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Neural Responses to Hedonic and Utilitarian Banner Ads: An fMRI Study

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Abstract

Previous interactive marketing literature has concluded that banner attributes are key drivers of ad effectiveness and online consumer behaviors. In particular, prior advertising studies have largely defined the two most commonly used ad appeals in online settings: hedonic (i.e., visually attractive, joy-focused, and interactive) and utilitarian (i.e., informative, convenient, and functional). However, no unanimous conclusions have been drawn about their effects on online consumer behavior. Furthermore, no studies have assessed the psychological mechanisms underlying the processing of hedonic and utilitarian banner ads, which could be crucial given the unconscious, internal, and introspective nature of ad evaluation and online purchasing decisions. In this research, the authors used neuroimaging (functional magnetic resonance imaging [fMRI]) to identify the neural mechanisms underlying the evaluation of hedonic and utilitarian banners. The results reveal that whereas hedonic layouts engage brain areas associated with reward, self-relevance, and emotion, utilitarian banner ads trigger brain networks related to object identification and recognition, reasoning, executive function, and cognitive control. This research also examines the extent to which neural data derived from processing hedonic and utilitarian banners complement the ability of self-reported banner effectiveness to predict online consumer behavior. The results reveal that neural data from banner appeals help predict between 9% and 18% of online consumer behavior beyond that indicated by the perceived ad effectiveness reported by consumers. Taken together, these results provide new insights into the connection between neuropsychological data and real-world online consumer behavior.

Keywords: consumer neuroscience, online ads, fMRI, hedonic banners, utilitarian banners, self-reported ad effectiveness

The growth of the internet has been coupled with an increase in the number of digital users around the world, as well as the proliferation of devices through which it is accessed, from laptops and smartphones to smart TVs and smartwatches. As of January 2021, there were 4.66 billion active internet users worldwide, and almost half of the world's population (3.8 billion) owned a smartphone (Statista 2021). With the increasing importance of individuals' internet activity, advertisers are eager to invest large amounts of resources into this new channel to deliver advertising messages that fulfill their communication purposes, known as online advertising (Wang et al. 2009). Data corroborate this trend: despite the COVID-19 crisis, online ad spending grew by 12.2% in 2020, and it is expected to grow by 20% in 2021 and increase at an average rate of 14% in 2022 to 2024 (IAB 2020). Online advertising revenues followed a similar tendency and reached $41.5 billion in 2020, an increase of 12.2% over 2019 (IAB 2020).

Online advertising has been favored for its advantages over traditional TV, radio, and magazine advertising. For example, the online environment offers greater flexibility to present diverse types of advertising formats, including social media and viral ads, search engine results, email ads, interstitial ads, pop-up windows, mobile ads, advergames, and display advertising (such as banner ads) shown on desktop and laptop devices (Campbel et al. 2014). Furthermore, online advertising allows for the creation of a more impactful and flexible product/service presentation by efficiently including ad attributes such as design components (e.g., color, shapes, images, font type, font size dynamic techniques) and message content (e.g., slogans, product descriptions) that best match the preferences of target consumers (Wang et al. 2009).

The enormous spending on online advertising, together with the thousands of advertisements competing for consumer interest, has forced firms to dedicate considerable resources to selecting the most effective online ad attributes that will make the ads more attractive to consumers and strengthen the acceptance or promote the purchase of their products. The literature on digital marketing and online advertising effectiveness is making great strides in this direction and confirms that online ad attributes (e.g., shape, size, font, spatial division of text, brand location) indeed constitute the most critical elements in influencing consumer attitudes toward the ad, perceived online ad effectiveness, recall and recognition of the advertiser, and even online consumer behavior (Auschaitrakul et al. 2017; Guitart and Stremersch 2021; Lambrecht and Tucker 2013).

Given the importance of online ad attributes in the process of evaluating communication messages, prior research has focused on exploring how diverse typologies of online ad attributes affect consumer reactions. For example, prior research has provided insights into the effects of the type (static or dynamic), size (pixel ratios) and format of a banner on click-through rates (CTR; Namin, Hamilton, and Rohm 2020); evaluated consumer reactions to online ads with varying levels of entertainment value (Jung et al. 2011); and assessed the impacts of two dimensions of online ad aesthetics (classical and expressive) on consumer values (Cai and Xu 2011). Some studies have confirmed that such an influence is not necessarily conscious but occurs at an internal, implicit, and introspective level (Mazaheri, Richard, and Laroche 2012). In fact, research has shown that psychological, internal affective and cognitive processes in response to perceiving online ad environments determine consumer sentiment toward the ad (Guo et al. 2016), trust in the online retailer's offers (Casado-Aranda, Liébana-Cabanillas, and Sánchez-Fernández 2018) and even online consumer behavior via CTR on the online ad (Couwenberg et al. 2017).

Studies on internal responses to online ad attributes have largely been implemented using self-report techniques (i.e., reports on consumer attitudes, intentions, or perceived effectiveness of the online ad), which, however, have proven insufficient to capture the innermost states of ad evaluation. For example, self-reporting methodologies alone are not capable of capturing moment-to-moment consumer reactions or identifying the origin of psychological states such as trust, value, or reward toward online ad attributes, and they are subject to biases such as social desirability (Hubert et al. 2018; Motoki et al. 2020). Given the crucial role of internal processes in determining online ad effectiveness, tools that complement self-reporting by recording a more precise, objective, and instantaneous measurement of such mechanisms are crucial.

In accordance with this reasoning, consumer neuroscience techniques are being consolidated in the field of online advertising as tools of enormous value to provide a richer and unbiased understanding of the internal origin of consumer evaluation of online ads (Casado-Aranda, Dimoka, and Sánchez-Fernández 2019). Through techniques such as functional magnetic resonance imaging (fMRI), electroencephalography (EEG), or eye-tracking, it is possible to access the cognitive and affective processes that occur as consumers evaluate ad attributes or make online decisions (Harris, Ciorciari, and Gountas 2018). In the present study, we used neuroimaging, namely fMRI, with the aim of assessing the neural mechanisms underlying the processing of banner attributes, this latter the online ad typology, which, after the search engine, constitutes the format associated with the highest spending in the United States (22.6%) (Clow and Baak 2019). More specifically, we are interested in (1) evaluating the neural responses to two different designs of static banner ads (namely, hedonic vs. utilitarian) and (2) identifying how these neural mechanisms complement self-reported data in predicting consumer behavior (using online ad CTR as a proxy) in response to both hedonic and utilitarian banners. Accordingly, the primary contribution of this study is that it examines how potential differences in the neural processing of hedonic and utilitarian banners can help to predict online consumer behavior beyond that indicated by the self-reported perception of online ad effectiveness.

Theoretical Background and Study Rationale

Online Ad Attributes Matter!

Advertising has long been understood as the process of informing consumers about the characteristics of a given product or service (benefits, functioning, brand, price, uses, etc.) and persuading them to purchase it (Wang et al. 2009). Traditional ad researchers have reported that users' perception of the information provided in the ad as attractive, interesting, and valued, as well as the potential that the ad increases their willingness to purchase the product, largely depends on the attributes with which the message is presented (Bigne et al. 2021). These attributes play an even greater role in online settings due to the instantaneousness of online decision-making processes and the possibility of including a wide variety of designs, images, and videos in online ads (Hubert et al. 2018). According to Braun-Latour and Zaltman (2006), the attributes of online advertising are elements such as color, shapes, images, font type and size, or dynamic techniques. Recent typologies of online ads also allow users to share their content on social media (e.g., interstitial or viral ads) or interact with it (e.g., "swipe up" on Instagram ads). In an attempt to summarize the typologies of banner attributes—the online ad type of interest in the current research—Hussain et al. (2010) identified six key elements: (1) type of banner: static (a GIF or JPEG file that does not move on the web page), pop-up (appears on a separate small window at the top of the screen when a website is initially activated), animated (includes several GIF or JPEG files that are shown in quick succession to create animation effects), or dynamic (made up of audio, video, Java, and Macromedia Flash); (2) size of banner: in terms of display resolution, such as a medium banner (300 × 250 pixels), leaderboard (729 × 90 pixels), or half-page (300 × 600 pixels); (3) number of banners: total number of banner ads on a web page; (4) shape: vertical, horizontal, square, or round; (5) location: position where banner advertisements are posted on web pages; and (6) design: the inclusion of product information based on images or videos (with different levels of luminance, brightness, or colors) and/or text (with different font types, font sizes, and line spacing).

The first stream of online advertising scholars evaluated the effects of these attributes on consumer reactions. For instance, while pop-up ads are considered intrusive and discouraging because they interrupt consumers' web navigation (Edwards, Li, and Lee 2002), animated banners are especially successful in attracting attention and creating brand awareness (Diao 2004) as well as improving recognition effects (Kuisma et al. 2010). In terms of the type and size of the banner, Namin, Hamilton, and Rohm (2020) recently concluded that banner ad sizes with higher pixel ratios and dynamic (vs. static) banners significantly increased advertising engagement based on the total number of clicks. As to the shape of the online ad, although some research has concluded that vertical banner ads, which are aligned in an up–down orientation, are more effective than horizontal ones (Drèze and Hussherr 2003; Simola et al. 2011), other studies have reported that horizontal banners attract greater attention than skyscraper banners (Li, Huang, and Bente 2016). Liu et al. (2018) even showed that ad effectiveness depended on the consumers' previous schema with banners, with a schema-incongruent shape increasing visual attention. Furthermore, Shaouf, Lü, and Li (2016) evaluated the effect of audiovisual design on online purchase intention and found that visually attractive online ad designs positively influenced online purchase intention via attitudinal effects. Along the same lines, Lee and Cho (2010) concluded that banner complexity did not necessarily lead to negative effects on recall, attitudes and behavior. Finally, a large body of online ad research has corroborated the so-called picture superiority effect and confirmed that pictorial and easily processed banners increase the viewer's information-processing ability and fluency, which in turn inspire favorable attitudes toward the ad and a higher recognition accuracy (Park and Ohm 2014; Van Rompay, De Vrienes, and Van Venrooij 2010). Nevertheless, some studies, such as that of Chandon, Chtourou, and Fortin (2003), have not found a direct effect between pictorial messages and click-through responses.

A second research line has followed the traditional ad stream to explore the persuasive effects of diverse types of advertising appeals on consumers—that is, the central argument of a message that, through the combination of several ad attributes, highlights specific advantages of the product or service (Couwenberg et al. 2017). Although appeals are generally used to enhance persuasion, their effectiveness varies across different processing strategies (Klein and Melnyk 2016). For example, conventional ad researchers have extensively analyzed the circumstances under which the design of environmental messages emphasizing the positive consequences of performing a certain behavior (e.g., “if you recycle, there will be less pollution”) is more persuasive than highlighting the negative effects (e.g., “if you don’t recycle, there will be more pollution”) (Casado-Aranda, Sánchez-Fernández, and Montoro-Ríos 2017; Casado-Aranda, Sánchez-Fernández, and Luque-Martínez 2020; Martinez-Fiestas et al. 2015; Zhao and Nan 2010). Similarly, the ad effectiveness literature has explored the effectiveness of ad appeals focusing on the environmental versus cost-saving attributes of the product (Schuhwerk and Lefkoff-Hagius 1995); ad appeals with or without a celebrity accompanying the product (Chang et al. 2016); ad appeals using future versus past scenarios to promote proenvironmental behaviors (Casado-Aranda, Martínez-Fiestas, and Sánchez-Fernández 2018); demand- versus supply-related scarcity appeals (Aguirre-Rodriguez 2013); or tailored versus nontailored design of healthy messages (Chua et al. 2011).

The two advertising appeals that have received the most attention in the online ad effectiveness literature are the hedonic and utilitarian ad appeals. In particular, scholars have compared ads that combine layout attributes to emphasize the experiential, social, and ludic benefits of buying the product (i.e., hedonic ads) with others that focus on the rational aspects, such as product information, convenience, or monetary savings derived from the product (i.e., utilitarian ads) (Chiu et al. 2014; Couwenberg et al. 2017). The current research focuses on this type of appeal to explore the effectiveness of employing recent and reality-based combinations of banner attributes that are more focused on emotion (i.e., hedonic) or reasoning (i.e., utilitarian).

The Role of Hedonic and Utilitarian Appeals in Banner Ads

Definition of hedonic and utilitarian banners

Traditional ad research has attempted to clarify how the use of hedonic or utilitarian arguments in communication strategies affects consumers. According to Lin, Murshed, and Zhang (2020) and López and Ruiz (2011), hedonic ads appeal to sensory gratification, pleasure, emotions, and the social benefits of purchasing the product (e.g., an image of an athlete wearing Nike shoes with the message, “These Nike shoes will make you freer and more powerful”). In contrast, utilitarian ads use informational, instrumental, and convenience-related arguments to boost consumer purchases (e.g., an image of Nike shoes with the message “The cushioning in these Nike shoes absorbs shock and immediately returns to its original shape”).

In the field of online advertising, hedonic ads are those that use a combination of attributes appealing to the feelings and pleasure of consumers, whereas utilitarian online ads are designed to provide convenient information about the product for rational-based processing and decision making (Scarpi 2012). Based on the seminal study of Arnold and Reynolds (2003), who specified the dimensions of hedonic and utilitarian ad arguments, Chiu et al. (2014) further defined and characterized the definition of hedonic and utilitarian benefits in the context of banner ads. According to these authors, the major benefits provided by hedonic banners are (1) adventure: conveying stimulation and the feeling of being in another world when viewing the product, for example, by means of pictures or videos in a real situation of product usage; (2) social: emphasizing enjoyment and provide options to socialize with friends and family, for example, by means of links to social networks; (3) gratification: highlighting the personal and special benefits of buying the product through images that reflect stress relief or avoid evoking a negative mood; (4) idea: emphasizing the product's novelty and innovation by including, for example, images referring to the latest fashion or technology trends; (5) role: appealing to the moods, feelings, and happiness of the observer when viewing the advertised product or when shopping for others, for example, by means of rating systems; and (6) value: highlighting discounts and bargains. Conversely, Chiu et al. identified utilitarian banners as those emphasizing the following benefits: (1) product offerings, for example, reflecting both the breadth and depth of the products offered by a retailer; (2) product information: providing a detailed description of the functions and utilitarian benefits, usage situations, technical specifications, and the quality of the offered product or service (such as specifications of the product size or battery life); (3) convenience: highlighting benefits in terms of time and effort saved by the viewer if they purchase the product (e.g., package shipping time); and (2) monetary savings: including sales that allow the audience to spend less and save money.

Taken together, these studies converge on the fact that utilitarian banners present a message focusing on factual information (product attributes, use, and performance) and functional benefits to convince consumers to buy goods. In contrast, the value of hedonic banners does not reside in the product itself but in the emotional, symbolic, and experiential attributes and benefits associated with the product and its use (Couwenberg et al. 2017). In line with these specifications, some scholars (e.g., Cai and Xu 2011; Motoki, Sugiura, and Kawashima 2019) have used scales to corroborate manipulations and consumer perceptions of hedonic and utilitarian appeals. In this sense, there is unanimous agreement that utilitarian environments are those that, through a combination of message attributes, convey an “informative” and “convenient” argument, while the hedonic ones offer “visually attractive,” “joy-focused,” “interactive,” and “hedonic” layouts.

Online ad scholars have recently evaluated these two types of layouts to determine which is more effective in enhancing consumer attitudes toward the ad, purchase intentions, and online behaviors, but no consensus has been reached. The study implemented by Rosen and Purinton (2004) demonstrated that sensory attributes, such as those included in hedonic banners, play a crucial role in promoting repeat purchases. Hausman and Siekpe (2009, p. 6) found that offering richer media in a more realistic ad context (i.e., hedonic banners) “has a more positive influence on user involvement with the purchase over utilitarian factors.” However, Bilgihan and Bujisic (2015) concluded that both hedonic and utilitarian appeals are indispensable for building trust and loyalty in an online system. More specifically, the authors revealed that hedonic layouts are successful in building affective commitment—that is, an emotional attachment that allows consumers to develop a positive relationship with the website. Utilitarian banners, in contrast, are crucial in developing a calculative commitment—that is, the intention to continue the relationship with the company, considering the costs and lack of alternatives.

Nevertheless, other scholars have claimed that the effectiveness of the banner predominantly relies on the product itself. They particularly indicate that the banner appeal must be suitable for the product type; that is, a utilitarian banner is more appropriate for utilitarian goods (e.g., microwaves), while a hedonic banner is more efficient for promoting hedonic goods (e.g., chocolate) (Johar and Sirgy 1991; Li et al. 2020; Motoki et al. 2020). In other words, “consumers purchasing utilitarian products tend to prefer information arguments that allow for convenient and efficient comparisons for product attributes," while the experiential nature of hedonic purchases is more closely aligned with hedonic arguments characterized by fewer product details and more visual and affective information (Li et al. 2020, p. 5). Other studies indicate that "in a product category that is neither clearly hedonic nor utilitarian, there are no significant differences in variety-seeking motivation when variation stems from sensory or functional attributes" (Baltas, Kokkinaki, and Loukopoulou 2017, p. e2).

Processing of hedonic and utilitarian banners

As research on the effectiveness of hedonic or utilitarian appeals in online ads has generated ambiguous results, it is imperative to clarify how internet users process hedonic and utilitarian banners. The literature on advertising effectiveness suggests that the two types of appeals use different processing paths of persuasion: affect is targeted with hedonic executional attributes, and cognition is targeted with utilitarian elements. In particular, research indicates that positive brand attitudes toward emotion-conveying ads (i.e., hedonic banners) are generally driven by feelings that, in turn, positively influence ad enjoyment and purchase intentions (Moon et al., 2017; Yoo and MacInnis 2005). According to Cai and Xu (2011) and Scarpi (2012), consumers use strong holistic and affective processing when exposed to hedonic ads and are more likely to consider ad information only superficially by relying on heuristics, cues (such as images or links to social media), and emotional reactions. In other words, instead of trying to find the most beneficial alternatives and goods, "consumers may develop an affective attachment to brands and products offered and may process ad information more leisurely, emotionally and holistically" (Li et al. 2020, p. 12). The possibility of including attributes that reflect the novelty and value typical of hedonic ads (such as pictures conveying high-tech or stress relief) may stimulate experienced positive rewarding feelings (Melnyk, Klein, and Völckner 2012)—that is, the hypothesized positive state of the viewer in response to the visualization of valuable hedonic attributes. Lee and Labroo (2004) corroborated this perspective by showing that when a product comes to mind more readily or fluently (e.g., products in hedonic ads), consumers regard it more hedonically and view more favorable and rewarding product benefits. Furthermore, the inclusion of attributes that encourage adventurousness and enjoyment in hedonic advertisements may trigger positive emotions among online viewers (Chiu et al. 2014). Furthermore, the gratification included in hedonic banners, which highlight the personal and social benefits of the advertised products, may also induce self-relevant or self-referential processing of the ad, that is, the perception of an item (i.e., the ad or good) as relevant because it is similar to the viewer's environment, life, or perspective (Casado-Aranda, Dimoka, and Sánchez-Fernández 2019; Couwenberg et al. 2017).

Other studies have reported that the formation of positive brand attitudes in response to utilitarian ads may be predominantly triggered by deliberate assessments and beliefs that decrease the uncertainty associated with the advertised product. According to Klein and Melnyk (2016), the perception of utilitarian ads is more effortful and leads consumers to engage in deeper-level processing and thoroughly analyze all of the relevant ad information to make a rational decision. Utilitarian ads cause viewers to assess the outcome of the purchase by comparing the perceived benefits of purchasing the online product against the costs, with the aim of making the most optimal purchasing decision (i.e., reasoning; Park et al. 2012). Therefore, consumers may process the ad more deliberately as they consider the concrete attributes specified on the banner, such as product information, convenience, and monetary savings (Ghose and Yang 2009). In line with this reasoning, some studies on processing fluency (i.e., "the subjective ease with which people process information"; Couwenberg et al. 2017, p.

357) have concluded that users always process utilitarian attributes deliberately, effortfully, and less fluently than hedonic ones, as they require more time to identify the goods and extract value from them (Brakus, Schmitt, and Zhang 2014; Tang and Jang 2014). Therefore, consumers may experience mechanisms of object identification and recognition (i.e., the ability to locate objects and items within a picture with a given degree of confidence) when observing the product and reading the related detailed information within the ad. Furthermore, consumers may experience cognitive control—that is, a set of processes that organize, plan, and schedule decisions of buying, or not, a product online (Li et al. 2020)—when extracting value and organizing their thoughts about the product features. Finally, when making decisions about the purchase of advertised products, consumers may experience higher-level cognitive processes of decision making and problem solving (i.e., executive functions).

fMRI and Online Ads: Neural Responses to Hedonic and Utilitarian Banners

The value of neuroimaging in online environments

Traditional tools that have been used to identify consumers' inner processes in response to advertising and online attributes rely on declarative and self-reported opinions from consumers, especially surveys, focus groups, and interviews (Dimoka et al. 2010; Martinez-Fiestas et al. 2015). Although these tools are relatively inexpensive and easy to use, they are based on the notion that viewers can successfully express their internal cognitive and emotional processes and subsequently use them in their ad evaluation and subsequent purchase choices (Casado-Aranda, Sánchez-Fernández, and Montoro-Ríos 2019; Ramsøy 2019). This is only partially true; as these tools are not able to capture the quick and lower-order emotions that traditionally take place when people are exposed to online layouts, they are susceptible to social desirability and subjectivity and do not easily enable the real-time collection of consumer reactions when executing a task (Dimoka et al. 2010). A direct consequence of the limitations of self-reports is the lack of ability to record much of the ad processing; consequently, data from these techniques risk not entirely explaining the innermost processes underlying ad perception and online consumer behavior, leading to an incomplete understanding.

Consumer neuroscience constitutes one of the modern branches of marketing with the greatest potential to complement traditional tools and identify the implicit origins of ad effectiveness and online consumer decision making. Through techniques such as fMRI, EEG, or eye-tracking, it is possible to access the cognitive and affective processes that occur as consumers evaluate ad attributes or make online decisions (Casado-Aranda and Sánchez-Fernández, 2022; Harris, Ciorciari, and Gountas 2018). For example, fMRI is the technique with the greatest spatial resolution, utility, and capacity to evaluate brain structure reactions in great depth during exposure to ads. This tool detects changes in the level of brain blood oxygenation (namely, the "BOLD" signal), which is then used as a proxy for neural activation. As different regions of interest (ROIs) are associated with particular mental functions (e.g., reward, value, risk), it is, therefore, possible to locate and explore the neural mechanisms triggered by diverse ad appeals and represent them visually by means of magnetic resonance brain images. EEG constitutes another noninvasive tool that measures the frequency of the brain's electrical currents (Ohme et al. 2011) and changes in voltage via electrodes placed on the scalp. Although EEG provides lower spatial resolution than fMRI, it is especially useful in detecting electrical changes that occur within an interval of 250–400 milliseconds. This higher temporal resolution has made it a particularly useful tool for measuring neural responses in advertising environments with a variety of static and dynamic, text-based and image-based, or hedonic and utilitarian attributes, such as banner ads. For these reasons, EEG was the first neuroimaging technique used in the field of advertising (Krugman 1971; Rothschild and Hyun 1990) and, since then, has enabled the identification of attention, emotion, and learning processes in response to different offline and online advertising attributes (Deitz et al. 2016; Yoder et al. 2020). The lower cost and greater flexibility and accessibility of the eye-tracking tool have made it the most traditionally and widely used consumer neuroscience tool in the field of advertising (Casado-Aranda, Sánchez-Fernández, and Ibáñez-Zapata 2020). Eye trackers allow eye movements to be recorded during exposure to marketing stimuli (e.g., ads), thus informing about the cognitive processes underlying ad evaluation. In particular, this methodology records two alternating events in the eyes: fixations, when the eyes are relatively still for about 200–300 milliseconds, and saccades, when the eyes make quick "jumps" between scenes. Eye-tracking scholars have used these events as a proxy for attention, as eye movements allow for discrimination between items in the visual field by processing and selecting the preferred ones at the expense of others (Meißner and Oll 2019). Accordingly, these methods could enable us to identify the implicit neural origin of the evaluation of hedonic and utilitarian banners.

Although consumer neuroscience has disadvantages such as difficult data analysis, an artificial environment, and high cost (Riedl, Davis, and Hevner 2014), recent fMRI, EEG, and eye-tracking studies have shed light on the origin of consumer evaluations in the online environment and have provided fruitful insights that are complementary to self-reported data. For example, Jai et al. (2021) used fMRI to evaluate whether and how several neural mechanisms are elicited in online purchase decisions when exposed to diverse types of visual product presentation. Their results indicate that, in the product evaluation process, brain activity is able to predict online purchase decisions. Furthermore, Casado-Aranda, Liébana-Cabanillas, and Sánchez-Fernández [2018] and Casado-Aranda, Martínez-Fiestas, and Sánchez-Fernández [2018] analyzed the neural processing of risky and secure e-payments and concluded that PayPal is regarded as a more trustworthy means of payment because of the (experienced) reward- and trust-related areas that it engages when compared with a debit card. Interestingly, Motoki et al. (2020) used a combination of self-reported and social-related neural measures to predict viral marketing success on social networks. In a similar vein, Hubert et al. (2018) used fMRI to identify how consumer impulsiveness modulates the neural processing of diverse online offers with varying levels of trust. Ad scholars have also corroborated the ability of EEG to distinguish video ads varying in emotional arousal (Eijlers, Boksem, and Smidts 2020), identify neural differences in short-term versus long-term memory (Rossiter et al. 2001), and predict TV attention and Twitter interactions via brain oscillations (Shestyuk et al. 2019). Furthermore, eye tracking has been largely used in the field of advertising, for example, to detect visual attention toward online ads with different levels of originality (Pieters, Warlop, and Wedel 2002), visual complexity (Pieters, Wedel, and Batra 2010), animation (Holmberg 2016; Kuisma et al. 2010), and platform of exposure (Luan et al. 2016). Surprisingly, to date, no research has analyzed the neural basis of the evaluation of different types of banner ads, which may be able to specifically shed light on the scarce unanimity about the effectiveness of hedonic and utilitarian online appeals. This research attempts to fill this gap by using the neuroimaging technique with the highest spatial resolution and ability to detect changes in the deepest structures of the brain, namely, fMRI.

The current study: neural mechanisms of processing hedonic and utilitarian banners

The present research builds on the extensive literature on the effects of ad appeals on online consumer behavior by using innovative neuroimaging techniques (1) to better understand the inner neural basis of evaluating hedonic and utilitarian banners and (2) to assess how these neural responses predict online consumer behavior in response to these banner typologies beyond that indicated by self-reported data.

Specifically, the emotional processing likely experienced during exposure to experienced- and enjoyment-based hedonic banners may activate brain regions related to affect, such as the inferior (orbito)frontal gyrus, the posterior cingulate cortex (PCC) and the medial superior frontal gyrus (Bartra, McGuire, and Kable 2013; Goodman et al. 2017; Vytal and Hamann 2010). In fact, a recent consumer neuroscience study linked areas associated with emotion (such as the medial prefrontal cortex) to the processing of experiential and holistic advertising (Couwenberg et al. 2017). Furthermore, the inherent gratification in hedonic banners, which highlights the personal and social benefits of the advertised products, may stimulate the activation of areas associated with the (experienced) reward and self-reference circuit, as viewers may perceive the advertised items as relevant because they are reminiscent of themselves or their environment. In particular, extensive neuroimaging literature has concluded that processing rewarding stimuli engages the precuneus, the inferior orbitofrontal gyrus and the hippocampus (Morelli, Sacchet, and Zaki 2015). Guided by similar reasoning, Schaefer and Rotte (2007a, b) carried out an fMRI study and found that symbolic and experiential car brands (e.g., Lexus, Mercedes) activated reward-related brain networks such as the ventromedial prefrontal cortex (vMPFC), precuneus, and hippocampus, as compared with other more functional brands (e.g., SEAT, Toyota). Neuroimaging research has largely studied the neural correlates of self-reference, which refers to the processing of stimuli that are perceived as strongly related to the individual (Casado-Aranda, Sánchez-Fernández, and Luque-Martínez 2020; Ebner et al. 2013; Falk et al. 2011). These studies concluded that evaluating elements that are highly salient to the individual activates the medial superior frontal gyrus, the vMPFC, the angular gyrus, and the cingulate gyrus. Therefore, we formally propose the following:

H$_1$: Hedonic (vs. utilitarian) banners elicit implicit responses associated with (1) consumer emotions (inferior frontal gyrus, PCC, and medial superior gyrus), (2) consumer reward (precuneus, inferior orbitofrontal gyrus, or hippocampus), and (3) self-reference (medial superior frontal gyrus, the vMPFC, the angular gyrus, and the cingulate gyrus).

However, detailed and accurate product information, such as features and performance, that infuses utilitarian banners may first involve the activation of brain areas related to object identification and recognition. For example, Couwenberg et al. (2017) concluded that information related to product benefits included in audiovisual ads engages brain networks associated with object recognition, such as the middle temporal and superior parietal gyri. Previous neuroimaging research has corroborated the involvement of these brain areas in object identification and recognition processes (Pins et al. 2004; Winlove et al. 2018). In addition, more deliberate and attentive information processing of concrete product attributes could more quickly prepare a consumer for the ad evaluation and, thus, activate brain regions associated with goal direction, executive functions (i.e., higher-level cognitive processes of planning, decision making, and problem solving), reasoning, and cognitive control (i.e., processes related to organization, planning and scheduling mental operations) (Shang, Jin, and Qiu 2020). Several studies in the field of consumer neuroscience support such a rationale. For example, Schaefer and Rotte (2007a) demonstrated that functional and utilitarian car brands (such as SEAT or Toyota) activated the dorsal part of the prefrontal cortex and the middle temporal gyrus. Furthermore, Couwenberg et al. (2017) and Goodman et al. (2017) related the activation of the middle temporal gyrus, superior parietal gyrus, and precentral and supplemental motor areas to the processing of utilitarian benefits, which could imply their relationship with cognitive processes of executive function, goal direction and cognitive control. These notions lead to the following hypothesis:

H_2: Utilitarian (vs. hedonic) banners elicit implicit responses associated with (1) consumer recognition and identification (middle temporal and superior parietal gyri), (2) executive function and goal direction (superior parietal and supplemental motor area), and (3) reasoning and cognitive control (middle frontal gyrus, precentral and superior parietal gyrus).

In addition to identifying the brain mechanisms underlying the evaluation of hedonic and utilitarian banners, we attempted to explore the extent to which such brain networks predict online consumer behavior in response to each banner ad beyond that indicated by the perceived banner effectiveness reported by consumers. Here, we used customers' online search activity in response to viewing products in both hedonic and utilitarian banners (i.e., CTR on the product ads) as a proxy for consumer behavior.

Methods

Participants

We recruited 30 participants were recruited for the fMRI experiment, although ultimately, data from only 27 healthy participants were retained because 2 men and 1 woman became uncomfortable during the experimental task. Specifically, we selected 15 right-handed women and 12 men, with an average age of 24.30 (SD = 5.40) years. All participants provided informed consent before the fMRI sessions in accordance with the Ethics Committee of the University of Granada and the Declaration of Helsinki. Because the participants' level of expertise and frequency of online shopping may affect their processing of the banner ads (Rose, Hair, and Clark 2011), we selected only participants with similar values of these variables. Specifically, all participants reported an average computer and online proficiency level of 5.52 (SD = 1.12) on a seven-point Likert scale (anchored at 1 = "low expertise," and 7 = "high expertise"). In addition, 100% of the participants reported buying a product on the internet at least once a year, with 88% shopping online at least once a semester and 8% doing so once a week.

Banner Layouts

The purpose of the fMRI task was to simulate the presentation of technological products on two different types of banner ads: hedonic and utilitarian. Specifically, we used a within-subject design in which each participant had to evaluate 60 different headphones ads, 30 in a hedonic banner layout and 30 in a utilitarian one. The choice was restricted to headphones because the most recent neuroimaging research has used this product category (Casado-Aranda, Dimoka, and Sánchez-Fernández 2019; Casado-Aranda, Sánchez-Fernández, and Montoro-Ríos 2019; Dimoka 2010; Hubert et al. 2018) and because technology, alongside entertainment, culture, and food, is one of the sectors with the highest number of online sales in Spain (IAB 2021). To control for a degree of variability in consumer tastes and experience, we aimed to ensure that all participants had recently purchased technology products on the internet and that they also had a common interest and intention to purchase headphones. Specifically, 73.1% of the sample reported buying technology products in the last year, compared with 65.2% for fashion, 56% for education, and 48% for music. On a seven-point Likert scale (1 = "lowest level," and 7 = "highest level"), the participants reported their interest in purchasing headphones to be an average of 5.74 (SD = 1.29) with a purchase intention of 4.70 (SD = 1.73). Furthermore, we showed participants 30 pictures of headphones and asked them to indicate their level of agreement with the item "I am familiar with this headphone" on a seven-point Likert scale (1 = "strongly disagree," and 7 = "strongly agree"). All participants confirmed being highly familiar with all headphones (mean = 6.6, SD = .5).

As explained previously, the ad literature confirms that the type of product (i.e., pre-eminently hedonic or utilitarian) can affect the processing of the product and the ad appeal in which it is presented (Li et al. 2020). To determine whether headphones are distinctly perceived as either a hedonic or utilitarian product, we used the hedonic and utilitarian scales of consumer attitudes, as reported by Motoki et al. (2020) and Bucklin and Sismeiro (2009), Couwenberg et al. (2017), and Kannan, Reinartz, and Verhoef (2016). In particular, participants were asked to express their opinions on a seven-point Likert scale from 1 ("not at all") to 7 ("very much") on hedonic and utilitarian items (hedonic: “fun/not fun,” “exciting/dull,” “delightful/not delightful,” “thrilling/not thrilling,” “enjoyable/unenjoyable”; utilitarian: “effective/ineffective,” “helpful/unhelpful,” “functional/not functional,” “necessary/unnecessary,” “practical/impractical”; Motoki et al. 2020). After averaging the scores for each product typology, we found that headphones could not be classified as either a pre-eminently hedonic or utilitarian product, as there were no significant differences between the hedonic (mean = 5.45, SD = .93) and utilitarian (mean = 5.79, SD = .53) scales (p = .123). Consequently, and following the conclusions of Baltas, Kokkinaki, and Loukopoulou (2017), the type of product here does not have an undesirable effect on the motivation or evaluation of the ad layout.

Once we confirmed that headphones were suitable products for the experimental design, we developed an initial set of 100 hedonic and utilitarian banner ads. For the design of these layouts, we strictly followed the attributes that Chiu et al. (2014) specified for typically hedonic and utilitarian banners. In particular, the hedonic banners featured adventure (e.g., images of athletes wearing headphones in real-life situations and/or text such as “lose yourself in the music”), social (e.g., links to social networks), gratification (e.g., images reflecting stress relief or text highlighting the personal value, “Headphones 100% adapted to you”), idea (e.g., “100% aerodynamic headphones,” “Soft foam tips”), role (e.g., images of happy and relaxed athletes, rating systems based on stars) and value (e.g., images of seals of approval or discount alerts). In contrast, the utilitarian ads included product offerings (e.g., various views of the headphones together with other models of the same brand), product characteristics (e.g., information on installation, noise suppression, cable length, battery life), convenience (text and images about warranty, after-sales service, or returns policies) and savings (e.g., offers and benefits of speed of purchase). With the aim of avoiding any type of color-related bias, we first designed both hedonic and utilitarian banner ads incorporating images and text with and without colors, meaning that all banners used in the pretest included simultaneously an image of a headphone and text describing the product (depending on the utilitarian or hedonic approach). Apart from these manipulation-based differences, all of the online ads included identical characteristics in relation to the banner attributes indicated by Hussain et al. (2010): all banners were static with the same size; same spatial position on the screen; and same font type, size, and line spacing; furthermore, all incorporated a box with the word "buy" and the same fictitious brand name ("Tecnobuy") (following Janssens, De Pelsmacker, and Geuens 2012). By means of a seven-point Likert scale (1 = "totally unfamiliar," and 7 = "totally familiar"), we corroborated that the brand was perceived as unfamiliar (mean = 1.21, SD = .2), which was useful for avoiding confounding effects on the ad evaluation (following Casado-Aranda, Dimoka, and Sánchez-Fernández [2019]). The ad and headphone pictures resembled real-life examples taken from Amazon, except they could not be clicked during the fMRI task, which we designed to prevent confounding effects between the time of exposure and the independent variables.

An independent sample (n = 60) in a preliminary test allowed us to select, among the initial 100 ads, those that were most typically perceived as hedonic and utilitarian. In particular, participants classified the ads on a seven-point Likert scale (1 = "informative, convenient and utilitarian banner, i.e., utilitarian ads," and 7 = "visually attractive, joy-focused, interactive and hedonic banner, i.e., hedonic ads"). Only the ads that obtained less than 3 points were selected and classified as utilitarian banners, while those higher than 5 points were categorized as hedonic banners. A paired-samples t-test revealed significant differences ($p < .001$) between the 30 slides finally selected and qualified as hedonic banners (mean = 5.23, SD = .25) and the 30 selected to represent utilitarian ads (mean = 2.08, SD = .36) (for the detailed list of all selected banners, see Appendices A and B). As our Appendices illustrate, the 30 selected hedonic ads included colors, and the 30 utilitarian ads did not.

Procedure

The subjects arrived at the fMRI lab one hour prior to the task to verify their informed consent data and to recheck for common fMRI exclusion criteria (e.g., pregnancy, metal implants, claustrophobia). Then, participants were instructed to watch diverse headphones advertised in 30 different hedonic banners and 30 different utilitarian banners. Each series of banner ads started with a display of a short period of fixation (4 seconds) followed by an 8-second display of a hedonic or utilitarian ad. The order of presentation of each of the 60 banners was random. We also counterbalanced the content of the ads and visually inspected and ensured that the majority of headphones that appeared in hedonic banners were also present in utilitarian ads, although two specific models were not shown in either ad typology, as they did not survive pretest filtering. Finally, participants were instructed to close their eyes to reimagine the ad[1] that they had previously viewed for 6 seconds. The total duration of the scan was around 24 minutes, including the anatomical imaging time. We used the E-Prime Professional 2.0 software to present the fMRI stimuli.

After the fMRI task, participants responded to self-administered computerized questionnaires aimed at capturing perceived effectiveness and preference toward each type of banner. Specifically, the participants were again exposed to the 60 ads viewed during the scanning and were required to answer the following questions as proxies for preference and perceived web effectiveness (Venkatraman et al. 2015): "After viewing this banner, i. what is your intention to purchase the headphones advertised in this ad,

[1] The reimagine task was developed during the fMRI experimental design for goals orthogonal to this study (i.e., to explore the neural mechanisms underlying how people reimagine ads. Because this objective is not aligned with the frame of the current research, we did not examine the neural response during ad recall in the present study.

and ii. to what extent did this ad attract/impact/persuade you to purchase the headphones?" (seven-point Likert scale; 1 = "the lowest," and 7 = "the highest"). We implemented a reliability analysis to determine whether these four variables (i.e., purchase intention, attraction, impact, and persuasion) could be used as a single measure of self-reported web preference.

To assess the extent to which the neural data and self-reported preference toward each ad typology were able to jointly predict consumer behavior in response to the visualization of the ad, we measured consumer performance for both types of banners. Specifically, we used CTR (i.e., the percentage of subjects in the sample population who clicked through to the product banner) as our core measure of consumer behavior. Click-through behavior indicates subjects' interest in the product as triggered by the ad layout, which could be a precursor to prospective purchase (Bucklin and Sismeiro 2009; Couwenberg et al. 2017; Kannan, Reinartz, and Verhoef 2016). Therefore, participants were instructed to click on the ads (out of the 60 previously displayed) that most persuaded them to purchase the headphones. Finally, the participants received the amount of money that one of the headphones cost from the ads on which they had previously clicked. It is worth noting that participants were not aware that the compensation would be linked to their click choices to avoid biasing their selections based on their prior preferences or the perceived price of the headset. For a summary of the experimental task structure, see Figure 1.

fMRI Analyses

Image acquisition, preprocessing, and statistical analysis

We used a 3T Trio Siemens Scanner with a 32-channel head coil to obtain the MRI images. Anatomical images were acquired using a sagittal orientation with 1 mm × 1 mm × 1 mm voxel size. Functional scans were acquired by a T2*-weighted echoplanar imaging sequence (TR = 2,000 ms, TE = 25 ms, FA = 90°, thickness = 3.5 mm;

slices = 35, slice order = descending). A distance factor of 20% resulted in a total of 790 slices with a field of view of 238 mm.

We preprocessed and analyzed the neuroimaging data using standard software (SPM12, Wellcome Department of Cognitive Neurology, London; https://www.fl.ion.ucl.ac.uk/spm/software/spm12/) run on MATLAB R2012a. Default settings were applied in SPM. The mean functional images were visually checked for artifacts. Then, functional images were realigned to correct motion, coregistered, segmented, normalized into standard stereotactic space and smoothed (7 × 7 × 7 mm Gaussian kernel full width at half maximum). Subsequently, we generated statistical maps for each participant by fitting a boxcar function to the time series convolved with a canonical hemodynamic response function. The result consisted of an estimation of a general linear model for each participant with the following regressors of interest: (1) hedonic banner, (2) utilitarian banner, and (3) reimagine period. In addition, we used six covariates associated with movement-related noise, a constant session term, and fixation crosses as regressors of no interest.

On the first level of analysis, to identify which brain regions showed different activations in response to hedonic and utilitarian banners, we calculated two contrasts: hedonic versus utilitarian banners (i vs. ii) and vice versa, applying a T-contrast to the first and second regressors of the model, respectively. On the second level, we subjected the hedonic minus utilitarian (and vice versa) contrasts to one-sample t-test analysis to identify brain activation networks common to all participants.

Regions of interest

Drawing on the methodology followed in previous studies (Guerrero Medina et al. 2021; Scholz, Baek, et al. 2020), for our ROI analysis, we first selected constructs that are theoretically expected to be involved with the processing of utilitarian and hedonic ads, as discussed previously. We then extracted ROI masks by implementing several searches referred to those constructs conducted in the Neurosynth reverse-inference meta-analysis database (Yarkoni et al. 2011). Neurosynth contains fMRI data sets from 14,371 published peer-reviewed articles and instantly generates meta-analytic false-discovery-rate-corrected maps for neuroimaging keywords. Particularly, this ROI analysis relies on a large existing literature of hundreds of brain-mapping studies that have identified neural substrates of mental states of interest (such as value, reward, self-relevance, or recognition). The Neurosynth database uses text-mining, meta-analysis, and machine-learning techniques to generate a large database of mappings between neural and cognitive/affective functions of interest. In other words, Neurosynth estimates the association between voxels and terms semantically related to the study hypothesis or to functional areas of interest (e.g., self-relevance). Therefore, using this database, scholars identify ROI masks consisting of voxels implicated in their states of interest, such as reward, value, and self-related and social processing. As explained by Yarkoni et al. (2011), the cognitive function of interest is entered as a "term" (e.g., reward), and the software returns a mask including voxels that show where there is likely to be significant activation based on the results from studies that used the word "reward" to describe their experimental contrasts. The overlap of significant activations among all of the studies is then converted to a z-score at each voxel. These Neurosynth maps are appropriate candidates for unbiased ROI analyses, as we can use the maps as masks, evaluate the peak voxel coordinates that survive the contrasts of interest within such masks, and then use those coordinates to create spherical ROIs (e.g., by using Marsbar). For the ROI analysis, we selected a threshold of seven contiguous voxels at an uncorrected *p*-value of .001 (family-wise error rate [FWE] = .05) (following prior studies; e.g., Thye, Murdaugh, and Kana 2018).

In this particular study, for the processing of hedonic banners, we created (1) a self-relevance mask based on 166 studies using the term "self-reference," (2) a reward mask considering 922 studies resulting from searching the term "reward," and (3) an emotional mask based on 1,708 studies using the term "emotional." For the processing of the utilitarian banners, we generated (1) a recognition mask considering 86 studies resulting from the "object recognition" search, (2) an executive function mask based on the coordinates resulting from 154 studies obtained in the search of "executive function," (3) a goal-directed mask based on 216 studies resulting from the "goal-directed" search, (4) a reasoning mask considering 182 studies resulting from the "reasoning" search, and (5) a cognitive control mask considering 598 studies resulting from the "reasoning" search. Because Neurosynth does not incorporate a mask for object identification, we generated a mask in Marsbar, adding 10 mm spheres based on the coordinates revealed in the Pins et al. (2004) study for object identification. Once the maps were downloaded, we applied them as masks in the main contrasts of interest (i.e., hedonic vs. utilitarian banners, and vice versa) to confirm which of the ROIs were significant. Appendix C includes multislice brain images based on the meta-analysis maps for each of the aforementioned ROIs.

To explore distinctive effects of hedonic and utilitarian banners on brain signals different from those chosen in our a priori ROI analysis, we also performed a whole-brain exploration in the main contrasts of interest by using a threshold of 20 contiguous voxels at an uncorrected *p*-value of .001 (FWE = .05) (following, e.g., Casado-Aranda, Dimoka, and Sánchez-Fernández 2019; Casado-Aranda, Liébana-Cabanillas, and Sánchez-Fernández 2018; Casado-Aranda, Martínez-Fiestas, and Sánchez-Fernández 2018).

Combination of brain data with self-reported effectiveness data

To assess the extent to which neural responses to hedonic and utilitarian banners complement the ability of self-reported ad effectiveness to predict consumer behavior (as indexed by CTR) for each ad, we ran a multiple-regression analysis. Specifically, we used self-reported ad effectiveness of the hedonic/utilitarian ads by averaging purchase intention, attraction, impact and persuasion. As regards the neural predictors, we used Marsbar to extract parameter estimates (10 mm radius spheres) from the significant set of ROIs derived from the contrasts of interest that survived the masks. In particular, in the case of hedonic banners, we ran a multiple-regression model with the self-reported ad effectiveness of the hedonic ads and the parameter estimates of all the significant hedonic-related (i.e., self-relevance, reward, and emotion) and utilitarian-related (i.e., object recognition and identification, executive function, goal direction, reasoning, and cognitive control) ROIs as predictors in the model and CTR on hedonic banners as a dependent variable. Similarly, we ran a multiple-regression model with the self-reported utilitarian ad effectiveness and the parameter estimates of both significant hedonic- and utilitarian-related ROIs as predictors and CTR on utilitarian ads as a dependent variable. We incorporated all of the significant ROI activations to test whether brain regions that were responsive to a specific ad (e.g., hedonic) helped predict CTR of the opposite ad (e.g., CTR on utilitarian ads). In this way, we determined whether the neural mechanisms were distinct between the two online banners.

Results

Self-Reported Data on Hedonic and Utilitarian Banners Predict Consumer Behavior

First, we implemented an internal consistency analysis to corroborate that the variables of purchase intention, attraction, impact, and persuasion could be summarized in an aggregate score of hedonic and utilitarian ad effectiveness. The responses of these variables to each banner were highly correlated, with a Cronbach's alpha for hedonic and utilitarian ads of α = .95 and α = .90, respectively, meaning that two aggregate scores would be sufficient to capture self-reported measures of perceived effectiveness of both hedonic and utilitarian ads, respectively. A Mann–Whitney–Wilcoxon test implemented in the IBM Statistical Package of Social Science (IBM SPSS Version 20) software indicated that the perceived effectiveness of hedonic ads (mean = 4.24, SD = 1.68) yielded significantly higher scores than utilitarian ads (mean = 3.12, SD = 1.49; $p = .04$). The Mann–Whitney–Wilcoxon test also revealed that the percentage of hedonic ads that received clicks (mean = 51.85%, SD = 14.1) was significantly higher than the percentage of utilitarian ads that were clicked (mean = 35.45%, SD = 21.28; $p = .004$).

The results of the multiple-regression model evaluating the link between the self-reported hedonic ad effectiveness and consumer behavior (i.e., CTR on hedonic banners) revealed that the perceived ad effectiveness itself predicted 48.4% of CTR on the hedonic ads (adjusted R-squared = .48, standardized β = .69, $F(1, 25) = 23.47$, $p < .001$). In a similar vein, the multiple-regression model for the utilitarian banners indicated that the perceived ad effectiveness predicted 77.6% of CTR on the utilitarian banners (adjusted R-squared = .77, standardized β = .88, $F(1, 25) = 86.49$, $p < .001$). The interaction effect of the self-reported hedonic and utilitarian ad effectiveness was not a significant predictor of CTR on either the hedonic (Δadjusted R-squared = .002, standardized β = −.14, $p = .623$) or utilitarian (Δadjusted R-squared = .000,standardized β = .065. $p = .882$) banners.

Neural Responses to Hedonic and Utilitarian Banners

We then tested whether there were neural differences in the processing of hedonic and utilitarian ads. The results indicated that the hedonic banners triggered significantly stronger brain activations in the expected ROIs related to self-reference, reward, and emotion. Specifically, the hedonic layouts elicited significant activity in brain areas within the self-relevance mask, including the angular gyrus, precuneus, cingulate cortex, vMPFC, and bilateral superior medial frontal cortex, brain areas that conform to prior (metanalytic) studies investigating the neural correlates of self-relevance (e.g., Ebner et al. 2013; Yaoi, Osaka, and Osaka 2015). The hippocampus, precuneus, and inferior orbitofrontal gyrus, brain areas within the (experienced) reward mask, were also significantly and strongly activated during the evaluation of hedonic layouts, a finding that aligns with prior meta-analyses on reward processing (Bartra, McGuire, and Kable 2013; Haruno and Kawato 2006). Finally, the hedonic layouts also significantly activated brain areas within the emotion-related mask, including the inferior frontal gyrus, inferior orbitofrontal gyrus, and superior medial frontal gyrus, a finding that converges with prior studies investigating the neural correlates of emotion (Kim and Hamann 2007; Schilbach et al. 2012) (for a detailed list of significant ROIs, see Table 1, Panel A). We implemented an exploratory whole-brain analysis to corroborate the previous neural ROIs and reveal others involved in the visualization of hedonic banners. In addition to finding significant activations in the hypothesized hippocampus, medial superior frontal gyrus, angular gyrus, and inferior orbitofrontal gyrus, we also found activations in regions associated with the regulation of affection, emotion, and motor control (cerebellum) and visual attention/visual imagery (fusiform gyrus). A complete table of results for this analysis can be found in Appendix D.

By contrast, the utilitarian banners evoked activations in the expected ROIs related to object recognition and identification, executive function, goal direction, reasoning, and cognitive control. Specifically, the utilitarian banners triggered activity in regions within the object recognition mask, including the bilateral middle temporal gyrus, which conforms with prior research analyzing the processing of object recognition (Couwenberg et al. 2017; Riesenhuber and Poggio 2002). These layouts also elicited activations within the executive function mask, such as the superior parietal gyrus, supplemental motor area, dorsolateral prefrontal cortex, precentral cortex, and PCC—all brain regions widely shown to be related to executive functions (Logue and Gould 2014), goal direction (Rangel and Hare 2010), reasoning (Seo et al. 2014), and cognitive control (Egner and Hirsch 2005) (for a detailed list of significant ROIs, see Table 1, Panel B). The exploratory whole-brain analysis revealed significant activations in the hypothesized middle temporal gyrus, supplemental motor area, and superior parietal lobe. We also found additional activation in brain areas related to orientation and spatial frequencies (calcarine) and execution planning and learning (caudate). A complete table of results can be found in Appendix D.

Neural and Self-Reported Predictors of Consumer Behavior in Hedonic and Utilitarian Banners

Next, we examined the extent to which the previous significant activations of ROIs in response to the hedonic and utilitarian ads complemented the ability of self-reported ad effectiveness to predict consumer behavior (as indexed by CTR) for each banner separately. For the hedonic banners, a model was first created using perceived ad effectiveness, and then we added the parameter estimates of the significant ROIs resulting from the previous analysis (i.e., Table 1) as independent variables, and CTR on the hedonic banner as a dependent variable. The results of the multiple-regression analysis revealed that a model with the self-reported hedonic banner effectiveness, the angular gyrus ($x = 47$, $y = -60$, $z = 27$), and the inferior frontal gyrus ($x = 57$, $y = 32$, $z = 14$) as significant independent variables predicted 66.5% of the variance in CTR ($p < .001$). That is, only these two brain regions, strongly related to self-reference and emotion, were significantly associated with the actual number of clicks on the hedonic ads. Specifically, the inclusion of the angular gyrus and inferior frontal gyrus as predictors resulted in an 18.1% increase in the explained variance in CTR on hedonic ads beyond that predicted by the self-reported responses (Figure 2). None of the ROIs associated with the processing of utilitarian banners were significant predictors of changes in CTR, thus corroborating that those neural mechanisms are distinctive in the two banner types. All coefficients, R-squared values, and statistics are reported in Table 2.

Following a similar procedure, in the case of utilitarian ads, the multiple-regression analysis revealed that a model with the self-reported banner effectiveness of utilitarian layouts and the parameter estimates of the middle temporal gyrus ($x = -50$, $y = -18$, $z = -4$) and the precentral cortex ($x = -45$, $y = -4$, $z = 49$) as independent variables predicted 84.9% of the variance in CTR ($p < .001$). In other words, only these two ROIs, associated with recognition and cognitive control, respectively, were significant predictors of CTR on utilitarian ads. More specifically, the inclusion of these neural data in the model provided an additional 9.1% explanation for the variation in CTR on utilitarian banners (Figure 3). Here again, none of the ROIs associated with the processing of hedonic banners were significant predictors of changes in CTR on utilitarian ads. Table 2, Panel A, lists all the coefficients, R-squared values, and statistics.

Discussion

In recent years, competition in the online marketplace has grown exponentially, and retailers are seeking strategies to create online ads that most effectively encourage the purchase of online products. Previous studies on advertising and interactive marketing have concluded that ad attributes are key drivers of consumer attitudes toward the ad and even behaviors. Although the two most commonly used ad appeals—namely, hedonic and utilitarian—have been largely defined, there are no unanimous conclusions about their effects on consumer behavior. Furthermore, surprisingly, no studies have assessed the psychological mechanisms underlying the processing of hedonic and utilitarian banners, which could be crucial given the unconscious, internal, and introspective nature of online purchasing decisions. In our research, for the first time, neuroimaging was used to identify the neural basis of the evaluation of these two typologies of banner appeals. The results reveal that, while hedonic banners engage brain areas associated with reward, self-relevance, and emotion, utilitarian ads trigger brain networks related to object identification and recognition, reasoning, executive function, and cognitive control. This research is also the first to examine the extent to which neural data derived from processing hedonic and utilitarian ads complement the ability of self-reported banner effectiveness to predict online consumer behavior. Here, the results reveal that brain data produce increases of 8% and 18% in explained variance in CTR on utilitarian and hedonic ads, respectively, compared with the predictive ability of self-reported effectiveness. Taken together, these results provide new insights into the connection between neuropsychological data and real-world online consumer behavior.

On the one hand, self-reported data reveal that participants perceived hedonic ads as more effective (i.e., they triggered greater purchase intention, attraction, impact and persuasion) than utilitarian ones. These data align with the findings of studies by Rosen and Purinton (2004), and Hausman and Siekpe (2009), who stated that hedonic online environments are more attention-grabbing, facilitate usability at purchase, and improve consumer engagement. In our study, we went a step further and identified the neural mechanisms associated with the higher effectiveness of hedonic ads. In particular, and in line with H_1, we concluded that hedonic banners engage areas extensively involved in self-relevance and attention (angular gyrus, precuneus, or vMPFC), reward (hippocampus or inferior orbitofrontal gyrus) and emotion (inferior frontal gyrus or PCC) (Bartra, McGuire, and Kable 2013; Casado-Aranda, Dimoka, and Sánchez-

Fernández 2021; Vytal and Hamann 2010). These results align with previous consumer neuroscience research analyzing hedonic and utilitarian environments from different perspectives. For example, Schaefer and Rotte (2007b) found that luxury experiential brands (similar to hedonic ads) provoked the activation of brain areas related to reward (e.g., vMPFC, precuneus). In a similar vein, Goodman et al. (2017) analyzed hedonic and utilitarian consumer motivations through fMRI and concluded that experiential motivation (similar to hedonic ads) engaged areas associated with emotion and self-reflection, such as the PCC and inferior frontal gyrus. Similarly, Goel and Dolan (2003) found that the vMPFC and the angular gyrus are responsible for the processing of emotionally salient stimuli (which they call "hot" evaluation), such as hedonic layouts.

These findings have two important implications for the interactive marketing literature concerned with consumer processing of banners. First, we established a neural basis of the processing fluency theory, which claims that viewers process fluent information more holistically, and, in the case of ads, such fluency may translate into positive psychological mechanisms and attitudes (Van Rompay, De Vrienes, and Van Venrooij 2010). Here, we reveal that the inclusion of combinations of banner attributes (not just a single item, a single product, a single sentence, or a single picture, but a higher-level mixture of elements) in hedonic appeals (such as links to social networks, the text "Headphones 100% adapted to you," or images of happy and relaxed athletes) generates holistic neural processing in consumers that manifests in the activation of emotion-, reward-, and self-relevant-related brain areas. Second, previous ad literature has suggested that the presence of rewarding, self-relevant, and emotional neural experiences during exposure to hedonic ads may have positive marketing outcomes. For instance, Guo et al. (2019) reported that the mere feeling of reward during ad processing triggers stronger levels of consumer enjoyment and engagement with the advertised product, which, in turn, could translate into better outcomes for advertisers. Other scholars have concluded that designing ad environments that encourage self-related and self-relevant processing (as indicated by our hedonic findings) can create more positive attitudes toward the advertisement, including the purchase of the advertised product/idea (Chua et al. 2011; Lustria 2017), ad effectiveness (Kranzler et al. 2019) and ad-sharing intentions (Motoki et al. 2020). Furthermore, the stronger neural emotion experienced in hedonic environments may well increase the persuasiveness of the ad argument, as prior studies have found that emotion-eliciting appeals increase positive consumer behavior in response to the advertised product/idea (Wirz 2018). Therefore, we show that the higher perceived effectiveness of hedonic banners originates in neurological mechanisms involved in self-relevance, reward, and affect.

Interestingly, our study reveals that, among the aforementioned significant brain networks, only the areas related to self-relevance (i.e., angular gyrus) and emotion/affect (i.e., inferior frontal gyrus) are able to predict CTRs on hedonic ads. These results are in line with the findings of previous studies demonstrating that areas involved in personally relevant processing largely influence behavioral outcomes and contribute to the efficacy of messages in diverse ad environments, namely, antismoking messaging (Cooper et al. 2015; Falk et al. 2016) and social sharing (Scholz, Jovanova, et al. 2020). The predictive ability of emotional brain responses is also consistent with research proposing that affective responses are a core component of attitudes in general and central to the effects of persuasive communications (DeSteno et al. 2004; Doré et al. 2019). However, our study does not corroborate the findings of previous research showing that reward-related brain areas predict market-level outcomes for music sales (Berns and Moore 2012) or the success of public health campaigns (Falk, Berkman, and Lieberman 2012). Several reasons could potentially explain these results. First, previous neuroimaging studies agree that the two brain areas more broadly involved with reward, namely ventral striatum and MPFC, are those predictive of consumer behaviors or liking while participants simply watch ads or videos (Enax et al. 2015; Tong et al. 2020; Venkatraman et al. 2015). However, our results (see Table 1) showed that hedonic ads did not reveal greater activations in such networks but rather in the precuneus, hippocampus, and inferior orbitofrontal gyrus. In addition to their role in reward processing, these three brain areas are crucial in the evaluation of high personal value and self-relevant stimuli. Indeed, studies such as Cavanna (2006) and Eckstrand et al. (2017) have concluded that these networks (above all, the precuneus) are strongly involved in the connectivity between reward and self-processing. Therefore, it appears that despite the reward elicited by the novelty and experiential value of hedonic ads (in line with studies such as Motoki, Sugiura, and Kawashima [2019]), the predictive ability of CTR of reward processing is irrelevant when compared to that of emotion and self-relevance networks. In fact, these results are in line with the findings of Couwenberg et al. (2017), who found that object identification and self-relevance processing are responsible for higher online ad effectiveness. Investigations in the field of health advertising support our findings (Chua et al. 2011; Garrison et al. 2021), as they conclude that self-related brain areas (and not reward-associated ones) also have the ability to forecast changes in individual behavior. The recent study by Motoki et al. (2020) interestingly stated that social- and value-related (and not reward-associated) brain areas forecast the viral marketing success of internet ads, suggesting that the role of activity in value and mentalizing-related brain regions may become crucial when forecasting the success of online ads, even more than the reward networks. Accordingly, it could be that, unlike previous studies using actual physical sales with possession of the purchased item, the online behavior used in this research (i.e., CTR) does not involve direct physical possession of the headphones (i.e., the headphones will take time to reach the buyer's hands), so the experienced reward may be less responsible for such online behavior. These results open up future research, which should corroborate the limited capacity of reward-related brain processing in the prediction of online purchases. All in all, these results confirm that the effectiveness of online hedonic environments is mostly based on the elicited consumer's emotion of shopping and self-relevance of the purchased product and ad context.

However, confirming H_2, utilitarian layouts elicited stronger activations in brain areas associated with object identification and recognition (e.g., the middle temporal gyrus), as well as reasoning, executive function, and cognitive control (e.g., the superior parietal lobe, precentral and supplemental motor areas) (Logue and Gould 2014; Rangel and Hare 2010; Seo et al. 2014). These results corroborate the findings of previous studies indicating that functional and utilitarian items (e.g., concrete product attributes presented in utilitarian ads) are associated with "cold" processing (Goel and Dolan 2003), deliberate and reasoned evaluations (Couwenberg et al. 2017), and functional motivations (Goodman et al. 2017). Our findings also corroborate the results of the processing fluency theory and reveal that, even in a higher-level mixture of utilitarian attributes (i.e., not just text), viewers process utilitarian banners deliberately, effortfully, and less fluently than hedonic ones, as they may need more time to identify the goods and extract value from them.

Among all significant brain areas, the middle temporal gyrus (object identification and recognition) and the precentral cortex (cognitive control) were able to predict, together with the self-reported web effectiveness, changes in CTRs. According to the American Psychological Association (2021), the goal direction and executive functions involve "higher level cognitive processes of planning, task assignment and organization, effortful and persistent goal pursuit, flexibility in goal selection, and goal-conflict resolution. These often involve the use of language, judgment, abstraction and concept formation, and logic and reasoning.” As explained in our theoretical background, and consistent with prior research (e.g., Couwenberg et al. 2017), during the exposure to utilitarian ads, which offer detailed and accurate product information such as features and performance, participants likely experience higher-level cognitive processes of evaluation and organization of headphones’ characteristics and imagination/abstraction of a situation of use and purchase in which they value the benefits explained in the utilitarian banner, regardless of their aim to purchase (to click) the product. Therefore, the involvement of goal direction and executive functions processing during the exposure to utilitarian banners is logical (aligning with our findings). However, because there was not a clear instruction of buying the product and fulfilling the final goal of purchasing during the fMRI task (i.e., the audience was not required to click or make a purchase decision), the ability to predict further CTR of these two brain networks may have been reduced. Future research is in a good position to further analyze the predictive role of goal direction and executive functions of online purchases. Consequently, we could infer that effective processing of product information (e.g., product characteristics or functions: object identification and recognition) and how the product should be used (extract value, organize and plan decisions: cognitive control) may lead to increased success of the banner at the behavioral level. These results undoubtedly warrant further research to corroborate our reasoning, which aligns with the results of Couwenberg et al. (2017).

These results shed light on the lack of unanimity around the evaluation of the effectiveness of hedonic and utilitarian ads. Specifically, we not only explain differences in the neural and unconscious processing of both banners but also uncover the psychological processing that might be responsible for their greater effectiveness. The present findings differ from previous studies evaluating neural correlates of functional and experiential layouts and motivations. Couwenberg et al. (2017), for example, analyzed the neural mechanisms underlying the processing of messages that emphasize the functional and experiential benefits of a product in an offline advertising context without strict, controlled, and pretested manipulation of functional (similar to utilitarian) and experiential (similar to hedonic) environments. Those authors did not test the combination of ad attributes included in the messages but rather only confounding stimuli. Furthermore, Motoki, Sugiura, and Kawashima (2019) and Goodman et al. (2017) analyzed the neural correlates of hedonic and utilitarian items and purchase motivations, respectively, thus omitting the importance of the product presentation environment (i.e., hedonic or utilitarian ads) in the evaluation of the purchasing process. In contrast to just evaluating the neural correlates of low-order items, our study moves a step forward and explores the neural mechanisms underlying the processing of combinations of banner attributes (not just a single item, a single product, a single sentence, or a single picture, but a higher-level mixture of elements) that together form more reality-based hedonic and utilitarian ad appeals. In addition, the current research is the first to use a combination of self-reported and neural data derived from online ad evaluations to predict online behaviors. The greater predictive ability of neural responses and the lower capacity of self-reported ad effectiveness to predict CTR in hedonic environments may be due to the more fluent, heuristic, and emotional nature of hedonic processing, which reduces the participant's rationality and planning (and therefore their ability to reflect their intentions in self-reported data) and the ability to predict behaviors in response to this type of banner. In contrast, the effortful, deliberate and attentive processing of utilitarian ads may facilitate a more rational understanding of the functional benefits of the advertised product and, therefore, decrease the importance of inner, introspective thoughts (i.e., neural data) in predicting CTR. Thus, effectiveness perceptions predict CTR better in utilitarian than in hedonic layouts.

Furthermore, we controlled the type of product and motivation so that the neural mechanisms were driven exclusively by the condition of interest: the web environment. Our study further constitutes a further step in identifying the neural mechanisms involved in the processing of products in different online layouts. Previous consumer neuroscience studies evaluated the neural processing of e-payments (Casado-Aranda, Liébana-Cabanillas, and Sánchez-Fernández 2018; Casado-Aranda, Martínez-Fiestas, and Sánchez-Fernández 2018), the neural correlates of online trust signals (Casado-Aranda, Dimoka, and Sánchez-Fernández 2019; Casado-Aranda, Sánchez-Fernández, and Montoro-Ríos 2019), the neural processing of effective product presentations (Jai et al. 2021), and the neural forecasting of viral marketing success (Motoki et al. 2020).

E-retailers could make use of our results in three main ways. First, the increased neural processing involved in affect and relevance in response to hedonic ads might suggest the use of such a web environment for product strategies that are intended to elicit holistic and cue-based processing of products and attributes related to emotion and reward (hedonic products; e.g., chocolates, luxury cars). Conversely, the deliberative, reasoned, more attentive executive processing associated with utilitarian ads and their ability to predict purchase behaviors might suggest employing utilitarian elements for products that require specific, concrete and intentional understanding, such as pre-eminently utilitarian products (e.g., calculator, microwave). Second, our findings suggest that, for products that are not clearly pigeon-holed as hedonic or utilitarian (e.g., sunglasses, electric scooters, smartwatches), hedonic ads may be more effective in creating affect and self-relevance, which in turn may translate into actual online behavior. Finally, e-retailers should use neural results as a new methodology for analyzing ad effectiveness. If companies are able to create hedonic web environments that evoke brain activations related to self-relevant and emotion and utilitarian banners that promote strong cognitive control processing and object identification, then they could be considered effective without resorting to biased and often inconclusive tools such as self-reporting.

Limitations and Future Research

The current manuscript has several limitations that should be considered. First, we controlled the type of product in the ad (neither hedonic nor utilitarian) so that it did not affect the evaluation process of the banner web environment (Baltas, Kokkinaki, and Loukopoulou 2017). However, future research should corroborate our neural results with the presentation of pre-eminently hedonic and utilitarian products because, in such cases, the predictive ability of neural data may be stronger. Despite controlling certain details of the hedonic and utilitarian ads' manipulations (to avoid the presence of confounding factors), these purchase environments may differ from real online layouts; therefore, the artificiality of the experimental design and fMRI context may constitute a drawback. Despite 30 different banner layouts (e.g., with diverse dimensions as specified by Chiu et al. [2014]) within each banner typology were used, the decay effect of multiple exposures (namely during the fMRI, self-reported, and CTR phases) may constitute a potential limitation of our conclusion. Furthermore, the fact that the independent sample perceived all colorful banners as hedonic and all colorless banners as utilitarian may have exerted some bias based on the theory of media richness (Moran, Muzellec, and Johnson 2019), and therefore our findings should be interpreted with caution. Although previous studies have used CTR as a behavioral measure (Couwenberg et al. 2017), future research could associate neural data with actual purchases in the online marketplace. Furthermore, prospective studies are a good opportunity to use other psychophysiology techniques (e.g., skin conductance, eye tracking, heart rate, electromyography) to offer new psychological insights and corroborate the results of the present investigation.

In conclusion, the current findings show, for the first time, the neural basis of processing hedonic and utilitarian banners. Interestingly, this research constitutes the first report to demonstrate that neural data in response to banner attributes help predict online consumer behavior beyond that indicated by the perceived ad effectiveness reported by consumers. Therefore, our results prove the need to complement traditional self-report techniques with more objective and moment-by-moment neuroimaging data to explain online consumer behavior.

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Appendix A: Selected Hedonic Banners from the Pretest

Fx1

Appendix B: Selected Utilitarian Banners from the Pretest

Fx2

Appendix C: Multislice Brain Images Based on the Meta-Analysis Reverse Inference Maps Extracted from www.neurosynth.org

Fx3

Fx4

Appendix D. Whole-Brain Analysis Activation Table for Hedonic > Utilitarian and Utilitarian > Hedonic Contrasts.

Brain Regions	**Peak of Coordinates MNI (mm)**			**k**	**t(1, 26)**
	x	**y**	**z**		
Hedonic Versus Utilitarian Banners					
Cerebellum (peak)	29	−74	−18	4,091	12.10
Fusiform gyrus	36	−53	−21		
Medial superior frontal (peak)	1	67	18	352	6.39
Angular gyrus	47	−60	11	80	8.82
Medial orbitofrontal gyrus	−6	67	−4		
Hippocampus	−17	−7	−18	60	5.42
Inferior frontal gyrus	−31	25	−14		
Middle frontal gyrus (peak)	−41	18	39	31	4.87
Inferior frontal gyrus (peak)	57	32	14	46	4.83
Inferior orbitofrontal gyrus (peak)	33	28	−14	31	4.64
Utilitarian Versus Hedonic Banners					
Precentral (peak)	−45	0	49	150	9.60
Supplemental motor area (peak)	−6	4	70	138	7.97
Caudate	12	11	49		
Middle temporal gyrus (peak)	−59	−21	−4	249	6.69
Superior parietal lobe (peak)	−27	−56	56	51	6.58
Calcarine	12	−74	7	54	5.20
Middle frontal gyrus (peak)	29	42	28	29	4.52

Notes: k = cluster size defined as the number of voxels; t = t-value derived from the t-test analysis contrasting utilitarian versus hedonic banners.

Figure 1. Visual diagram of each of the participants' tasks in the experimental design.

Notes: First, subjects underwent the fMRI task in which they had to watch the 60 manipulated ads. Second, out the scanner, participants reported their perceived effectiveness of each of the previously seen ads. Third, they instructed to click on those ads in which they desire to purchase the headphones.

Figure 2. Diagram of the predictive capacity of perceived effectiveness toward hedonic ads and brain areas (angular gyrus and inferior frontal gyrus) for CTR on hedonic banners.

Notes: The graph shows that the combination of self-reported effectiveness and neural responses in the angular and inferior frontal gyri predict 66.4% of the CTR variance.

Figure 3. Diagram of the predictive capacity of perceived effectiveness toward utilitarian ads and brain areas (precentral and middle temporal gyrus) on CTR in utilitarian banners.

Notes: The graph shows that the combination of self-reported effectiveness and neural responses in the precentral and middle temporal gyrus predicts 86.7% of the CTR variance.

Table 1. ROIs Showed Significant Activation.

A: Hedonic Versus Utilitarian Banners					
Brain Regions	**Peak of Coordinates MNI (mm)**			**k**	**t(1, 26)**
	x	**y**	**z**		
Mask Self-Reference					
Angular gyrus	47	−60	27	21	7.31
Precuneus	1	−56	21	80	6.93
Medial superior frontal	1	67	14	39	6.13
Medial superior frontal	−6	49	35	16	4.22
Cingulate gyrus	5	−42	35	10	4.19
vMPFC	2	53	7	11	4.14
Mask Reward					
Hippocampus	26	−11	−11	33	5.94
Inferior orbitofrontal gyrus	33	28	−14	10	4.64
Precuneus	−6	7	11	9	3.56
Mask Emotion					
Inferior frontal gyrus	57	32	14	26	4.83
Inferior orbitofrontal	−31	28	−14	16	4.23
Frontal superior medial	−3	63	18	68	5.41
PCC	1	−49	32	10	4.42

B: Utilitarian Versus Hedonic Banners					
Brain Regions	**Peak of Coordinates MNI (mm)**			**k**	**t(1, 26)**
	x	**y**	**z**		
Mask Recognition					
Middle temporal gyrus	−50	−18	−4	29	6.69
Middle temporal gyrus	−59	−39	4	10	5.72
Object Identification					
Superior parietal lobe	−32	−64	48	18	6.55
Mask Executive Function					
Superior parietal lobe	−24	−60	53	24	6.55
Supplemental motor area	−3	7	56	25	5.44
Inferior frontal gyrus	−48	11	21	8	3.83
Mask Goal Directed					
Superior parietal lobe	−24	−63	60	8	4.32
Supplemental motor area	−6	4	60	35	5.48
Mask Reasoning					
Precentral	−45	0	46	19	7.51
Supplemental motor area	−3	7	60	29	5.60
Cognitive Control					
Precentral	−45	−4	49	82	9.60
Middle frontal gyrus	33	46	25	7	4.19

B: Utilitarian Versus Hedonic Banners					
Brain Regions	**Peak of Coordinates MNI (mm)**			**k**	**t(1, 26)**
	x	**y**	**z**		
Supplemental motor area	−3	4	63	68	6.61
Superior parietal lobe	−27	−56	56	31	6.58

Notes: ROIs were extracted from the database www. neurosynth.org. k = cluster size defined as the number of voxels; t = t-value derived from the t-test analysis contrasting hedonic versus utilitarian banners (Panel A) and utilitarian versus hedonic banners (Panel B).

Table 2. Self-Reported and Neural Data Predicting CTR in Hedonic and Utilitarian Ads.

A: Hedonic Ads						
Predictor (s)	**Coefficients**			**Change Statistics**		
	B	**T(26)**	**SE of the Estimation**	**R-Square Change**	**Total R-Square**	***p*-Value**
DV: CTR Toward Hedonic Banners						
Self-reported banner effectiveness	*.866*	*6.47*	*.11*	*.484*	*.484*	*p < .001*
Self-Relevance Mask						
Angular gyrus	*.359*	*2.675*	*.12*	*.119*	*.603*	*p = .013*
Precuneus	−1.02	−.971				
Medial superior frontal	.53	.82				n.s.
Medial superior frontal	.05	.16				n.s.
Cingulate gyrus	−.78	−2.21				n.s.
vMPFC	.29	1.10				n.s.
Reward Mask						
Hippocampus	−.01	−.04				n.s.
Inferior orbitofrontal gyrus	−.05	−.17				n.s.
Precuneus	.93	.84				n.s.
Emotion Mask						

Inferior frontal gyrus	*.249*	*2.053*	*.11*	*.061*	*.664*	$p = .05$
Inferior orbitofrontal	−.29	*−1.01*				n.s.
Frontal superior medial	−.7	−1.18				n.s.
PCC	.32	.86				

B: Utilitarian Ads						
Predictor (s)	**Coefficients**			**Change Statistics**		
	β	**t_{26}**	**SE of the Estimation**	**R-Square Change**	**Total R-Square**	***p*-Value**
DV: CTR Toward Utilitarian Banners						
Self-reported banner effectiveness	*.772*	*9.366*	*.08*	*.776*	*.776*	$p < .001$
Mask Recognition						
Middle temporal gyrus	*.250*	*3.158*	*.08*	*.071*	*.847*	$p = .003$
Middle temporal gyrus	.18	1.01				ns
Object Identification						
Superior parietal lobe	−.11	−.33				ns
Mask Executive Function						
Superior parietal lobe	.19	.70				ns
Supplemental motor area	.58	.92				ns
Inferior frontal gyrus	−.24	−1.09				ns
Mask Goal Directed						
Superior parietal lobe	.15	.69				
Supplemental motor area	−.39	−.93				ns
Mask Reasoning						
Precentral	−.21	−.12				ns
Supplemental motor area	−.37	−.13				ns

Cognitive Control						
Precentral	*.152*	*1.846*	*.09*	*.020*	*.867*	$p = .07$
Middle frontal gyrus	.16	1.10				ns
Supplemental motor area	−.06	−1.12				ns
Superior parietal lobe	.14	.87				ns

Notes: n.s. = Nonsignificant predictor ($p > .05$). None of the ROIs associated with the processing of utilitarian (hedonic) banners were significant predictors of changes in CTR on hedonic (utilitarian) ads.