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The Role of Neuroeconomics in Advertisement: a Systematic Review

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Abstract

The integration of neuroscience into decision-making research started in the mid-1970s and its goal was to gain insight into the hidden sub-conscious cognitive processes that occurred during decision-making. This study analyzes the effectiveness of neuromarketing techniques, comparing them with traditional methods in order to shine a light on the role neuroeconomics plays in the advertising industry. The databases used for searching were PubMed, JSTOR, DOAJ, and Nature Communications. Experimental studies on healthy adult populations with full cognitive function were included. All the papers were screened by one person. Papers were screened according to abstract and title first, and then full texts were further screened for eligibility and inclusion. 201 studies were screened describing studies that applied neuromarketing methods in advertising campaigns with subjects that were healthy. 66 articles made it through to full-text screening for eligibility and 24 were selected for quality checking. Four papers were subject to in-depth analysis, and the main neuromarketing techniques used were discovered to be eye-tracking, biometrics, EEG, and fMRI with all of them having many advantages over traditional methods. Neuromarketing techniques can explain the correlations between regions of the brain and the implicated cognitive processes with much greater detail and depth than traditional methods, with the usage of fMRI being the best predictor of advertising success. One limitation was the inclusion of too few articles for analysis, and future research could include companies modifying their ads in subtle ways using the existing knowledge to best target consumers.

Keywords: neuroeconomics, advertisement, marketing, neuroimaging, decision-making

Introduction

Research in consumers' decision preferences in the industry has been done for quite a while, with interests going back to the early 1950s, where the goal was to mathematically model judgment and judgment and decision preferences (Hammond, 1955). During this time, research was done mostly using self-reported measures with traditional methods like surveys. Then, the use of neuroscience in decision research started to become popular in the mid-1970s (Payne, 1976) to early 2000s (Loewenstein et al., 2001). Now, the use of neuroscience and psychology in the field of decision-making research is coined "neuroeconomics" or "neuromarketing."

In neuroeconomics, the main techniques used are functional magnetic resonance imaging (fMRI), electroencephalogram (EEG), eye tracking, and biometrics, with fMRI and EEG being the most popular (Venkatraman et al., 2015). fMRI measures the changes in blood oxygenation in different parts of the brain during cognitive tasks which indicates the level of neural activity, while EEG reveals variations of electrical signals of cortical regions recorded at different frequencies (delta, theta, alpha, beta, gamma). Unlike the

other two techniques, eye tracking and biometrics do not directly measure brain modalities, with eye-tracking using an optical camera to determine the position of the pupil and cornea through infrared light. Similarly, biometrics measures physiological responses to stimuli through evaluation of heart rate, and skin conductance (Venkatraman et al., 2015).

Even with all the technologies and advancements that have been made in this field, there is still a lot yet to be uncovered and known. Studies have tried to identify the parts of the brain that are stimulated in the decision-making process and viewing of the advertisement to correlate it to already known functions of that specific part. For instance, research has been done on the neural activation of different structures of the prefrontal cortex, including the dorsolateral and ventromedial sections, and how it relates to a known function of the PFC, responsiveness (McFadden et al., 2015; Vezich et al., 2017). Another study has investigated the relationship in neural activity between other regions of interest (ROIs) including orbitofrontal, prefrontal, anterior cingulate cortex (ACC), cingulate motor (CMA), and parietal areas in attentiveness and memory retention for decision-making related to advertisements (Astolfi et al., 2008).

From the above sections, it is clear that neuroeconomics has had a profound impact on the advertisement industry, offering an unbiased look at what exactly happens in a consumer's brain during advertisements and after, in a shopping scenario. To further research in this avenue, a systematic review of the most vital findings of neuroscience in advertising must be done to summarize what has been achieved so far and how to proceed. To my knowledge, there are few recent systematic reviews conducted on this topic that discuss the same topic of neuromarketing's role in advertising through contrasting it with traditional methods, so in that sense, my study is novel.

Research question and objective

This review attempts to answer the following question: How has neuroeconomics played a role in advertisement? This study discusses the role neuroeconomics plays in the advertising industry through comparisons between the effectiveness of neuromarketing techniques and traditional techniques.

Methods

The target papers of this systematic review are populations that have data on the methods that neuroeconomics employ in advertisement, its effects, and comparison between traditional and neuroscience-based techniques.

This systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Moher et al.) to select research papers that provide new insight into the role of neuroeconomics in the advertisement industry. The methodology is explained with five sections: search strategy, inclusion and exclusion criteria, databases, and study selection.

Search strategy

The databases used for searching were PubMed, JSTOR, DOAJ, and Nature Communications. The keywords used in searching were generated through the reading of definitions related to the research question in academia. The relevant papers found from each of the databases used the following keywords applied to the title and abstract: "neuromarketing", "neuroeconomics", "advertisement", "decision-making", and "marketing". A combination of keywords was most often used including: "neuromarketing in advertisement" or "neuromarketing and decision-making" as two examples.

Inclusion and exclusion criteria

The target of this systematic review is healthy adult populations with no dementia and full cognitive ability that have data via neuroscience to gauge the advertisement industry. The selected studies applied neuromarketing methods in advertising campaigns and used such techniques to determine neural correlates of both cognitive and emotional processes. Study outcomes included findings on relationships between regions of the brain in response to advertisements, brain activity signaling neural correlation to the processes mentioned earlier, the differences between traditional methods and neuromarketing and its impact, and the benefits behind adopting neuromarketing techniques for product advertisements. The study design is experimental studies, more specifically, pre-test post-test control group design.

Databases

The databases listed were searched from the earliest available date to August 7, 2021: PubMed (from 1966), JSTOR (from 1665), DOAJ (from 2002), and Nature Communications (from 2010). The reference section was analyzed to find more articles in the full papers included in the review. All papers were stored in Zotero version 5, and duplicates were deleted.

Study selection

The screening was done on Zotero, and one person was involved in the process and completed the screening. Articles were stored in Zotero, a reference managing software, where duplicates were deleted. Titles were screened for relevance, category, and language, and those that did not satisfy the criteria were deleted. The abstracts of the remaining papers were then screened in further detail.

Results

Two hundred one records were identified through database searching. Duplicates were removed (n = 64) and one hundred thirty-seven abstracts were screened. Sixty-six abstracts were assessed for eligibility and twenty-four studies in full text were analyzed further. Figure 1 is the PRISMA flow chart of the process of screening and determining eligibility and inclusion in the review.

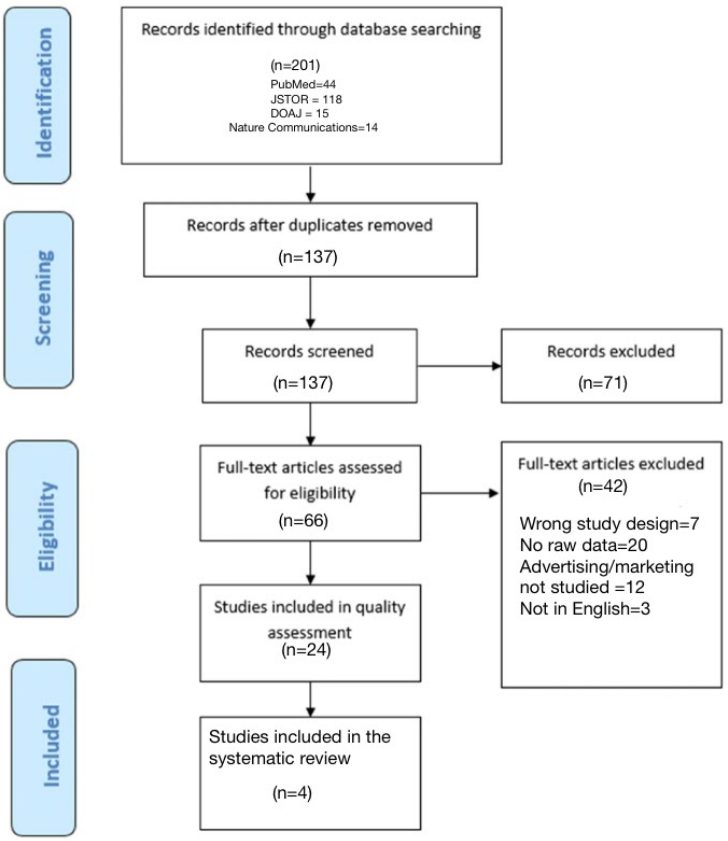

FIGURE 1: PRISMA flow diagram of the process of screening and determining inclusion in the review.

Techniques used in studies

As previously mentioned, neuromarketing is so highly sought after because of its use in determining the advertisement's effect on the consumer in projecting how well the product would do. The techniques discussed in the selected studies were EEG, fMRI, biometrics, and eye-tracking. These techniques were compared in a study based on the core measures of advertising research: attention, affect, memory, and desirability, extended from the AIDA model (Venkatraman, 2015). First, details of each measure will be discussed, then how traditional measures are insufficient, the specifics of each non-traditional technique, and finally a summary

of multiple results on which technique was the best to use in predicting ad success and elasticity will be presented.

Core measures in advertising research

Attention

Attention, generically, is the level of alertness or ability to interact with the environment (Lindsay, 2020). However, in terms of neuroeconomics, it is the ability to capture the focus of the consumer through informativeness, relevance, etc. Thus, attention can be divided into endogenous and exogenous attention. Endogenous attention is cognitive in origin and allow the consumer to control where their attention lies. It is sometimes also called "top-down" attention. Exogenous attention is the opposite, which describes how "salient" (prominent or noticeable) a stimulus is regarding its characteristics (Erickson, et al., 2015). Exogenous attention can additionally be referred to as "bottom-up" attention. With only traditional methods, distinguishing between these types of attention is not possible.

Affect

Affect as defined by the circumplex model, arises from two independent neurophysiological systems with one related to valence and the other related to arousal. Valence is the feeling of pleasantness or unpleasantness while arousal is the physiologic activation or deactivation, also known as alertness. (Posner, et al., 2008). When using traditional methods to measure affect, it would be inaccurate due to distortion from high-level cognitive processes.

Memory

Memory is another core measure and is associated with the three processes of encoding, consolidation, and retrieval. Advertisement research focuses on retrieval which itself has two measures: recall and recognition.

Desirability

Desirability is how much the people want the product in the ad, measured by contrasting purchase intent before watching the ad and after. Desirability may be biased through increased desirability for more popular luxury brands if measured using traditional methods.

Traditional methods used in advertising

As mentioned in the introduction, some common traditional methods include self-reported measures like surveys. This section aims to go more in-depth into the traditional methods in order to properly compare it to modern neuromarketing techniques. Traditional methods include interviews, focus groups, surveys, and questionnaires. In interviews, the results are purely qualitative, as results are based only on what the customer says or how they respond. Contrary to this, surveys and focus groups provide both qualitative and quantitative results because of the different structure of questions asked as well as how the research is conducted. In surveys, participants are given questions that are either in a closed format (i.e., multiple choice or multi-select) or in a short response. Focus groups are similar to interviews but have multiple participants actively answering instead of just one. Finally, questionnaires are similar to surveys, but all of the questions are in a closed format with pre-determined answers, therefore providing only quantitative results (Straker et. al., 2013). All of these methods are commonly used to explore the how, what, and where, less so the why in the relationship between the customer and the marketed product (Zaltman, 2003).

Neuromarketing techniques' use in evaluating core measures of research

In the previous paragraphs, the referred techniques were EEG, fMRI, biometrics, and eye-tracking. In this section, the mechanics of each technique and which measures they analyze will be mentioned.

Eye Tracking

Eye tracking, as the name suggests, tracks the movement of your eyes and analyzes it. It's used to determine the relationship between visual

attention and arousal (affect), and the responses of consumers (Oliveira Joaquim dos Santos et al., 2015). Eye-tracking measures three main variables, the gaze point of the eye (what the consumer is looking at), eye movement compared to the position of the head, and pupil dilation (Zurawicki, 2010). Through these variables, eye tracking may be able to determine where the attention is directed at through examining the gaze point as well as to measure arousal through pupil dilation (Duchowski, 2003). The reason eye tracking is used in neuroeconomics is that eye movements are closely related to high-order cognitive processes and because vision is one of the main modalities of receiving stimuli.

Biometrics

Biometrics measure the physiological and automatic responses to external stimuli. The variables measured with biometrics are most commonly heart rate and galvanic skin response (or skin conductance) (Cherubino et al., 2019). Several studies have found that heart rate is related to the valence (affect) of stimuli, the positive or negative feeling. It was hypothesized that an index of attention could be heart-rate deceleration through parasympathetic response, which occurs in information processing (Graham & Clifton, 1966; Baldaro et al., 2001) Galvanic skin response, quantified through skin conductance level (SCL) and short-duration skin conductance responses (SCRs) are considered to be a good measure of changes in arousal caused by sympathetic activation (Critchley, 2002).

EEG

EEG uses electrodes applied to the scalp or a head cap which measure the voltage of action potentials and the frequency of oscillations (measured in Hz) determining brain activity. EEG consists of 5 frequency bands of delta, theta, alpha, beta, and gamma, listed in increasing frequencies. Data from EEGs include spatial and temporal low amplitude signals which are separated into multiple components (each frequency band) through a power spectrum analysis. In consumer neuroscience, many studies using EEG will try to estimate cortical activity and reconstruct the 3D configuration to identify specific brain areas involved (Bazzani et al., 2017). The specific brain areas that are analyzed (regions of interest, or ROIs) are orbitofrontal, prefrontal, anterior cingulate cortex (ACC), cingulate motor (CMA), parietal, and occipital alpha areas as well as measures of frontal asymmetry. These areas are associated with the measures of attention (occipital alpha, ACC, CMA), memory (parietal, prefrontal), and affect (a measure of frontal asymmetry).

fMRI

fMRI combines magnetic fields with radio waves allowing the viewing of brain structures. In experiments the subject is placed on a bed with their head surrounded by a magnet allowing protons inside their head to align with the magnetic field and active parts of the brain will have more blood flow, less oxygen-free hemoglobin, producing a BOLD (Blood Oxygen Level Dependent) signal that can be viewed on a computed. (Zurawicki, 2010). This process allows for observation of intricate brain structures, localizing brain activity changes even deep within the brain (Plassmann et al., 2008). fMRI also analyzes specific ROIs including the dorsolateral prefrontal cortex (dlPFC), ventral striatum, ventromedial prefrontal cortex (vmPFC), amygdala, and hippocampus. These regions are associated with measures of attention (dlPFC, vmPFC), affect (amygdala), memory (hippocampus), and desirability (vmPFC, ventral striatum). Table 1 lists each technique, and which measures they are associated with.

In the 2015 study done by Venkatraman et al., the techniques were examined to test for correlations between ad-related and product-related measures. Ad-related measures included liking, familiarity, relevance, informativeness, and responsiveness. Product-related measures included changes in purchase intent, usage

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TABLE 1: Neuromarketing techniques and the associated core measures

Techniques	***Core Measures***			
Eye Tracking	*Attention*	*Affect*	*Memory*	*Desirability*
Pupil size		+		
Fixation count	+			
Biometrics				
Heart rate deceleration	+			
Skin conductance		+		
EEG				
Occipital alpha	+			
Frontal asymmetry		+		
Parietal area			+	
Prefrontal area			+	
Anterior cingulate cortex	+			
Cingulate motor area	+			
fMRI				
Dorsolateral prefrontal cortex	+			
Ventral striatum				+
Ventromedial prefrontal cortex	+			+
Amygdala		+		
Hippocampus			+	
Anterior cingulate cortex	+			

intent, recommendation intent, familiarity, and recognition. In this section, the correlations found for each technique will be discussed, first for Venkatraman's study and then for other related studies.

Eye Tracking and Biometrics

In the analysis of eye-tracking, the percentage of fixations on a certain part of the commercial correlated with the measure of liking, consistent with findings that liked ads were associated with increased attention. In the analysis of biometrics, deceleration of heart rate correlated with liking, recognition, and change in purchase intent, increasing the possibility of purchasing the object/service advertised. (Venkatraman et al., 2015)

fMRI

In the analysis of fMRI, activations in the right amygdala, dlPFC, and vmPFC were associated with liking. Activations in the vmPFC and ACC

were associated with increased purchase intent. Activations in the hippocampus, as hypothesized, were associated with recognition. (Venkatraman et al., 2015) The technique of fMRI was also used in the 2017 study by Vezich et al. which found that an engagement of the vmPFC and ventral striatum influenced purchase intent. Additionally, the 2015 study by McFadden et al., used fMRI too, with application to egg production systems where the subjects were presented with multi-attribute choices with conflicting individual attributes (i.e., increased price for cage-free eggs) to test activation in dlPFC. The study found that the right dlPFC (rdlPFC) signaled a larger response to information. However, the study didn't find this with the left dlPFC (ldlPFC), suggesting a laterality effect. Not only did the activation of rdlPFC increase the responsiveness to the ad, but activation also implied that the participants thought about the tradeoff in the multi-attribute choices. Furthermore, people with more uncertainty (i.e., people who don't feel particularly strong about one side or the other) were more responsive.

EEG

In the analysis of EEG, ads with higher arousal levels were associated with higher frontal asymmetry (Venkatraman et al., 2015). The technique of EEG was also used in the 2008 study by Astolfi et al., finding that cortical activity during the observation of ads that were forgotten is different from the activity during those that were remembered. They also found that the prefrontal and parietal areas were critical in recognition through storing and remembering information. Those areas had a high increase in cortical connectivity inflow. Moreover, the ACC and CMA were found to increase attention, thus liking because of the increased outflow out of those areas. All observations were found across all frequencies, so they were not frequency dependent.

Table 2 lists all of the techniques and the correlations they were discovered to have with both ad-related and product-related measures.

Comparison between the effectiveness of techniques applied to real-world ads and companies

After examining the cognitive processes leading to increases in the related measures, research of the effectiveness of each technique when applied to real-world scenarios was done to discover which technique was the most useful. The 2015 study by Venkatraman et al. investigated which technique best explained the variation in advertising elasticities. Advertising elasticity of demand (ad elasticity) measures a company's advertising campaign's effectiveness in producing new sales. Needless to say, anything that is a good predictor of ad elasticity would be greatly beneficial to a company, as they would be able to visualize how well the product would do. The study found that only fMRI measures were significant predictors of ad elasticities, more specifically, the positive impact of activation in the ventral striatum. Eye-tracking and EEG measures were moderate predictors, but not as significant as those of fMRI.

Discussion

Weaknesses of traditional methods

In the attempt to compare and contrast traditional methods with neuromarketing ones, the flaws of traditional methods must be identified. The methods of surveys and questionnaires often rely on customer awareness and self-reflection as they have to recall a previous experience with the advertised product/service and thus are categorized as "reactive" or "backwards looking". Often times that memory will be biased as the "conscious mind finds it almost impossible to resist putting its spin on events." This is known as recall bias (Graves, 2010). Focus groups and interviews also have weaknesses because they cannot build the trust to discuss personal feelings over the short speaking time of ten to twelve minutes. The data collected are harder to analyze

TABLE 2: Neuromarketing techniques and their respective correlations with ad-related and product-related measures

Techniques	***Ad-Related Measures***		***Product-Related Measures***	
Eye-Tracking	*Liking*	*Responsiveness*	*Purchase Intent*	*Recognition*
Fixation count	+			
Biometrics				
Heart rate deceleration	+		+	+
EEG				
Frontal asymmetry		+		
Prefrontal areas				+
Parietal areas				+
Anterior cingulate cortex	+			
Cingulate motor area	+			
fMRI				
Dorsolateral prefrontal cortex	+	+		
Ventromedial prefrontal cortex	+		+	
Amygdala	+			
Anterior cingulate cortex			+	
Hippocampus				+
Ventral striatum			+	

than the surveys and questionnaires which have pre-determined answers. Furthermore, in traditional methods, the participants may not be able to evaluate their decisions and priorities with one potential cause being that they feel the need to provide a socially "acceptable" response.

Strengths of neuromarketing techniques

A study done in 2020 by Nilashi et al. examined the factors that impacted advertising managers' decision in choosing to use neuroscience techniques specifically for sustainable product marketing (green marketing). They found that the benefits of neuroimaging for neuromarketing are based on a few assumptions. The first is that the brain of consumers contains invisible information regarding their motives and if discovered, could increase product design and enhance sales. The second is that neuroimaging information would be a more precise indicator of priorities compared to information obtained from traditional methods and would be insensitive to bias. The benefits of neuroimaging include simultaneous tracking of the consumer's neural response during processing of desired stimuli, therefore eliminating the recall bias mentioned before. It can

also capture the thoughts, emotions, and state of mind that happens below the level of awareness of the consumer (Stanfey et al., 2003). Also mentioned before, these cannot be measured by traditional methods. Nilashi et al. also found that accuracy and bias were the two factors that had a significant influence on marketers in utilizing neuromarketing for advertising and branding purposes.

Similar to this "application" or real-world driven comparison, the study findings mentioned in the results section suggest that neurophysiological methods can explain the relationships among regions of the brain and the resulting cognitive processes as well as variance in ad elasticities much better than traditional ad methods. Those relationships provide insight into the increase or decrease of each core measure via comparison to the regions' neurological roles. Because it can visualize the relationships between areas of the brain so well, the best predictor of ad elasticities is fMRI, which is also able to accurately evaluate the most amount of core measures.

Implications and limitations of the study

Future research could be on how advertising campaigns could alter their ads to target people with more uncertainty, thereby increasing responsiveness, or in general, altering their ads by making little changes using the given knowledge to see which would impact consumers the most. Other future implications would be an uprising in the use of fMRI techniques in neuromarketing, and an investigation of which core measure plays the largest role in ad elasticity.

This study includes several limitations. First of all, the number of studies subject to analysis was low, so, arguably, any conclusions drawn are not reliable. Secondly, the number of studies available is questionable because of the many databases that were behind a paywall. Finally, as one person, the reviewing of all the articles in every database was not possible and an in-depth analysis of the sheer number of articles on this topic over the past decades was not feasible.

Conclusions

This review screened over 200 papers to determine the role of neuroeconomics in the advertisement industry. The techniques used in neuroeconomics, the relationships they found, and which one was best for predicting advertisement success were criteria that were all addressed. However, it is important to remember that there was a low number of studies analyzed here and the results may be more significant if a higher number were used.

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