A current overview of consumer neuroscience

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The emerging discipline of neuroeconomics employs methods originally used in brain research for investigating economic problems, and furthers the advance of integrating neuroscientific findings into the economic sciences. Neuromarketing or consumer neuroscience is a sub-area of neuroeconomics that addresses marketing relevant problems with methods and insights from brain research. With the help of advanced techniques of neurology, which are applied in the field of consumer neuroscience, a more direct view into the "black box" of the organism should be feasible. Consumer neuroscience, still in its infancy, should not be seen as a challenge to traditional consumer research, but constitutes a complementing advancement for further investigation of specific decision-making behavior.

The key contribution of this paper is to suggest a distinct definition of consumer neuroscience as the scientific proceeding, and neuromarketing as the application of these findings within the scope of managerial practice. Furthermore, we aim to develop a foundational understanding of the field, moving away from the derisory assumption that consumer neuroscience is about locating the "buy button" in the brain. Against this background the goal of this paper is to present specific results of selected studies from this emerging discipline, classified according to traditional marketing-mix instruments such as product, price, communication, and distribution policies, as well as brand research. The paper is completed by an overview of the most prominent brain structures relevant for consumer neuroscience, and a discussion of possible implications of these insights for economic theory and practice.

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Introduction

In recent years, interest in applying neuroscientific findings and methodologies to other disciplines has been increasing. The innovative approach of neuroeconomics demonstrates that this development has been incorporated into economic research (Braeutigam, 2005; Camerer et al., 2005; Kenning and Plassmann, 2005; Singer and Fehr, 2005). Neuroeconomics employs methods originally used in brain research to investigate economic problems, and further advances the integration of neuroscientific findings into the economic sciences. Although both economists and neurologists attempt to understand and predict human behavior, they have used quite different methods in the past. Whereas economic research has tried to explain behavior through observational data and theoretical
constructs such as utility or preferences, neurology contemplates the physiological elements and somatic variables that influence behavior. Neuroeconomics, which evolved from the combination of both disciplines, proposes an interdisciplinary approach and specifically examines the neural correlates of decision-making (Sanfey et al., 2006). Marketing research has discovered neuroscience as well. Neuromarketing or consumer neuroscience is a sub-area of neuroeconomics that addresses marketing relevant problems with methods and insights from brain research (Fugate, 2007; Lee et al., 2007).

Classical consumer research has seen the human organism figuratively as a “black box,” into which investigators could not gain direct insights. Instead, they had to use theoretical constructs in order to explain human behavior. In this sense, the stimulus–organism–response model, which originated in neo-behaviorism, explains the initiation of behavior by a controlled stimulus (e.g., price) or an uncontrolled stimulus (e.g., weather). The still unobservable processing of this stimulus inside the organism is then related to the resulting observable reaction (e.g., purchase) (Howard and Sheth, 1969). Examinations of the processes inside the human organism are based on established indirect methods such as electrodermal response (EDR) measurement, pupillography, and, most common, self-assessment methods (Bagozzi, 1991; Groeppel-Klein, 2005). A more direct view into the black box of the organism should be feasible with the help of advanced techniques and methods of brain research that are now applied in the field of consumer neuroscience (Kenning et al., 2007a). Even though the application of neurobiological methods such as electroencephalography (EEG) is not new in marketing research, the direct observation of the reactions within the brain that is now available through the use of steadily improving methods of imaging techniques, for example, positron emission tomography (PET) or functional magnetic resonance imaging (fMRI), is providing a completely different perspective (Plassmann et al., 2007a).

The determination of cortical areas that are stimulated during consumer decision processing is important for various reasons. First, the approach of consumer neuroscience enables the researcher to reassess existing theories that theoretically assume different brain mechanisms (e.g., hemisphere theory) by investigating the actual brain activations. Beyond this, the observation of the total brain has the potential to yield new, unpredictable results, and enhances the explorative character of consumer neuroscience. This contrasts measuring the brain activity by recording only one signal, as it is used, for example, in EDR or eye tracking, which can be compared to an effort to capture the musical sounds of an orchestra by measuring only the noise level (Kenning et al., 2007a). Third, concerning the empirical data ascertainment, the observation of brain activity can offer another, and more objective, perspective: self-assessment methods that rely totally on the ability of the respondent to describe and reconstruct feelings and thoughts are very subjective. Many effects in the human organism that influence behavior are not perceived consciously; hence, the cognitive filter of the test taker may bias the results. For example, a person who has a temperature may determine that his body feels cold, even though the objective measurement of a clinical thermometer indicates that it is not. Fourth, strategic behavior and social desirability, which can confound findings of self-assessment methods, can be eliminated, given that the participating subjects have little to no influence on the measurement of their brain activity (Camerer et al., 2005). A last, but very important, advantage of determining the cortical stimulation is the simultaneousness of measurement and experiment. Some processes might not be stable over time, making it very difficult for researcher and participant to reconstruct them ex-post (Lee et al., 2007).

As a consequence of these advantages, the crossing of the own disciplinary boundaries and the consideration of all aspects that determine decision-making can help consumer researchers and social scientists to more fully understand human behavior (Zaltman, 2000).
With better comprehension and steadily improving methods, it may be possible to derive new theories for marketing research and to arrive at a higher level of explained variance (Knutson et al., 2007). This may in turn help to improve companies’ actions, for example, marketing responses that are based on a better satisfaction of unconscious emotional consumer needs. However, consumer neuroscience is still in its infancy and should not be seen as a challenge to traditional consumer research. Rather, it constitutes a complementing advancement for further investigation of specific decision-making behavior.

The increasing relevance of this area of research is indicated by the growing interest of science and practice (Fugate, 2007; Lee et al., 2007; Plassmann et al., 2007a). For example, numerous conferences, calls for papers from prominent scientific journals, and calls for research by institutes such as the Marketing Science Institute, the Institute for the Study of Business Markets (Lee et al., 2007), and the World Advertising Research Centre focus on this subject. The Association of Consumer Research even implemented a new content area code for neuroscience. Furthermore, “googling” the term “neuromarketing” currently yields more than 800,000 hits, which establishes the field’s move into the mainstream of research (Figure 1).

Against the background of the embryonic nature of the field, a key contribution of this paper is to suggest a distinct definition of neuromarketing and consumer neuroscience. The term “consumer neuroscience” comprises the scientific proceeding of this research approach, and “neuromarketing” designates the application of the findings from consumer neuroscience within the scope of managerial practice. Because of the way the terms are applied in the existing literature, and to prevent misunderstandings, both terms are still used synonymously in the following. Furthermore, we aim to develop a definitive foundation, moving away from the derisory assumption that consumer neuroscience is used for locating the “buy button” in the brain (Blakeslee, 2004). In order to achieve our goal, this paper discusses a wide scope of marketing-mix instruments and addresses the question of the extent to which the application of

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Development of google hits on neuromarketing 2003–2007.

_Sources: Fugate, 2007; Lee et al., 2007; Plassmann et al., 2007a._
neuroscientific methods can help to identify the cortical areas that drive consumer behavior. We attempt to connect consumer research and neuroscience in order to provide a better understanding of current proceedings in neuromarketing.

**Neurally reconstructing the marketing mix — overview of selected studies**

In order to show the close alliance between consumer neuroscience and established market research, we present here specific results and implications of selected exemplary studies from this recent field of research. The selection takes into account whether or not the study was related to marketing issues. Regarding content, the overview is structured according to traditional marketing-mix instruments such as product, price, communication, and distribution policies, as well as brand research, because they represent predominant and essential elements of marketing theory and operational marketing management (Winer, 1986; Constantinides, 2006). In this connection, neural activation patterns evoked by stimuli of each mix instrument and branding research are identified. Additionally, Table 1 offers a graphical overview of selected studies in consumer neuroscience.

**Product policy**

Product policy is also called the “heart of marketing,” as it includes all decisions that a company makes regarding the market-driven composition of its offered services (Kotler and Keller, 2006). It is an essential element of successful corporate policy, because a product range that satisfies the needs, demands, and problems of the customer can be the key for sustainable corporate success (Cooper, 1979; Selnes, 1993; Anderson et al., 1994; Bailetti and Litva, 1995). However, the application of conventional market research methods such as self-reports often does not yield the desired information about consumers’ real opinion of a product. For example, self-reports are frequently in contrast to the actual inner states of the subjects, because people are generally not able to reconstruct and interpret their thoughts and feelings retrospectively (Bagozzi, 1991). In this area, consumer neuroscience can yield a more complete and objective understanding of consumer’s desires, and may consequently assist companies to adjust their strategies.

One important aspect of product policy is the optimal design of a product according to the preferences of the customer (Bloch, 1995). The investigations by Erk et al. (2002) provided the first central insights into how the brain processes differently designed goods (e.g., sports cars, limousines, and small cars). Their fMRI results showed that reward-related brain areas are activated by objects that have gained a reputation as status symbols through cultural conditioning signaling wealth and social dominance. In relation to the perceived attractiveness of the products, pictures of the cars in their study led to activation in the left anterior cingulate, the left orbitofrontal, and bilateral prefrontal cortex, as well as in the right ventral striatum. According to the present standard of knowledge, these regions are associated with motivation, the encoding of rewarding stimuli, the prediction of rewards, and decision-making (Bechara et al., 2000; O’Doherty, 2004). A very interesting finding for the optimal design of a product is the measured activation in the ventral striatum in which the nucleus accumbens is located: The more attractive the subject perceived a car to be, the stronger the detected activation. Hence, the most intense average activation signal was measured when the subjects looked at sports cars, followed by limousines, and then small cars. Erk et al. (2002) reasoned that the relative activation in the ventral striatum can be seen as an indicator for how attractive a visual stimulus (i.e., product design or shape) is evaluated to be. Assuming that there is a relation between product design and purchase decision, we can hypothesize that activity changes in the reward system of the brain induced by an attractive product design can
Table 1. Overview of selected studies in alphabetical order

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<tr>
<th>Study</th>
<th>Subject</th>
<th>Problem</th>
<th>Method</th>
<th>Experimental set-up</th>
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<th>Results</th>
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| Ambler et al., 2000    | Communication policy     | What impact does affective advertisement have on the neural activity in comparison with cognitive advertisement? | MEG    | The subjects watched different commercials with either affective or cognitive content | $n = 3$ | - Cognitive pictures: stronger activation in posterior parietal areas and in the superior prefrontal cortex → stronger use of working memory  
  - Affective pictures: activation in the areas of the ventromedial prefrontal cortex (VMPFC), the amygdala and the brainstem → processing of emotional stimuli |
<p>| Deppe et al., 2005a    | Distribution policy      | Is it possible to find the ‘framing effect’ on a neural basis?           | fMRI   | Evaluation of the credibility of fictive headlines that are combined with different newspaper logos | $n = 21$ | - If the newspaper brand had a strong impact on the judgment of the person, a strong activation in the VMPFC was measured → integration of implicit framing information in the decision-making process |
| Deppe et al., 2005b    | Brand research           | What are the neural correlates of brand choice?                          | fMRI   | Binary decisions between ‘target’ brand and diverse brand                              | $n = 22$ | Only the favorite brand is able to emotionalize the decision making process. First choice brands lead to a deactivation in areas that are associated with analytical processes and to activation in areas that are associated with integrating emotions in the decision-making process |</p>
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<th>Study Subject</th>
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<th>Experimental set-up</th>
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<tr>
<td>Deppe et al., 2007</td>
<td>Distribution policy: What influence does the &quot;framing effect&quot; have on</td>
<td>fMRI</td>
<td>Evaluation of the attractiveness of print ads that are combined with different newspaper logos</td>
<td>n = 21 If the newspaper brand had a strong impact on the judgment of the person, a strong activation in the anterior cingulate cortex was measured → evaluation of the relevance of the framing stimulus</td>
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<td>Erk et al., 2002</td>
<td>Product policy: Is there a neural representation of product attractiveness?</td>
<td>fMRI</td>
<td>Ranking of attractiveness of sports cars, limousines, and small cars with scanner and questionnaire</td>
<td>n = 12 Products that symbolize wealth and prestige lead to a higher activation in areas that are associated with the perception of rewards</td>
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<td>Kenning et al., 2007b</td>
<td>Communication policy: Can the perceived attractiveness of an advertisement be associated with specific neural activations?</td>
<td>fMRI</td>
<td>The subjects had to evaluate different advertisements by their attractiveness while their brain activity was measured</td>
<td>n = 22 Attractive ads lead to a stronger activation in</td>
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<td>Knutson et al., 2007</td>
<td>Price policy: Which impact does the price have on product preferences and neural activity?</td>
<td>fMRI</td>
<td>While measuring their brain activity, products with corresponding price information were presented to the subject. In the end they had to make a buying decision</td>
<td>n = 26</td>
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<td>Koenigs and Tranel, 2007</td>
<td>Brand research</td>
<td>Is it possible to receive the same results as McClure et al. 2004a, through the observation of people with lesions in the MPFC?</td>
<td>Lesion-study</td>
<td>In order to test the ‘Pepsi-paradox’ (people prefer Pepsi in blind tests, but Coca Cola if they know the brand), three groups were formed and the taste test from McClure et al. 2004a was repeated, this time without the fMRI scanner: 1. Healthy subjects 2. Subjects with lesions not including the VMPFC 3. Subjects with lesion in the VMPFC</td>
<td>Groups</td>
<td>The results from McClure et al. 2004a could be validated: 1. Only persons with lesions in the VMPFC did not show preference bias when exposed to brand information 2. The other groups were susceptible to brand information 3. The results show that the VMPFC seem to play a key role in developing brand preferences</td>
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<td>McClure et al. 2004a</td>
<td>Brand research</td>
<td>What effect does brand information have on the sensory perception of similar products (Coca Cola/Pepsi)?</td>
<td>fMRI</td>
<td>Anonymous and semi-anonymous taste tests of Coca Cola and Pepsi inside and outside the scanner</td>
<td>n = 67</td>
<td>- The VMPFC evaluates sensory information - Through the cooperation with the dorsolateral prefrontal cortex and the hippocampus, memories and cultural information (e.g., brand knowledge) are integrated in the decision-making process</td>
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<td>Plassmann et al., 2005</td>
<td>Brand research</td>
<td>What are the neural correlates of brand choice under risk?</td>
<td>fMRI</td>
<td>Subjects participated in a brand choice task where they had to choose between 16 travel brands to a risky and a less risky destination</td>
<td>n = 15</td>
<td>- ’First brand effect’ was confirmed - More prominent activation of the MPFC when the subject faced risky decisions - Integration of emotions in the decision-making process of particular importance in risky decision-making</td>
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<td>Plassmann et al., 2007b</td>
<td>Distribution policy</td>
<td>What are the neural correlates of brand loyalty?</td>
<td>fMRI</td>
<td>The subjects had to decide from which retail brand they would prefer to buy a certain garment. In addition to measuring their brain activity, data about their buying behavior were collected.</td>
<td>Loyal customers probably integrate emotions more intensively in the decision-making process. For loyal customers the favorite brand can be a rewarding stimulus.</td>
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<td>Plassmann et al., 2007d</td>
<td>Price policy</td>
<td>Is there a neural correlate for the individual willingness to pay?</td>
<td>fMRI</td>
<td>They presented hungry subjects food, while measuring their brain activity. The participants had to evaluate their individual willingness to pay.</td>
<td>The medial orbitofrontal cortex plays probably a key role for computing the individual willingness to pay. The DLPFC encodes the final decision and is responsible for the motor signal (key press).</td>
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<td>Plassmann et al., 2007e</td>
<td>Price policy</td>
<td>Is a high price able to change the experienced utility and the corresponding neural activity?</td>
<td>fMRI</td>
<td>The subjects tasted different kinds of wine with the explicit price information, while their brain activity was measured.</td>
<td>A high price led to a better evaluation of the taste and to a change in the neural activity in the MPFC and in the rostral anterior cingulate cortex.</td>
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<td>Rossiter and Silberstein, 2001</td>
<td>Communication policy</td>
<td>Is it possible to derive how well ads are remembered from neural activation pattern?</td>
<td>EEG</td>
<td>The subjects watched different commercials and were asked which single scenes they remembered.</td>
<td>Scenes that evoked a fast response in the left hemisphere were better remembered.</td>
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| Schaefer et al., 2006 | Brand research | What are the neural correlates of brand knowledge?                       | fMRI   | The researchers presented subjects cultural familiar and cultural unfamiliar logos of car manufactures and asked them to imagine themselves driving the car | $n = 13$ | - Significant activations in the MPFC were found, when the subjects were exposed to familiar brand information → confirmation of the importance of this brain region for the processing of culturally based brands  
- Brands might function as subconscious presentiments that influence the decision-making process, before the participants even started thinking about advantages and disadvantages of the cars |
| Yoon et al., 2006 | Brand research | Do persons build up a connection to a brand that resembles a social relationship? | fMRI   | Participants were scanned while making judgments about whether a trait adjective described a target cue (products and persons) | $n = 25$ | Characterization of persons leads to a stronger activation in the MPFC in comparison to the characterization of brands  
For the evaluation of product attributes a stronger activation in object related brain areas was measured → the concept of ‘brand personality’ has to be revised because it is not possible to transfer humanlike attributes to brands in an unlimited way |
partly be applied in order to predict purchasing behavior. Knutson et al. (2007) supported these findings: results from their study provided evidence that activation of the nucleus accumbens correlates with individual product preferences and that activation in this area during product presentation may at least partly predict subsequent purchasing decision.

**Price policy**

Price policy is a central concept in marketing because it constitutes a basic influencing factor of the company’s sales result and profits (Rao, 1984; Pasternack, 1985; Gabor and Granger, 1979; Lichtenstein et al., 1993). Particularly in saturated markets, this marketing-mix instrument has gained greater importance. A very interesting phenomenon often observed in price policy is that a similar price level can be perceived by the buyer in two different ways, depending on diverse product categories. On the one hand, high prices can deter customers from buying a product because those prices are perceived as a loss. On the other hand, high prices can be seen as an indicator for high quality, and can enhance the product value and the probability that the customers will buy the goods (Lichtenstein et al., 1993; Völckner, 2007). This holds particularly true when customers have uncertainty about buying a product, because they are not familiar with it, yet. However, asking consumers about pricing issues can sometimes be ineffective. For instance, consumers are often not able to recall prices (Vanhuele and Drèze, 2002; Evanschitzky et al., 2004), and it is very difficult for them to specify abstract economic concepts like the “willingness to pay” or experienced utility. In addition, they might respond strategically when asked about constructs like price fairness.

Against this background, Knutson et al. (2007) examined the neural correlates of the negative price effect. While lying in the fMRI scanner, subjects had to solve an exercise in which they first saw a product, and then saw the same paper with its corresponding price information. In the end they had to decide whether or not to buy the product. The results resembled those of studies examining the neural correlates of anticipation and the receipt of gains (Breiter et al., 2001; Knutson and Peterson, 2005) and losses (Sanfey et al., 2003). Hence, the activation of the nucleus accumbens (activation through the anticipation of gains) correlates with product preferences, the activation of the insula (activation through the anticipation of losses) with high prices, and the activation of the medial prefrontal cortex (activation through the processing of gains and losses) with reduced prices. This result supports the speculation that activity changes in the insula might reflect the perception of a loss and, thus, the neural representation of a negative price effect. In the future this information can be important, for example, in the identification of price limits.

A more recent study from Plassmann et al. (2008) examined the opposite positive skewing impact of price setting on the evaluation of a specific product. In their fMRI experiment, subjects consumed wine that was presented with explicit price information. The results showed, among other things, that the persons not only evaluated the more expensive wine as being better, but also that the neural activation — in the medial prefrontal cortex and in the rostral anterior cingulate cortex — indicated significant activation differences in relation to higher price information. Based on these results, Plassmann et al. (2008) assumed that the experienced utility of a product is not only dependent on intrinsic aspects such as the composition of the wine or thirst, but it is also impacted by other adjustable factors within the frame of marketing-mix instruments such as price setting.

Another important issue in price policy is the high degree of wasted opportunities for customization. It can be very profitable for firms with heterogeneous customer segments to charge individual prices according to the value that different customers place on a product. For the adjustment of prices at the right level, it is necessary to know how people compute their individual “willingness to pay”
— the maximum price that a buyer is willing to pay for a specific object (Simon and Dolan, 1998). As mentioned above, the determination of this abstract concept is very difficult with existing research methods. Recently, in an fMRI study from Plassmann et al. (2007d), hungry subjects were scanned while different edibles were presented. The task was to propose a specific amount of money that suited the subject’s personal “willingness to pay.” The data showed that the medial prefrontal cortex is likely to play an active role in computing the maximal acceptable price. The dorsolateral prefrontal cortex codes the final decision and seems to be essential for the motor signal (e.g., the push of a button, or buying).

Communication policy

Besides products and prices, communication plays an increasingly decisive role in marketing. In the future, one important challenge for this marketing-mix instrument is the psychological differentiation of brands (Milgrom and Roberts, 1986; Meenaghan, 1995). We assume that, especially within communication policy, consumer neuroscience can help to bridge the existing lack of theory (Pitt et al., 2005). The question of how the brain processes and stores advertising stimuli may have essential importance.

Regarding the short-term processing of advertisements, two studies by Kenning et al. (2007b) and Plassmann et al. (2007c) dealt with the neural correlates of attractive advertisements. Brain activity of subjects was measured by an fMRI scanner while they rated different advertisements according to their attractiveness. The data showed that an advertisement that was rated as attractive led to activation in brain areas associated with the integration of emotions in the decision-making process (ventromedial prefrontal cortex) and the perception of rewards (ventral striatum/nucleus accumbens). Kenning et al. (2007b) concluded from these results that attractive ads can act as a rewarding stimulus. In addition, the studies revealed that positive facial expressions are an essential component of attractive advertisements. A possible explanation for this is provided by Aharon et al. (2001), who showed that beautiful female faces led to the activation of reward-related areas in the brains of heterosexual males. Future studies may provide further information about the effect of typical ad stimuli such as the schemes of childlike characteristics or puppies.

Referring to the long-term memorization of brand information, two exploratory experiments conducted by Ambler and Burne (1999) and Ambler et al. (2000) showed that an advertisement is remembered better if it is connected with emotional images, in comparison to use of exclusively rational arguments. In a preliminary pharmacological study (Ambler and Burne, 1999), β-blockers (propranolol) and placebos were randomly dispensed to the participants, who were than asked to watch brand advertising. β-blockers are defined as a class of drugs that block specific receptors and hence inhibit the effect of certain stress hormones (www.texasheartinstitute.org, 4.3.2008). Ambler and Burne (1999) used this class of medication because it is noted to reduce affective responses to stimuli, which would enhance their goal of examining the effect of emotions on the recall and recognition of advertising. Results showed that the suppression of emotions due to the pharmacological treatment had an effect on recall and recognition of ads. The placebo and control group that did not receive β-blockers showed a higher recall and recognition rate of affective ads, in comparison to cognitive ads. In contrast, subjects from the β-blocker group did not show similar effects. The participants treated pharmacologically, in fact, remembered the cognitive ads better than the emotional ads. Within the main experiment, Ambler et al. (2000) applied magnetoencephalography (MEG) to prove that cognitive pictures cause a stronger activation in posterior parietal areas and in the superior prefrontal cortex, which may be traced to a more intense use of working memory. After
presenting the more affective images, a significant activation was observable in the areas of ventromedial prefrontal and orbitofrontal cortex, as well as in the amygdala and the brain stem.

**Distribution policy**

The distribution policy comprises all decisions concerning the optimal distribution of goods between manufacturer and retailer. The optimal distribution of products can have a prominent influence on the buying decisions of customers (Ailawadi and Keller, 2004; Kotler and Keller, 2006). Therefore, a central aspect of this important marketing-mix instrument is the choice of product- and brand-adequate marketing channels, in order to define the optimal frame for the presentation of a brand (Pasternack, 1985; Eliashberg and Steinberg, 1987; Choi, 1991; Lee and Staelin, 1997). In two similarly constructed studies, Deppe et al. (2005a, 2007) examined the neural correlates of this “framing effect.” A main finding of their investigations was that the medial prefrontal cortex and the anterior cingulate cortex, in particular, play a central role for the integration of implicit framing information, for example, the importance of emotions and unconscious memories in the decision-making process.

In a similar vein, Plassmann et al. (2007b) identified the neural correlates of retail brand loyalty. In their fMRI study, subjects had to choose between retail brands from which they would prefer to buy an identical garment. With the help of previously collected information about the buying behavior of the subjects, the researchers were able to identify the favorite retail brand of the participants. Furthermore, a division into two groups was possible, and was made according to the previous average buying behavior of the subjects. Group A spent a minimum of 250€ on five or more shopping days per month at a certain retailer (so-called “loyal customers”), Group C spent a maximum of 50€ and had only one shopping day per month at the same retailer (so-called “disloyal customers”). The analysis of the data showed that loyal customers integrate emotions into the decision-making process in a more intense way (activation in the ventromedial prefrontal cortex), and that the favorite brand can act as a behaviorally relevant rewarding stimulus. In contrast, this activation was not measurable for disloyal participants. Plassmann et al. (2007b) concluded from their results that the use of emotional reinforcers in marketing can constitute the base for long-term customer retention. Through a learning process, positive experiences are combined with the retail brand, then stored in the memory of the customer and recalled for buying decisions.

**Brand research**

The field of brand research is concerned with examining the important influence of brand information on decision-making (Ailawadi and Keller, 2004). One central topic of brand research is whether or not consumer decisions are influenced by brand information. Deppe et al. (2005b) addressed this question in a study designed to determine which neural processes are involved in the brain during the processing of brand information. In their fMRI study, subjects had to make fictitious buying decisions between two very similar products that were differentiated only by brand information. In one part of the study, subjects had to choose between the brand with the greatest market share — which had been declared as the target (“T”) brand in the preliminary phase — and diverse (“D”) brands (TD decisions). In the next part of the study, they had to decide between two diverse brands (DD decisions). The data analysis showed a significant difference in brain activity between TD and DD decisions, if the subjects had declared the target brand as their preferred brand (first choice brand, FCB group) in the pretest phase. A closer look into the brain activities of the FCB group showed a reduced activity in the dorsolateral prefrontal cortex, left premotor area, posterior parietal, and occipital cortices — areas that are generally associated with...
working memory, planning, and logic decisions. Deppe et al. (2005b) assumed that for decisions comprising the favorite brand of the consumer, strategic processes are no longer as relevant. The responsible brain region is deactivated and a “cortical release” occurs (Kenning et al., 2002). In contrast, an increased activity was measured in the ventromedial prefrontal cortex, the inferior precentral, and the posterior cingulate cortex. These areas operate as association cortices and have important functions in combining incoming information with background knowledge, the recall of episodic memories, and self-reflection. The increased activation in the ventromedial prefrontal cortex during decisions in the FCB group could be interpreted as integration of emotions into the decision-making process (Bechara and Damasio, 2005). Thus, the results revealed a so-called “winner-take-all” effect: only the favorite brand of the subject is able to emotionalize the decision-making process. This finding is crucial for marketing research because it is contrary to the well-established consideration-set concept. Whereas the consideration-set theory assumes that there is set of goal-satisfying alternatives (Shocker et al., 1991), the results of Deppe et al. (2005b) provide evidence that only the favorite brand is able to trigger significant cortical activation pattern. Intriguingly, a lesion study conducted by Koenigs and Tanel (2007) confirmed the suggestions of Deppe et al. (2005b). Persons with damage within the ventromedial prefrontal cortex that exhibit irregularities in emotional processing did not show the normal preference bias when exposed to brand information.

Plassmann et al. (2005) provided additional support for the investigated “first choice brand effect.” Their study aimed to explain the influence of brand information within uncertain situations, by investigating the role of the prefrontal cortex during decision-making under risk. The subjects participated in a brand choice task where they had to choose between sixteen travel brands, for travel to a risky and a less risky destination. In addition to the “first choice brand effect,” the data analysis exhibited a more prominent activation of the medial prefrontal cortex when the subject faced risky decisions. Plassmann et al. (2005) reasoned that the integration of emotions in the decision-making process, as opposed to analytical decision strategies, is of particular importance in risky decision-making. One potential reason for this might be that emotions could provide additional conscious or unconscious information.

Analogous to the studies mentioned, Schaefer et al. (2006) confirmed the reported importance of the medial prefrontal cortex for decision-making influenced by brand information (Plassmann et al., 2005; Deppe et al., 2005b). Schaefer et al. (2006) presented their subjects with culturally familiar and unfamiliar logos of automobile manufacturers, and asked them to imagine themselves driving the car. If they did not know the car manufacturer, participants were instructed to imagine a generic car. Interestingly, Schaefer et al. (2006) found significant activity changes in the medial prefrontal cortex when the subjects were exposed to familiar brand information, a result that confirms the importance of this brain region for the processing of culturally based brands. Because the medial prefrontal cortex is often associated with self-reflection and self-relevant information processing, Schaefer et al. (2006) concluded that the imagination of driving a familiar car led to self-relevant thoughts. Furthermore, the results suggested that brands might function as subconscious presentiments that influenced the decision-making process even before the participants began thinking about advantages and disadvantages of the cars. This suggestion is supported, to some degree, by Deppe et al. (2007) and their investigations of the neural processing of magazine brands.

Another abstract and implemented concept within the framework of brand research is “brand personality” (Aaker, 1997). Advertising often applies this construct by using product descriptions that correspond to humanlike traits (e.g., Henkel: “a brand like a friend”). For example, it is possible to describe both a friend and a car as “reliable.” Yoon et al. (2006) examined the concept of “brand personality”
by addressing the question of whether the brain processes semantic judgments about objects and persons in different ways. Their data analysis revealed that the characterization of persons leads to a stronger activation in the medial prefrontal cortex, compared to the characterization of brands. For the evaluation of product attributes, a stronger activation in object-related brain areas, such as the left inferior prefrontal cortex, was measured. These results might be crucial for marketing research and brand management, as they support a conclusion that it is not possible to transfer human-like attributes to brands in an unlimited way. This observation is also supported by the phenomenon that subjects reveal higher rates of missing values when the "brand personality" scales are applied to unfamiliar brands.

Prominent brain structures for consumer neuroscience

The discussed studies show that consumer neuroscience has already localized important brain structures associated with the processing of products, prices, advertisements, and (retail) brands. However, it is crucial to use caution for the interpretation of neural activation patterns, because the activation of a specific area can mean different things depending on the context (Sanfey, 2007). Accordingly, one aim of this paper is to enable consumer researchers to better understand the functionality of the brain. To achieve this goal, the following summary of the discussed brain structures is organized as follows. First, the construct of interest is described. Next, the delineation of marketing stimuli that can affect this variable is detailed, followed by a brief depiction of the brain structures associated with the construct of interest.

Reward

The encoding of rewards as stimuli that positively reinforce behavior is dependent on learned expectations, context, time dimensions, and reward amplitude (McClure et al., 2004b). Brain structures that are involved in processing rewards are often summarized by the term "reward system." This complex network of different brain areas plays an important role for the understanding of consumer behavior. By evaluating the stimulus value and by predicting when a certain stimuli will occur, the reward system seems to be concerned with seeking out rewards and evading punishments (O'Doherty, 2004). In general, the reward system is seen as a complex evaluation system that drives particularly goal-directed behavior and corresponds to a closely linked network of different brain structures with various functions such as the ventral striatum/nucleus accumbens, the orbitofrontal cortex, and the amygdala (McClure et al., 2004b; Sanfey, 2007). Recent findings show that the reward system can be activated not only by primary rewards such as food, water, and sexual stimuli, but also through attractive advertisement (Kenning et al., 2007b), price reductions (Knutson et al., 2007), beautiful faces (Aharon et al., 2001), or status symbols such as sports cars (Erk et al., 2002). The reward system also seems to be involved in the development of product preferences and brand loyalty (Plassmann et al., 2007b).

The nucleus accumbens, a component of the ventral striatum, belongs to the mesolimbic dopamine system that is often associated with the pursuit of pleasure. Erk et al. (2002) and Knutson et al. (2007) point out that the nucleus accumbens is involved in the formation of product preferences, because its activity scales with the evaluation of a stimulus. Therefore, recent findings often connect the nucleus accumbens with the anticipation and prediction of rewards (McClure et al., 2004b; Sanfey, 2007; Plassmann et al., 2007b).

The evaluation of the rewarding aspects of incoming stimuli is primarily assigned to the orbitofrontal cortex (O'Doherty, 2004). The studies conducted by Erk et al. (2002) and Ambler et al. (2000) demonstrate the importance of the orbitofrontal cortex for the
evaluation of incoming stimuli such as attractive cars or emotional ads. Due to its close connection with numerous brain structures and its capability to memorize the reward value of sensory stimuli, the orbitofrontal cortex might play an important role for the processing of rewards and the emergence of behavior (O’Doherty, 2004; McClure et al., 2004b).

Another important structure of the reward system might be the amygdala. In contrast to the orbitofrontal cortex, which seems to encode for the valence of a stimulus, the activation of the amygdala may indicate the perceived strength of arousal of an incoming stimulus (McClure et al., 2004b).

### Punishment

An additional issue of interest is the encoding of punishment in the human brain. Punishing stimuli are defined as incentives that lead to avoidance behavior, in the sense that people expend energy in order to evade them (Seymore et al., 2007). Primary stimuli that induce punishment are, for example, physical pain, aversive odors/tastes, or disgust.

Recent studies from consumer neuroscience and neuroeconomics discovered that these neural mechanisms can also be activated by relevant economic stimuli such as the perception of unfair offers, monetary losses, and high prices (Sanfey et al., 2003; Knutson et al., 2007).

Brain structures involved in the processing of punishment are, among others, the orbitofrontal cortex, the amygdala, and the insula cortex. Although their functions are not fully understood, these areas seem to correspond to the reward system, and it is not possible to accurately delineate the reward and the punishment system. For example, the orbitofrontal cortex not only encodes the rewarding value but also the negative value of an incoming stimulus. Another example for an area that seems to be involved in both systems is the amygdala, because aversive stimuli can lead to activation in this area as well. In fact, earlier studies predominantly associated the amygdala with the perception of fear or negative emotions (McClure et al., 2004b).

Today, it is assumed that both rewarding and aversive stimuli can lead to an activation of the amygdala, depending on the strength of arousal and the intensity of a stimulus (O’Doherty, 2004; McClure et al., 2004b).

A structure that is primarily associated with the processing of aversive stimuli is the insula cortex. Again, its functions are to a large extent still unexplored, but the insula cortex seems to be involved in the anticipation of losses (e.g., processing of high prices; Knutson et al., 2007) and the perception of unfair offers (Sanfey et al., 2003).

### Decision-making

Decision-making can be described as the evaluation of a situation and the choice of an appropriate action. For consumer research, the understanding of this decision-making process is very important, because consumers have to make specific decisions, for example, for a brand, in almost every shopping situation. Even though a strict distinction of the different mechanisms behind the decision-making process is not possible, there are three crucial aspects for a certain choice: the evaluation of an incoming stimulus, rational consideration, and the emotional component (Bechara and Damasio, 2005).

The prefrontal cortex is a very important brain structure linked to decision-making (Ridderinkhof et al., 2004). In addition to its interaction with emotional structures in the rewarding/punishment system, this brain area plays a key role in consumer decision-making (Wood and Grafman, 2003; Bechara and Damasio, 2005). The prefrontal cortex can be divided into three parts that appear to fulfill different functions: the orbitofrontal cortex, the ventromedial cortex, and the dorsolateral cortex.

As already mentioned above, the orbitofrontal cortex is closely connected to the reward/punishment system and is often associated with the evaluation of an incoming stimulus.
The dorsolateral part of the prefrontal cortex is primarily involved in cognitive actions. Interestingly, its activation can be reduced if consumers have to make decisions that comprise their favorite brand (Deppe et al., 2005b). On the other hand, the dorsolateral prefrontal cortex is very important for rational decision-making such as estimating the “willingness to pay” (Plassmann et al., 2007d). The ventromedial part of the prefrontal cortex might be crucial for the integration of emotions in the decision-making process, due to its close connection to the amygdala and the hippocampus (Wood and Grafman, 2003). The studies of Ambler et al. (2000), Deppe et al. (Deppe et al., 2005a,b), Kenning et al. (2007b), and Plassmann et al. (2007b) indicate that the ventromedial prefrontal cortex is not only associated with the processing of attractive and affective images, but that it is also relevant for building up product preferences and brand loyalty. Furthermore, activation in the ventromedial prefrontal cortex can be an indicator of how easily people are influenced by brand information, and thus can be interpreted as the individual “framing effect.” Interestingly, brain damage in this area leads to less susceptibility to brands (Koenigs and Tranel, 2007).

Conclusion

By giving a general overview of the current state of consumer neuroscience, the aim of this paper was to show that a wide spectrum of the traditional marketing-mix components and brand research is already being investigated in this new research area. Key contributions were to make a first move toward defining neuromarketing as an applied science, and to highlight the importance of consumer neuroscience as a more objective measure of individual responses to marketing stimuli.

The application of methods from brain research to marketing relevant problems has already yielded several theoretical implications. First, as discussed in the introduction, the neuroscientific measurement approach can lead to more objective results, and the researchers hope to gain specific new insights into unconscious and automatic processes that influence human behavior. Second, neuroeconomics and consumer neuroscience emerged from the consolidation of economics and neuroscience. This transdisciplinary approach may assist both disciplines to gain innovative perspectives and to generate new ideas. From this, it follows that consumer neuroscience can confirm, reconfigure, or improve conventional theories of marketing theory (Fugate, 2007). In this regard, one important contribution of consumer neuroscience is the emphasis on emotions and their influence on consumer decision-making. Consumers are no longer considered as completely rational, because emotions, unconscious and automatic processes, play a central role in generating behavior (Bechara and Damasio, 2005; Camerer et al., 2005). The strict distinction between marketing-mix instruments is another example that can be derived from the studies presented. The studies on “framing effect” (Deppe et al., 2005a, 2007) yield important insights not only for distribution policy, but also for communication policy. In fact, there is a strong interaction between the classical marketing-mix instruments because the consumer perceives all elements simultaneously (Plassmann et al., 2008). Therefore, a possible implication could be a new conceptualization of this approach.

However, consumer neuroscience is still in the fledgling stages, and current investigations have been mostly targeted to basic research. For that reason, to date, the direct practical recommendations must be derived from the new findings very carefully (Plassmann et al., 2007a). Nevertheless, in the next years a concrete deduction of practical implications will be very likely. In order to achieve short-term operative optimization goals, consumer neuroscience could, for example, examine whether a variation of the brand is reasonable, or how the communication between consumer and company can be improved. With regard to long-term product strategy, consumer neuroscience could be used to determine which consumer segments are reached by
advertisement strategies, or whether a future purchase of the brand is probable. Another possible field of application is the determination of the market potential for a new product or for discontinued products. The new techniques offered by the emerging field could address the questions associated with the potential profitability of revitalization of a discontinued brand (Kenning et al., 2002; Braeutigam, 2005). With respect to current regulatory policies such as competition law, the findings of consumer neuroscience can help to improve existing practices, which were previously based on erroneous theoretical assumptions, such as the consumer making a buying decision on a rational basis (Chorvat et al., 2004).

As the ultimate buying decision-makers, consumers can profit from the findings of consumer neuroscience as well, by being presented with products that they actually desire. Moreover, consumers will learn to better understand their own behaviors. From an ethical point of view, neuromarketing is often associated with the abuse of neuroscientific methodologies, as a means to ‘read’ consumers’ minds and to manipulate their thoughts and behaviors. At present, such concerns are arbitrary, because the technologies are still very imprecise and investigating the brain activations does not necessarily yield an understanding of how the brain works (Fugate, 2007). Another way that consumer neuroscience can benefit the consumer is, for example, to investigate the neural correlates of shopping addiction. It could be hypothesized that people suffering from shopping addiction show irregularities in executive regions (e.g., prefrontal cortex) or in areas associated with the perception of losses (e.g., insula; Knutson et al., 2007). Thus, they might experience only the rewarding feeling and are not able to control themselves. Even though investigations by Bijou et al. (2004) that explore the connection of prefrontal dysfunction and credit card use do not support this assumption, further investigations may help people control their buying habits, and may help consumers in general to protect themselves from their own emotions in the buying process. In order to prevent the risk that neuromarketing intervenes in personal privacy to an unacceptable degree (The Lancet, 2004), institutions and neuroethical conferences are already discussing the need for the responsible use of the new techniques and the associated findings.

As with any new approach, consumer neuroscience must face the challenge of some limitations. For example, the studies are very cost and time intensive, and are associated with legal and moral considerations. As mentioned above, the outcome of experiments to date needs to be further validated and expanded, because of the complex data analysis required, the relatively small number of existing studies, and the relatively simple experimental setting that is necessary for conducting brain imaging studies (Plassmann et al., 2007a). Even though the technical methods are steadily improving, they still only offer a relatively indirect measurement of cortical activity changes, due to limitations in temporal and spatial resolution. Beyond this, all results provided by consumer neuroscience rely on the assumption that the measured activation is not the result of only noise or systematic errors, that a correct spatial and temporal assignment of measured quantities is possible, and that the supposition about typical functions of certain brain areas is valid in the actual case as well. Furthermore, it is presumed that the stimulus under investigation and no confounder leads to the cortical response of the participating subject (Kenning and Plassmann, 2005).

Another limitation could be the validity of the studies, which is often called into question. Due to high costs, the number of the participating subjects is usually very low and a small sample size may include the possibility of false positives and a higher probability of committing a type II error (Tversky and Kahneman, 1971). However, an argument for the validity of the results could be that several researchers of different nationalities, applying various experimental settings to investigate marketing relevant questions with the help of brain research methods, have arrived at very similar
results concerning the specific brain activation (Ambler et al., 2000; McClure et al., 2004a; Koenigs and Tranel, 2007; Kenning et al., 2007b; Plassmann et al., 2007a). On the other hand, the described robustness of the neuroeconomic findings may also constitute a counter-argument for the validity. For example, we know that there are both semantic and phenomenological variations between different brands, but the brain seems to process them in a very similar way, as can be deduced by observing the specific activation pattern with fMRI. Thus, it could be possible that the research method is still too inaccurate to measure small variations in brain activation.

With this paper we hope to rectify the sometimes over-simplified assumption that consumer neuroscience is focused on a search for the “holy grail” of marketing, the “buy button” in the brain. Our evidence shows that there is no possibility of such a result. Furthermore, though the application of neurological methods in the area of marketing research has already yielded relevant findings in both theory and practice (Plassmann et al., 2007a), because of the complex data analysis required and the relatively small number of existing studies, the outcome of experiments to date needs to be further validated and expanded (Cacioppo et al., 2003; Kenning and Plassmann, 2005). Nevertheless, by observing the brain — the organ of (buying) decisions — one of the most fascinating objects of research is now spotlighted by marketing research.

Biographical notes

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