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Fundamentals of Neuromarketing

An Interdisciplinary Field That Changes How Marketers Understand Consumers

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Thesis abstract

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Neuromarketing or consumer neuroscience has recently emerged as a supplement to existing marketing methods, thanks to the more widely available and advanced technologies that help probe consumers' brains, such as neuroimaging techniques (i.e., electroencephalography – EEG, magnetoencephalography – MEG, and functional magnetic resonance imaging – fMRI) and methodologies to measure physiological responses (i.e., eye-tracking, skin conductance response, body temperature, and facial effective coding) and pharmacological responses (dopamine, oxytocin, and testosterone).

The purpose of the present paper is to demonstrate neuromarketing's organic inception due to the rise in popularity of neuroeconomics, which leads marketers, who have worked interminably to better understand consumers' needs and preferences, to merge them into the interdisciplinary field of neuromarketing. Furthermore, thanks to the availability of the aforementioned technologies, neuromarketers can study the relationships and connections between consumers' responses and specific marketing stimuli during advertisements or product selection and evaluation before purchasing as well as between these actional and emotional responses and the associated brain areas.

Public studies from scientific journals and practical applications from businesses using neuroimaging, physiological, and pharmacological measurements will illustrate such relationships and connections. However, since consumer neuroscience remains a field of research rather than a conclusive result, it is usually combined with existing marketing tactics to give more insights. Thus, the studies and examples in this thesis will surround the four Ps of marketing.

Lastly, this thesis discusses the skepticism the interdisciplinary study faces toward its efficacy as well as the critics concerning its ethical issues about consumers' freedom of purchasing decisions and research participants' data security. It also covers which measures and code of ethics should be taken into consideration to avoid misuse and

[1] Keywords: Neuromarketing, consumer neuroscience, brain-imaging, neuroimaging, fMRI, EEG, MEG, psychology, physiology, neurology

exploitation of neuromarketing, resulting in it being banned like its predecessor, subliminal messaging.

TABLE OF CONTENTS

Figures and Tables

Terms and Abbreviations

CAGR	Compound annual growth rate
DLPFC	Dorsolateral prefrontal cortex
EEG	Electroencephalography
fMRI	Functional magnetic resonance imaging
MEG	Magnetoencephalography
mOFC	Medial orbitofrontal cortex
NAcc	Nucleus accumbens
RP	Readiness potential
WTP	Willingness to pay

1 OPENING WORDS

The thesis commences with the philosophical question, “Do human beings have free will?” McKenna and Pereboom (2016, 6) have a contemporary approach to this controversial topic:

> Free will is the unique ability of persons to exercise the strongest sense of control over their actions necessary for moral responsibility.

From Leo Tolstoy’s unphilosophical perspective in his influential novel published in 1869 “War and Peace,” free will is defined much simpler (Tolstoy and Edmonds, 2009):

> You say: I am not free. But I have raised and lowered my arm. Everyone understands that this illogical answer is irrefutable proof of freedom.

Regrettably, his argument is refutable if one takes into account robots – the human-like machines specifically designed and programmed to replicate human movements. Free will is irrelevant in such a case.

However, for advocates of determinism, free will is irrelevant in most if not all cases. Soft determinism stands on the middle ground and believes humans have a choice, but humans are not the sole agent that decides their fates (Lavazza, 2016).

Thanks to the more recent availability of neuroimaging technology and equipment, cognitive neuroscientists have made their own determination on the question of free will’s existence based on psychological and neuroscientific research. One of the most recognized studies belongs to the American physiologist Benjamin Libet, who based his work on the groundbreaking yet controversial discovery of readiness potential (RP) or Bereitschaftspotential in 1965 by two German scientists Kornhuber and Deecke (Lavazza, 2016).

In brief, RP determines the millisecond uptick that took place prior to the study subjects’ action of spontaneously tapping their fingers, signaling that there occurred changing brain waves that led to the voluntary action. In other words, by means of electroencephalography

(EEG), Kornhuber and Deccke argued that the brains were preparing themselves to carry on a spontaneous movement (1965).

With such a substantial finding, the idea of free will was shaken to a certain extent. Better yet, Libet's discovery in 1985 added a second layer of skepticism about human being's freedom in acting and making decisions – by observing that the negative brain potential (also RP) was visible in EEG scanning even before a person has the intention to consciously perform a voluntary task – finger tapping (Lavazza, 2016).

So, indeed, when humans do not have complete freedom of choice on even such a mundane task of slightly moving a finger, what does it mean when it comes to purchasing decisions? Do consumers have a "buy button" in their brains marketers can take advantage of to manipulate their buying habits? Is subliminal messaging as corrupt and influential as it was depicted? These are myths to be crushed with the help of neuromarketing – a bridge of neuroscience and marketing and a potential approach to further understanding consumers' brains without the limitation of social biases, guesswork, conforming participants in focus groups faced by conventional marketing.

This thesis, therefore, dives into the emergence of this marketing approach as the result of easier accesses to more advanced technologies and the constant pursuit for alternatives to the incompetent results of the traditional advertising and public relations industry, costing roughly 150 billion dollars in the USA alone (Guttmann, 2021). The section was then followed by the definitions of the terminology "Neuromarketing" and its relevant subjects such as the physiological and pharmacological measurements and brain-imaging technologies used to study neuromarketing itself, i.e., functional magnetic resonance imaging (fMRI), electroencephalography (EEG), and magnetoencephalography (MEG).

Hence, the question of whether neuromarketing can play a role in the deeper comprehension of consumer's decision-making and brain perception as well as a partial substitute for conventional marketing arises. The focal point of this research will answer such a question with the help of case studies in which brands use neuromarketing to analyze the four Ps of marketing and customers' five senses when first encountering an ad or a product.

As up-and-coming as neuromarketing sounds, there remains critics and skepticisms regarding its ethical issues, just as with anything novel introduced to the public. Thus, this thesis will also focus on methodology to establish neuromarketing's position in the industry as well as public eye – preventing the ephemeral popularity of subliminal messaging to repeat its story with neuromarketing. As a result, the thesis's last section answers the question, "What will be the future of neuromarketing?"

2 THE EMERGENCE OF NEUROMARKETING

In the first section, the thesis questions the concept of free will during human's decision-making process or, in fact, the lack thereof, which can be proven with neurosciences. The substantial growth of neurosciences has advanced its applications to the realm of marketing. This leads to the inception of the interdisciplinary field of neuromarketing – the paper's focal point of study. Following the introduction of the thesis' basic elements in section one, this section further elaborates the emergence of consumer neuroscience due to not only neurosciences' widespread popularity but also marketers' constant endeavors to better understand consumers.

2.1 History Of Marketing

The term Marketing, despite not having been officially recorded and registered to the dictionaries until the 16th century to describe the act of selling and buying at a market (Merriam-webster), is more or less as old as civilization itself. It was the most fundamental principle of persuading to accomplish a final purchasing decision through simple communication between traders and potential buyers at ancient bustling Greek and Roman markets. Evidence of the first scribbled ad on papyrus originated from the most influential cultures of ancient time, Egyptian, as early as 3200 BCE – over 50 centuries ago (Starcevic, 2015).

Even though this concept was utilized in such far distanced surroundings, it remained relevant and flourished, especially during the 18th and 19th centuries, alongside the industrial revolution, as a form of outbound marketing – when the marketers interrupt and talk at potential consumers rather than talk with them. The latter form of communication is referred to as inbound marketing and only emerged very recently in the 21st century, thanks to the development and popularization of the Internet.

The outbound-type marketing era can be divided into three periods spread from 1730 until 2000: printed advertising, advertising through electronic devices, and advertising during the digital age. It is noteworthy that by this point (about 1910), the definition of the term "Marketing" was elaborated as the process or technique to invent, promote, deliver, and

exchange goods or services to best benefit customers, partners, or the society (American Marketing Association; Morin, 2011). The initial definition back in the 1600s was no longer able to cover the wide range of marketing activities at this point.

> With the invention of Gutenberg's metal movable type from 1452 to 1455, mass printing was no longer a pipe dream. This durable typesetting and the small number of alphabetic European language characters opened a new chapter for printing presses with beautifully uniform typography and fonts. Gutenberg's first creation – Gutenberg Bible – pioneered the rapid popularization of movable printing presses around Europe regardless of the invention's father's attempt to keep his techniques a secret (Kreis, 2016).
>
> Thanks to this invention, information was available in much greater quantities and to a wider range of the world's population. Adhere to the Information revolution initiated by the printing press, the first printed newspaper called Relation aller Fürnemmen und gedenckwürdigen Historien (Account of All Distinguished and Commemorable News) was released in Strasbourg in 1605 (Tietz, 2021). However, it was not until the 1730s that magazines with a balanced blend of text and colored images emerged as a medium that pioneered printed advertising, followed by other visual-focused means like posters, billboards, or brochures throughout the 17th and 18th centuries.
>
> Unfortunately, the printed advertising industry plummeted during the 1900s due to the emergence of new mediums with the inventions of electronic devices, such as radios, telephones, and, most significantly, TVs. Although interrupted by the Great Depression in 1929, the production orientation era of the industrial revolution reached its maturity at this point, saturating the marketplace with goods and kickstarting the sales orientation era as supply had become much greater than consumers' demand. The increasingly crowded market created competition for companies where they raced to convince unwilling consumers into buying their abundant products, and the aforementioned creations supported them tremendously. At this stage, more electronic inventions equaled more marketing opportunities and channels. By 1933, more than half of U.S.

households owned at least one radio, bringing in millions of listeners across the country and making the period between the late 1920s and early 1950s the Golden Age of Radio. Radio advertising in the middle of comedies, dramas, game shows, and popular music shows naturally became the norm for listeners. This norm, however, took a quick downturn in the 1950s as home television sets were introduced to the public (The Development of Radio | PBS).

As many nicknames as television had, “a salesman in every living room” or “a member of the family,” its main role was to deliver entertainment to millions of people, reaching the halfway mark of all American homes by 1955. Television advertising, as a result, became a form of entertainment itself with the utmost advantage of sound and movement instead of text and two-dimensional images from printed advertisements and static from radios. The TV set reached 90% of the nation’s homes by 1959. Backed up by the fact that World War II ended and the postwar economy started to recover, this decade was the golden years for advertisers in general and television advertising in particular, boasting a drastically 10-time growth in TV ad spending from 1949 to 1951 (at $12.5 million to $128 million) and finally, reaching the $1 billion milestones in 1955, only four years later (O’Barr, 2010).

Even before the invention of handheld mobile phones, telemarketing has already bombarded consumers via landline phones since the early 1970s. However, the emergence of the first mobile phone in 1973 marked the beginning of the new advertising era: one made possible through digital technology. Exceptionally, print advertising made a comeback during the 1980s after personal computers were commercially introduced, first by IBM in 1981 (IBM 5150) then by Apple in 1984 (Macintosh 128K), enabling desktop publishing and acquiring $25 billion in newspaper ad revenue. With mobile and personal devices, consumers were now able to easily access information about the products or services they wished to acquire. Following new inventions like the 2G mobile network, SMS messaging, search engines, spamming, and so many more, an explosion in marketing was expected from the 1990s onward. An explosion as it was but not only the growth of marketing, the dot-com bubble

> also popped on March 10, 2000, nearly collapsing the technology stocks and most Internet-related companies and changing the landscape of the Internet entirely.

The 2000 tech bubble was seen by most as a crisis, but unarguably, it opened new opportunities as well. Take the Internet, for example; instead of investors blindly pouring money into tech startups and users racing to adopt the technology with its many perks but also downsides, this new stage of the Internet targeted information sharing, user-friendly interface, and collaboration. Marketing and communicating between brands and consumers, as a result, took a turn; brands did not want to simply expand their presence online and offline and speak to the consumers about their products. Indeed, they wanted to speak with potential buyers, reaffirm the values they would deliver, and build organic and close relationships via search engine marketing, social media marketing, content marketing, viral marketing, and information-based marketing sources like email and blog, in other words, digital inbound marketing. The phenomenon was reinforced with various bans in the U.S. on information flooding tactics of old-fashioned marketing troubling the population: the Controlling the Assault of Non-Solicited Pornography And Marketing (CAN-SPAM) Act that ruled out uncalled-for commercial emails or the National Do Not Call Registry that halted telemarketing. Instead of focusing on quantity, reaching out to as many people as possible (including those not relevant) to hurriedly but not sustainably increase sales, inbound marketing's aim was being recognized by targeted consumers and retaining long-lasting relationships with them, turning potential consumers into regular, if not, aspirational ones. By targeting a certain audience only, digital inbound marketing is more cost-efficient, proven by the fact that a lead generated by it costs 62% less than traditional marketing (Jain and Yadav, 2017). Thus, it is inevitable that outbound marketing was eventually toppled by digital marketing in 2019 and is reported to suffer from a continuous decrease in the following years (see Figure 1) (Cramer-Flood, 2021).

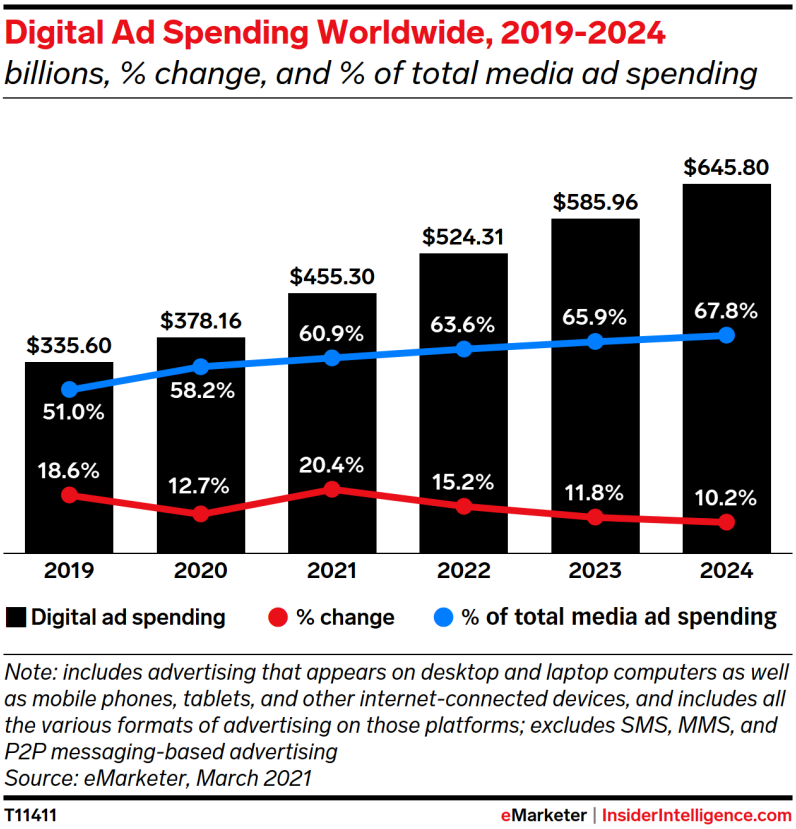

Figure 1: Worldwide digital ad spending forecast, 2019-2024 (Cramer-Flood, 2021)

2.2 A New Perspective Through Neuroscience To Look At Marketing

From the 1700s until only recently, the 2000s, marketing methodology underwent a significant transformation from traditional marketing to digital inbound marketing. The focus was shifted from pushing products to consumers by bombarding them with information via printed ads, radio ads, telemarketing, and spam emails to establishing a position of trust and helpfulness in consumers' minds.

Regardless, this approach has been refined by marketing experts up to the point that marketing in general and advertising, in particular, suffer a bad reputation, being perceived by the public as "trying, with all the intelligence, technology, and cunning it can command, to get people to want what they don't need." Other claims include magnifying what a product can deliver while playing down its cons and taking advantage of subtle psychological, psychosocial, and biological cues to manipulate consumers into "value, want, and expect" unrealistic needs and expectations (Star, 1989). However, considering the negative bias humans are hardwired for, with which negative events are often registered and fixated in

mind with much heavier impact than positive or even neutral ones, marketing may have been under too harsh scrutiny. The true aim of the marketing concept is to pinpoint what consumers want and need and come up with a solution to satisfy the said demands, within economic and strategic reason – not to bombard consumers with purchasing possibilities and subtly manipulate them to close the deal; one has a solution-seeking approach to best accommodate (a specific group of) consumers – or builds the right relationships with the right target groups, while the other is a profit-focused plan that has no regards for consumers – in broad terms, consumerism.

2.2.1 Limitations Of Conventional Marketing Methods

Having that said, successfully identifying what consumers need and want and introducing it to the right group is unarguably more demanding than cookie-cutting mass outbound marketing. The big data revolution is, however, a double-edged sword, providing businesses with tremendous information that has never been seen before about their customers at recorded speed and through elaborated data analytic programs while also confusing them. The conclusion from quantitative research is programmed to show correlations that are not causality on which many companies have comfortably based their decisions regarding marketing strategies and missed the mark, thus, creating three partly imbricated consumer groups, with “frustrated, distracted, or irritated consumers” being the overwhelming dominant group (see Figure 2).

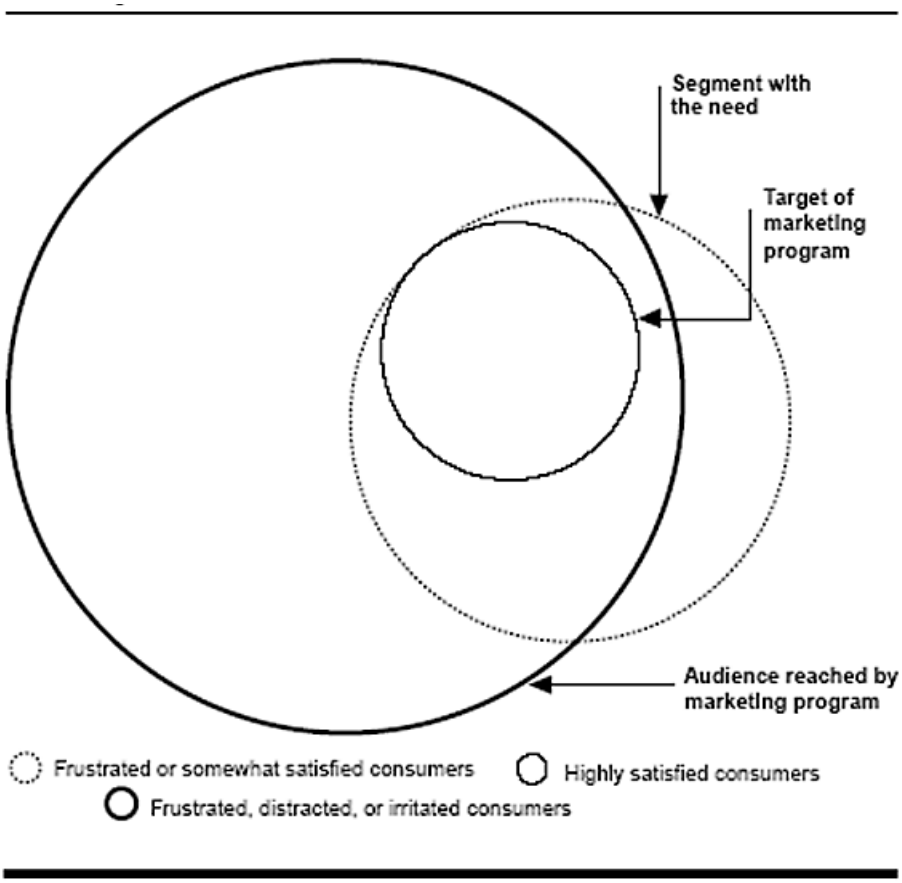

Figure 2: Marketing effort and consumer discontent (Star, 1989)

That is when qualitative research based on psychology analysis in marketing that involves one-on-one interviews, stimulated choice methods, preference surveys, market tests, and focus groups is taken into account by the company's marketing department. While each research has its unique advantages, drawbacks are naturally unavoidable (Table 1). Particularly, focus groups are considered a part of a larger equation to acquire general consumer perceptions to generate new ideas and evaluate marketing concepts. This methodology has proven effective as long as enough respondents are carefully yet randomly selected to avoid homogenous representations (sex, age, education, occupation, societal group, and so on) (Smithson, 2000). It is also noteworthy that a limited sample size reduces the forecast's accuracy when reflecting on a larger population.

However, there are more subtle variables that considerably influence the outcome of marketing focus groups. They include social bias, pressure to follow the dominant voices of the group and avoid dissents, moderator's and other volunteers' overenthusiasm over the topic in question that leads to bias and subconscious narration to steer participants' answers

to fit their existing belief. The unanimous results, in this case, may originate from group dynamics or the moderator's attributes and not personal perceptions and evaluations (Welch, 1985; Smithson, 2000).

Focus groups in particular and psychology tests in marketing, in general, have limitations due to the fact that consumers' nature is diverse, unpredictable, and always under peer pressure. Their true preferences regarding a product or service may indeed reside deep in their brain, which is another pitfall where marketers assume consumers can actually describe their cognitive process (behaviors, emotions, reasons) when they make purchasing decisions. This, in turn, can lead the market research astray, paid with millions of euros in misdirected marketing campaigns.

Table 1: Comparison of qualitative market research methods (Ariely and Berns, 2010)

	Focus groups	**Preference questionnaires**	**Simulated choice methods**	**Market tests**
What is measured	Open-ended answers, body language, and behavior. Not suitable for statistical analysis	Measurement of the importance of each product's many attributes	Choices among products or features of a product	Willingness to pay (WTP) and decision-making among products
Types of the response process	Speculative	A process of ranking each attribute on the importance scale through introspection	A simulation of the buying process where no actual monetary value is involved	An actual buying process with customers' own money being involved
Typical use in product development processes	At an early stage to determine a product prototype, user interface (UI), and useability	At the design stage to determine what attributes the target customers will be willing to trade off	At the design stage to determine what attributes the target customers will be willing to trade off. Also, a forecasting tool	At the last stage to forecast sales and measure behaviors towards other marketing factors (price)
Cost and competitive risk	Low cost. Low risk, only occurring in the case of being misused by the company	Moderate cost. Moderate risk of competitors being alerted	Moderate cost. Moderate risk of competitors being alerted	High cost. High risk of competitors being alerted and the product being copied before launch
Technical skill required	Moderation skills for participants. Ethnographic skills for moderators and analysts	Skills required to design the appropriate questionnaire and statistical analysis	Skills required to design the stimulation that includes choice modeling and statistical analysis	Highly specialized skills to imitate a market and forecast sales

2.2.2 Neuroimaging Technologies Becoming More Accessible

The limitations mentioned in the subsection 2.2.1 are where neuromarketing can step in to effectively and directly bridge the gap between neuroscience and consumer behavior, eliminating any possible bias caused by peer pressure, social standards, and so on. Another obstacle consumer neuroscience can lift is the assumption that market research participants are actually able and willing to articulate and report how they perceive a marketing stimulus, which, in many cases, involves lying, not being able to clarify what is on their minds, being pressured into group agreement to avoid dissent, to name a few (Morin, 2011).

Neuromarketing provides a modern lens that probes consumers' minds directly through brain-imaging technologies that measure neural signals and physiological activities (e.g., eye movements, a shift in body temperature, heart rates, pupil dilation, and so on), skipping the need for cognitive and conscious participation and providing marketers with a better mean to observe and understand consumers' neurological responses and what motivates their buying decisions. In broad terms, it illuminates the relationship between the brain and mind without any filter. In other words, it emphasizes the value of interpreting consumer behavior through a neuroscience perspective that effectively supports in marketing a product (Ariely and Berns, 2010; Morin, 2011; Plassmann, Ramsøy and Milosavljevic, 2012; Karmarkar and Plassmann, 2017; Slijepčević, Šević and Radojević, 2018).

Neuromarketing or consumer neuroscience is a subdivision of the neuroeconomics study. This large academic field's inception dated back to the beginnings of the 2000s from laboratory and psychological studies, following a group of behavioral economists' effort to validate the theory: principles and ideas from psychology study can lay the path to a better understanding of neoclassical economics' model of human behavior while making decisions. As a result, neuroeconomics emerged rather organically without the recognition for any particular individual. The natural next step of the progress to prove this theory was to gather data through both neurological and physiological approaches, which remain the major methodologies in researching consumer neuroscience as well. This, in turn, brought together behavioral economists, neuroscientists, and cognitive psychologists who actively advocated for such convergence and relied on brain activities and physiological cues to understand this interdisciplinary field. And as the rapid growth of non-invasive neuroimaging and single-cell recording approaches and continual meetings and conferences of the

converging group were constant, the exponential development of neuroeconomics was unavoidable (Glimcher, Camerer, Fehr, and Poldrack, 2009). It was proven by the fact that within the period of less than two decades, numbers of research with “brain” and “decision making” together as keywords in the neuroscientific literature rocketed (see Figure 3).

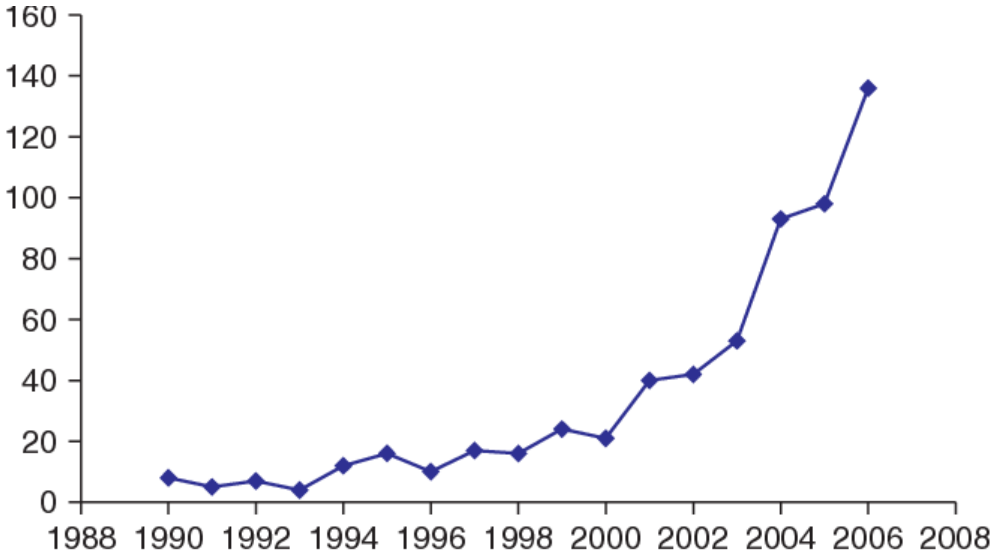

Figure 3: The increase in numbers of papers on decision-making studies in the neuroscientific literature, 1990-2006 (Glimcher, Camerer, Fehr, and Poldrack, 2009)

With neuroeconomics’ many impressive advancements and applications to overcome past limitations, e.g., regarding risk aversion, time preference, or altruism during the economic-related decision-making process, the utilization of neurological and physiological cues has advanced to the realm of marketing.

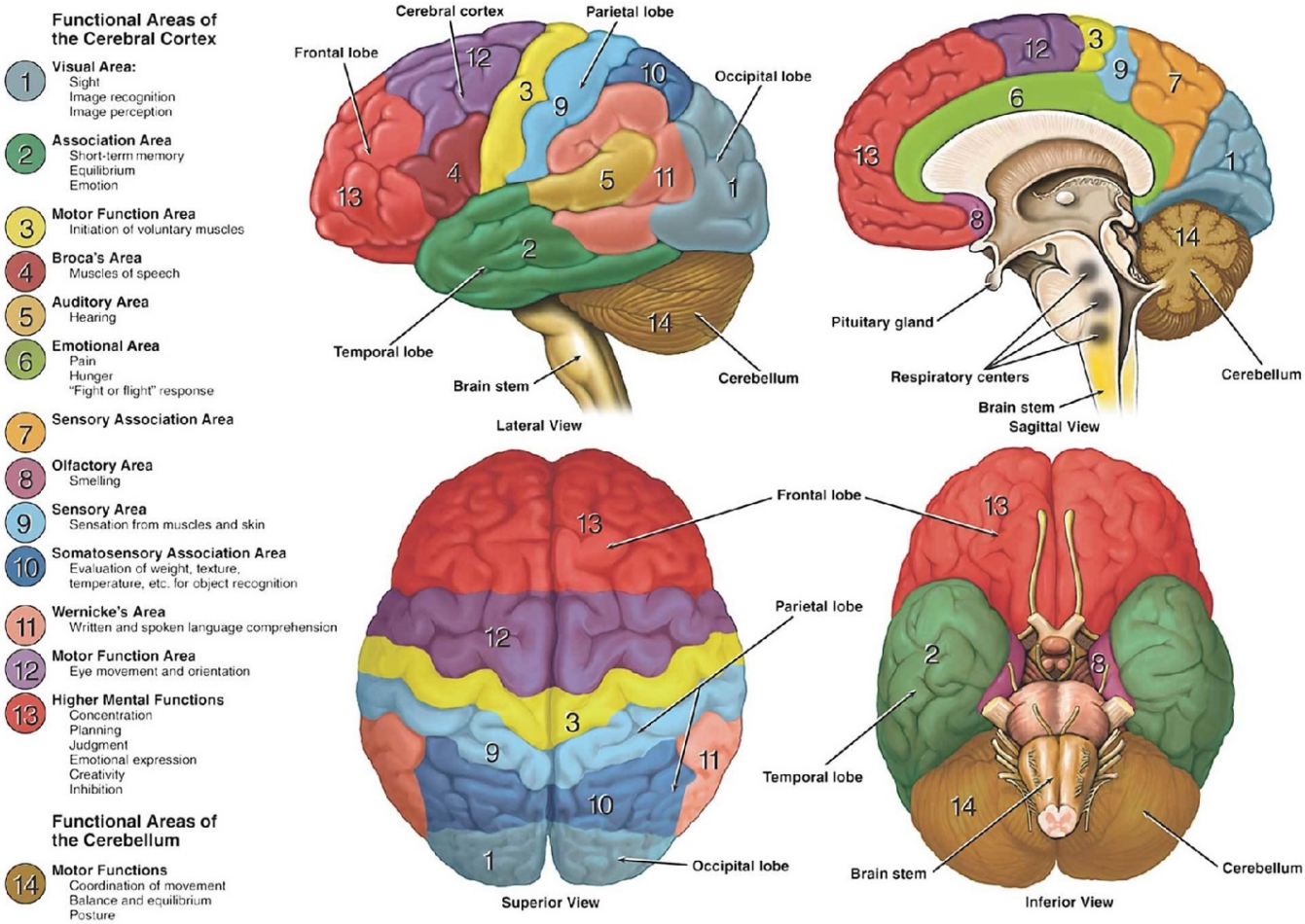

Figure 4: Functional neuroanatomy that is economically relevant (Sukel, 2019)

Shortly after, in 2005, the term “neuromarketing” was added to the Harper Collins dictionary. Catching up with consumer neuroscience’s inception, there has been a constant and exponential growth of interest in this interdisciplinary field. The data is clearly demonstrated in the case of Google organic search and published papers related to the topic; the number of neuromarketing companies has been picking up on the slack as well (see Figure 5).

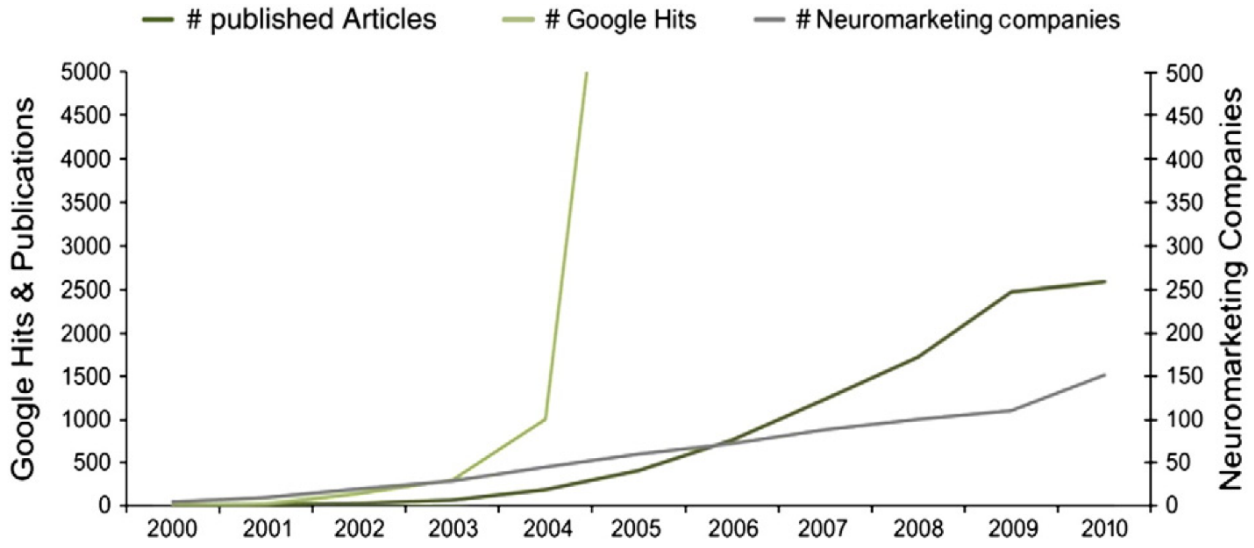

Figure 5: Growth in interest in applying neuroscience into marketing, 2000-2010 (Plassmann, Ramsøy and Milosavljevic, 2012)

Human beings only use 10% of the total brain capacity is one of many widely popular misconceptions about psychology. Indeed, it has been proven that humans capitalize nearly 100% of their brain over the course of the day. Even during sleeping or resting, many brain regions remain active (Herculano-Houzel, 2009). That explains why the brain requires a substantial amount of body resources, in particular, oxygen and glucose, regardless of its humble sum of 3-5% of the total body's weight. With that being said, humans only consciously use 20% of the brain capacity since the majority of it is required to scan the environment for potential threats and maintain the baseline activity levels. On average, a person perceives through the five senses an enormous amount of more than 11,000,000 bits of information every single second. Remarkably, due to the limited information processing capacity, only a fraction of the big picture can consciously reach the said person (50 out of 11,000,000 bits, or 0.00045%). The eyes play a major role in interacting with the brain, taking charge of exchanging 10,000,000 signals each second with the head of the central nervous system (Wilson, 2004).

Although so many inputs are smashed with each other at once, like thoughts, sounds, smells, conversations, memories, the significant majority goes unnoticed. The brain has been wired this way as survival was and still is the priority, and surviving for primitive men was far from simple compared to nowadays. Thus, humans still rely greatly on the ancient reptilian brain to function, which is responsible for the fight, flight, or freeze response. The

reptilian brain or R-complex located in the brainstem and cerebellum was the first to evolve in the triune brain concept, followed by the paleomammalian brain (in charge of the limbic system and resides in the cerebral amygdala) and lastly, the neo-mammalian brain – the so-called human brain in the neocortex (also, frontal lobes) (see Figure 6 and 4) (MacLean, 1977). What is most noteworthy about the primal brain is its ability to process visual cues without the need of the visual cortex, saving time in dangerous situations and engraving such situations and what is relevant to them more vividly into the brain. This can explain human beings' tendency to process images much faster than words and remember experiences much longer than explanations (Morin, 2011). So, is the R-complex the ultimate answer for neuromarketers in understanding consumer behaviors?

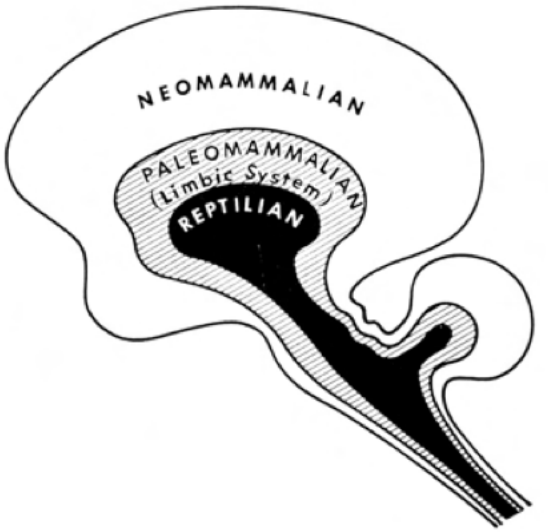

Figure 6: The triune concept of the brain (MacLean, 1977)

Nevertheless, the definite answer is No; it is worth remembering that there is not a "buy button" in the human brain. Consumer neurosciences rely on neuroimaging of activities throughout the entire brain and other physiological measurements to reveal consumer perceptions in situations that can trigger negative feelings (fear, insecurity, danger, and so on) or positive ones and utilize them to promote WTP, ranging from designing a prototype to pricing, displaying, promoting, and the like.

3 METHODS TO VISUALIZE THE BRAIN

In the second section, the thesis focuses on how marketing has consistently been improving despite its long-lived presence comparable to that of the civilization. The traditional outbound marketing methodology was toppled by inbound marketing that aims to build connections between brands and consumers through better understanding consumers and thus their individual needs and preferences. However, digital inbound marketing is not without limitations. In particular, regardless of marketers' endeavors to gather as much information about consumers as possible via focus groups, one-on-one surveys, questionnaires, and so forth, some insights remain hidden inside consumers' minds. Therefore, in this chapter, the paper aims to study the main methods used in neuromarketing to visualize the brain and have more insights into consumers' purchasing behaviors.

The basic tool set of methodologies used to visualize the brain can be divided into two groups: one to generate neurological images, including EEG, MEG, and fMRI, and the other to analyze physiological and pharmacological cues (eye-tracking, facial electromyography, biometrics, and measurements of hormones and neurotransmitters like oxytocin, testosterone, and cortisol, to name a few).

In general, the three neuroimaging methodologies in the former group are well-established, non-invasive, accurate, and useful in drawing a brain map that illustrates which brain areas are stimulated when exposed to a given marketing cue (Morin, 2011). They produce neuroimages with marked active brain areas by detecting the activities of the 86 billion neurons within the nervous system that communicate with each other or relevant cells through synapses. These activities require extra resources, namely either oxygen (fMRI) or electricity (EEG and MEG), which, in turn, signal the neuroimaging machines to capture these millisecond-long moment-to-moment neuronal events. Electrical neuronal communication is often considered a direct measure. At the same time, fMRI, for example, requires analysis of the combination of the brain activity itself and measured variables – thus, is an indirect method (Newman, 2019). Physiological and pharmacological measurements have been implemented much prior to neuroimaging technologies with relatively reliable results on analyzing unconscious and implicit responses to a given marketing stimulus but at substantially lower costs.

3.1 EEG: Electroencephalography

Although the oldest non-invasive neuroimaging technique, EEG, was first developed in the 1930s, the first psychological research utilizing it was first recorded much later, in 1979. The technique measures the electrical activity caused by the communication between neurons within the brain via scalp electrodes located outside the head and saves this data digitally. It is, therefore, a direct measurement of brain activity (Newman, 2019). Besides the measure parameter (direct or indirect), the next two crucial criteria of any technique that generates neurological images are temporal and spatial resolutions; both are often taken into account and compared in order to determine the proper application. Temporal resolution refers to how a technique is sensitive to neuronal events relative to time, and the latter is the technique's ability to distinguish adjacent high-contrast structures happening in the object (Bushong and Clarke, 2015).

EEG's most prominent advantage is its exquisite temporal resolution due to its ability to record up to 10,000 measurements per second – something especially valuable, considering how swiftly a neuronal alternation can occur; the five senses can acquire stimulants, and thoughts can be processed within a matter of a few milliseconds. On the flip side, EEG has a rather poorer spatial resolution (roughly one centimeter) compared to the other counterparts (MEG and fMRI) with a millimeter-diameter level of precision, which can be justified with two explanations. The first reason behind this drawback is the nature of the brain with billions of neurons and trillions of synapses that contribute to the basis of neural circuitry, while an EEG machine typically has only three to 256 electrodes located on the scalp (Ariely and Berns, 2010; Morin, 2011; Newman, 2019).

Figure 7: Examples of different EEG caps and hardware (Newman, 2019)

Figure 7 illustrates three different sorts of EEG caps connected with 32, 64, and 256 electrodes, respectively from left to right, with the middle option having the most widely used electrode count in cognitive neuroscience. The far-left cap is the fundamental hardware out of the three with 32 disc-type passive electrodes. The second is an upgraded version with built-in circuit boards and pre-amplifiers within each of the 64 active electrodes with the purpose of reducing environmental noise and boosting the signal and measurement's accuracy. Both of these elastic caps require electrolyte gel to create contact between the caps' electrodes and the scalp, something the far-right option does not. Rather, it resembles a net with plastic conducting strands that connect sponges soaked in a liquid electrolyte solution; each sponge contains in itself an electrode, making up the total of 256 sensors. Even though the last version has a considerably greater number of electrodes than the two predecessors, it is still not adequate compared to the enormous number of neurons, synapses, and even existing functionally distinct areas in the brain. The best spatial resolution EEG can offer is one-centimeter-diameter precision, which can only be achieved under optimal conditions. Adding more and closer electrodes to the EEG caps will not solve this drawback due to the fact that each electrode detects not only the brain activity directly under it but also from neighboring brain areas, creating mixing signals.

The second explanation for EEG's typical attenuated and blurry spatial resolution is the skull's poor capability of conducting electricity, leading to difficulty picking up electrical signals residing much beyond the cortex. Although electricity does not conduct very well through the skull, it does so excellently within the brain. This fact combined with EEG's nature of collecting the sum of all neuronal activities from all brain regions, the technique is likely to cause difficulty in pinpointing the precise location within different areas of the brain in which one individual electrical signal occurs.

Another limitation EEG faces is the potential of strong electrical signals that do not originate from the brain, for example, eye blinks or twitches and contractions of face, neck, and shoulder muscles, not to mention external sources of electricity from the environment, got picked up by the EEG hardware. Although these signals may not be relevant, they are strong enough to be picked up even through the low conducting skull, which hinders commonly weak signals generated from individual neurons. The neuroimages can pose a challenge for marketers to differentiate between neuronal activities to non-brain signals and external artifacts in this case.

Setting up an EEG measurement is rather quick and simple; the only task is to put the EEG cap with built-in electrodes on the participant. Another more time-consuming option is to use sticky paste and manually place individual electrodes on the participant according to their head's shape and size. This method produces more accurate results, and the paste enables longer-lasting recordings, even during sleep. However, it requires much more time to clean up due to its stickiness, adding to the total time to conduct the measurement. Regarding the infrastructure, the recording environment should (1) have comfortable seats with a low back to avoid any discomfort that causes muscle tension and potential artifacts when the participant's head touches the chair's headrest, (2) be acoustically quiet and free from distractions, (3) be climate-controlled as a too hot environment can lead participants to intense sweating and skin potentials, while a too cold surrounding can lead to sudden movements (shivering) and artifacts. The experiment itself should not be longer than an hour and should minimize stimuli that can cause sudden physiological shifts, thus, artifacts. These stimuli include sudden visual or loud auditory cues that cause sudden and longer blinks, long sentences that require excessive eye movements, and the like (Newman, 2019).

All in all, EEG research is not demanding, and the cost to carry them out is low, with expenses on equipment being below US$10,000 (Ariely and Berns, 2010).

3.2 MEG: Magnetoencephalography

The mid-1960s invention, MEG, is closely related to EEG, but instead of measuring the changes in the electricity induced by neuronal activity like EEG, it does so with the magnetic fields. Similar to the predecessor, MEG is a direct measure of brain activity with an exquisite temporal resolution of millisecond-based upticks. But more importantly, it has a better spatial resolution than EEG (down to details of a few millimeters compared to roughly one centimeter) because its measuring target, the magnetic field, is less distorted by the low-electricity-conducting skull. As a result, it does a better job pinpointing the activity's exact location in certain brain areas, especially those located on the cortical surface. Another factor contributing to MEG's better ability to localize the activated brain area is the fact that the deeper the neuronal activity is located, the substantially stronger it has to be in order to be detected by the MEG machine. The neuronal activity's strength, therefore, is a good indication for source localization (see Figure 8) (Żurawicki, 2010; Newman, 2019).

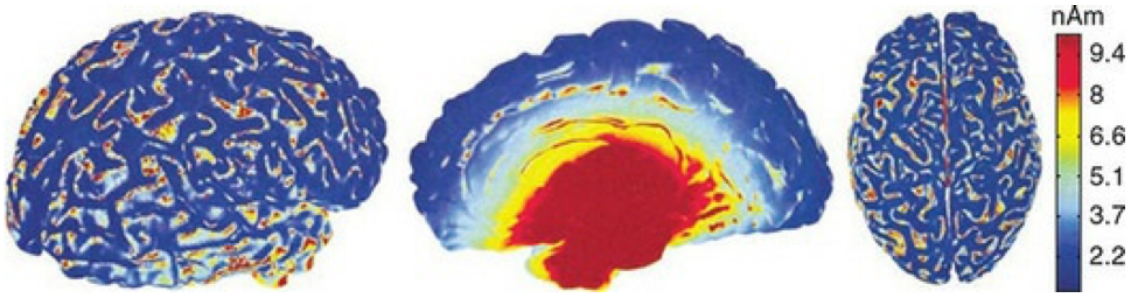

Figure 8: The increase in strength of a neuronal activity that is required to be detected by MEG, in accordance with its depth (Newman, 2019)

The magnetic fields are measured through a MEG helmet that contains either magnetometers or gradiometers. The former is the simpler magnetic flux transformer out of the two and is inferior to gradiometers' accuracy because it records both neuronal signals and unnecessary external background noises. Magnetometers and axial gradiometers perform at their peak when detecting signals entering or exiting the head, like planar gradiometers with signals parallel to the scalp's surface. The helmet is located inside the MEG scanner with an adjustable seat to best accommodate different participants. The MEG

helmet itself is also universal, not snug-fitting but made spacious enough to suit most head sizes (see Figure 9).

Figure 9: Examples of a MEG system and a MEG helmet with sensors (Newman, 2019)

Therefore, the design is more flexible for participants as they can move their heads inside. On the flip side, head movement is not recommended during a MEG scan due to potentially misleading results caused by the shift in the sensors' positions not in accordance with the brain. Besides, MEG is very technically demanding and cost-intensive, with set-up expenses almost toppling that of fMRI. The reasons are (1) the technique is much more sensitive to external electromagnetic interruptions than EEG, and neuronal magnetic fields are tiny in comparison to environmental ones, thus, requiring more intense and expensive shielded structures, and (2) magnetometers need to be submerged in liquid helium to meet the functional temperature's demand at absolute zero. It also requires participants to prepare up to a certain point. For example, they should not have on jewelry and clothing with metal pieces (zippers, buttons) as metal moving caused by the participants, as subtle as breathing, also induces magnetic fields. As a result, like EEG, experimental design should be free from stimuli involving heart race, sudden blinks, excessive eye movements, and so on (Newman, 2019). Beauty products (make-ups and hair products) and tattoo pigments can also contain

ferromagnetic metallic compounds that potentially distort the magnetic field images (Ross and Matava, 2011). Those with implanted metal work, such as dental braces, dental fillings, pacemakers, plates or pins in the head, and the like, are not eligible for the MEG scan due to safety reasons.

3.3 fMRI: Functional Magnetic Resonance Imaging

It is not an exaggeration to say that since its inception in 1992, fMRI has revolutionized the field of cognitive neuroscience, and it quickly became and still remains the most frequently used neuroimaging technique to probe consumer minds. Through an MRI scanner, fMRI measures the shifts in the concentration of oxygenated blood within the brain vessels or blood oxygenation level-dependent (BOLD) signal caused by neuronal activities that communicate via synapses. For example, when exposed to a marketing stimulus like an ad, oxygenated blood flow will increase in localized brain regions compared to other regions as well as themselves during rest time. The basis of the fMRI technique is the measurement of this change in the BOLD signal that creates distortions in the magnetic field. Therefore, it is an indirect measurement of brain activity, which is also the technique's rare limitation. Other drawbacks lie in the low temporal resolution at 1-10 seconds, and some important brain areas, especially the orbitofrontal cortex, are easily affected by signal artifacts and, therefore, causing inaccuracy in the measurement. The reason behind the limited temporal resolution is the time lag of a few seconds between the two activities: a neuron being activated and the BOLD signal starting to change due to the physiological process that occurred, namely, neurotransmitter release and reuse, chemical messengers, and blood vessel dilation.

On the other hand, the fMRI's utmost competitive advantage is its excellent spatial resolution of 1-10 millimeters (ten times better than that of EEG), and remarkably, state-of-the-art techniques can bring it down to a sub-millimeter level of accuracy, enabling neuroimages with clear small structures, even those deep in the brain and involved in emotional responses. Another highlight of the neuroimaging technique is that the series of colored fMRIs is a visual illustration of the whole-brain measurement with activated regions being highlighted, much easier to interpret than sequences of fluctuated wavelengths like with EEG and MEG (see Figure 10).

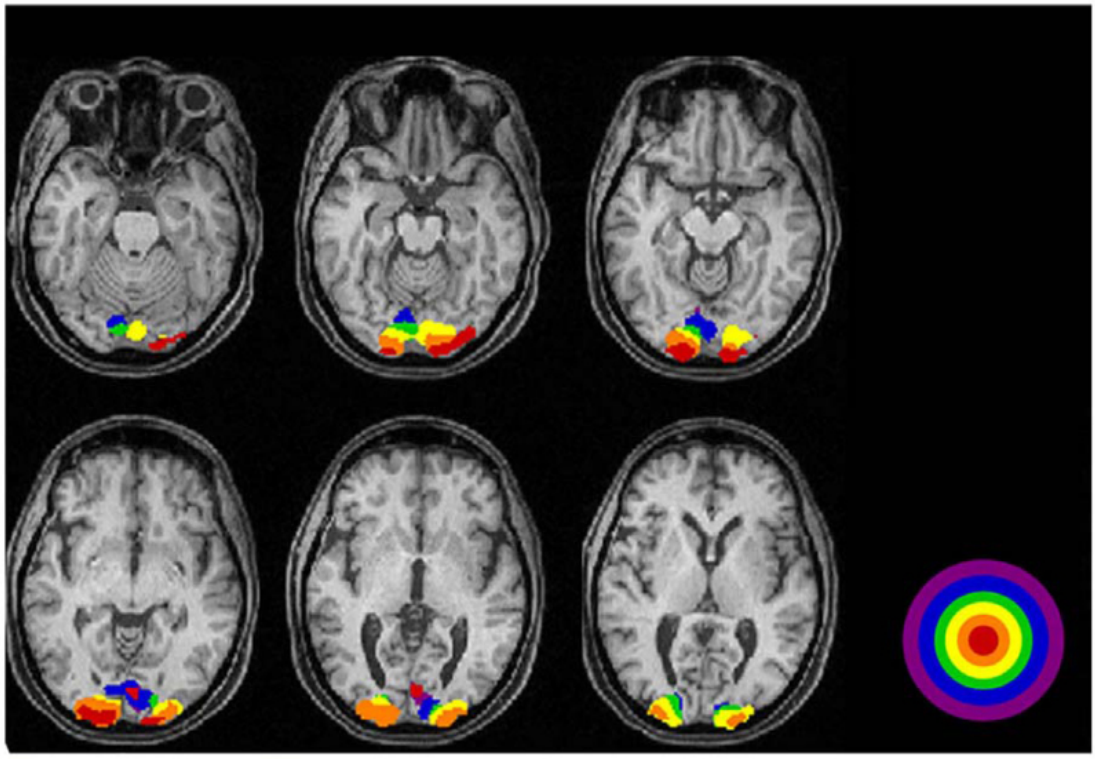

Figure 10: A series of fMRIs of the activated occipital visual regions during visually evoked stimuli. Red represents maximum signals; blue to purple represents minimum signals (Kolb, Fernandez and Nelson, 1995)

Similar to MEG, fMRI functions depending on a very strong magnetic field that is active 24/7, even when the machine is not scanning and switched off. It has to be strong in order to accommodate the entire human body while guaranteeing accurate scanning results by detecting minor neuronal activities (0.1-0.2 Hertz). This characteristic requires the scanning room to be extremely carefully shielded because ferromagnetic objects, even from ten or more meters away from the fMRI scanner, can be easily pulled into the room by the magnetic field at incredible velocity, causing unwanted unfortunate incidents. Even a minor piece of metal like an earring or loose change in the pocket can turn into dangerous projectiles if carried into the scanning room. Therefore, (1) participants have to make sure they do not have any metal implants, tattoos, clothing with metal buttons or zippers, accessories, and the like, similar to MEG, and (2) medical and research equipment in such a case has to be specifically MR-safe, which, in turn, increase the total expense of each fMRI measurement. Even though expensive, the technique is much more widely available than MEG, enabling more research institutions and businesses to rent a lab with an fMRI scanner. This familiarizes the industries (both business and science) with the technique and further popularizes it.

However, in the marketing context, businesses should keep in mind that the participants have to lie very still inside the fMRI scanner for 45-90 minutes (the duration varies based on how complex the experiment is) to minimize distortions, which can cause boredom, irritation, discomfort, or fatigue (see Figure 11). The general rule of thumb here is to keep the experiments on the shorter side in order to limit artifacts and inaccurate measurements due to participants feeling unpleasant. Another noteworthy point related to the fMRI's set-up is that it does not exactly resemble participants' usual surroundings when interacting with a marketing stimulus, such as lying on the couch watching an ad, shopping in a brick-and-mortar store, or scrolling through their phones – which can be argued to be less likely to elicit the same reaction when organically exposed to the same marketing cue (Ariely and Berns, 2010; Żurawicki, 2010; Whitten, 2012; Newman, 2019).

Figure 11: An example of an fMRI scanner (BRAIN Lab)

A comprehensive comparison of EEG, MEG, and fMRI can be found in Table 2 below.

Table 2: Comparison of neuroimaging methods when applied to marketing (Ariely and Berns, 2010; Żurawicki, 2010; Newman, 2019)

	EEG	MEG	fMRI
What is measured	Neuronal electrical activity caused by the communication between neurons when a participant is exposed to a marketing stimulus. Also, the difference in electrical potential between the two locations	Magnetic fields caused by the communication between neurons when a participant is exposed to a marketing stimulus	Images of neuronal activities across the entire brain (whole-brain measurement) with exact sources, separated from neighboring regions. Thus, useful to draw a brain map with active regions related to a specific stimulus
Type of measurement	Unit: Hertz (2-40) Device: cap with electrodes	Unit: Tesla Device: helmet with magnetometers or gradiometers	Unit: Hertz (0.1-0.2) Device: color images obtained in seconds via the scanner
Typical use in marketing processes	Instant interaction with a marketing stimulus, a salesperson, or generally, time-sensitive cues	Probability of choice in relation with familiarity, genders, and memories Also, time-sensitive stimuli	Marketing stimuli related to brands and prices. Source localization during decision making, purchasing, value learning
Costs	Low Equipment cost is commonly below US$10,000 State-of-the-art EEG technology can cost much more	Very high, not easily accessible Set-up cost: approximately US$2,000,000	Very high, ubiquitous Each MRI system: US$1,200,000-US$3,000,000 Annual operation cost: US$100,000-US$300,000
Technical skill required	No skills required for participants. Easy preparation with minimum equipment: video monitor, speakers, response device.	No skills required for participants, but conditions related to safety. Demanding preparation: very shielded environments.	No skills required for participants, but conditions related to safety. Very demanding preparation for safety.

Table 2: Comparison of neuroimaging methods when applied to marketing (Ariely and Berns, 2010; Żurawicki, 2010; Newman, 2019) - Continued

	EEG	MEG	fMRI
	Skilled experimenters and analysts.	Highly skilled experimenters and analysts.	Highly skilled experimenters and analysts.
Limitations	Insufficient when it comes to measuring answers to spatially-located questions and the cognitive process	Very expensive Insufficient when measuring both higher cognitive and emotional functions while the subject is exposed to a marketing stimulus	Very expensive Physically restrictive for participants have to lie still on their backs in the scanner for an extended time period

3.4 Physiological And Pharmacological Responses

Besides brain-imaging technologies, physiological and pharmacological measurements are also useful for marketers to understand the consumers' minds by how they react to marketing stimuli. They include eye-tracking (movement and dilation), facial effective coding, hormone secretion (oxytocin, testosterone, cortisol, and more), biometrics (see further details in Table 3). These measures are generally much more cost-effective compared to neuroimaging techniques and substantially more portable, making it easy for marketers to replicate real-life experiments with them. They are quite often used in association with each other or with brain-imagining ones. It is worth remembering that they are most helpful in tracking attention span (applicable for advertisements, website designs, shelf placement, and the like) and whether the arousals or emotions occurring during the stimulus were intended.

Table 3: Consumer neuroscience measurements based on physiological and pharmacological proxies (Karmarkar and Plassmann, 2017)

	What is measured	**Typical use in marketing**	**Limitations**
Eye movements	Visual attention (eyes' fixation points), blinking, and gaze pathways	Track attention-span toward: • Front-end website design • Shelf layout, packaging design, ad	Unable to measure the strength of the responses, emotions, thoughts, or the sources
Facial electromyography	Unconscious emotional responses traced via facial muscle activity	• Reactions toward commercials • Emotions during negotiations	• Complicated to set up the experiments: attach individual electrodes to the participant's face • Has to be carried out in the lab
Biometrics	• Heart race • Skin conductance response (sweat glands, skin, and muscle tissues) • Pupil dilation • Body temperature	• Reactions, arousals, or engagement toward commercials and marketing persuasive messages • Emotions during decision-making processes	• Unable to differentiate between positive and negative responses
Pharmacology	• Oxytocin • Testosterone • Cortisol • Dopamine	• Love and trust hormone, stress during social reactions • Male sex hormone, risk behavior, impulsiveness • Stress hormone, general arousal • Pleasure hormone	• Unable to capture immediate changes • Data can vary amongst participants due to the hormone's unique nature

4 APPLICATIONS OF NEUROSCIENCE IN MARKETING

As discussed in the second section, since there is not a “buy button” inside the consumers’ brains – a single brain region responsible for buying behaviors, marketers want to divide attention equally across the entire brain structure to understand the relationship and connection between a marketing stimulus and a consumer’s response. It is, however, common to find more than one neuronal region being activated simultaneously by not only a marketing cue but even an emotion or a reaction, making a brain map insufficient on its own for marketers to pinpoint the exact brain area in accordance with a response.

In other words, neuroimaging alone is not the key to opening the door to peek into consumers’ minds; it is rather an escalator that supports market research, accelerating the process to understand consumers quicklier and more thoroughly. How can neuroscience benefit current market research tools? What are some already existing applications, case studies, or academic papers using methods mentioned in section three to visualize the brains? This section explores these questions by taking a look at the four Ps of marketing.

4.1 Products

A consumer’s decision-making process is influenced by countless factors, i.e., previous user experience, basic expectations, social influences, and so on, in which some are unconscious. In such a circumstance, neuroimaging techniques will be useful in detecting unbiased and innate responses toward the product itself, leaving underlying biases aside. This, in turn, will help marketers in product design and packaging, ensuring the outcome is more likely to be appealing to its target markets and their preferences (Fugate, 2007).

In 2002, Daimler-Chrysler used fMRI to investigate unconscious responses to their different car types, including Mini Coopers and Ferraris. The result turned out as a big surprise as the majority paid extra attention to none other than the Mini Coopers – a car associated with an adorable baby face in the participants’ minds, thus, lighting up the face-recognition region (fusiform gyrus) located at the back of the brain (see Figure 12). The automobile was registered in the participants’ brains as “Pikachu with an exhausted pipe” or “Bambi on four wheels” rather than any technological unique selling point the brand has boasted about this

automobile line. All in all, this finding reaffirmed consumers' preferences regarding the Mini Coopers line and hinted Daimler-Chrysler to be watchful when deciding to change the design in the future (Lindstrom, 2008).

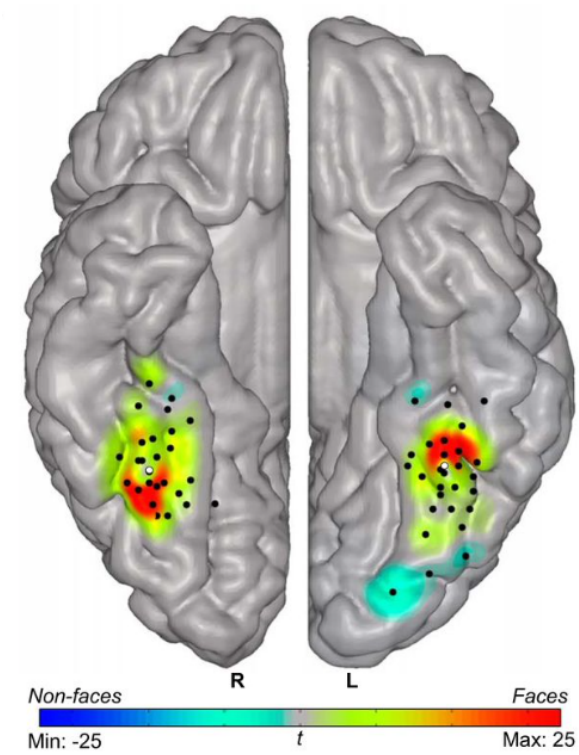

Figure 12: An example of activated fusiform gyrus electrodes when consciously introduced to a face (Rangarajan et al., 2014)

Another research also from Daimler-Chrysler involved a dozen men lying in the fMRI scanner while being shown pictures of 66 automobiles, from sports cars and sedans to small cars. They then were asked to rank each car's aesthetic attractiveness. This time, the result did not turn out surprising like the former. Expensive sports cars were clearly the winner, being rated significantly more appealing than the rest. However, what was intriguing was how just flashing pictures of sports cars increased brain activity in the region associated with self-rewards and reinforcements called nucleus accumbens (NAcc) (see Figure 13) (Fugate, 2007; Lindstrom, 2008). The conclusion from this research was pleasure-inducing product designs are likely to be purchased more than those not associated with rewards.

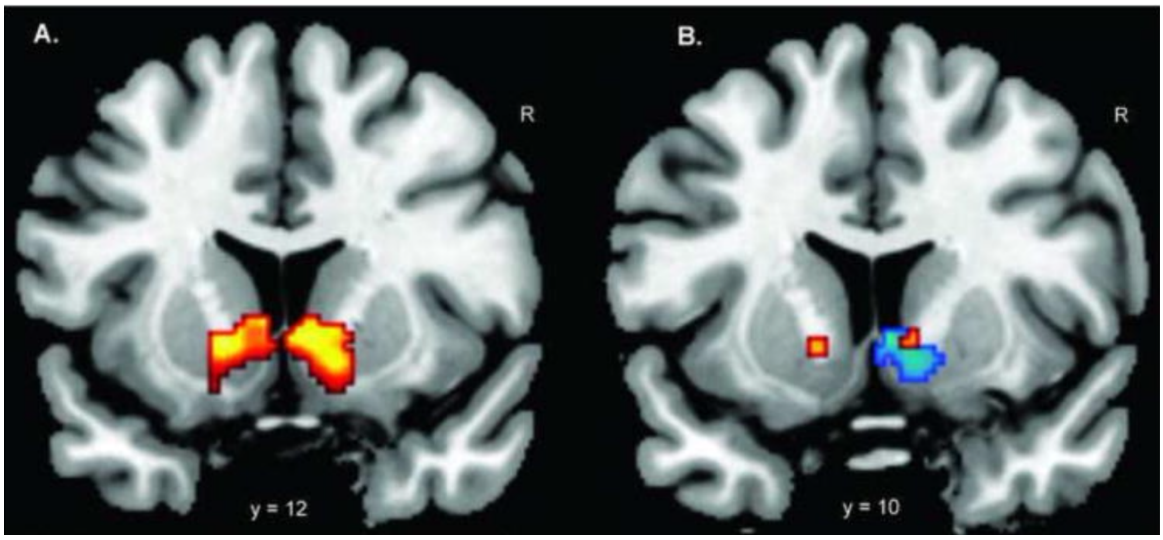

Figure 13: An example of the nucleus accumbens stimulated during receiving social reward and avoiding social punishment (Kohls et al., 2013)

4.2 Place

It has been proven with the eye-tracking technique that visual fixations are coherent with value-based decision-making processes. Although participants in the trials looked at all the items before making a final choice, they tended to fixate the longest on the item they considered the best, which was also the item they ended up choosing (Krajbich and Rangel, 2011). This is where neuromarketing can step in and pinpoint effective product placements by identifying strategic shelf positioning or areas they may never pay attention to.

In one study carried out at a local Malaysian market to best replicate a realistic shopping experience in the retail environment, eye-tracking measurements were utilized to understand consumer behavior. Amongst many conclusions, i.e., product sizes, package designs, brands, and prices, researchers also found a pattern in shelf placements. In particular, the third row was the highest area of interest, attracting the most attention in all three measurements: fixation count, gaze plot, and heat map. The second-best row was the second, with only more than half the attention score of the leading row (46 vs. 85 counts). On the other hand, the first row barely received any attention, if not at all (see Figure 14) (Zamani, Abas, and Amin, 2016).

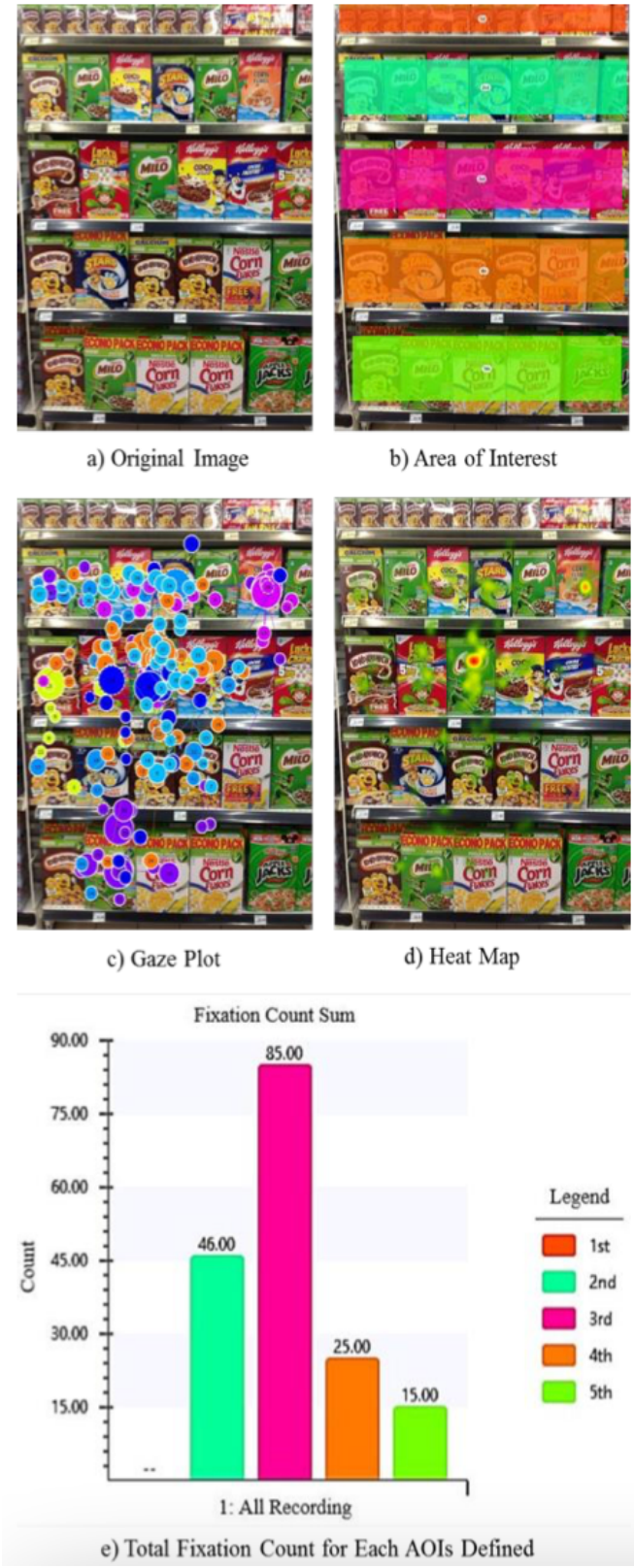

Figure 14: Comparison of product positions based on eye-tracking proxies (Zamani, Abas, and Amin, 2016)

However, in another research that combines both eye tracker and purchase data, the conclusion was different. Chandon and his colleagues figured out from their eye-tracking experiment that the top and middle shelves gained the most attraction. Still, in-store traction is not the decisive factor when it comes to making the final purchasing decision because, according to their results, only the top-shelf positions lead customers to evaluate brands before purchasing (Chandon, Hutchinson, Bradlow, and Young, 2009).

Facing hundreds if not thousands of products of various brands, it is understandable that consumers are only capable of looking at and evaluating a certain division of the supermarket shelves; businesses can take advantage of such research combined with data on final purchasing decisions to best position their products or products that should be prioritized to be sold first.

4.3 Price

It is a pipe dream to expect neuromarketing to generate the exact price that consumers will be willing to pay for a product. Nevertheless, it can aid marketers in comprehending what price means to consumers. Interestingly, a high price can be perceived as both an exorbitant spend for one product category and an indication of high quality for another.

To identify the correlation between the price and taste of wine, and therefore, the correlation between the adjustment in marketing action (price) and consumer perception on a product (taste), a study using an fMRI scanner was carried out with participants being presented with wine samples at different price ranges and asked to assess them. The result of this study would answer the mentioned question, “How do prices matter to consumers?”, something they are not usually able to interpret consciously in regular one-on-one interviews.

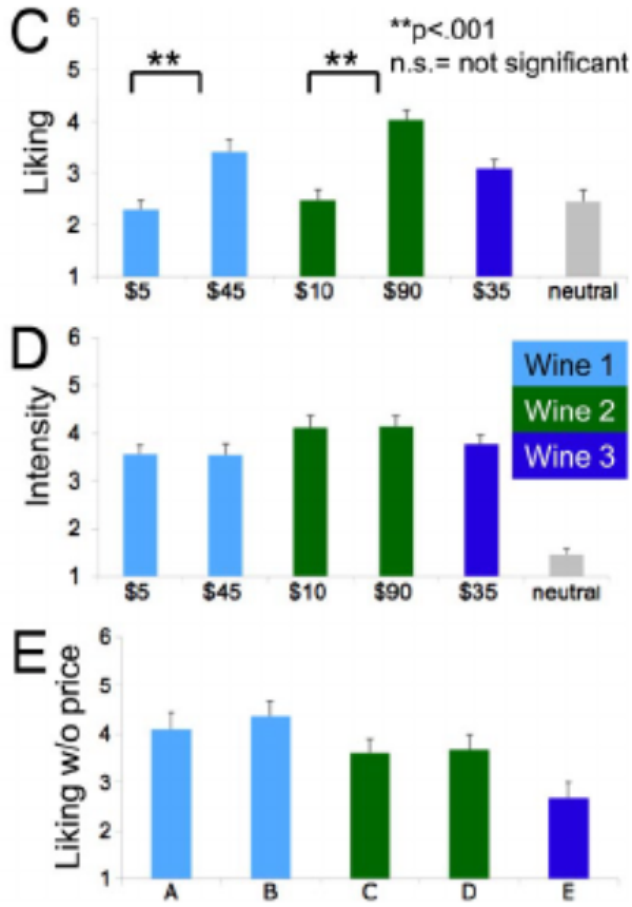

Figure 15: Correlation between price and quality perception, with 1 being not (liked/intense) at all and 6 being (liked/intense) very much. (C) Ranking of wine pleasantness when prices were presented. (D) Ranking of wine intensity when prices were presented. (E) Ranking of wine pleasantness without price cues (Plassmann, O'Doherty, Shiv and Rangel, 2008).

During the experiment, each participant received six cups in random orders containing only three wine types but with five different price tags and one with a neutral solution. Wine 1 was presented at US$5 half of the time and US$45 the other half; wine 2 was labeled with US$10 and US$90 price tags, and wine 3 costed US$35 a bottle. Although there are two pairs of identical wine samples, the one with a higher price tag from each pair received significantly more favors or pleasantness (almost double) regarding the taste than its identical counterpart at a lower price (see Figure 15).

The neuroimaging also found increased neuronal activity in the brain region related to the reward system (medial orbitofrontal cortex or mOFC) when the participants tried the allegedly more expensive wine (see Figure 16).

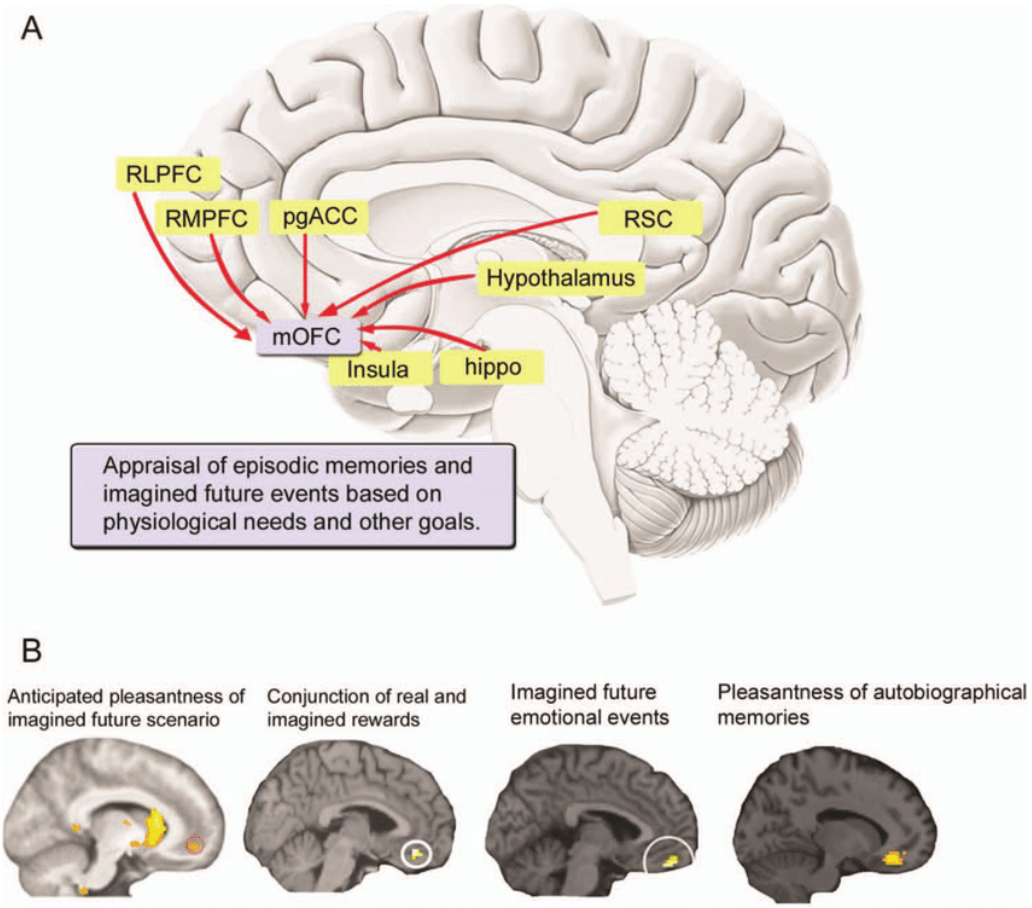

Figure 16: Contributions of mOFC to emotional responses (Dixon, Thiruchselvam, Todd and Christoff, 2017)

Particularly, the most expensive option (wine 2 at US$90) showed the highest peak of neuronal activity (0.4% - twice as much as that of wine 1 at US$45) while its drop in neuronal activity was the lowest (0% rather than negative results like with other options) (see Table 4).

Table 4: Brain activity enhanced in relation to the price increase (Plassmann, O'Doherty, Shiv and Rangel, 2008)

	Price tag shown	**Peaked % signal change in mOFC**	**Lowest % signal change in mOFC**
Wine 1	US$5 (retail)	0.1	- 0.3
Wine 1	US$45	0.2	- 0.1
Wine 2	US$10 (retail)	0.15	- 0.35
Wine 2	US$90	0.4	0

On the whole, the finding provided evidence for a price-quality relation, in which the higher the price, the better the wine quality and consumer's enjoyment were perceived (Plassmann, O'Doherty, Shiv and Rangel, 2008; Plassmann, Ramsøy and Milosavljevic, 2012).

Bearing in mind the fact that simply enjoying a glass of allegedly expensive wine could effectively generate brain activity in the reward system, it is not out of the ordinary to assume the same if not more would occur when splurging on lavish purchases. Indeed, neuroscientists had found out that participants' brain regions with NAcc (see Figure 13) and dorsal anterior cingulate cortex (see Figure 17) were triggered when they were exposed to a sale of luxury goods at full prices. NAcc is linked to the pleasure of self-rewarding (also mentioned in subsection 4.1. Price with flashing pictures of sports cars), conflicting with the latter that is responsible for impulse control on such frivolous. This conflict was, however, resolved when participants saw a discounted price tag on the same products with decreased brain activity in the dorsal anterior cingulate cortex and stronger signals in the NAcc (Lindstrom, 2008). This revelation, in turn, is useful for marketers in determining pricing, sales, and promotion strategies by avoiding negative or cautious associations caused unconsciously in the brain.

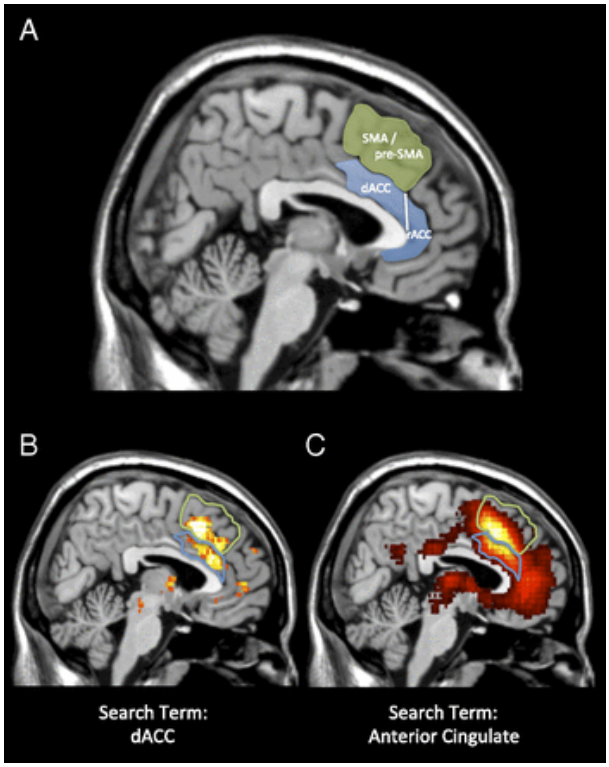

Figure 17: An example of the dorsal anterior cingulate cortex, dACC, or simply anterior cingulate location (A) and peak performances in different search terms (B and C) (Lieberman and Eisenberger, 2015)

Consumers' product evaluation and product selection process could be influenced by not only the price difference but also the given timing of price information. The latter was proven by Karmarkar and his colleagues after their recent research done in 2015 using the fMRI technique. With the neural data, they came to a conclusion that when presented with the price before the product (also called price primacy), participants were prone to evaluate the product's price-value ratio rather than their personal preference to it. In other words, participants were more concerned about "Is the product worth it?" rather than "Do I like the product?", causing them to eliminate the insufficient products from the shortlist rather than devaluing them. This questioning would also justify the increase in sales in the experiment for products with recognized utility. The second finding was about the pain of paying, in which the neuroimaging showed no signal of decreased product value nor purchasing likability even when price primacy triggered pain early in the product selection process (Karmarkar, Shiv, and Knutson, 2015). With these insights, marketers can establish better pricing strategies, both value- and timing-wise.

4.4 Promotion

Using celebrity and influencer endorsements has been one of the oldest tricks in the book of marketing, as neuroscientists have discovered the correlation between increased sales and profits and positive emotions and trust as a result of dopamine release when consumers see promotional messages delivered by familiar faces. This phenomenon is a plausible explanation for why word of mouth is a powerful tool for marketing when consumers have a higher tendency to give a new product a go after being recommended by friends or acquaintances (Fugate, 2007). Dopamine is influential on its own, but when combined with mirror neurons, it can strongly affect consumers' shopping experiences and purchasing decisions. Mirror neurons are responsible for humans' tendency to imitate surrounding people's behaviors unwittingly. The most typical examples are yawning when someone yawns, smiling when someone smiles or is happy, or having empathic pain when someone is in physical torment. More interestingly, one does not need to see a person performing these actions to mimic them; just by reading about these actions could trigger the mirror neurons and the person to repeat them. Marketers have resorted to this combination of the self-rewarding neurotransmitter dopamine and mirror neurons and use celebrity and influencer endorsement to bring regular and multiple exposures to consumers. Repetition in seeing something used by more people in higher frequency can even turn a disinterested product into a desirable purchase (Lindstrom, 2008). However, this marketing tactic can also backfire when the endorsers face scandals or pushbacks, which reflect negative or unpleasant associations that human brains (the reptilian brain, particularly) are wired to withdraw from behavior for the sake of survival (Fugate, 2007).

The promotional channel is another section marketers can take advantage of neuromarketing to improve. In one study regarding attention given to ads with baby pictures, neuromarketers, with the help of MEG, discovered that participants' mOFC (see Figure 16) was strongly stimulated after being exposed to a baby's face in such a negligible duration of 150 milliseconds. On the flip side, little to no neuronal activity was traced when adult photos were presented. Undoubtedly, infants' adorable appearance is crucial for their survival, as they are vulnerable, absolutely helpless, and unable to survive with neglect not only from their parents but other adults as well. That explains why paying attention to them is such an innate behavior, and converting baby pictures to suit the product and brand message can

play an important role in successfully grabbing consumers' attention when the said product or brand is more or less relevant to babies. Although, the parental instinct can be so strong that consumers may lose track of what the ads with the baby pictures want to elicit initially. One study employing eye-tracking measurements pointed out that in an ad with a baby looking straight, the majority of attention was concentrated on the baby's face and barely on the headline, content, and product image. The results returned differently when the baby was facing the ad headline, content, and product image's direction since the attention was also divided into these parts (see Figure 18). All in all, the ad's most essential factor should be placed at the face of the ad's point of gaze, which will naturally draw consumers' eyes in the same direction (Dooley, 2011).

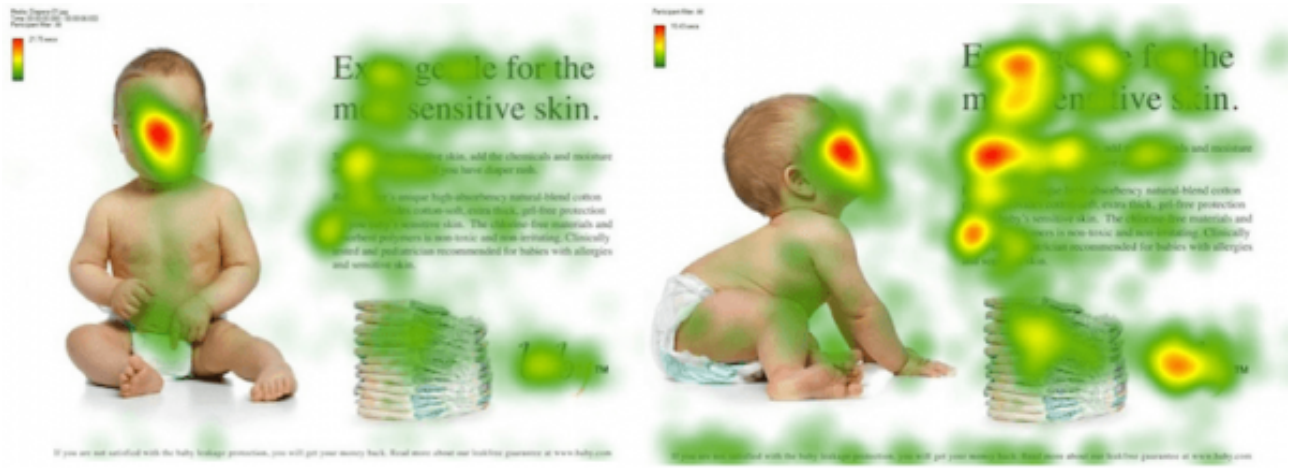

Figure 18: An eye-tracking heatmap on ads with babies looking in different directions. Red represents maximum signals; green represents minimum signals (Dooley, 2011)

Also using the eye-tracking technique, another paper carried out experiments to unveil email design effectiveness in engaging readers. One hundred participants were screened and measured to which parts of the emails they paid most attention and for how long. The email samples are large, with 50 different emails categorized into eight sectors, namely women's fashion, young women's fashion, men's fashion, photographic retailers, holidays, holiday homes, daily deals, and Christmas gifts. Regardless of the wide variety, the conclusion is unanimous: use captivating first impressions, calls to action for more clicks, emotion-inducing and value content, digital sales techniques, graphic and text combination, keep it short and simple, and decrease space between elements, to maximize engagement (Rowe and Burridge, 2012).

Apart from sight, hearing is another sense that was evaluated with the EEG technique to improve the performance of a German financial institution's TV ad. Nielsen Consumer Neuroscience came to the financial firm's assistance and investigated the efficacy of two different versions of the same ad with two distinctive music genres: classical music with drastic changes in rhythms and upbeat modern music that centers around drum sets and synthesized instruments. The focal point of the TV ad was to communicate trust to prospective consumers, a critical factor to consider when deciding with whom to invest their savings. However, trust is a matter of personal approach that is usually nonconscious, instantaneously formed, and influenced by biases and past experiences. Therefore, self-assessment research methods were not helpful in this case, but the neuroscience technique was. EEG neuroimaging showed participants' stronger brain waves throughout the entire ad with classical music, signaling deeper emotional engagement toward it. Dramatic rhythm changes in the classical piece were proved to build up participants' emotions and pair nicely with the ad's climatic moments. In addition, it also outperformed the modern counterpart in communicating trust with approximately 90% of the database for message association, ranking at level 3 (strong). On the other hand, the figure of modern music was 30% at level 1 (fair) (see Figure 19). This can be explained by the fact that music with classical instruments is associated with seriousness and stability rather than excitement and risk like with modern beats (Westoby, 2017).

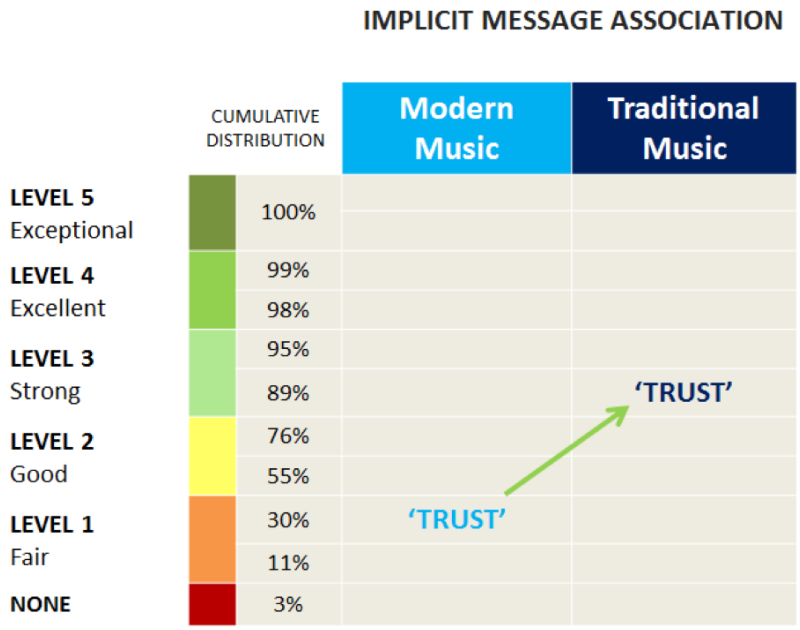

Figure 19: Perceptions of trust when exposed to two TV ads with modern music and classical music (Westoby, 2017)

5 SKEPTICISM, CRITICS, AND THE ETHICAL ISSUES

It is without a doubt that anything novel would face doubts, concerns, and criticisms when introduced to the public; neuromarketing is no exception, even though section four proves the interdisciplinary field's applications in determining the relationship between product, place, price, or promotion and consumers' emotional and actional responses.

Nevertheless, neuromarketing is not the first psychological application to marketing; indeed, its predecessor, subliminal messaging, came under harsh criticism and ban for ethical issues related to consumer behavior manipulation. But is it true that subliminal marketing can be so insidious? And how can neuromarketing avoid the same bad reputation and tragic and ephemeral fate? The following subsections dive into these two questions.

5.1 Subliminal Messaging

The initial event that sparked the subliminal messaging fright dated back in September of 1957, when James Vicary, an American marketing consultant, flashed "Drink Coca-Cola" and "Eat popcorn" on the cinema screen. The texts appeared supposedly so quickly that no one from the audience could consciously be aware of them and were claimed to be the reason behind the exponential sales of Coca-Cola and popcorn then. Even though Vicary admitted that the results of his experiment were a hoax not long after, the spread of information about such an allegedly powerful marketing method was quick enough to scare the public. This caused many countries to launch legislations, regulations, and bans against subliminal messaging (see Figure 20) and sparked controversy from those trying to protect consumers from being manipulated by such a force. The fundament of subliminal messaging was based on the Freudian notion that unconscious wishes could be used to trigger suppressed feelings that led to certain behaviors. In order to do so, the messages had to be delivered quickly or disguised enough so that they were below participants' recognition thresholds, and the audience, even with the keenest eyes, would not be able to detect. But they had to be clear enough to penetrate the participants' conscious awareness at the same time. At the end of the day, subliminal messaging's efficacy was overenthusiastically and grossly exaggerated, proven by countless unfruitful research to replicate that of Vicary (Saegert, 1987; Sutherland, 2008).

Besides, modern neurological studies can prove its efficacy (or, in fact, the lack of it) in triggering consumers' buying behavior. There is a spectrum to conscious awareness, unlike the notion of subliminal stimuli where a person has to be aware of something or not. In theory, subliminal messaging should be presented barely below the threshold of awareness, but realistically, the threshold varies from person to person at different levels toward various things and even day to day or hour to hour within a person. It can be affected by many external factors like hunger, tiredness, or the influence of substances or caffeine that cause a person to be more alert or inattentive toward a certain thing. For example, the higher tendency to be aware of subtle noise when walking alone at night or quicker recognition of food words when hungry (Sutherland, 2008).

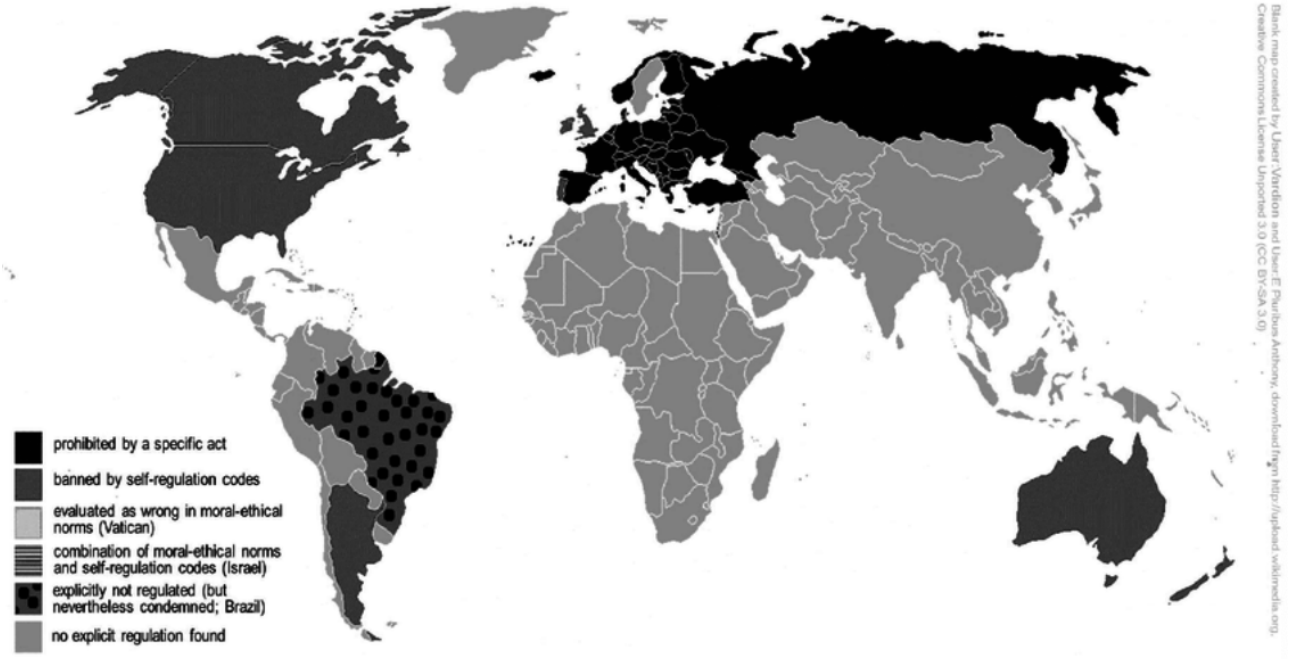

Figure 20: Regulations amongst countries regarding unconscious, subconscious, unaware, not clearly recognizable, and below threshold marketing stimuli (Bermeitinger and Unger, 2013)

5.2 Regulate Neuromarketing

The recent decades have seen an explosion in marketing activities, bombarding consumers with unsolicited ads in various forms: magazines, radios, TVs, phone calls, billboards, emails, and pop-up ads on browsers. Neuromarketing has the upper hand in circumventing this issue because it can detect hidden insights from studying consumers' brains to target a more accurate audience with more effective marketing tactics. However, it is a double-edged

sword, raising public outcry not over “Whether or not” but, “When will a marketing campaign that is impossible to ignore and resist be created?” This ethical concern aside, privacy violation when neuroimaging usage invades consumers’ autonomy is another controversial topic. While exchanging and selling data from internet marketing, for instance, email addresses, search and click histories, and archived purchases, has become more or less familiar to the public, the questions here are whether the same would be applied to the acquired neuroimages, who should own them, who should be able to access them, and the like (Krajnovic, Sikiric, and Jasic, 2012).

Diving deeper into the ethical issues, neuromarketing opponents have raised concerns about the “buy button” in the brain that is believed to be able to manipulate consumers’ purchasing behavior. Regardless, as mentioned in the previous sections of this paper, a “buy button” does not exist due to the complexity of the brain nature with 86 billion neurons and trillion synapses that connect them, and the question regarding “When will a marketing campaign that is impossible to ignore and resist be created?” is a grossly exaggerated concern (Fisher, Chin, and Klitzman, 2010; Krajnovic, Sikiric, and Jasic, 2012). As stated in subsection 2.2, marketing in general and neuromarketing, in particular, are under unfair scrutiny. Indeed, there are skeptics who have suggested that neural technology is far from precise, and being able to dissect the brain structure with neuroimaging does not necessarily equal the understanding of how it makes decisions. Besides, results from research done in one country or region are rather limited in application since consumers of different cultures, ethnicities, and backgrounds will have diverse ways to perceive a marketing stimulus related to humor, provocative images, and so on (Fugate, 2007). These two arguments, as a matter of fact, can further confirm the absence of a “buy button” in an individual’s brain.

There are governments who takes the matters their own hands and rules an outright ban on using brain-imaging for commercial purposes – which is the basis of neuromarketing, for example, France (see Figure 20). The country’s law categorizes such a usage as illegal and limits it exclusively for medical and scientific research purposes as well as in courts (Oullier, 2012). That is to say, not every country followed suit. Adhered to the First Amendment of the U.S. Constitution, including freedom of speech, the U.S. government does not object the use of neuroimaging for commercial purposes as long as the commercial speech must be lawful and not deceptive (Central Hudson Gas & Elec. v. Public Svc. Comm'n, 447 U.S. 557,

[1980]). Undoubtedly, with a comprehensive and transparent approach and strict but fair regulations regarding ethics, neuromarketing can bring consumers and businesses a win-win outcome. With more insights about consumers' neuronal responses, consumers themselves will have a better understanding of their product preferences, while marketers gain not only this knowledge but also how to market the more desirable products in better manners. It is without a doubt neural marketing's purpose: to supplement existing marketing practices with hidden information to best accommodate consumers rather than manipulative tactics (Krajnovic, Sikiric, and Jasic, 2012). Generally, the code of ethics should at least (1) cover research participants' data security and privacy, ensuring that their data can only be used for the agreed purposes and punishments will be applied upon privacy breach, (2) ban discriminations against individuals based on their neuroimages and exploitation of neurological traits or biological weaknesses, (3) be prohibited from promoting harmful, fraudulent, and illegal products and services, and (4) ensure fairness in market competition due to the fact that neurological technology remains relatively expensive and not all business can afford to experiment with it (Ariely and Berns, 2010). By way of illustration for the second point of the code of ethics, exploitation of neural data of any vulnerable group such as children has to be prohibited. Children's cerebral cortex, also called the prefrontal cortex, does not fully develop until the age of 25 years, which confines their abilities to make decisions and control impulses. By capitalizing on this knowledge and further invasive research, marketers may potentially influence the purchasing decisions, purchasing tendencies, and buying habits of an entire generation and many following.

6 FUTURE OF NEUROMARKETING

Undeniably, with its ability to fill the gaps left by existing marketing research and techniques, like marketing mix, qualitative research with one-on-one interviews, focus groups, and so on, neuromarketing poses many potentials in future applications. It has positively changed the perception of the marketing field and consumers' position in the field with more focus on individuals and their particular needs and preferences, thanks to brain-imaging and data of neuronal activities' frequency as well as temporal and spatial characteristics. This, in turn, sheds more light for marketers into understanding the connections between consumers' behavior and specific marketing stimuli during advertisements or product selection and evaluation before purchasing. Thus, future research will be expected to clarify the relationships between consumers' emotional and actional responses and the brain areas they triggered and vice versa, something current technology and understanding have not been able to manage. Besides, in order to catch up with market globalization, these neural studies should cover a larger base with universal stimulus systems to be applied to a broad target group. The application of each stimulus to a limited market group will be otherwise too expensive and impractical. Generally, neuromarketing's global market showed a constant growth during the period of 2015-2021, from US$21 million to US$50.3 million, equivalent to an 18% compound annual growth rate (CAGR) (Ionescu and Romanelli, 2019). This trend is forecasted to repeat from 2021 to 2026 as well, at a CARG of 15.6% (Neuromarketing Market | 2021 - 26 | Industry Share, Size, Growth - Mordor Intelligence, 2021).

Another noteworthy point is that general results of neuromarketing research from individual businesses should be more publicly available while participants of such research should be ensured about their data security. This measure will protect consumer neuroscience's transparent image, avoid subliminal messaging's ephemeral fate, support policymakers in rolling out adequate regulations and legislations, and encourage consumers to be more aware of their product preferences and purchasing habits, thus curbing unhealthy consumptions like impulse shopping.

To stimulate greater attention to consumer neuroscience research, neuromarketers are expected to not only concentrate on commercial applications but also expand the scope of

discussion on neuromarketing itself and the uses of brain-imaging on legitimate bodies like the Association for Consumer Research and the Marketing Science Institute (Fugate, 2007). That is not to mention, bearing in mind the complex nature of the brain, further studies digging deeper into the relationship between the mind and purchasing behaviors will likely be more complex and time-consuming, requiring more patience from the marketing community for fruitful and accurate results. Regardless, with the help of more available and advanced technologies and the decrease in operating costs of such technologies due to easier access, more studies can be expected in the future with deeper and more accurate outcomes. Specifically, the recent introduction of nanomarketing, an integration of consumer neuroscience and nanotechnologies, is potentially the answer to neuroimaging's existing limitations, i.e., high costs, requirements to be carried out in a lab instead of brick-and-mortar stores, inability to replicate a real-life and real-time shopping experience, difficult demands related to research participants, and so on. In contrast to the immovable machines like MEG and fMRI, nanotechnology devices are wireless, portable, and compact enough to be worn on wrists without disturbing the wearers, thus enabling data collection during not only the exposure point to the marketing stimuli but also daily regular activities. They, hence, are anticipated to work alongside laboratory neuroimaging results to bring neuromarketers a more comprehensive understanding of consumers (Mileti, Guido, and Prete, 2016).

7 CONCLUSION

The interdisciplinary field of neuromarketing or consumer neuroscience probes the consumers' brains to better comprehend their behaviors before and during making a purchase, i.e., product exploration, evaluation, and selection. The brain, with 86 billion neurons and trillion synapses that help them communicate with each other, is what makes a person who they are. As a result, it also determines each individual's needs and preferences; we are indeed "not thinking machines that feel, we are feeling machines that think."

"This feeling machine" is wired to seek pleasure and avoid unpleasant and dangerous experiences for the sake of survival, thanks to the ancient reptilian brain. However, the R-complex or any neural region alone is not adequate to answer such a complex matter concerning the consumers' brains. Therefore, neuroimaging technologies and physiological and pharmacological measurements are utilized to visualize the entire brain and bring to light unconscious emotional and actional responses when consumers are exposed to marketing stimuli related to product, place, price, and promotion. The former technologies contain EEG, MEG, and fMRI, and some typical examples from the latter are eye-tracking, skin conductance response, facial effective coding, alternation in neurotransmitter and hormone levels, and the like. Within which, eye-tracking is beneficial for research that investigates product packaging, product placement in brick-and-mortar stores, and ad and promotion designs. On the other hand, neuromarketers capitalize on fMRI with excellent spatial resolution to record neuronal activities deep in the brain and involved in emotional responses. The insights from this can be applied to understand the relation between brands or price differences and product perceptions. Despite its superior spatial resolution, fMRI is far behind EEG and MEG in terms of temporal resolution. Both neuroimaging techniques can capture brain activity with a millisecond-grade precision and are favored in researching different versions of marketing ads with various picture or music options. All in all, techniques using neurological images are often very costly, requiring million-dollar budgets to implement, with the exception EEG that costs roughly US$10,000 for equipment. Physiological and pharmacological applications do not require a large budget either.

With the insights elicited from the abovementioned applications in marketing four Ps, both businesses and consumers have a better understanding of each other and themselves, creating a better relationship between supply and demand. Neuromarketers can accommodate consumers better, from the product itself to how to deliver it, while consumers can acknowledge their own preferences to save time and unhealthy purchasing behaviors to save money. This is indeed the intention of neuromarketing in particular and marketing, in general. Regardless, neuromarketing still faces connotations regarding the public's outcry over the violation of consumers' free will and research participants' data security when neuromarketing is flagrantly misused. Fear of unfair competitions between companies due to neuroimaging technologies is another controversial topic. Although they are valid concerns, they can be avoided when businesses and neuromarketers adhere to the field's code of ethics, rules, and legislations. By applying these measures, consumer neuroscience can expect to continuously evolve in the future, regarding both technology and insights in the cause-effect relations between consumer responses to marketing stimuli and the correlated brain regions.

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