Anatomy of methodologies for measuring consumer behavior in neuromarketing research

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Abstract

Over the last decade, research methods aimed to explain and anticipate how effective marketing campaigns are. However, most of the conventional techniques have failed. Since emotions are mediators of how consumers process messages, understanding and modeling of cognitive responses to advertisements have always been a challenge in methodology. In this context, starting the analysis from the gaps in traditional marketing research, the study reviews and discusses the advantages and limitations of using these relatively new alternative techniques such as neuroimaging or bio-signal analysis in neuromarketing research, providing a brief analysis on when they are used and what do they measure for each tool. Neuromarketing is the branch of neuroscience research that aims to better understand the consumer through his unconscious processes and has application in marketing, explaining consumer's preferences, motivations and expectations, predicting his behavior and explaining successes or failures of advertising messages. Literature results indicate that neuroimaging tools have the potential to provide valuable consumer insights and can develop marketing research. The study closes by explaining the implications of neuromarketing studies and anticipate the needs for the evolution of this field.

Introduction

As a result of combining neuroscience with marketing, neuromarketing arises as a relatively new research discipline. Taking advantage of advances in technology, this emerging field goes beyond traditional tools of quantitative and qualitative research, focusing on consumer's brain reactions in front of marketing stimuli. Reimann et al. (2011) formally defines consumer neuroscience as the study of the neural conditions and processes that underlie consumption, their psychological meaning, and their behavioral consequences.

Technical instruments, mostly used in medicine, are used in neuromarketing studies. This paper analyzes each instrument's advantages and drawbacks from a neuromarketing study perspective. Neuromarketing measures responses of the consumer's brain to advertising messages using neuroimaging tools such as electroencephalography (EEG), magnetic resonance imaging (fMRI) or magnetoencephalography (MEG), so methodology has raised ethics issues concerning privacy. As Reimann et al. (2011) confirms, neuroimaging allows researchers to interpret psychological processes in the brain as they take place during information processing, unlike surveys that most often require respondents to make judgments about *ex post* conditions. Neuroimaging does not rely on verbal or written information from the respondent, as traditional measures commonly used in marketing research rely on the ability and willingness of the respondent to accurately report their attitudes or prior behaviors (Lee et al. 2007).

Neuromarketing studies aim to analyze different brain areas while experiencing marketing stimuli in order to find and document the relationship between behavior and the neuronal system. Using knowledge and know-how from brain anatomy and knowing the physiological functions of brain areas, it is possible to model neuronal activity and investigate behavior. So neuromarketing research tries to better understand the effects of marketing stimuli on consumers, having the possibility to obtain objective data through the use of the available technology and advances in neuroscience. As Morin (2011) considers, neuromarketing research should be applied to advertising messages in order to optimize the processing of information in our brain.

Ariely et al. (2010) states that the main objective of marketing is to help match products with people. Neuromarketing research aims to match activity in the neuronal system with consumer behavior, and it has a wide variety of applications for brands, products, packaging, advertising or in-store marketing, being able to determine purchase intent, level of novelty, awareness or elicited emotions. Although neuroimaging data collection implies a quantitative approach, measuring our brain activity in numbers, neuromarketing research seems to have common aspects also with the qualitative side of research. Butler (2008) proposes a neuromarketing research model that interconnects marketing researchers, practitioners and other stakeholders and states that more research needs to be performed in order to establish its academic relevance.

The purpose of the current paper is to identify the gaps in traditional marketing research, review the relatively new alternative techniques such as neuroimaging or bio-signal analysis used in neuromarketing research

and discuss each tool's advantages, limitations, what does it measure and when it can be used, in order to provide a clear idea of the insights that neuroscience can offer to market research.

Neuromarketing techniques

Given its status as a young discipline, the theoretical, empirical and practical scope of neuromarketing is still being developed, as Garcia et al. (2008) remarks. Theoretical research in neuromarketing is based on neuroscience, and neuroimaging techniques are used in this emerging field in order to test hypothesis, improve the existing knowledge or in order to test the effect of marketing stimuli on the consumer's brain. Research already established that patterns in brain activity are closely correlated with behavior and cognition (Alwitt 1985).

Reimann et al. (2011) states that advances in brain imaging allow researchers to enhance knowledge about how individuals process different stimuli and reach decisions. On using neuroimaging methods, researchers compare brain activation during a specific task and its activation during a control task.

Zurawicki (2010), Kenning et al. (2005) and Calvert et al. (2004) divide the types of tools used in neuromarketing research into the ones that record metabolic activity and the ones that record electric activity in the brain. In the following sections there will be further presented each technique and its experimental procedure.
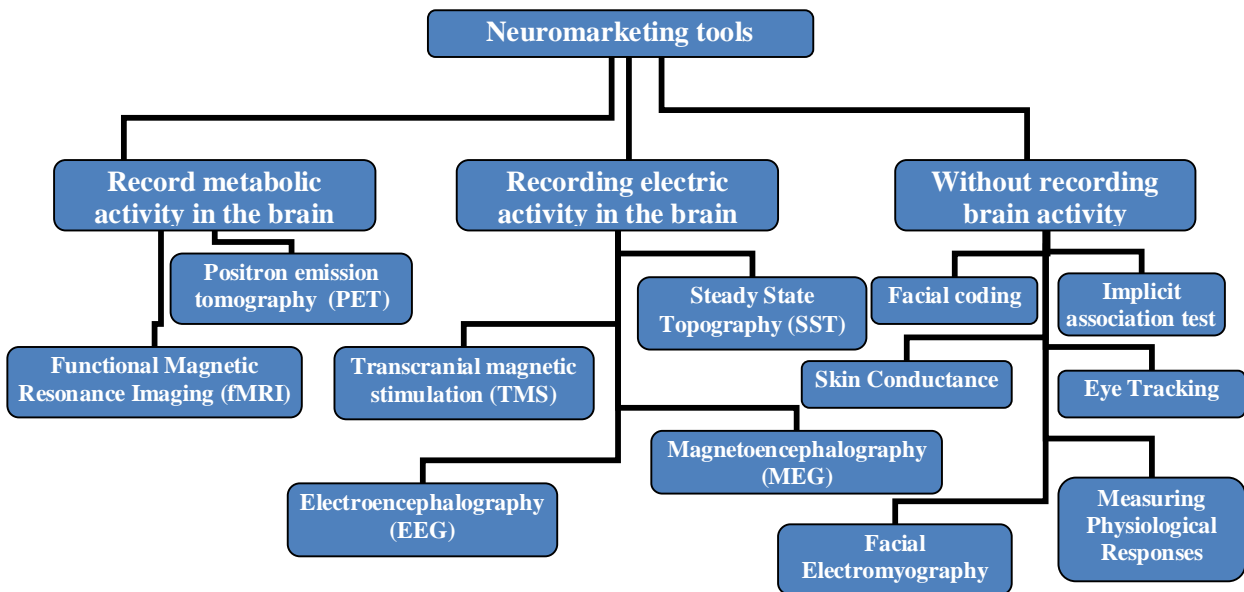
Figure 1. Classification of neuromarketing tools

According to Morin (2011), the first neuromarketing empirical study was conducted in 2003 and published in 2004 by Read Montague. In the experiment, a group of people drank Coca Cola or Pepsi while their brains were scanned using functional magnetic resonance imaging (fMRI), an appropriate methodology for uncovering the areas of the brain activation in response to a very simple experimental design with little potential for the temporal dimension to be a problem, as Lee et al. remarks (2009). Thus, it was concluded that different brain areas are activated when people know the brand consumed, compared to when they do not know it. According to the study, when people knew that they consumed Coca Cola, they said they prefer Coca Cola over Pepsi and their frontal lobe was activated, an area that coordinates attention, controls short-term memory and directs thinking - especially planning. However, when they did not know the brand used, they have reported that they prefer Pepsi, and the limbic system structure was activated, which is responsible for emotional and instinctual behavior. This finding reveals that emotional stimuli used as product brands affect cortical activity in ventromedial prefrontal cortex and thus can influence purchasing behavior.

The following discussion and tables will describe and summarize what each tool measures, when it is used, as well as its advantages and limitations, as methods vary in their invasiveness, portability, budget needed, data retrieved and technique. This could allow researchers to identify the best option for their own studies and alert them of all issues involved.

Recording metabolic activity of the brain

(functional) Magnetic Resonance Imaging

Functional Magnetic Resonance Imaging (fMRI) has become popular in neuromarketing research in the last decade, and it combines magnetic field and radio waves, producing a signal that allows viewing brain structures in detail. As Zurawiki (2010) explains, the subject lies on a bed, with the head surrounded by a large magnet which causes the atom particles (protons) inside the subject's head to align with the magnetic field. When a certain brain area is active, corresponding blood vessels dilate and more blood rushes in, reducing the amount of oxygen-free hemoglobin and producing a change in the magnetic field in the active area. A computer screen allows viewing this change, displaying colored areas overlapping the grey-scale image of the brain and refreshing the image every 2 to 5 seconds. This signal that is changed is called *BOLD signal* (Blood Oxygen Level Dependent signal). Technology allows also 3D vies of coordinates that denote certain location, making possible to investigate established areas.

fMRI allows observation of deep brain structures and it is suitable for neuromarketing studies, as it allows measuring brain activity while subjects perform certain tasks or experience marketing stimuli, searching for patterns. One of the disadvantages is that the method is very expensive. Restrictions include that the subject must remain still during the procedure and avoid as much as possible head movement. As Zurawicki (2010) states, future advances in allowing the fMRI scanner to be used standing up or sitting down would reduce the stress in subjects (as now they have to lie down). Hopefully, advances in technology will allow also improving spatial (1-2 mm for the moment) and temporal resolution (2-5 s for the moment).

Poldrack et al. (2008) report in their study a set of guidelines for studies using fMRI and provide a checklist to assist authors in preparing manuscripts that meet these guidelines on experimental design (design specification, task specification, planned comparisons), human subjects (details on subject sample, ethics approval, behavioral performance), data acquisition (image properties), data pre-processing (general, inter-subject registration, smoothing), statistical modeling (general issues, intra-subject fMRI modeling info, group modeling info), statistical inference and images or tables.

Table 1. Overview of fMRI in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• memory encoding • sensory perception • valence of emotions • craving • trust • brand loyalty • brand preference • brand recall	• testing new products • testing new campaigns • testing and developing advertisements • identifying the key moments of an advertisement or video material • testing packaging design • testing prices • repositioning a brand • predicting choices • identifying needs • sensory testing celebrity endorsement
Advantages	**Limitations**
• high spatial resolution, allows viewing deep brain structures in detail (Zurawicki 2010), as it localizes brain activity changes within a spatial resolution of 1-10 mm of deep structures in the brain (Plassmann et al. 2011) • permits interpretation of psychological processes in the brain (Reimann et al. 2011) • able to localize neural processing during consumer choices and consumption experience (Plassmann et al. 2011) • available statistical software packages which allows both preprocessing and statistical analysis, such as	• expensive, thus using small sample sizes, making it non-scalable (O'Connel et al. 2011); equipment costs around 800.000 €, operating costs are around 80.000 - 200.000 € per year, analysis cost around 100-50 €per subject (Plassmann et al., 2011; Ariely et al., 2010) • subjects must remain still during the procedure and avoid as much as possible head movement (Zurawicki 2010) • low temporal resolution, as it captures dynamic changes with a temporal resolution of 1-10 s

BrainVoyager QX (Levy et al. 2011, Morris et al. 2009) and *Statistical Parametric Mapping (SPM5)* (Falk et al. 2009, Plassmann et al. 2008, Stoll et al. 2008, Plassmann et al. 2007), as the later is able to realign and correct images for motion, perform time correction, or normalize data into standard space or smooth data with a Gaussian model • reliable and valid measure for cognitive and affective responses (Wang et al. 2008) • able to detect changes in chemical composition or changes in the flow of fluids in the brain (Wang et al. 2008), as it follows the metabolic activity in the brain (Perrachione et al. 2008) • non-invasive method	(Plassmann et al. 2011; Kenning et al. 2007) • non-scalable (O'Connel et al. 2011) • uses reverse inference from brain activation to brain function (Reimann et al. 2011) • tasks have a restricted level of complexity (trials) (Reimann et al. 2011) • high complexity in data analysis (Plassmann et al. 2011, Kenning et al. 2007, Savoy 2005) • ethical barriers raised such as invasion of privacy (Wang et al. 2008)

Positron emission tomography

With positron emission tomography (PET), another expensive method to use, there can be obtained physiologic images with spatial resolution similar to fMRI by recording the radiation from the emission of positrons from the radioactive substance administered to the subject (the radioactive chemicals in blood). A battery of detectors surrounds the subject's head and traces radiation pulse, without precisely identify the location of the signal, as Zurawicki (2010) notes. Technical issues involve obtaining the radioactive material and it's short life.

Table 2. Overview of PET in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• sensory perception • valence of emotions	• testing new products • testing advertisements • testing packaging design
Advantages	**Limitations**
• high spatial resolution (similar to fMRI) (Zurawicki 2010; Kenning et al. 2007) • reliable and valid measure for cognitive and affective responses (Wang et al. 2008) • able to detect changes in chemical composition or changes in the flow of fluids in the brain (Wang et al. 2008) • follows the metabolic activity in the brain (Perrachione et al. 2008)	• technical issues involve obtaining the radioactive material and it's short life (Zurawicki 2010) • poor temporal resolution (Kenning et al. 2007) • expensive method • ethical barriers raised such as invasion of privacy (Wang et al. 2008) • invasive method, application of radioactive contrast (Kenning et al. 2007)

Recording electric activity in the brain

Electroencephalography

Electroencephalography (EEG) is one of the most used tools in neuromarketing research, after fMRI. It captures variations in brainwaves, and the amplitudes of the recorded brainwaves correspond to certain mental states, such as wakefulness (beta waves), relaxation (alpha waves), calmness (theta waves) and sleep (delta waves). Morin (2011) notes that the measure of alpha-band waves (8-13 Hz) in the left frontal lobe indicated positive emotions, speculating that this is a good predictor of how motivated we are to act. A number of electrodes (up to 256) are placed on the scalp of the subjects, in certain areas, in order to measure and record the electricity for that certain spot. For the analysis, voltage and frequency are measured for each subject and compared to the data that was recorded without using marketing stimuli. Technology allows EEG to be a portable device and record brain activity in any many circumstances, as for example in supermarkets. As Zurawicki (2010)

states, electric conductivity may differ from person to person, so it is difficult to retrieve the exact location for each recorded signal. Also, EEG is able to record only activity data from superficial layers of the cortex. Vechiatto et al. (2011) used in his study EEG equipment in order to calculate the product moment correlation coefficient in obtaining subject's pleasantness while watching a TV advertisement.

As for using both EEG and the survey, a traditional marketing research method, in order to evaluate a TV advertisement for a body lotion product, O'Connel et al. (2011) notes that although there was convergence from the two methods on some moments, there were insights from explicit measures that could not be observed in brainwave data and brainwave data provided information that the survey did not.

Ohme et al. (2011) states that EEG has become a very popular method used by cognitive neuroscientists, neurologists, psychophysiologists and neuromarketers as a noninvasive, relatively inexpensive method to measure brain activity with high temporal resolution, although it has limited anatomical specificity and can only gather information from the peripheral regions of the cortex

ERPs (Event-Related Potentials) use EEG technology in order to investigate certain occurrences that appear after presenting a marketing stimuli and allows following the response to visual, tactile olfactory or gustatory stimuli and evaluating designs of objects.

As Fugate (2007) states, advances in imaging technology will no doubt also provide cheaper, smaller and les obtrusive devices in the near future, as in 2011 was released an EEG portable brain scanner with the phone NokiaN900.

Table 3. Overview of EEG in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
- attention - engagement / boredom - excitement - emotional valence - cognition - memory encoding - recognition - approach / withdrawal	- testing and developing advertisements - testing new campaigns - testing movie trailers - identifying the key moments of an advertisement or video material - testing websites design and usability - testing in-store experience - testing taglines
Advantages	**Limitations**
- simpler in use that fMRI (O'Connel 2010) - able to measure variations in the frequency of electrical activity in the brain (Wang et al. 2008), following the population neural activity in the brain (Perrachione et al. 2008) - high temporal resolution, so researchers can detect changes in the brain activity precisely, connected to rapidly changing stimuli (Ohme et al. 2011) - allows comparisons between left and right hemispheres (Plassmann et al. 2011), measuring approach-related tendencies (left-hemisphere dominance - positive emotional responses) or withdrawal-related tendencies (right-hemisphere dominance - negative emotional response) (Ohme et al. 2011) - strong correlation between EEG asymmetry and personality traits (Plassmann et al. 2011) - statistical software packages available (Plassmann et al. 2011) - relative low equipment costs (Kenning et al. 2007), around 7500 € (Plassmann et al. 2011; Ariely et al. 2010); low analysis costs; relatively straight forward data analysis (Kenning et al. 2007) - non-invasive method - can be portable - valid measure for cognitive information processing (Wang et al. 2008)	- as electric conductivity may differ from person to person, it is difficult to retrieve the exact location for each recorded signal (Zurawicki 2010; Kenning et al. 2007) - low spatial resolution, it records only activity data from superficial layers of the cortex (Zurawicki 2010) - non-scalable (O'Connel et al. 2011) - can identify only if the emotion is positive or negative (O'Connel et al. 2011) - moderate to high complexity (Plassmann et al. 2011) - results are influenced by experimental settings (Wang et al. 2008) and by moving artifacts

Magnetoencephalography

Magnetoencephalography (MEG) uses magnetic potentials to record brain activity at the scalp level, having sensitive detectors in the helmet placed on the subject's head. Magnetic field is not influenced by the type of tissue (blood, brain matter, bones), unlike electrical field used in EEG, and can indicate the depth of the location in the brain with high spatial and temporal resolution. MEG follows the population neural activity in the brain (Perrachione et al. 2008) , and research costs on using MEG rise if we take into account that experiments need a room free of earth's magnetic field.

Morin (2011) notes that specific frequency bands correlate to controllable cognitive tasks as recognizing objects, accessing verbal working memory and recalling specific events. Vechiatto et al. (2011b) presents a variety of results and experiments that use MEG or EEG in order to study product choice, gender differences in decision making, TB advertising, hedonic logos evaluation, pleasantness or tracking cultural differences in advertising between Western and Eastern users.

Table 4. Overview of MEG in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• perception • attention • memory	• testing new products • testing advertisements • testing packaging design • identifying needs • sensory testing
Advantages	**Limitations**
• good temporal resolution (Ariely et al. 2010; Kenning et al. 2007) • non-invasive method • reliable and valid measure for cognitive and affective responses (Wang et al. 2008) • able to detect changes in chemical composition or changes in the flow of fluids in the brain (Wang et al. 2008)	• experiments need a room free of earth's magnetic field (Zurawicki 2010) • limited spatial resolution, but better than EEG (Ariely et al. 2010; Kenning et al. 2007) • non-scalable (O'Connel et al. 2011) • expensive method, equipment costs around 150.000 € (Ariely et al. 2010) • ethical barriers raised such as invasion of privacy (Wang et al. 2008) • relatively complex data analysis (Kenning et al. 2007)

Transcranial magnetic stimulation

Transcranial magnetic stimulation (TMS) uses magnetic induction in order to modulate the activity of certain brain areas that are located 1-2 centimeters inside, without reaching the neocortex. TMS follows the population neural activity in the brain (Perrachione et al. 2008), and new technology allows also targeting lower brain areas. The instrument is less expensive than PET or fMRI scanners. A plastic case containing an electric coil is positioned near to the subject's head. TMS discharges a magnetic field that passes through the brain, allowing making changes in the brain tissue in certain locations and being able either to temporary activate neurons (using high frequency) or temporary disable neuronal activity (using low frequency). Zurawicki (2010) compares TMS to fMRI, stating that TMS is able to highlight causal inferences by analyzing the subject in front of a marketing stimuli while certain brain areas are disabled, stimulated, or normal.

Table 5. Overview of TMS in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• attention • cognition • changes in behavior	• testing new products • testing advertisements • testing packaging design • testing other marketing stimuli
Advantages	**Limitations**

• can be portable • allows studying changes in behavior (or physiological responses) after manipulation of brain activity (Plassmann et al. 2011) • used in studying causality of specific brain regions for specific mental processes (Plassmann et al. 2011) • its effects are assessed indirectly through behavioral responses such as accuracy or reaction time (Perrachione et al. 2008) • studies causality of specific brain regions for certain mental processes (Plassmann et al. 2011)	• expensive, equipment costs around 80.000-120.000 €(Plassmann et al. 2011) • ethical barriers raised • cannot stimulate deep brain structures directly

Steady State Topography (SST)

Steady State Topography (SST) is a tool used in cognitive neuroscience and neuromarketing research for observing rapid changes and measuring human brain activity that was developed by Richard Silberstein (Silberstein et al. 1990). It records brain electrical activity (EEG) while a sinusoidal visual flicker is presented in the visual periphery, eliciting an oscillatory brain electrical response known as the Steady State Visually Evoked Potential (SSVEP) (Vialatte et al. 2010). Task related changes in brain activity are then determined from SSVEP measurements. One of the most important features of the SST methodology is the ability to measure variations in the delay (latency) between the stimulus and the Steady State Visually Evoked Potential response over extended periods of time. This offers new insights based on neural processing speed as opposed to the more common EEG amplitude indicators of brain activity.

Table 6. Overview of SST in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• consumer behavior • video materials effectiveness • long term memory encoding • engagement • emotional intensity • emotional valence • processed visual and olfactory input • attention	• testing advertisements • testing movie trailers • testing prints and images • testing brand communication
Advantages	**Limitations**
• high temporal resolution, SST is able to continuously track rapid changes in brain activity over an extended period of time (Silberstein 1995) • tracking rapid changes in the speed of neural processing in different parts of the brain • able to tolerate high levels of noise or inference due to such things as head movements, muscle tension, blinks and eye movements (Silberstein 1995, Gray et al. 2003) and able to work with data based on a single trial per individual (Silberstein et al. 1990)	• low spatial resolution

Without recording brain activity

The following methods can be used together with the neuroimaging tools described above in order to obtain more insights and internal validation in studies.

Eye Tracking

Eye tracking allows studying behavior and cognition without measuring brain activity, but where the subject is looking at, for how long he is looking, the path of the subject's view and changes in pupil dilation while the subjects looks at stimuli. As Laubrock et al. (2007) state, eye tracking allows measuring the attention focus and thus monitoring types of behavior. Zurawicki (2010) states that eye movements fall into two categories: fixations and saccades. Fixation is when the eye movement pauses in a certain position and saccade is a switch to another position. The resulting series of fixations and saccades is called a scan path, and they are used in analyzing visual perception, cognitive intent, interest and salience. Eye tracking is usually used in combination with electroencephalography.

O'Connel et al. (2011) reports a study that confirms that eye tracking provides more accurate information than self-report, as research shows that claimed viewing is not always the same as measured actual viewing. As Zurawicki (2010) points out, eye tracking can be used in marketing stimuli research and also in HCI (human-computer interactions) research on evaluating the design of an website and its browsing patterns. O'Connel et al. (2011) claims that eye tracking can be useful in advertisements development and assessment, concept testing, logo and package design, online usability and micro-site development or in-store marketing.

Table 7. Overview of eye tracking in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• visual fixation • search • eye movement patterns • spatial resolution • excitement • attention • pupil dilation	• testing websites and user-interface effectiveness (usability research) • testing in-store reactions • testing packaging design (the visibility of brand and product name) • testing advertisements and video materials • testing prints and images design • testing how the consumer filters information • determining hierarchy of perceptions of stimulus material (which elements are perceived first, which last, which remain unnoticed) • testing shelf layout • testing product placement
Advantages	**Limitations**
• changes in pupil dilation and blink rate speed provide accurate information on involvement in processing images and on the degree of excitement (Zurawicki 2010) • portable, in kits that can be carried to any location (O'Connel et al. 2011) • able to detect spatial attention (Perrachione et al. 2008) • non-invasive method	• equipment costs around 25.000 €, including eye-tracker, host computer and monitor, software and technical support (Plassmann et al. 2011) • considered to be not reliable (Wang et al. 2008) • results depend on participants' eye conditions (Wang et al. 2008)

Measuring Physiological Responses

Biological reactions to stimuli can provide information on the subject's emotional effects, just as lie detectors. Monitoring the heart rate, blood pressure, skin conductivity (affected by sweat, measuring arousal level), stress hormone from saliva, facial muscles contractions (for facial expressions of emotions) researchers can infer the emotional state for each moment.

Table 8. Overview of measuring physiological responses in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• emotional engagement during choice processes • emotions	• testing advertisements • testing movie trailers

Advantages	Limitations
testing websites design • identifying in-store reactions • identifying consumer behavior in its natural environment	
Advantages	**Limitations**
• can provide information on the subject's emotional reaction to the stimuli (Zurawicki 2010) • can identify a large variety of emotions, unlike EEG (O'Connel et al. 2011) • inferences of emotional engagement / arousal during choice processes (Plassmann et al. 2011) • data acquisition toolbox available (Plassmann et al. 2011) • portable, non-invasive method	• physiological responses lag behind brain activity by several seconds, being hard to determine emotional states (O'Connel et al. 2011) • equipment costs can be vary between 100 € and 15.000 €, depending on its sophistication (Plassmann et al. 2011)

Implicit association test

An implicit association test (IAT) is used in measuring the individual behavior and experience, and it allows identifying hierarchies of products (using comparisons). As Houwer & Bruycker (2007) note, implicit measures might be less biased by deliberate attempts to conceal the attitude and that they might even reflect attitudes of which the respondent is not aware.

IAT measure the underlying attitudes (evaluations) of the subjects by assessing reaction times on two cognitive tasks, identifying the speed with which they can associate two different concepts (stimuli such as advertisements, brands, concepts) with two different evaluative anchors (attributes) is computed. Measuring the amount of time between stimuli appearance and it's response (response time or reaction time) can inform researchers on the complexity of the stimulus to an individual and how the subject relates to it, as Zurawicki (2010) states. This method can be used on recall studies or on measuring subject's attitude towards certain stimuli.

Table 9. Overview of IAT in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	**It is used when:**
• reaction time • underlying attitudes / evaluations	• celebrity endorsement (choosing the right option) • category segmentation • brand positioning • salient packaging features
Advantages	**Limitations**
• draws a more holistic picture of individual behavior and experience • allows identifying hierarchies of products • less biased by deliberate attempts to conceal the attitude	• results also depend on the availability of the subject to collaborate, as he or she needs to focus on the task

Skin Conductance

Skin conductance (SC) is based on the analysis of subtle changes in galvanic skin responses (GSR) when the autonomic nervous system (ANS) is activated (Ohme et al. 2009), measuring arousal. LaBarbera and Tucciarone (1995) state that skin conductance predicts market performance better than self-reports.

Table 10. Overview of SC in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	**It is used when:**
• arousal	• predicting market performance
Advantages	**Limitations**
• software allows separating noise from true arousal	• it cannot determine the valence of an emotional

	reaction (excitement and stress look similar)
response	
• able to measure the degree of arousal	
• predicts market performance better than self-reports	

Facial Coding

Facial Coding identifies (using a video camera) and measures micro-expressions that code non-conscious reactions, based on the activity of the facial muscles. Facial expressions are spontaneous, they provide real time data, but they are based on subjectivity in deciding when an action has occurred or when it meets the minimum requirements for coding.

Table 11. Overview of the use of facial coding in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• non-conscious reactions	• testing advertisements
• 43 facial muscles	• testing movie trailers
• 23 action units	
• 6 core emotions (anger, dislike, envy, fear, sadness, surprise, smile - that can be either genuine or social)	
Advantages	**Limitations**
• facial expressions are spontaneous	• subjectivity in deciding when an action has occurred or when it meets the minimum requirements for coding
• provide real time data	

Facial Electromyography

Facial electromyography (Facial EMG) measures and evaluates the physiological properties of facial muscles (Ohme et al. 2011), testing voluntary and involuntary facial muscle movements that reflect conscious and unconscious expressions of emotions (Dimberg et al. 2000, Cacioppo et al. 2006), as each emotion is characterized by a specific configuration of facial actions. Facial EMG is generally recorded in a bipolar manner (on both sides of the face), using small surface electrodes that record activity from specific muscles playing a prominent role in the expression of elementary emotions. Facial EMG is a more precise and sensitive method in detecting changes in facial expressions that visual observation, identifying any electrical impulse generated by muscle activity (micro-movements), even when subjects are instructed to inhibit their emotional facial expression.

Table 12. Overview of EMG in neuromarketing research:
what it measures, when it is used, its advantages and limitations

It measures:	It is used when:
• emotional expressions	• testing consumer reactions to advertising
• social communication	• testing video materials
• mood state, emotional valence	• testing brand recall
Advantages	**Limitations**
• able to test both voluntary (conscious) and involuntary (unconscious) facial muscle movements	• low-frequency artifacts such as motion potentials, eye movements, eye blinks, activity of neighboring muscles, respiration, swallowing, fatigue, speech or mental effort may infer the signals if the signal is not filtered
• able to detect the valence of the emotion depicted (positive or negative) (Bolls et al. 2001)	• equipment costs range between 10.000 € and 20.000 € depending on its sophistication (Plassmann et al. 2011)
• sensitive and precise	• emotional experiences under natural circumstances often consist of a mixture of elementary emotions which, in addition, may rapidly change so that EMG response patterns may thus be a function of such undetermined or dynamic emotional states (van Boxtel, 2010)
• able to measure facial muscle activity even to weakly emotional stimuli	
• able to identify the valence of the mood state (positive of negative)	
• available software to remove artifacts	

Data Collection and Analysis

As O'Connel et al. (2011) remarks, neuroscience techniques are useful in uncovering two types of information: things people do not want to reveal, and things people are unaware of or do not realize have influenced them. They emphasize that integration with conventional marketing research techniques is important, as we must consider the marketing questions and research objectives, and then which methods are best suited to answering the questions and meeting the objectives. Also, it is very important to identify which segment of the market one is targeting with the brand and choose the subjects for the study from that target, as scanning the brains of random people and exposing them to a brand or an advertisement wouldn't be relevant.

Usually, neuromarketing studies are small sample sized. Taking into consideration that the data collected also contains noises that must be removed, at least 15 to 20 participants should be recruited to such studies in order to obtain internal validity. Participants should also be asked before scanning if they take medication or have brain injuries in order not to bias the data. During the experiment, as Reimann et al. (2011) notes, participants should achieve maximal comfort and minimal head movement, and devices for collecting data (neuro-signals) should be response boxes or joysticks.

Most data analysis in neuromarketing research includes preprocessing, statistical analysis, data interpretation (behavioral analysis and neuroimaging data analysis) and triangulation. Reimann et al. (2011) presents preprocessing as having different phases which perform time correction (between appearance of stimuli and recording the signal of its effect), head motion correction, normalization (using algorithms in order to obtain a standard brain template) and smoothing (removing noises using Gaussian filters). Statistical analysis on the level of brain regions in order to find coordinates for which the time series (fitting a general linear model) significantly correlate with a specific experimental condition. Data interpretation should confirm or infirm the hypothesis of the research, and triangulation should validate the research by correcting complementary sources and linking them to the data acquired with neuroimaging. Vechiatto et al. (2010) present some considerations concerning the use of adequate statistical techniques in neuroimaging data analysis, as this data can contain errors and needs to be checked before the analysis. They observed that more than a third of the studies published don't take into consideration this errors and use the data without the necessary adjustments.

Ethics in Neuromarketing Research

As in the last ten years neuromarketing has been introduced and it's evolution lead to questionable issues in terms of ethics, the next decade will be decisive in this concerns. There is still much to investigate on understanding human decisions, emotions, reasoning and moral, but we are witnessing an increasing number of neuromarketing studies and interest in this area, so this should bring stability and standardization in research.

Literature reveals that neuromarketing has often been disregarded by some, in terms of ethics. Neuroethics is concerned with both the nature of the tools it uses and with the problems it seeks to apply (Levy, 2008), as its interest consists in ensuring that the subjects don't do anything against their will or affecting them physically and also in censoring the use of the information retrieved in unethical or illegal purposes

Ethical issues act like a barrier in the development of neuromarketing, but at a certain extent they are a regulatory mechanisms for the progress of the field. This is the main potential benefit of neuroethics in neuromarketing, and the reason societies and organizations in neuroscience use it. Of course, ethics needs also to be delineated between it's limitations and risks. There has to be taken into consideration: responsibility towards subjects participating to studies, responsibility towards consumers, responsibility concerning researchers. Also, neuromarketing research could serve the society and the environment, promoting a healthy life for the individuals and for the society and helping consumers find what they really want.

Conclusion

Each of the techniques used in neuromarketing research have specific strengths and weaknesses, which make them more or less appropriate for different research situations. Certain combinations between techniques seem more appropriate to develop more accurate and thus effective neuromarketing studies. As for example, using fMRI together with EEG or MEG (both have good temporal resolution, but MEG is more expensive to use) develops a powerful tool in research, mixing a great spatial resolution (of fMRI) with a very good temporal

resolution (EEG or MEG). Also, using PET and fMRI in the same study could enhance results with information on *what* happens at every moment (with PET) and *where* the change occurs (using fMRI). For a less expensive budget, EEG can be use together with physiological responses and develop inferences on emotions assessed and the brain area that shows a greater electric activity. Using TMS with EEG or fMRI is a good combination also, as TMS is used in studying causality of specific brain regions for specific mental processes and EEG and fMRI study only correlations between data acquired and stimuli.

Taking into account the advantages and limitations of the methods used in neuromarketing research, we can infer that using some of the techniques together will generate better results that will be able to find new valuable consumer insights revolutionize marketing research.

After exploring various types of instruments used in neuromarketing research and what kind of information can a marketer obtain from such a study, it is clear that there is a great need for clear standards in neuromarketing research and hopefully the new established *Neuromarketing Science & Business Association* (http://www.neuromarketing-association.com/) will provide the necessary guidelines and restrictions, as neuromarketing research has the potential to provide rich consumer insights.

Researchers are advised to integrate neuroscience to traditional marketing research techniques, as neuromarketing alone is not always the answer to the research questions. So considering the research questions and objectives, it is easier to choose the right neuromarketing technique which is best suited. The instruments presented are the source of understanding mechanisms underlying consumer behavior and they add value to traditional marketing research techniques. Using them, researchers are able to uncover what people do not what to reveal and what exactly influences their decisions, even things they are not aware of.

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