New frontiers in neuromarketing research: Benefit and potential applications of GRAIL

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Recent years has seen an explosion in the application of neuroscience techniques to market research, known as neuromarketing. The aim of this paper is to contribute to both theoretical and practical aspects of neuromarketing research by presenting a new and innovative neuroscience tool for studying marketing-relevant behavior, namely GRAIL. GRAIL combines different devices (e.g. EEG, ET, facial EMG) into one single real-time device. It can help researchers and practitioners to measure physiological responses (internal reflexes) and brain activity (external reflexes) simultaneously. We argue that this new tool can improve neuromarketing research in several ways, namely in reducing the costs of neuromarketing research, improving the efficiency and accuracy of neuromarketing experiments, and recreating real-life purchase experiences using virtual reality and personalized scenarios.

Keywords: Neuromarketing, Neuromarketing tools, GRAIL

Paper track: Consumer Behavior

1. Introduction

The last two decades have seen an explosion in the use of neuroscience techniques in market research. The integration of neuroscience tools, psychological methods, and marketing theories has led to the development of a new and interdisciplinary field of study, known as neuromarketing. Research conducted using neuroscience tools provide both researchers and practitioners with in-depth information on previously little understood psychological mechanisms (e.g. brand association, attitude, marketing placebo effect) (Lee & Chamberlain, 2018; Smidts et al., 2014). A better understanding of these psychological mechanisms allows studying emotional processes (e.g. happiness, sadness, positive vs negative) and human cognitive functions (e.g. verbal communication, memory, attention) underlying consumer behavior without resorting to the subjective reports that have long been the mainstay of marketing studies (Alvino et al., 2019; Miljkovic & Alcakovic, 2010; Russo, 2015). Neuroscience tools can measure neurophysiological responses while a consumer is exposed to marketing stimuli or even *before* the subject consciously makes a decision. Hence, neuroscience data remain insensitive to the biases that often characterize traditional marketing research (e.g. information bias, selection bias, and confounding bias; Ariely & Berns, 2010). In this way, neuromarketing can contribute to a more accurate and objective investigation of consumer behavior and decision-making processes in order to improve marketing strategies. There are several tools used in neuromarketing research to study neuronal and physiological mechanisms underlying the perception and processing of marketing stimuli. Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) rank among the most popular neuroimaging tools in neuromarketing (Bercea, 2013; Koc & Boz, 2018). Many companies and researchers also use biometric methods such as eye tracking, galvanic skin response, and facial coding to measure consumers' preferences (Smidts et al., 2014).

The aim of this paper is to contribute to both theoretical and practical aspects of neuromarketing research by presenting a new and innovative neuroscience tool for studying marketing-relevant behavior, namely *Gait Real-time Analysis Interactive Lab (GRAIL)*. GRAIL is a system that allows the combination of multiple separate devices into a single real-time device and immerse the subject in a virtual reality setting. To our knowledge, GRAIL has never been used before in neuromarketing studies.

In this paper, we used a literature review in order to identify the main neuroscience tools used in neuromarketing research in the last two decades. The literature review provides

an overview of the most used tools in neuromarketing, a classification and characteristics of neuromarketing tools, and possible uses of GRAIL in neuromarketing research.

The papers used for the literature review were selected on the basis of their title and abstract, using databases such as Scopus and ScienceDirect. The papers were selected from top journals in different domains (e.g. marketing, neuroscience, psychology), where neuromarketing is an accepted topic of research.

The paper is structured as follows. First, we illustrate the main neuroscience tools commonly used in neuromarketing research to analyze consumer behavior. Second, we explain the key features of GRAIL. Finally, we analyze the benefits and potential outcome of GRAIL in neuromarketing research at both theoretical and applied levels.

2. Neuromarketing tools

Nowadays, neuroscience tools are used to study consumer behavior and decision-making processes. Neuroscience tools enable researchers to measure physiological signals that arouse from marketing-related stimuli (e.g. products, advertisements, websites, brands). Such tools allow to measure signals as heart rate, skin conductance, and brain activity while consumers are exposed to products with different design.

According to Postma (2017), it is possible to divide consumers' physiological signals in two groups, namely *external reflexes* and *internal reflexes*. External reflexes measure human reactions that originate in the brain but do not directly reflect brain activity (Postma, 2017). Examples of external reflexes are body language, facial expression, eye movement, pupil dilatation, palm sweating and pulse (Postma 2017). Several tools can be used to measure external reflexes such as galvanic skin response sensors, eye tracker and facial electromyography. Internal reflexes are automatic, subconscious responses that reflect directly brain activity (e.g. electrical, blood flow) to various stimuli like products, advertising, packaging, and brands (Constantinides & Roth, 2015). Measuring Neuroimaging tools such as functional magnetic resonance imaging and electroencephalogram are used to identify and analyze the brain's internal reflexes (Postma, 2017). Postma (2013) also describes Input/Output models. An Input/Output model is a method to assess brain activity by analyzing the pattern of brain activity to certain stimuli. This method works on the principle that there is always a measurable output to any marketing stimulus. However, Input/Output models do not refer to any specific neuromarketing tool so they are not considered in the present study.

The following sections explain the more frequently used neuromarketing tools using the internal and external reflexes classification (Postma, 2017), see Table 1.

Table 1. *List of Neuromarketing tools*

Tools	Internal Reflexes	External Reflexes	Output	Use in Neuromarketing
Facial Electromyography		X	▪ Voluntary and Involuntary Facial Muscle Movements ▪ Positive and Negative Emotional Reactions	Product design, brand, advertisement
Eye tracking		X	▪ Visual Behavior (duration and numerous of fixation) ▪ Pupil Dilatation	Websites, in-store reactions, packaging designs, advertisement
Galvanic Skin Response		X	▪ Skin Temperature ▪ Skin Electric Conductance ▪ Heart Rate	Product perception, brand design, movie-trailer
Electroencephalogram	X		Electrical Brain Activity using ▪ Frequencies bands (delta, theta, alpha, beta, gamma) ▪ Time domain (ERP)	Product experience, product design, brand association & brand recall
Functional Magnetic Resonance Imaging	X		▪ Brain activity by detecting changes associated with Blood Flow	Product experience, price evaluation, product packaging

3.1 Neuromarketing tools to measure external reflexes

Facial expressions are important indicators of positive and negative emotional reactions (Horska & Bervcik, 2017). Changes in facial expression can be divided in observable changes of expressions (e.g. smile) and unobservable changes of mimic muscles (e.g. muscle contractions imperceptible to the human eye) (Fortunato et al., 2014; Horska & Bervcik, 2017). Detecting changes in mimic facial expressions is possible using facial electromyography (facial EMC). Facial EMC measures voluntary and involuntary facial muscle movements that reflect positive or negative emotional reactions towards a stimulus (e.g. product, brand, advertisement) (Barcea, 2012; Cherubino et al., 2019). These changes can be detected even when subjects are instructed to inhibit their emotional facial expression.

An eye tracker (ET) is an instrument for measuring eye positions and eye movement, in particular, the focus of customers' attention, visual behavior of fixation of the gaze, and pupil dilatations (Fortunato et al., 2014). The speed and sight direction changes provide information of consumers' attention, interest and attraction towards a product or an advertisement (Horska & Bervcik, 2017). Similarly, pupil dilatation can give information

about excitement, fear and pain (e.g. website) (Horska & Bervcik, 2017). Wearable eye trackers can also be used to test in-store reactions (e.g. supermarkets) (Russo, 2015).

Galvanic skin response (GRS) or skin conductance detects changes in skin temperature, influencing the skin's electrical conductance (Kumar & Singh, 2016; Koc & Boz, 2018). The heart rate could also be measured through galvanic skin response (Kumar & Singh, 2016). GRS is useful to determine the level of excitement or stress that the person experiences as a response to certain triggers (e.g. a movie, brand design, movie trailers) (Barcea, 2012). However, GRS cannot determine the valence of an emotional experience (Kumar & Singh, 2016).

3.2 Neuromarketing tools to measure internal reflexes

Electroencephalography (EEG) is one of the most used tools in neuromarketing research (Cherubini et al., 2019). EEG measures the electrophysiological signals resulting from brain activity (Zhang et al., 2014). The oscillations measured by EEG can be analyzed in two domains, time and frequency (Cohen, 2014). The main frequencies of the human EEG have been classified in five frequency bands, namely delta, theta, alpha, beta and gamma (Abhang et al., 2016; Rahman et al., 2015). Oscillations in the time domain involve the study of potentials, for instance Event-Related Potential (ERP). An ERP is generally elicited by an event or a stimulus followed by different operations, such as sensory-related operations (estimation of color), by affective operations (brand associations with positive or negative emotions) or memory-related operations (recalling a brand) (Alvino et al., 2019; Kropotov, 2016). Thus, ERP can be used to investigate brain responses involving attention, emotion, memory and other cognitive processes for brands or products (Ohme, 2015).

Functional magnetic resonance imaging (fMRI), is one of the most popular brain imaging technique used in neuromarketing, after EEG (Cherubini et al., 2019). fMRI detects changes in brain activity through the increasing of blood flow (Buxton, 2013). The blood oxygenation level-dependent (BOLD) rises when changes in neuronal activity occur following a change in brain state. The blood oxygen level–dependent changes in the MRI signal may be produced, for example, by a stimulus (e.g. brand logo) or task (e.g. drinking wine, price evaluation) (Plassman et al., 2008; Gore, 2003). fMRI also provides a three-dimensional view of the brain parts that show increased activity during a task or marketing stimulus presentation (e.g. packaging) (Bercea, 2012; Zurawicki, 2010).

3. What is GRAIL?

The GRAIL (Gait Real-time Analysis Interactive Lab) system is a new medical device that uses an instrumented dual-belt treadmill (with fast pitch or sway), a motion-capture system (VICON system) and synchronized virtual reality (VR) environments. GRAIL allows users to perform clinical gait analysis, which consists of an evaluation of gait performance of a subject in terms of different parameters such as posture, muscles activation, and ground reaction forces in a VR environment. The self-paced mode of the treadmill allows the participant to walk at a self-selected speed, while the treadmill and the VR environment run in perfect synchronization. All gait parameters are calculated in real-time using the Human Body Model and are processed in real-time (Geijtenbeek et al., 2011; van den Bogert et al., 2013).

The GRAIL runs on a D-Flow software platform, which integrates both motion capture technology and a motion platform, allowing the subject to interact in real time with the system and receive feedback from it. GRAIL system consists of a motion capture system with ten infrared cameras, a computer, receiving data from the motion capture system to record a subject's motion and three video cameras to record the scene in a lab of 25m^2. Thus, the GRAIL system allows to record videos in real-time while the subjects are immersed in a in a virtual reality environment, projected on a semi-cylindrical screen (180°). In addition to this, it is possible to integrate other tools such as electromyography (EMG), electroencephalography (EEG), electrocardiography (ECG) and Galvanic Skin Response (GSR).

4. Application of GRAIL in Neuromarketing

The GRAIL is a unique medical device that combines multiple separate devices into one single real-time device, offering unique opportunities for neuromarketing research. GRAIL allows to study consumer behavior based on various types of visual, mechanical and cognitive measurements (see Table 2).

First, the combination of different tools can improve the efficiency of neuromarketing research. Using traditional neuromarketing tools makes it necessary to carry out different experiments or to alternate different tools in order to study both internal and external responses. Using GRAIL, it is possible to measure both internal and external reflexes in a single experiment. For instance, it is possible to test the effectiveness of an advertisement or a

new website using EEG, eye tracking, electromyography and GRS simultaneously. Performing one experiment combining different tools reduces the time and costs for carrying out neuromarketing experiments drastically.

Second, GRAIL improves the accuracy of neuromarketing experiments. In fact, measuring internal and external responses simultaneously helps researchers to have clearer and more precise insights into decision-making processes and the resulting consumer behaviors. Measuring brain activity and physiological responses at the same can help researchers to link cognitive and emotional aspects with neuronal processes during product experience (e.g. beverage tasting), purchase decisions (e.g. preference, attitude) and expectations about product quality (e.g. price) (Plassman et al., 2008). Thus, it contributes to create more realistic theories and models in neuromarketing research.

Third, GRAIL uses an intuitive interface that allows operators to easily control hardware, tailor applications, or define their own applications. Thus, using GRAIL would make it easier for researchers to design neuromarketing experiments. For instance, researchers would be able to analyze different responses using only one piece of software instead of a suite of software applications. GRAIL interface does not require programming skills. So, GRAIL require less training for researchers and practitioners who do not have technical skills (e.g. coding, programming) compared to other neuromarketing tools. Hence, using GRAIL enhance both companies and university to reduce the time and expenses of their employees' training (e.g. fewer training sessions, in-house training).

Table 2. *GRAIL key features and uses in Neuromarketing research*

Tools	Internal Reflexes	External Reflexes	Output	Use in Neuromarketing
Gait Real-time Analysis Interactive Lab	X	X	▪ Voluntary and Involuntary Facial Muscle Movements ▪ Positive and Negative Emotional Reactions ▪ Visual Bbehavior (duration and numerous of fixation) ▪ Pupil Dilatation ▪ Skin Temperature ▪ Skin Electric Conductance ▪ Heart Rate ▪ Electrical Brain Activity	Advertisement, movie trailer, product quality, brand recognition & recall, virtual reality experience (supermarket, shopping mall, hotel), product experience

Finally, neuromarketing experiments too often simplify the complexity of the decision process because experiments are carried out in a laboratory setting (Alvino et al., 2019; Lee &

Chamberlain, 2018). Participants are subjected to a standardized procedure and there is no interaction with the external environment. The GRAIL system provides synchronized virtual reality (VR) environments. Participants are immersed in a virtual scenario that reproduces real-life situations, while researchers can monitor participants' emotions, using different types of tools. Thus, GRAIL would allow to recreate real-life purchase situations, for instance walking in a supermarket, mall or hotel while participants are still in a controlled environment. Plus, it would help researchers to study brain activity and physiological responses while participants perform complex tasks (e.g. look at advertisement while walking) or make complex choices (e.g. choosing between several products on a shelf).

5. Conclusions

Recent years have seen an explosion of neuroscience techniques applications to market research, known as neuromarketing. Several tools are used in neuromarketing research to study physiological responses (internal reflexes) and/or brain activity (external reflexes) in consumer decision-making process and behavior.

In this paper, we present a new and innovative tool that can help improving our understanding of consumer behavior, namely GRAIL. GRAIL allows to combine multiple separate devices (EEG, ET, facial EMG) into a single real-time device, while participants are immersed in a synchronized virtual reality environment. We argue that GRAIL could improve neuromarketing research in several ways. First, GRAIL can improve the efficiency and accuracy of neuromarketing experiments. Measuring brain activity and psychological responses at the same can help researchers to better link cognitive and emotional aspects with neuronal processes. GRAIL would also help to reduce the costs of neuromarketing research for carrying out experiments and training employees (e.g. fewer training sessions, in-house training). In fact, GRAIL allows to measure both internal and external responses in a single experiment and using only one piece of software. Plus, the GRAIL interface is easy to use and does not require programming skills. Finally, GRAIL allows to recreate real-life purchase experiences using virtual reality and personalized scenarios (e.g. supermarkets, shopping mall, hotels), thus adding much needed ecological validity to such research.

Overall, we argue that due to the combination of different tools, real-time analysis and unique software, GRAIL is a unique tool that offers multiple solutions and potential benefits to neuromarketing research.

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