analysis also show that there was a major effect of labels on participants' brain activity (F(2.08,40.38)>19.69 p=0.000). Indeed, a comparison between wine labels showed that there was a significant difference between the wine Alturis and Los Boldos (F(1,55.06)>56.66 p=0.000), Alturis and Camelot (F(1,66.72)>30.3 p=0.000), Alturis and Cimarosa (F(1,42.23)>20.66 p=0.000). A small difference was

Table 8.7: *The table shows the results of the separate t-test in the third time window (80 to 120 ms). The analysis show the difference for the four labels in the two sessions (Label, No Label).*

Label	Mean	t	df	p value
Los Boldos (CE)	-0.39434	-1.973	25	0.06
Camelot (IE)	-0.56374	-2.731	25	0.011
Cimarosa (CC)	0.02454	0.091	25	0.928
Alturis (IC)	0.62284	3.191	25	0.004

Table 8.8: *The table shows the mean for each label in the two different sessions (Label, No Label) for the third time window (from 80 to 120 ms).*

Label	Mean No Label	Std. Error	Mean Label	Std. Error
Los Boldos (CE)	-0.3006	0.1203	0.0937	0.1196
Camelot (IE)	-0.1315	0.0992	0.4322	0.1564
Cimarosa (CC)	0.0191	0.1304	-0.0054	0.2008
Alturis (IC)	0.4005	0.1330	-0.2223	0.1218

observed between the wine Camelot and Cimarosa (F(1,2.78)>3.12 p=0.089). No significant difference was observed between Los Boldos and Camelot (F(1,.55)>.63 p=.433); Los Boldos and Cimarosa (F(1,0.849)>0.548 p= 0.466). The analysis show that there was a deviation of mean activity from the baseline, thus it confirmed the presence of an early PCN. Precisely, the mean values of participants' brain activity reveal that participants' attention was strongly oriented towards the Camelot label (No Label: -0.4241; Label: -0.6300), Los Boldos label (No Label: -0.2514; Label: -0.5093) and Cimarosa label (No Label: -0.2689; Label: -0.1304). Mean values for Altruris label reveal that the participants did not attend the label (No Label: 0.9298; Label: 1.2199).

5. The statistical analysis shows that in the fifth time window (from 160 ms to 200 ms), no significant interaction effect was found between label and session (F(2,0.36)>0.37 p=0.692). However, there was a major effect of the labels (F(2.58,22.28)>23.72 p=0.000) and the sessions (F(1,0.226)>5.78 p=0.002) on participants' brain activity. The comparison between wine labels show that there was a significant difference between the wine Alturis and Los Boldos (F(1,19.29)>27.05 p=0.000), Alturis and Camelot (F(1,35.18)>26.07 p=0.000), Alturis and Cimarosa (F(1,49.94)>64.16 p=0.000). A difference was observed also between the labels of Los Boldos and Camelot (F(1,2.37)>4.02

Table 8.9: *The table shows the results of the repeated measures ANOVA for all the seven time windows.*

Time Window	Variables	Correction	df	Mean Square	F	p value	η^2
1	Sessions	Sphericity Assumed	1	0.007	0.301	0.588	0.588
	Label	Greenhouse-Geisser	2.152	0.692	1.195	0.313	0.046
	Sessions * Label	Huynh-Feldt	2.222	0.828	1.67	0.195	0.063
2	Sessions	Sphericity Assumed	1	0.015	0.386	0.54	0.015
	Label	Sphericity Assumed	3	0.962	2.041	0.115	0.075
	Sessions * Label	Huynh-Feldt	2.574	0.073	0.163	0.897	0.006
3	Sessions	Sphericity Assumed	1	0.314	1.945	0.175	0.072
	Label	Sphericity Assumed	3	0.627	1.131	0.342	0.043
	Sessions*Label	Huynh-Feldt	2.681	4.062	4.622	0.007	0.156
4	Sessions	Sphericity Assumed	1	0.004	0.106	0.747	0.004
	Label	Greenhouse-Geisser	2.082	40.387	19.696	0.000	0.441
	Sessions * Label	Greenhouse-Geisser	1.894	1.454	1.522	0.229	0.057
5	Sessions	Sphericity Assumed	1	0.226	5.781	0.024	0.188
	Label	Huynh-Feldt	2.586	22.28	23.728	0.000	0.487
	Sessions*Label	Greenhouse-Geisser	2.001	0.364	0.372	0.692	0.015
6	Sessions	Sphericity Assumed	1	0.034	0.856	0.364	0.033
	Label	Sphericity Assumed	3	19.505	13.643	0.000	0.353
	Sessions * Label	Sphericity Assumed	3	0.461	0.792	0.502	0.031
7	Sessions	Sphericity Assumed	1	0.039	1.153	0.293	0.044
	Label	Sphericity Assumed	3	10.912	4.639	0.005	0.157
	Sessions * Label	Sphericity Assumed	3	0.227	0.442	0.723	0.017

p=0.056); Los Boldos and Cimarosa (F(1,7.15)>9.29 p=0.00). No significant difference was observed between Camelot and Cimarosa (F(1, 1.28)>1.96 p=0.174). However, the mean values of participants brain activity reveal that participants' attention was strongly oriented towards the Cimarosa label (No Label: -0.5063; Label: -0.5197), the Camelot label (No Label: -0.291; Label: -0.2899), Los Boldos (No Label: -0.2514; Label: 0.1467). It suggests that the labels Camelot and Los Boldos strongly drew the participants' attention in the previous time windows (80-120 ms, 120-160 ms) and it slightly returned to the baseline (0) in the fifth time window. Instead, these results suggest that participants' attention for the Cimarosa label increased in this time window. Participants did not attend the Alturis label (No Label: 0.8702; Label: 0.8756).

6. In the sixth time window (from 200 to 240 ms) no significant effect was found for sessions (F(1,0.00)>0.85 p=0.364) or interaction effect between session and label (F(3,0.46)>0.792 p=0.502). However, the statistical analysis also show that there was a major effect of the labels on participants' brain activity (F(3,19.50)>13.64 p=0.000). Indeed, a comparison between wine labels shows that there was a significant difference between the wine label Los Boldos and Camelot (F(1,20.48)>7.95 p=0.009), Los Boldos and Cimarosa (F(1,104.42)>26.1 p=0.000), Alturis and Cimarosa (F(1,66.42)>21.55

$p=0.000$); Camelot and Cimarosa ($F(1,32.4)>18.33$ $p=0.000$). No significant difference was observed between Los Boldos and Alturis ($F(1,4.27)>1.47$ $p=0.236$); Camelot and Alturis ($F(1,6.04)>2.13$ $p=0.156$). Results show that Cimarosa label (No Label: -0.8706; Label: -0.7082) drew the participants' attention. Mean values for Los Boldos (No Label: 0.7133; Label: 0.5421), Camelot (No Label: 0.0488; Label: -0.0488) and Altruris (No Label: 0.2361; Label: 0.4456) labels reveal that the participants did not attend the labels.

7. Finally, no significant effect was found for sessions ($F(1,0.03)>1.15$ $p=0.293$) or interaction effect between session and label ($F(3,0.22)>0.44$ $p=0.723$). However, the statistical analysis also shows that there was a major effect of labels on participants' brain activity ($F(3,10.91)>4.63$ $p=0.005$). Indeed, a comparison between wine labels shows that there was a significant difference between the wine label Los Boldos and Camelot ($F(1,40.96)>8.87$ $p=0.006$), Los Boldos and Cimarosa ($F(1,49.96)>9.76$ $p=0.004$), Los Boldos and Alturis ($F(1,38.84)>5.71$ $p=0.025$). No significant difference was observed between Camelot and Alturis ($F(1,0.02)>0.00$ $p=0.941$), Alturis and Cimarosa ($F(1,0.69)$ >0.18 $p=0.668$); Camelot and Cimarosa ($F(1,0.44)>0.14$ $p=0.704$). Results show that participants' attention was strongly oriented towards Cimarosa label (No Label: -0.3192; Label: -0.1167), Camelot (No Label:-0.0874; Label:-0.1631) and Altruris (No Label:-0.065; Label:-0.1391). Mean values for Los Boldos (No Label: 0.7339; Label: 0.7906) label reveal that participants did not attend the label in this time window.

8.4 Discussion

Consumer Neuroscience literature shows that consumers' preference for a good is strongly influenced by product external cues such as price, aesthetic or brand (Plassman et al. 2008; Venkatraman et al. 2012) (see also Chapter 5). In particular, product aesthetic characteristics have the most immanent impact on consumers' judgment. In fact, the aesthetic characteristics of a product (e.g., color, package, label) represent the external features of a product, and they affect how the product is designed and perceived by a consumer. Investigating consumers' preferences for product aesthetic characteristics helps to define how consumers select a product and they can play an important role in product differentiation.

In order to understand consumers' preferences for aesthetic characteristics of a product, Consumer Neuroscience research studies the psychological and neural mechanisms that drive visual attention. Literature

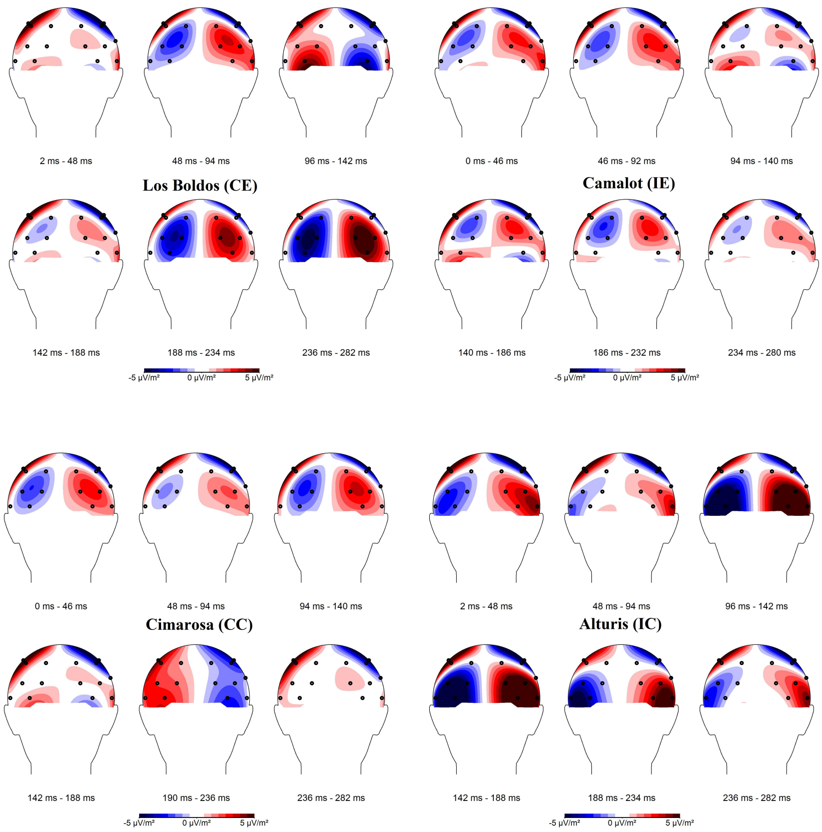

Figure 8.6: *Maps of EEG lateralization for each label at specific relevant points in time in the Label session.*

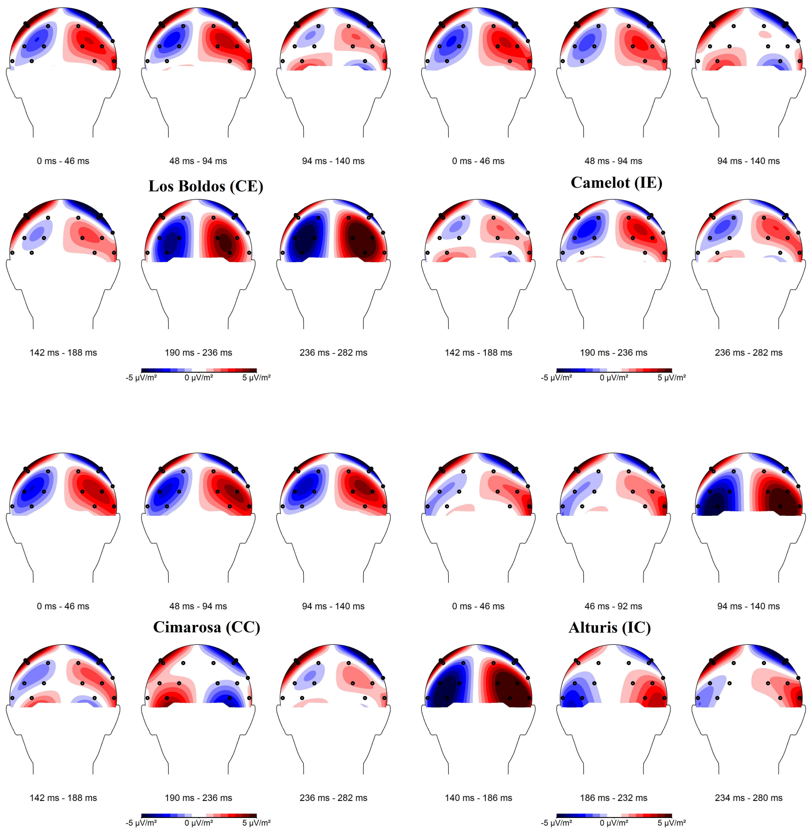

Figure 8.7: *Maps of EEG lateralization for each label at specific relevant points in time in the No Label session.*

shows that consumers' attention towards a product is strongly influenced by brain processes of visual stimuli (Karmarkar and Plassmann 2015; Miljkovic and Alcakovic 2010). Hence, studying visual allocation of attention mechanisms helps to define how aesthetic information are processed in the brain, determine the visual saliency of a product and how aesthetic characteristics can influence consumer preferences.

EEG has been broadly used in Consumer Neuroscience research in order to study visual attention mechanisms involved in product evaluation of product aesthetic characteristics. However, EEG studies mostly used ERP components to evaluate consumer neuronal responses to aesthetic features (Nazari 2014; Pozharliev et al. 2015; Thomas et al. 2013; Wang et al. 2012).

The present study aimed at investigating if the PCN components can be used in Consumer Neuroscience research in order to measure consumers' visual attention processes during the evaluation of the aesthetic characteristics of a product. Specifically, I analyzed the contribution of PCN components to the prediction of individual preferences for wine labels with different aesthetic characteristics (e.g., traditional or particular, light or dark color). EEG measures and subjects' preferences were obtained from a sample of 26 volunteers, during the view of four different wine labels. The participants were asked to indicate their preferences for the wine labels while their brain activity was recorded. In order to determine the presence of a PCN, lateralized EEG potentials were analyzed in the parieto-occipital area (PO8/PO7 electrode pair), using the following procedures: attend left (PO8-PO7) and attend right (PO7-PO8/2). Firstly, I assumed that the view of the four labels result in different PCN latencies (H1). Secondly, I hypothesized that the participants' preferences for a wine label are indicated by more negative-going deflection (PCN).

Finally, this study follows the experiment 1 described in Chapter 7 (wine tasting). In the experiment 1, the volunteers tasted wines in two different conditions (Label, No Label). In the No Label session, the participants tasted wines without the labels. In the Label session, the wines were tasted and presented together with their corresponding labels. Hence, the participants' brain activity and preferences were measured twice also for this study. Therefore, I assumed that PCN latencies in the two sessions (Label, No Label) for each wine are different (H3).

According to the first alternative hypothesis, results reveal that the view of the four labels resulted in different PCN latencies (H1). In fact, EEG data confirmed the presence of a PCN for all the wines. This was reflected in an effect of EEG lateralization on the PO8/PO7 electrode, being significant from 120 ms to 240 ms. These results suggest that the participants' attention was oriented differently among wine labels. Hence, the four labels had a different impact on the participants' brain activity as well as their preferences. This hypothesis is also confirmed by the behavioral data. In fact, there was a significant difference in the participants' preferences for the different wine labels.

Interestingly, these considerations do not apply to the second alternative hypothesis (H2). According to this hypothesis, the participants' preferences for a wine label would be indicated by more negative-going deflection (PCN). Consumer Neuroscience studies suggest that consumers' preferences for a product is strongly influenced by brain process of visual stimuli (Glimcher and Fehr 2013; Karmarkar and Plassmann 2015; Miljkovic and Alcakovic 2010). Hence, I hypothesized that a greater visual attention towards a label (increased negativity) would reflect participants' preference for that label. As discussed above, EEG lateralization on the pair electrode (PO8/PO7) was significantly different among wines over time, specifically from 120 to 240 ms. Results show that a more negative-going deflection can be observed for the (1) Camelot (IE), (2) Los Boldos (CE) and (3) Cimarosa (CC) labels from 120 to 160 ms. Similarly, a more negative-going deflection can be observed for the (1) Cimarosa (CC), (2) Camelot (IE) and (3) Los Boldos (CE) labels from 160 to 200 ms. This suggests a stronger and faster (before 175 ms) attention towards the three labels. A lack of lateralization was observed for the Alturis label. It also suggests that attention was indeed not oriented towards this label. These results are not supported by the behavioral data. In fact, the participants' preferences for wine labels show that the most preferred label was Los Boldos, followed by Camelot, Alturis and Cimarosa labels. Hence, there is a divergence between EEG and behavioral data. These observations might suggest that visual attention mechanisms do not necessarily influence individual preferences for a product. Hence, allocation of visual attention towards a product does not reflect a preference. A possible explanation for this findings is that visual attention is oriented towards that product with a stronger visual salience and not necessarily product that match personal preferences. In fact, it might be possible that the final choice of a consumer and consequently his preference for a product is influenced by a combination of more high-level information or more complex cognitive processes. Hence, a short time window (175 ms) might not be sufficient to define consumers' preference for a product.

Regarding the third hypothesis (H3), the EEG data support the view that there was a difference in PCN latencies between the Label and No Label sessions. Particularly, this difference was observed between 160 ms and 200 ms (fifth time window) after the stimulus presentation. These findings suggest that tasting the wine in different conditions (blind, with label) influenced the participants' visual attention. A possible explanation for this effect may be given in terms of differences in the variability of attentional reaction between conditions. Hence, tasting the wine with or without labels increased or decreased the participants' reaction (visual attention) for that product.

Overall, these results suggest that:

- The study of PCN components can be useful in Consumer Neuroscience research.
- Higher visual attention towards a product does not necessarily imply a particular preference for it.
- Product experience influence visual attention mechanisms.

In brief, these findings suggest that using EEG to examine visual attentional mechanisms can help to study individual preferences for product aesthetic characteristics. However, the present study has a few research constraints that can be addressed in future studies. For instance, future studies can test the effect of multiple external cues, such as price and brand, on participant's visual attention. Future research can also investigate whether gender and nationality have an impact on individual visual attention for external cues. Finally, future studies might consider to increase the number of stimuli (e.g., more labels) used in the study.

CHAPTER

9

CONCLUSION

This Ph.D. thesis focuses on the study of consumer behavior, investigating the factors that identify, define and affect the decision-making process and the buying behavior, two aspects far from being solved by Marketing research.

As outlined in Chapter 1, the combination of neuroscience, marketing and psychology research defines a new field (or sub-field) of study known as *Consumer Neuroscience*.

Consumer Neuroscience studies (1) the neuronal responses and psychological factors (e.g., motivation, attitudes) that support and affect individual preferences for products or services; (2) how consumers evaluate quality and experience product value and; (3) the effect of expectations and rewards through the study of how and when the human brain processes these informations. Hence, this thesis aims at contributing to both theoretical and practical aspects of Consumer Neuroscience research by establishing the realized benefits and potential outcome of Consumer Neuroscience research; to clarify whether and if so how neuroimaging techniques, such as EEG, can help to study consumer behavior and the influence of extrinsic cues on subject's preferences. Finally, this thesis intends at identifying potential problems in Consumer Neuroscience experiments in order to contribute to the development of future theories and improving research practice in Consumer Neuroscience research.

To address these goals, five research questions were proposed. To answer the research questions, I used both the systematic literature review and experimental results.

The chapter ends with an outlook on future research directions that build on and continue the work presented in the thesis.

9.1 Revisiting Research Questions

To provide a more detailed view of the methods and findings of this thesis, this section revisits each of the research question proposed in Chapter 1.

Research Question 1: *Does Consumer Neuroscience research improve marketing research? If is so, how?*

In Chapter 3, a systematic literature review was conducted to assess the current state of affairs in Consumer Neuroscience research. The first research question was addressed examining if and how the use of neuroscience tools can be useful for marketing research.

The literature review highlighted that Consumer Neuroscience research can help marketing research. Neuroscience methods can help marketing research due to the state of the art. In fact, these methods (e.g., questionnaires, focus groups) are not sufficient to deeply understand the mechanisms of the consumer's decision-making for two reasons. Firstly, people cannot explain completely and consciously their preferences. Secondly, the increasing non-response rates to surveys, the limitations of the Internet panels, the increased realization of a biased nature of findings in focus groups limit the efficiency of traditional marketing methods. Instead, neuroscience uses decisional models that integrate conscious and unconscious processes, without resorting to the subjective reports that have long been the mainstay of marketing studies (Miljkovic and Alcakovic 2010; Russo 2015). For this reason, neuroscience data remain insensitive to the types of biases that often hamper traditional marketing research. Neuroscience theories can give a more accurate and more objective indication of the underlying preferences of consumers (Ariely and Berns 2010).

Even though Consumer Neuroscience is unlikely to become the single way of investigating consumer behavior and market research in the future, due to a number of limitations (e.g., time consuming, cost, expertise of different neuroscience tools) compared to traditional methods, Consumer Neuroscience can help marketing research in three ways.

The most promising contribution that Consumer Neuroscience can offer is a deep understanding of cognitive and neuronal mechanisms that influence consumer decision-making and behavior (see Research Question 2 (9.1)). Consumer Neuroscience research aims at explaining and describing the neurobiological substrate of choice in consumer behavior and the decision-making process.

Furthermore, Consumer Neuroscience research can also be used to assess problems in company and organizations. In fact, Consumer Neuroscience research can help companies to understand consumer behavior as well as problems concerning business relationships, like trust and negotiation. Understanding neural and psychological mechanisms underlying trust can help companies to understand and build strong relationships with other stakeholders in the organization, for instance buyer/seller, partners in joint ventures and, strategic alliances. Similarly, Consumer Neuroscience can study how to negotiate and to deal with conflicts caused by the actual or perceived opposition of needs, values and interests between people working together. For instance, how emotions influence negotiating behavior, especially when business offers are considered to be unfair or studying cooperative and no-cooperative behaviors. However, researchers should analyze more problems in organizations that are relevant for marketing research; the risk is otherwise to focus on issues that are more related to neuroeconomics.

Finally, Consumer Neuroscience can be used to improve product and brand design. Consumer Neuroscience research investigates the neuronal and cognitive processes involved in the assessment of aesthetic characteristics and attractiveness of a product or brand. The influence of aesthetic characteristics on individual preferences for a product and brand design has been investigated in several different ways. Some researchers, using fMRI or EEG, investigated the emotional and social impact of brand logos on consumers' preferences. Using eye-tracking, other researchers investigated how aesthetic characteristics (e.g., brightness, color, shape) of a product can influence its visual saliency[i] and consequentially consumer preferences. Finally, some authors investigate how the content (e.g., ecologic) and position (e.g., bottom) of product information on the package affect consumers' perception of the product. Mostly, these studies focus on post-design application, Consumer Neuroscience can help companies also during the design process. In fact, Consumer Neuroscience offer new insights to understand how consumers assess product and brand design, to study the aesthetic characteristics that trigger consumers' attention, and to establish the main content and message that companies want to spread. Consumer Neuroscience can help to introduce new data and parameters in the design process in order to achieve a holistic product and brand design.

[i]Visual saliency (or visual salience) is the distinct subjective perceptual quality which makes some items in the world stand out from their neighbors and immediately grab our attention (Itti 2011)

Overall, Consumer Neuroscience can help marketing research by providing designers important information for testing prototypic ideas and concepts, developing the physical product; communicating product information; understanding user experience and segmenting consumers on the base of information obtained measuring brain activity during the product experience.

Research Question 2: *Does Consumer Neuroscience contribute to marketing research with regard to consumer behavior and preference?*

Chapter 3, Chapter 5 and Chapter 6 highlight whether Consumer Neuroscience research provide relevant information for marketing research with regard to consumer behavior and preference.

The literature showed that the major contribution Consumer Neuroscience offers to marketing is the study of consumer behavior. Traditional methods, such as focus groups and surveys, cannot adapt easily to new situations, for instance if the choice environment differs significantly (e.g., time, location). However, the application of Consumer Neuroscience tools and principles can help to overcome the limits that affect traditional marketing research. For instance, surveys have been for a long time an important marketing tool. Unfortunately, the non-response rates to surveys (e.g., telephonic) is extremely high and it limits marketing research.

Consumer Neuroscience instead can improve marketing research by simplifying data collection and reducing the number of methods (e.g., survey, focus group, observation) involved in the study of consumer behavior. In fact, Consumer Neuroscience experiments usually combine behavioral measurements (e.g., questionnaire) and neuroimaging data, it helps to avoid redundant measurement and it helps to study unconscious processes, hence those processes that consumers cannot explicitly explain. Moreover, the use of both psychological and neuroscience methods reduce biased results (e.g., observation) that also frequently affect marketing research. On one side, Consumer Neuroscience uses psychological methods[ii] to study the various individual aspects that play a role in human decision making and buying behavior, such as cognitive functions (e.g., verbal communication, attention) and emotions. On the other hand, neuroscience can give information on the reasons behind cognitive processes. Neuroscience methods study how cognitive functions are accomplished in the brain and what brain areas play a crucial role in these processes. Hence, the use of neuroscience

[ii]Psychology investigates how customers acquire and process information, how subjective factors (e.g., goals, beliefs, motivations) and emotions effect the decision-making process. However, psychological methods are influenced by subject's mental states and interpretations, additionally questionnaires cannot determine the reasons underlying consumer's choice, define the meaning of behavior and measure the effect or intensity of emotions (Whitley et al. 2012).

methods can help to explain how psychological processes can be tied back to neuronal processes.

The use of both psychological and neuroscience methods enables to:

1. use unbiased measures of consumer responses and to overcome the limits that affect marketing research;

2. study the decision-making process and buying behavior at different levels;

3. understand individual differences better;

4. focus on the entire buying process rather than only on the decision purchase (e.g., before that the stimulus is presented).

Due to these advantages, Consumer Neuroscience contributes the study of consumer behavior and preferences in three ways. Consumer neuroscience research focuses on how consumers evaluate quality and experience product value (subjective value), the effect of expectations, rewards and, external cues (e.g., brand, price, aesthetic) on neural and cognitive processes.

Firstly, Consumer Neuroscience research can help marketing to study and measure this subjective value and quality evaluation. The value and quality of a good are determined by intrinsic and extrinsic product cues as well as the importance that consumers place on that good and its symbolic meaning. Given that consumers are different due to several factors (e.g., personality, culture, economic status), it is plausible that preferences and buying behavior will change from individual to individual. However, as discussed in Section 2.3, people with different backgrounds (e.g., doctors, financial experts, college students) and in very different situations frequently make decisions in the same way (Hastie and Dawes 2010). Similarly, people might experience and assess value and quality in the same way. Consumer Neuroscience can help to investigate the brain areas (e.g., dlPFC) related to SV and quality; and the psychological processes involved when consumers predict, experience and remember quality and value of products or brands. Studying these processes can help to improve our knowledge of:

- how subjective value is assessed. It also helps to study the neural and psychological processes commonly involved during SV evaluation in different situation and for different subjects (e.g., socioeconomic status, nationality);

- quantify common patterns and experience (positive and negative) in the buying process (e.g., effect of light or music in a shop) on the base of neuronal processes;
- determine the level of absolute pleasure (e.g., buying the favorite clothes brand) or relative pleasure (it derives from the consumption of a specific good compared to another good; for instance, two different chocolate bars);
- measure the difference between perceived quality and value during the decision-making process and after the decision-making process.

These findings suggest that Consumer Neuroscience research helps to decompose the various components that play a role in the decision-making process and buying behavior. Companies can also benefit of these findings. In fact, understanding how quality and value are perceived and experienced helps to increase customer's satisfaction.

Secondly, Consumer Neuroscience studies focus on the study of reward. Consumer Neuroscience research studies how marketing stimuli can activate reward expectancy[iii], how and where aspects of both primary (e.g., food) and secondary (e.g., money) rewards are processed in the brain and when a reward serves as effect of positive and negative reinforcement in buying a specific product or brand.

The study of reward mechanisms can help researchers to:

- determine the level of attractiveness of a product;
- explain how negative and positive social events can affect behaviors;
- find the psychophysiological basis of brand loyalty;
- determine when consumers are more or less sensitive to marketing-based expectancy or MPE;
- better comprehend the influence of emotion in the decision-making process;
- understand how to control or to influence consumer's behavior (e.g., help people affected by compulsive shopping).

[iii]The internal process that occurs when a subject, in the case at hand a consumer, recognizes that it is in a circumstance that has been previously associated with a reward (Reber 1995).

In addition, reward contains distinguishable psychological or functional components such as liking (pleasure) and wanting (incentive motivation, such as buy the product) (Berridge 1996). These psychological components are usually difficult to explain or express consciously. However, liking and wanting have separable neural substrates (ibid.) that Consumer Neuroscience methods can better explain and define.

Overall, conscious experience seems to distort or to dim the underlying reward mechanisms that gave rise to it (ibid.). Consumers might easily fail to explain their behaviors or their preferences for a product. Hence, traditional marketing methods may contain false assessments of reward expectancy, or they even fail at all to register important reward mechanisms. Instead, the study of neural and psychological mechanism seems to be particularly suitable in order to predict and influence consumer's behavior and their preferences.

Finally, Consumer Neuroscience research helps marketing to define how internal and external cues influence product evaluation.

Particularly, Consumer Neuroscience research investigates the neuronal responses and psychological factors involved in the assessment of external cues (e.g., price, brand and aesthetic) (see also Research Question 5 (9.1). The use of neuroscientific and psychological methods helps to:

- comprehend how consumers assess preferences for products and how it influence individual preferences;
- understand how and when the human brain processes product information (e.g., before that the stimulus is presented);
- study how the external cues affect brain activity during the product experience;
- measure the influence of one or more external cues on the decision-making process and consumer behavior;
- measure the interaction of two or more cues and their degree of influence of each cues on consumer behavior.

Consumer Neuroscience research can offer useful information regarding the effects of external cues on individual preference and behavior that it is not possible to retrieve with traditional marketing methods.

Overall, these findings suggest that Consumer Neuroscience research can satisfactorily contribute to study the consumer's behavior. In fact, Consumer Neuroscience studies help to develop neuroscientific approach and to build psychological models, detailing how and why the study of neuronal and psychological mechanisms improves our understanding of the decision-making process and consumer behavior in marketing research.

Research Question 3: *What are the major problems in Consumer Neuroscience experiments?*

In Chapter 5, the last overarching research question was addressed by examining what are the major problems in Consumer Neuroscience research.

Research Question 1 (9.1) and 2 (9.1) answered if and how Consumer Neuroscience can help marketing research, specifically on the relevant information that can be obtained by the use of neuroscientific and psychological methods in the study of consumer behavior. Consumer Neuroscience seems to improve our understanding of decision-making process and consumer behavior. The number of studies in this field have rapidly grown in the past decade and consequently increasing number of methodological developments and innovations that represent significant markers of advancement. However, the literature review highlighted that Consumer Neuroscience studies present few issues and limitations. Three minor issues that affect Consumer Neuroscience research were identified.

1. The literature review underlines that there is a lack of a unified definition of Neuromarketing and Consumer Neuroscience. Mostly the two terms are considered to be interchangeable, however some authors consider Neuromarketing and Consumer Neuroscience as two distinct disciplines or activities. Moreover, there is not a clear understanding regarding the number of disciplines involved in Consumer Neuroscience. In fact, some definitions of Neuromarketing or Consumer Neuroscience include three disciplines, such as marketing, psychology and neuroscience, other authors suggested that this new field is the union of four or five disciplines (e.g., neuroscience, genetics, economics, and psychology or neuroscience, psychology, economics, decision theory, and marketing).

   There is not a clear identification of the psychological theories and methods used in Consumer Neuroscience research. Considering that Psychology encompasses a vast domain comprised of several different yet complementary areas of specialization; the use of the term Psychology might be too generic and imprecise. However, some authors used Consumer Psychology methods and theories in Consumer Neuroscience studies. However, I suggest that the subfield of Cognitive Psychology might also successfully applied in Consumer Neuroscience research. In fact, Cognitive Psychology studies cognitive processes, such as the how people think, perceive, learn, remember information, thought the use of neuropsychological, neuroimaging tools and computational models (Braisby and Gellatly 2012; Sternberg and Sternberg 2016).

2. The goals of the field are not set clearly. Defining goals and priorities is important in order to better understand valuable contributions and limits in this field. In addition it helps researchers to set priorities in their research. Finally, it limits the number of biased results, especially results spread by Neuromarketing companies.

3. The use of neuroimaging tools usually limits the product experience, especially with fMRI or MRI. In fact, analyzing preferences for food products is difficult due to administration route (how to supply the product); additionally, mastication can produce an excessive number of artifacts. Another problem that arises from the use of neuroscientific methods is that these tools demand highly artificial contexts and thus cannot provide useful data or theories about the contexts (e.g., shop) or the individual factors (e.g., economic status, motivation) that influence the buying process. However, these problems can be partially reduced using wearable devices (e.g., Emotiv) that allow to walk in a real store or implementing the experiments in a more natural and "warm" environment (e.g., light effect) that make the experience more realistic and less artificial for the test subjects. Moreover, it is important to consider that laboratory experiments possess internal validity due to the controlled and less complex environment.

The literature review also highlighted that there are five major limitations in Consumer Neuroscience research.

1. Reverse inference implies that researchers assume that the engagement of a particular cognitive process is inferred from the activation of a specific brain region (Henson 2006; Poldrack 2006, 2011). The reserve inference is based on the incorrect assumption that lead to a logical error of *affirming the consequent* (Luck and Kappenman 2011).

2. Forward inference instead is the erroneous use of different patterns of brain activity to distinguish between competing cognitive theories (Henson 2006). Forward inference refers to the incorrect assumption that if the manifestation of a cognitive process during the experimental conditions is related to one theory, but not to another, then the observation of distinct patterns of brain activity associated with those conditions establishes evidence in favor of the first theory (ibid.).

3. Consumer Neuroscience experiments can be characterized by a small sample size. Due to the overestimation of effect size and the low

reproducibility of results, small samples are more subjected to bias the results and to increase the number of false positive and Type II errors. This problem might be solved applying within-subject design. Within-subject experiments usually result in greater effectiveness and efficiency compared to experiments that employ one condition. In fact, within-subject experiments require a smaller sample (efficiency bonus), and second, the influence of participants' characteristics (e.g., age) on the dependent variable is completely eliminated (Koschate-Fischer and Schandelmeier 2014). However, numerous Consumer Neuroscience experiments still employ only one condition.

4. Consumer Neuroscience research involves the use of statistic methods. Mostly, Consumer Neuroscience experiments rely on *null hypothesis significance testing* (NHST) in order to analyze and interpret data. However, Consumer Neuroscience literature review points out that a small number of studies did not report the p-value. Even though p-values do not measure the probability that the studied hypothesis is true, it helps to determine the significance of an experiment results and its validity. In addition, Consumer Neuroscience experiments might present Type I and Type II errors. A Type I error occurs when the null hypothesis is rejected even if it is true. Type II errors instead occur when the null hypothesis is accepted when it is false.

5. Neuroscientific studies showed that it is possible to measure Marginal Utility (Pine et al. 2009; Stauffer et al. 2014). However, a literature review shows that there is no use of Marginal Utility theory in Consumer Neuroscience research. Marginal Utility can help researchers in several ways. This economic theory can be used to measure customer satisfaction and to reduce customer churn. Measuring MU benefits researchers to understand whether products and services meet or exceed customers' expectations. It also gives an indication of how likely a customer will make a purchase in the future. Hence, it can be used to improve and extend previous marketing theories and Consumer Neuroscience studies, such as study on customer's loyalty. Measuring the loyalty of customers allows to analyze how the consumer react to changing in the price. In fact, researchers might measure changing in customer total satisfaction, reducing the quantity of a specific product, when the MU of the product is less that its price. Moreover, if we consider that MU measures the rate of change in utility when the quantity of a good consumed varies (Karaivanov 2012), this parameter can be used in Consumer Neuroscience research to understand and evaluate how customers compare product.

In general, the future of Consumer Neuroscience is promising.

As discussed in Research Question 1 (9.1) and Research Question 2 (9.1), Consumer Neuroscience can improve the understanding of decision-making processes, and it revolutionizes how researchers investigate, analyze and explain consumer's behavior in marketing research. However, the use of theories and quantitative methods in Consumer Neuroscience studies present the above said issues and limitations. Hence, researchers should carefully address such limitations. In fact, these issues might drastically decrease research quality in this field and reduce academic reliability and enthusiasm in Consumer Neuroscience research. In particular, in order to improve theoretical contribution of the field researchers should try to define the goals and to identify the psychological theories and methods used. Moreover, a more careful study of the psychological and neuroscientific theories might be useful to prevent problems, such as forward and reverse inference. Improving the experimental design by using bigger simple size, within-subject design or repeated measurements can also help to reduce overall errors (e.g., Type I, Type II) and thus increase power and informativeness. Addressing these issues helps to reduce the number of false and biases results that are pervasive across scientific practice and that contaminate the neuroscience literature as well as marketing research.

Research Question 4: *Does individual preference affect the brain activity during the product experience? If so, is EEG a valid instrument to assess individual preference during the product experience?*

Giving a general overview of the current state of Consumer Neuroscience research, Chapter 5 and Chapter 6 addressed how individual preferences during the product experience can affect the brain activity. Additionally, Chapter 6 and Chapter 7 highlighted if EEG can be used to assess individual preference during product experiences.

My literature review highlight that often Consumer Neuroscience experiments extremely simplify the complexity of the buying process (Heit 2014; Koschate-Fischer and Schandelmeier 2014). In fact, Consumer Neuroscience researchers rarely investigate the neural mechanisms and responses involved in product experience. In real-life purchase experiences (except for on-line purchase), thus when consumers can interact with the product. For instance, consumer can touch, smell or taste the products. Instead, in numerous Consumer Neuroscience experiments, marketing stimuli (e.g., products) are digitally presented, thus there is no contact between the subject and the product. The lack of interaction between the subject and the product might excessively simplify the study of consumer behavior in Consumer Neuroscience. In fact, consumers cannot completely experience the product characteristics, for instance the real size of the product, its color as well as smell and taste. However, only a small number of studies discussed the effect of product experiences on consumer behavior. Particularly, researchers investigated the effect of food consumption on consumers' preferences and how this experience influence their brain activity.

In particular, Consumer Neuroscience research investigates how consumers assess product quality for food and drinks during product experiences. In fact, neuroimaging tools help researchers to explore the biological, cognitive and neurological mechanisms driven by food consumption and desires. For instance, several studies investigated how neuroimaging data can be used to predict individual preferences or craving for food (Hutcherson et al. 2012; O'Doherty et al. 2006) or to evaluate the effect of store designers (e.g., lighting conditions) on food purchasing decisions (Horska and Bercik 2014). However, numerous studies do not analyze directly how consumer preferences can influence the brain activity during product experiences. Instead, other studies investigate the brain mechanisms engaged during food product experiences in relation to extrinsic cues. Specifically, Consumer Neuroscience investigates how individual preferences for extrinsic cues such as price, label and packaging influence smell and taste perception (Lucchiari and Pravettoni 2012; McClure et al. 2004; Yucel et al. 2015).

My literature review show that individual preference for a drink and/or anticipation of a food can indeed result in an increased neural activity in different brain regions. Studies showed that reward processes and mechanisms play a role in individual preferences and hedonic decisions during product experiences. In fact, the neural structures, so called the reward system, are involved in mediating the effects of reinforcement (Reber 1995). A reinforce can be defined as the probability that a specific behavior's occurrence increases (e.g., eating more food, buying a product) over time. Hence, studying the reward system helps to understand reinforces and pleasantness as pleasure derived from repeating that behavior. For instance, the striatum (ventral striatum and bilateral striatum), as part of the reward system, has been found active during the exposure to high-calorie foods compared to low-calorie foods (Linder et al. 2010; Stoeckel et al. 2008); anticipation of a sweet food (O'Doherty et al. 2003); preference for organic label food compared to conventionally labelled food (Linder et al. 2010). Similarly, activation in the dlPFC is related to experienced pleasantness and memory for brand and/or price for food products. Particularly, increased activity in the dlPFC has been observed in the comparison between organic and conventional food (Laan et al. 2011); during the tasting of Cola Cola compared to Pepsi; cognitive regulation and craving for food (Hutcherson et al. 2012); preference for expensive wines (Plassman et al. 2008) and willingness to pay (Plassman et al. 2008; Plassmann et al. 2010; Plassmann and Weber 2015). Another brain region such as amygdala is related to taste pleasantness, for instance during the choice of healthy food compared to less healthy food (Grabenhorst et al. 2013).

Overall, these findings suggest that individual preferences during the product experience can affect brain activity in several ways. In fact, product experiences affect the performance of different cognitive (e.g., reward, memory) and brain areas (e.g., striatum, dlPFC) mechanisms. Simultaneously, it influences individual behavior, including the long-term transformations (e.g., preference for the same brand). In addition, the study of individual preference that underlying product experiences can help to understand how cognitive and neural mechanisms are involved with consumer behavior and purchasing decision-making. Finally, one important contribution of Consumer Neuroscience might be to understand how the brain "feels" food/drink product either as a form of fundamental physiological needs or a source of pleasure.

In general, my literature review also highlighted that mostly of these studies were conducted using fMRI. There are only a few studies that investigate individual preferences during product experiences using other neuroimaging tools such as EEG. These experiments mostly investigate the effect of extrinsic cues, such as brands on individual preference during the product experience. For instance, Park et al. (2015) investigated changes in alpha, delta, and high beta bands on the base of individual satisfaction scores derived from different tactile attributes for washing machines. The results showed that alpha, delta, and high beta bands were negatively correlated an individual satisfaction scores. Hence, it was not possible to relate these changes in the different frequencies bands to a specific brain region (Park et al. 2015).

Next, Lucchiari and Pravettoni (2012) examined the influence of different water brands on beta and theta bands activity during water tasting. Similarly, Yucel et al. (2015) investigated changes in alpha and theta band activity during the taste of branded coffee. Both experiments tried to determine whether individual preferences for a brand could influence the brain activity during the tasting process. However, the two experiments gave contrasting results. In fact, in the study of Yucel et al. (2015), results showed that increase in theta band activity was associated with the preferred coffee brand. Conversely, the study of Lucchiari and Pravettoni (2012) found that an increase in theta band was associated to less favorite brands and an increase in beta band activity was associated with the favorite water brands. Moreover, it is still not clear how changes in different frequency (alpha and theta, beta and theta) can be associated with the same process, such as influence of brand during product tasting.

For this reason, in this thesis, individual preferences for wines were measured with EEG during the wine tasting. A reverse inference was adopted to test the conceptual replication of the Boksem and Smidts (2015) study. Hence, I assumed that beta band oscillations reflect reward processes and pleasantness. Results identified changes in beta band activity for the four different wines. However, preferences for the wines were not related to increased beta band activity. On the contrary, there was a negative relation between individual preference and beta band activity. Hence, I could not relate neural activation to individual choice for wines.

It might be also possible that cognitive and neural mechanisms involved in movie evaluation (Boksem and Smidts 2015 study) are different from neural processes involved in product experiences. For instance, watching a movie might involve different cognitive and neuronal processes (e.g., visual attention) that are different from those that arise from a wine tasting (e.g., processing of olfactory and gustatory signals). Hence, the increased activation of beta band activity in the study of Boksem and Smidts (2015) might be related to an arousal of the visual system during increased visual attention. Instead, wine tasting does not imply a visual attentional process but processing of olfactory and gustatory signals that might have a different impact on beta bands oscillations. It might suggest that it is not possible to reproduce the findings of Boksem and Smidts (2015) study for the wine product. Hence, findings for the study of consumer behavior during the product experience with EEG cannot be easily generalized. Instead, it might imply that different products affect cognitive and neuronal processes in several ways.

Overall, EEG is a useful tool to study brain activity due to its high temporal resolution, low costs (for both the instrument and experiments), dimensions and, maneuverable compared to other tools. For instance, EEG, if compared to fMRI, does not restrict the participant in a small space. It allows the participant to accomplish small movements. Hence, EEG might recreate a more realistic and natural experience for the consumer during the experiment. However, the use of EEG to study consumers' preference in product experience is still limited. In fact, only a few studies used EEG to investigate brain activity during product experiences. It follows that there are still some constrains and issues that limit the use of EEG to assess how individual product experiences can influence cognitive and neuronal mechanisms in Consumer research.

Unlike studies conducted using fMRI, it is difficult to define a consistent and solid theoretical background. In fact, the study of brain activity using EEG seems based on isolated attempts to relate EEG components to the study of individual preferences. Usually, it is not clear the motivation that lead researchers to link some brain wave frequency (e.g., theta bands) to a specific cognitive process (e.g., reward mechanisms). Hence, it is not possible to identify a common experimental paradigm.

Finally, the lack of a solid theoretical background makes experiments difficult to replicate. One reason for the current state of affairs may be that studies have utilized experimental designs, which, although useful for establishing cause and effect relationships, tend to drastically limit the number of variables that can be examined in combination. Moreover, as discussed in the research Question 3 (9.1), Consumer Neuroscience experiments with EEG rarely apply within-subject design. Hence, there is no theoretical background of how the brain activity of the same subject changes in relation to the same product presented but in different conditions.

Overall, the study of consumer behavior during product experiences is still in the fledgling stage, and current investigations have been mostly targeted to basic research. For that reason, to date, the findings derived from the use of EEG tools in product evaluation must be carefully examined as well the use of EEG to predict consumer's preferences.

Research Question 5: *Do extrinsic cues influence individual preference and brain activity? If so, can the influence of extrinsic cues on individual preference be measured using EEG?*

In Chapter 5, 6, and 8 the last research question was addressed.

My literature review show that Consumer Neuroscience research focuses on the study of neural and cognitive mechanisms involved during different stages of product quality evaluation. Specifically, studies investigate how consumers evaluate the extrinsic cues of a product and how they influence and affect consumer behavior and decision-making process. Consumer Neuroscience research investigate the effect of three important extrinsic cues, such as price, brand and aesthetic on consumer behavior.

Firstly, Consumer Neuroscience studies focus on the effect of price on consumers' preferences. Researchers investigate how different prices can create positive or negative expectations in the purchase decision, thus how price differentials influence brain activity. For instance, studies show that usually low prices activate brain areas involved in reward mechanisms, such as middle temporal gyrus (Linzmajer et al. 2014; Xia et al. 2004). On the other hand, high prices activate brain areas, such as insula or prefrontal areas, that are usually associated with negative emotions or reflective process (Linzmajer et al. 2014; Xia et al. 2004). These findings suggest that (1) a higher price is associated with negative emotions, such as pain or anger, and that (2) purchase decisions for the same product became more complex and less certain if high prices are compared with low prices. However, several studies show that high prices can also create the opposite effect. In fact, researchers found that higher prices positively enhance consumers' experienced quality of a product, thus people enjoy consuming identical products more when they have a higher price (Geuter et al. 2013; Knutson et al. 2007; Plassman et al. 2008, 2015). For instance, Plassman et al. (2008), using fMRI, found that a high price changes consumers' preferences for wines, their pleasantness perceived and modifies consumers' brain activity. In fact, results showed that higher prices increase the activity in brain areas involved in pleasantness, such as left mOFC and the left ventromedial prefrontal cortex (vmPFC).

Secondly, Consumer Neuroscience studies neural processes involved with brand decisions. Particularly, Consumer Neuroscience research investigates how consumers predict, experience and remember brands. Several brain areas have been related to the psychology of brands, such as the anterior and the paracingulate cortex, the orbifrontal cortex (OFC) the striatum, the hippocampus, the ventral medial prefrontal cortex (vmPFC) and the dorsolateral prefrontal cortex (dlPFC) (McClure et al. 2004; Plassman et al. 2007, 2012, 2015; Santos et al. 2011, 2012; Schaefer and Rotte 2007). Each brain area has been related to one or more cognitive processes and brand judgment. For instance, the vmPFC has been related to preference judgments, processing emotions after the decision-making as well as brand loyalty (Plassman et al. 2007; Santos et al. 2011). As shown in Plassman et al. (2007), customers who are loyal to a brand, such as H&M vs. Zara, show a stronger activation in the striatum, in the vmPFC and the ACC compared to customers who are less loyal, even though both buying identical clothes.Similarly, McClure et al. (2004) investigated the effect of two famous drink brands: Coke and Pepsi on individual preference and brain activity in different tasks. Authors found that two brain areas related to emotional memory and cognitive control such as the hippocampus and the dlPFC, were more active during Coke delivery compared to Pepsi. This suggests that there was a significant influence of the brand Coca Cola on participants' preferences and brain activities (McClure et al. 2004).

Thirdly, Consumer Neuroscience studies the effect of aesthetics on individual preferences and product quality. Numerous studies examined how color, shape, proportions can influence individual perception of the same product and, thus subject's brain activity or visual attention. For instance, Rojas-Lopez et al. (2014) used eye tracking to investigate differences in the participants' visual attention for the same product (beer bottle) when they saw the real picture or a virtual one (rendering). Results showed that people spent more time to analyze the virtual picture, specifically the upper label. In fact, the representation in the real picture was excessively simplifying, meanwhile the virtual bottle showed a more visible text label (Rojas-Lopez et al. 2014). This study suggests that people take long to analyze the image with a better quality, which is reflected in the heat map capturing more attention from the observer. On the other hand, studies investigated the differences in the brain areas involved during product evaluation with different aesthetic components (e.g., luxury, ecofriendly labels). Several studies found that aesthetic components can modulate the brain areas related to reward. For instance, using fMRI Reimann et al. (2010) investigated the differences in consumers' brain activity during the view of decorated packaging compared to standardized packaging. The results show that intense emotional responses, such as the view of decorated packages elicited affective processes the most. In fact, specific affective brain areas of the reward system, such as the nucleus accumbens and the ventromedial prefrontal cortex were activated during the view of decorated packaging (Reimann et al. 2010). These results suggest that measurement of affective product engagement can be positively related to aesthetic product experiences in the brain.

Overall, these studies show that different tools, such as fMRI, and eye-tracking can be used to analyze the effects of extrinsic cues on product evaluation. However, my literature review highlights that EEG is also a useful tool for detecting the effects of external cues on consumer's preferences and brain activity. As for fMRI studies, EEG can be used to measure the electrical brain activity of consumer in order to determine the level of attention, preference, familiarity, pleasantness or unpleasantness that an individual has for a product or its peculiar characteristic. Studies conducted using EEG involve the measurements of EEG oscillations (regular cyclic voltage changes) in (1) different frequency bands or (2) changes in ERP amplitudes.

Firstly, researchers try to measure individual changes in frequency bands in order to relate variations of the activity of specific anatomical structures to cognitive process, such as attentional and emotional process, with respect to extrinsic cues. For instance, researchers study changes in different frequency bands in relation to individual preferences for brand, price and aesthetic characteristics. Balconi et al. (2014) found that increased theta band activity is related to individual preference for specific branded products. Precisely this increase was found in the dlPFC, the brain area related to reward mechanisms. Similarly, Apriliantry et al. (Balconi et al. 2014), comparing individual preferences for underwear of different prices (low, medium, high), found that an increase in beta band in the parietal lobe and in the temporal lobe is related to preferences for underwear of high price.

Secondly, researchers analyze changes in ERP amplitudes in order to measure changes in neuronal and cognitive with regard to individual preferences for external cues. In particular, studies used the ERP component in order to determine which cognitive or neural processes differ during consumers' evaluation of different brand or aesthetic properties. In fact, ERP allows to see processing that occurs before, during and after the execution of a specific behavioral responses (Luck and Kappenman 2011). For instance, studies investigated some differences in ERP to evaluate consumers' neural responses to aesthetic features of jewelries (Wang et al. 2012). Changes in the P2 component on the frontal, central and parietal areas show that the view of less beautiful jewelries resulted in greater latencies of the P2 than the view of beautiful jeweleries. This might suggest that at the early stage of an aesthetic experience, negative emotional experiences are automatically aroused for less beautiful (less selling) objects (ibid.). However, these changes might also suggest ERP may be a sensitive measure of attention for aesthetic components but not preferences. Similarly, studies investigated whether the ERP component could give useful information on the memorization of brand. For instance, Nazari (2014) investigated whether the N1 component of ERP can be used to measure consumers' preferences of familiar (e.g., Coke) and unfamiliar (e.g., Ayda cola) brand beverages. The results of the experiments showed that a significant increase in the N1 component amplitude was found in the occipital lobe for familiar logos compared to the unfamiliar ones, which might refer to a pre-comprehension brain activity (Nazari 2014). It suggests that familiar brands are processed faster in the brain and are easier to recall, compared to unknown brand. Finally, the ERP component can be used to assess how social context influence neuronal and cognitive processes. As shown in Pozharliev et al. (2015), the presence of a person during the view of pictures of luxury products versus basic branded products can affect consumer preferences and the ERP component.

In Chapter 8, I also used EEG to investigate whether participants' preferences for wine labels are reflected by changes in the participants' brain activity. Numerous psychological and neuroscientific studies investigated PCN parameter in order to trace whether the timing and the allocation of visuospatial attention is modulated by stimulus intensity, stimulus saliency and set size (Tollner et al. 2011a,b; Van der Lubbe and Abrahamse 2011; Van der Lubbe et al. 2014; Vossel et al. 2015; Zehetleitner and Muller 2010). However, my literature review highlights that there is no history that PCN parameter has been used in Consumer Neuroscience research. Hence, I analyzed whether PCN parameters, precisely EEG lateralization in the parieto-occipital area, can be used to assess and predict consumers' preferences for wine labels. Results show that the view of the four labels resulted in different PCN latencies. Hence, these results confirmed that the four different labels influence the participants' brain activity and the visual attention in a different way. However, results also show that the favorite labels were different from those labels that caught participants' visual attention. These observations might suggest that visual attention mechanisms not necessarily influence individual preferences for a product.

Hence, allocation of visual attention towards a product does not reflect individual preference for it. A possible explanation for this findings is that visual attention is oriented towards the product with a stronger visual salience and not necessarily product that match individual preferences. In fact, it might be possible that the final choice of a consumer and consequently his preference for a product is influenced by a combination of a high-level information or more complex cognitive processes. Hence, a short time window (175 ms) might not be sufficient to define consumer preference for a product.

Overall, these findings suggest that the use of EEG to examine cognitive and neuronal mechanisms during the exposure to product external cues can help the study of individual preferences and behavior. The main contribution that EEG can offer is the study of the visual attention mechanism in product evaluation. In fact, the track of emotional (pleasantness or unpleasantness) or reward processes with EEG is still in a immature stage compared to fMRI (see also Research Question 4); the measurement of ERP components seem to offer a better understanding of the attention-allocation behavior of consumers for external cues.

In particular, the study of visual attention mechanisms can help to define at a more general level the factors that influence consumer behavior as well as their preferences. In fact, studies with EEG help to (1) define the visual saliency of each product; (2) study which extrinsic cue has the major effect compared to the others (e.g., brand or design; brand or price). Moreover, the study of visual attention mechanisms helps to determine when individual preference for a product is directly related to its visual saliency or is modulated by more high level information. In general, investigating visual attention mechanisms help to define when a product is able to catch consumer's attention as well as match his/her preferences, thus whether the consumer is attracted to the product but he/she is also willing to buy it.

Finally, the experimental study presented in Chapter 8, also suggest that PCN components might be useful to study visual attention processes during product external cues evaluation. Hence, the study of PCN in Consumer Neuroscience research might add value to the study of product evaluation.

These findings showed that EEG is a useful tool to investigate the relation between cognitive function (e.g., attention) and brain activity during the exposure to product external cues. In fact, EEG data provide additional insight that cannot be gained with behavioral measurement alone.

9.2 Key Takeaways

This thesis provides both theoretical and empirical contributions to Consumer Neuroscience research. The literature review has highlighted both the benefits that Consumer Neuroscience research provides to marketing research and its limitations.

Contributions to marketing research:

- the combined use of neuroscience and psychological measurements provide unbiased measures of consumer responses and individual preferences
- the study of the decision-making process and buying behavior at different levels such as the study of subjective value and quality evaluation; reward mechanisms and the assessment of extrinsic cues

Limitations of Consumer Neuroscience research:

- the lack of a unified definition and the number of disciplines involved in the field
- unclear definition of the goals
- the difficulties to reproduce a natural environment and the study of the product experience
- reverse inference
- forward inference
- small sample size (less than 20 for most studies)
- Type I and Type II errors
- no use of Marginal Utility theory

In order to improve and avoid the aforementioned flaws and limitations in Consumer Neuroscience research, the experimental design was set up considering:

- a real product experience (Wine tasting)
- larger sample size (52 tests in total)
- repeated measurements (within-subjects design)
- testing the conceptual replication of an EEG study problem

Empirical results have shown that:

- there are changes in beta band activity during the product experience. However changes in beta band activity cannot be related to individual preferences
- EEG allows to measure the influence of extrinsic cues on individual preferences and brain activity
- EEG allows to study visual attention mechanisms during the product external cues evaluation
- the PCN component can be used to study consumers' visual attention

Overall, the findings presented in this thesis suggest that Consumer Neuroscience improves the study of consumer behavior.

9.3 Limitations and future directions

The studies documented in this thesis come with some limitations, which offer opportunities for future research. Although I have tried to minimize methodological short-comings, the present thesis is not completely error-free. Hence, the reliability and validity of the research study could be improved in future experiments.

I would like to highlight six directions for future work.

Firstly, I used EEG to study how individual preferences and brain activities during the product experience and evaluation of extrinsic cues. Future studies could involve the use of other biometrics tools such as hormonal responses, heart rate, respiration rate and skin conductance responses. For instance, the intake of different wines may result in differences in heart rate and blood pressure, hence whether it can add important information to the way consumers experience wine. Other tools such as eye-tracking could also be extremely useful for studying the influence of extrinsic cues. For instance, it might help to analyze visual saliency characteristics of wine labels better.

A second direction for future work is to improve the intake of wine during the tasting. In order to recreate a real wine tasting experience, participants were asked to pick up the glass and the taste the wines. However, the arm and head movements might create excessive artefacts. In future experiment, researchers might consider to use an automatic machine to administer the wine or another drink. Alternatively, wine could be given manually by a phial.

Thirdly, future research could increase the number of extrinsic cues analyzed in the experiment. For instance, researchers might analyze the effect of other extrinsic cues such as price or country of origin, on individual preference for wine. Eventually researchers could study the combined effect of two or more extrinsic cues on subject's brain activity and preferences. Hence determining which extrinsic cue has the major impact on individual preferences.

A fourth direction for future work is to analyze differences in brain activities and individual preferences between expert (sommelier) and inexpert wine consumers during the tasting procedure. Neuroscientific studies showed that several functional differences could be observed in brain activation patterns between experts and inexpert during wine tasting. Specifically, brain activity for sommeliers results in a large area involving the olfactory and memory regions, especially during the olfactory task. Hence, future experiments can analyze the difference in individual preference and brain activity for these two categories of consumers. The study could also be applied to test the difference between expert and inexpert during the extrinsic cues evaluation.

Next, I used four wine labels to analyze visual attention and individual preferences. However, researchers could consider to increase the number of stimuli involved in the study of visual attention mechanisms. A greater number of stimuli (e.g., 10 labels) might provide a more accurate analysis of individual preferences for wine labels as well as attention and memory mechanisms.

Finally, no moral issues and ethical implications of Consumer Neuroscience research are discussed in this Ph.D. thesis. Future research could analyze the effect of Consumer Neuroscience research on personal privacy and ethical values and principles. Economic implications of this research should also be analyzed. For instance, it is possible to compare the contributions of Consumer Neuroscience to marketing research with others disciplines for instance digital marketing.

Appendices

Appendix A

Participants Tasting Wine

Figure A.1: *The picture shows one of the participants during the water tasting.*

Figure A.2: *The picture shows one of the participants during the wine smelling.*

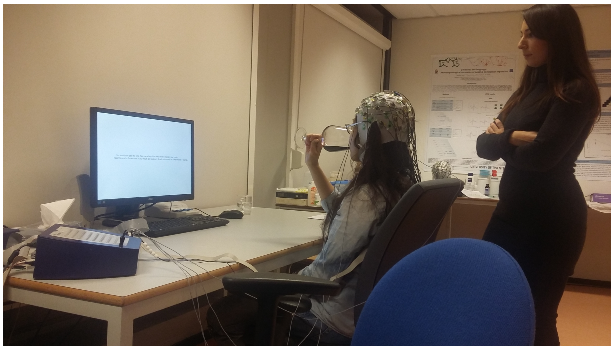

Figure A.3: *The picture shows one of the participants during the wine tasting.*

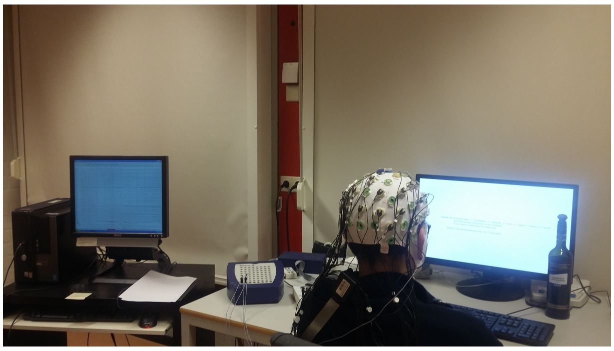

Figure A.4: *The picture shows one of the participants during the wine tasting in the Label session.*

Appendix B

Distribution of EEG Data

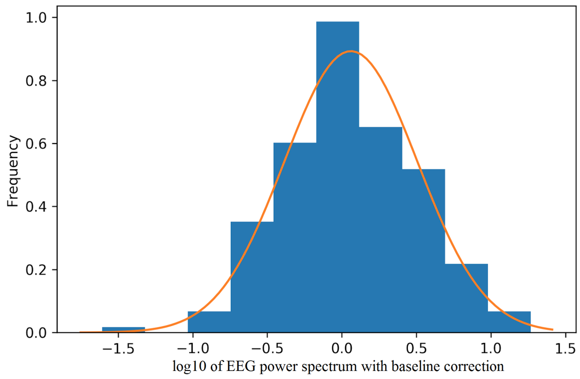

Figure B.1: *The figure shows that the output of the EEG data for the electrode FC4 (12-16 frequency) is normally distributed after the log10 transformation.*

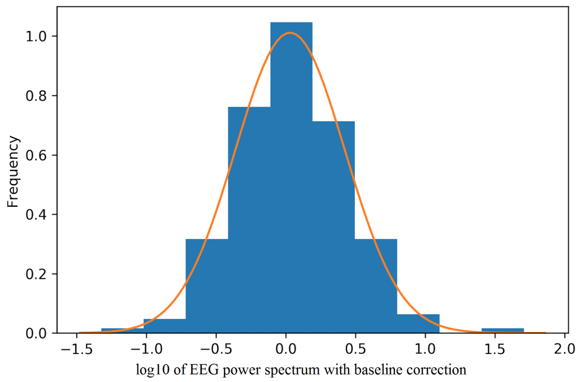

Figure B.2: *The figure shows that the output of the EEG data for the electrode FC3 (16-20 frequency) is normally distributed after the log10 transformation.*

Appendix C

Questionnaire

Wine Questionnaire

Name Participant: Progressive Number Assigned ☐

Name	Surname	
Age	Nationality	Gender Male ☐ Female ☐
Education level ☐ Bachelor; ☐ Master; ☐ Graduated; ☐ PhD student; ☐ Post Doc; ☐ University employee; ☐ professor ☐ Other_____________________________		

N.	Question
1	Did you ever drink wine before? YES ☐ NO ☐ (If No you cannot participate)
2	When was the last time you drank wine? ☐ Yesterday; ☐ Last week; ☐ Last month; ☐ Last 6 months; ☐ 1 year ago; ☐ 2-5 years ago
3	How frequently do you normally drink wine? ☐ Once in two months; ☐ Once a month; ☐ Once a week; ☐ More than once a week; ☐ Daily
4	Under what circumstances do you drink wine (You may choose more than one option). ☐ With meals at home ☐ With meals at restaurant ☐ With meals at wine bar/ winery ☐ Gathering with friends ☐ Gathering with families ☐ In the evening when watching TV alone (Without meals) ☐ Celebration of special occasion ☐ Others, Please explain____________________________
5	How would you classify your wine knowledge?

	□ Amateur; □ Basic knowledge; □ Expert; □ Professional
6	What are your criteria for choosing wine? (You may choose more than one answer) □ Price; □ Quality ; □ Grape variety; □ Wine type; □ Bottle Design; □ Label □ Familiarity with the brand; □ Recommendation of friend(s)/relative(s)
7	Places where you mostly purchased wine during the last year? (You may choose more than one option) □ Supermarket (Albert Heijn, Jumbo, Coop, etc.); □ Discount Store (Lidl, Aldi, etc.); □ Winery; □ Online wine shop ; □ Others (explain)________________________________
8	How much do you spend on average when you buy a bottle of wine? (You may choose more than one answers) □ 3-5 euros; □ 6-9 euros; □ 10-15 euros ; □ 15-20; □ 21-27; □ 28-34; □ 35-45; □ more than 50
9	When you buy wine how important is the "Country of origin"? □ Not important □ Not very important; □ Important; □ Very important; □ Extremely important
10	Indicate if you have ever tasted wine from any of the countries below: □Africa; □ Albania; □ Argentina; □ Armenia; □ Australia; □ USA (California); □ China; □ Chili; □ France; □ Georgia; Germany; □ Greece; □ Italy; □ New Zeeland; □ Portugal; □ Spain; □ South Africa; □ Other___________________________________
12	Could please rank the countries that you chose before from the best to the worst, according to your opinion (if you do not have one leave it blank):
13	When you buy wine, how important is the *type of grape* (e.g., Cabernet Sauvignon, Merlot, Syrah, Montepulciano, etc.) to you? □ Not important; □ Not very important; □ Important; Very important; □ Extremely important
14	When you buy wine, how important is the *wine type* (e.g., Chianti, Bordeaux, Amarone, Gewürztraminer, etc.)? □ Not important; □ Not very important; □ Important; □ Very important; □ Extremely important
15	When you buy wine, how important is the *brand* or the *producer* (e.g., Masi, Joseph Drouhin, Mommessin, Moët & Chandon, etc.)? □ Not important; □ Not very important; □ Important; □ Very important; □ Extremely important
16	When you buy wine, how important is the label (color, size, drawing, etc.)? (See Pag. 3) □ Not important; □ Not very important; □ Important; □ Very important; □ Extremely important
17	When you buy wine, how important is the design of the bottle? (See Pag. 3) □ Not important; □ Not very important; □ Important; □ Very important; □ Extremely important
18	Do you prefer a traditional bottle or a particular one (e.g., all colored, funny drawing, Swarovski, metallic, particular shape, etc.): □ YES (Traditional) □ NO (Particular)

19	How important are *advertisements* to you for buying wine (incl. printed, online and broadcasting media)? ☐ Not important; ☐ Not very important; ☐ Important; ☐ Very important; ☐ Extremely important
20	How important are the *opinions/suggestions from your family/friends/ wine shop's staff*? ☐ Not important; ☐ Not very important; ☐ Important; ☐ Very important; ☐ Extremely important
21	When you buy wine, how important is your own knowledge about the wine? ☐ Not important; ☐ Not very important; ☐ Important; ☐ Very important; ☐ Extremely important

http://www.montemaggiore.com/?method=blog.blogDrilldown&blogEntryID=2C240DC5-EDDA-2161-BC85-E879C25A2B78&originalMarketingURL=blog/All-you-need-to-know-about-Wine-Bottles

http://natashamonnereau.com/what-a-wine-bottle-can-tell-you-about-a-wine/



https://www.foodwise.marketing/trenduri-in-packaging-in-2016/

http://bestcreativity.com/blog/it/le-migliori-etichette-bottiglie-del-2013/b/

http://bestcreativity.com/blog/it/le-migliori-etichette-bottiglie-del-2013/p/

Appendix D

Guideline Experiment

Guideline

Emotional reactions of individuals will be measured while (1) tasting different types of wine, (2) observing labels of different wine bottles. The brain activity of the volunteer will be monitored using an Electroencephalography (EEG), under the supervision of Dr. Van der Lubbe.

The experiment is divided in 2 Sessions, divided by about 14 days. Volunteers will have to take part in both sessions.

Each Session has three Tasks.

Task 1. The subject will taste four different wines while EEG is being measured.

Task 2. After that, the subject has tasted four wines he/she will be asked to fill in a questionnaire. The subject should express his/her preference about the wine that was tested before.

Task 3. In this task, participants have to choose between different labels displayed on a monitor. After a short presentation (500 ms) of a pair of labels, volunteer waits for a Go/NoGo signal. When a NoGo signal is displayed, no response is given, when a Go signal appears, he/she chooses the preferred label. This Go/NoGo procedure helps to understand how consistent are volunteer's choices.

Before starting the experiment, volunteers will be asked to sign an Informed Consent Form, and will report personal information and wine purchasing and consumption habits.

Duration

Each session will last for about 2 hours and 30 minutes.
The first hour is required to prepare the subject and instruct him/her about the Tasks.

Appointment schedule

The time of each session will be set in in the afternoon, according to the volunteers' availability. The volunteers can choose the date and the hour that they prefer for the experiment.
Once set the date the volunteers will receive a questionnaire form to complete.

Volunteer Requirements

- The volunteers must be adult between 18 and 40 years.
- Non-smokers are preferable.
- If the volunteer is a smoker will be kindly required not smoking 12 hours before the EEG trial.
- Volunteers should not use scent the day of the experiment and preferably the day before.
- Volunteers must not use hair tonic or hairspray before taking part in the experiment.
- Subjects with particular vision problems or suffering from neurological diseases, metabolic or psychological diseases or with a history of alcohol abuse[1] will be excluded.
- Moreover, subjects will have to declare not to be under care of drugs that interfere with the EEG performance.
- Volunteer will not be paid.

A small quantity of gel will be used to fix the electrodes to the cap.
It is possible that at the end of the experiment you might need to wash your hair.

Please contact:
Letizia Alvino
l.alvino@utwente.nl

[1] A.U.D.I.T. (Alcohol Use Disorders Identification Test)
People with a score up 19 (4th zone) cannot participate

Appendix E

Guideline Experiment

UNIVERSITEIT TWENTE

EEG Research

Informed Consent

On a voluntary basis, I decided to participate in an experiment in which EEG, eye movements and response times will be measured to provide information on how people experience and evaluate wine.

After having finished the experiment, I will be informed on the specific purpose of the research, and the opportunity will be given to ask further questions. In case of later additional questions I can always contact Dr R.H.J. van der Lubber, researcher at the department Cognitive Psychology and Ergonomics at the University of Twente (tel: 053-4893585).

During the Experiment I have the right to quit my cooperation at any time.

I understand that the acquired data will be used for scientific publications and will be handled confidentially. In addition, my anonymity is assured.

Place: Date:

Name participant: Name researcher:

Signature participant: Signature researcher:

Add another part

Participant Registration Form

To fill in by the participant:

First appointment

Name: ____________________________________

Date of birth: __________________

For the next questions please circle the answer that is applicable for you:

Sex: Male / Female

Visibility: No eye correction / glasses / contact lenses

Neurological / psychiatric history: Yes / No If yes

Medication: Yes / No If yes

Have you got any hearing disabilities?	Yes / No
Have you got any electrical medical devices inside your body? (i.e. a pacemaker)	Yes / No
Have you got any extern electrical devices? (i.e. hearing devices)	Yes / No
Have you got any metal objects in your head?	Yes / No
Have you got a skin disease that affects your scalp?	Yes / No
Have you got any non-removable piercings in your ear/ eyebrow/face?	Yes / No
Do you have a history of extensive alcohol or drug use?	Yes / No
Have you consumed alcohol or drugs in the past 24 hours?	Yes / No
Have you smoked in the past 24 hours?	Yes / No
Have you used any hair gel?	Yes / No

Indicate the preferred hand:

	Always left	Mostly left	No preference	Mostly right	Always right
Writing a letter					
Throw a ball to hit a target					
To play a racket tennis, squash, etc.					
What hand is up to handle a broom removing dust from the floor					
What hand is up to manipulate a shovel					
Lighting matches					
Scissors when cutting paper					
To hold a wire to move it through the eye of a needle					
To distribute playing cards					
To hit a nail on the head					
To hold your toothbrush					
To remove the cover from a jar					
	-2	-1	0	+1	+2

- 24 tot - 9 Left handed
- 8 tot + 8 Ambidextrous
+ 9 tot +24 Right Handed

Annett Handedness Inventory

Annett, M. (1970). A Classification of Hand Preference by Association Analysis. British J of Psychol, 61, 303-321

Experiment Form

To fill in by the experimenter:

First Session

Date and time	
Participant number	
Group	
Wine Order	
Cap size	
Circumference (100%)	
Nasion-inion distant (10% up)	
Pre auricular distant	
FP1 FP2 (10% circumference)	
Color-blindness	
Preferred hand	

Second Session

Date and time	
Participant registration Form	
Number of days after the first experiment	
Group	
Wine Order	
Labels check	

Appendix F

Fisar Sommeliers' Judgment

As discussed in Chapter 7, the wine tasting procedure was based on procedure used to the FISAR form (Italian Federation of Sommeliers Hoteliers Restaurateurs). Hence, a comparative wine tasting, in a non-experimental condition (without EEG), was implemented for wine experts in order to determine the wine characteristics.

The results are summarized as follows:

1. The Chilean wine Los Bolds
   - Visual examination: Limpidity: Limpid; Color: Rubby red with purple reflex; Intensity: Intense; Consistency: Consistent.
   - Olfactory analysis: Intensity: Intense; Complexity: Complex; Quality: Fine; Description: Spicy and Fruity.
   - Taste analysis: Structure or Body: Full; Sweetness: Dry; Alcohol: Warm; Acidity: Fresh; Tannicity: Quite Tannic; Saltiness: Tasty; Softness: Soft; Balance: Balanced; Intensity: Intense; Persistence: Quite Persistent; Quality: Fine.
   - After taste analysis: Evolutionary State: Mature; Harmony: Harmonious.
2. The Italian wine Camelot
   - Visual examination: Limpidity: Limpid; Color: Rubby red with garnet reflex; Intensity: Intense; Consistency: Consistent.
   - Olfactory analysis: Intensity: Intense; Complexity: Complex; Quality: Fine; Description: Fruity, Spicy and Mineral.
   - Taste analysis: Structure or Body: Full; Sweetness: Dry; Alcohol: Alcoholic; Acidity: Fresh; Tannicity: Quite Tannic; Saltiness: Tasty; Softness: Soft; Balance: Balanced; Intensity: Intense; Persistence: Persistent; Quality: Fine.
   - After taste analysis: Evolutionary State: Mature; Harmony: Harmonious.
3. The Chilean wine Cimarosa

- Visual examination: Limpidity: Limpid; Color: Rubby red; Intensity: Intense; Consistency: Consistent.
- Olfactory analysis: Intensity: Intense; Complexity: Complex; Quality: Fine; Description: Floreal and Fruity.
- Taste analysis: Structure or Body: Full; Sweetness: Dry; Alcohol: Alcoholic; Acidity: Fresh; Tannicity: Quite Tannic; Saltiness: Scarcely Tasty; Softness: Soft; Balance: Quite Balanced; Intensity: Scarcely Intense; Persistence: Scarcely Persistent; Quality: Quite Fine.
- After taste analysis: Evolutionary State: Mature; Harmony: Quite Harmonious.

4. The Italian wine Alturis

    - Visual examination: Limpidity: Limpid; Color: Rubby red; Intensity: Intense; Consistency: Scarcely Consistent.
    - Olfactory analysis: Intensity: Intense; Complexity: Complex; Quality: Fine; Description: Floreal, Fruity and Spicy.
    - Taste analysis: Structure or Body: Full; Sweetness: Dry; Alcohol: Light Warm; Acidity: Fresh; Tannicity: Quite Tannic; Saltiness: Tasty; Softness: Soft; Balance: Quite Balanced; Intensity: Scarcely Intense; Persistence: Scarcely Persistent; Quality: Quite Fine.
    - After taste analysis: Evolutionary State: Mature; Harmony: Quite Harmonious.

Overall, all the sommeliers judged the wine Los Boldos and Camelot of as good quality wines. Instead, the sommeliers did not considered the wine Cimarosa and Alturis as good quality wines.

Appendix G

List of Publications

- Franco, M., d'Alfonso, L., De Icco, F., Mancini, R., Tursunbayeva, A., Alvino, L. et al. (2016). Percorsi di ricerca del Dottorato in "Innovazione e gestione delle Risorse Pubbliche" - Research Paths of PHD in "Innovation and Management of Public Resources". Editoriale Scientifica, Napoli. ISBN: 978-88-6342-908-4.

- Alvino, L., Constantinides, E. and Franco, M. (2017). Towards better understanding of consumer behavior: Marginal Utility as a parameter in Neuromarketing research. International Conference on Marketing (ICOM-2017), 25-26 May, Colombo-Sri Lanka.

- Alvino, L. and Franco, M. (2017). The decision-making process between rationality and emotions. International Journal of Scientific Research and Management (IJSRM), https://www.ijsrm.in, Volume 5 Issue 9, September 2017, 7074-7092, DOI: 10.18535/ijsrm/v5i9.18.

- Alvino, L., Constantinides, E. and Franco, M. (2017). Towards better understanding of consumer behavior: Marginal Utility as a parameter in Neuromarketing research. Accepted to the International Journal of Marketing Studies.

- Alvino, L., van der Lubbe, R., Constantinides, E. and Franco, M. Investigating individual preferences and brain activity in a wine tasting experience: a Neuromarketing approach. Submitted to the Global Marketing Conference at Tokyo (2018).

- Alvino, L., van der Lubbe, R., Constantinides, E. and Franco, M. Brain Responses to external cues: studying consumers' visual attention process with PCN. Working paper.

- Alvino, L., van der Lubbe, R., Constantinides, E. and Franco, M. How marketing meets neuroscience: Contributions and limitations of Consumer Neuroscience research. Working paper.

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