Journal of Consumer Behaviour
J. Consumer Behav. **7**: 272–292 (2008)
Published online in Wiley InterScience
(www.interscience.wiley.com) **DOI:** 10.1002/cb.251

A current overview of consumer neuroscience

Mirja Hubert*,† and Peter Kenning†
Zeppelin University, Am Seemooser Horn 20, 88045 Friedrichshafen, Germany

- *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.*

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

*Correspondence to: Mirja Hubert, Zeppelin University, Am Seemooser Horn 20, 88045 Friedrichshafen, Germany.
E-mail: mirja.hubert@zeppelin-university.de
†Chair of Marketing.

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).

DOI: 10.1002/cb

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

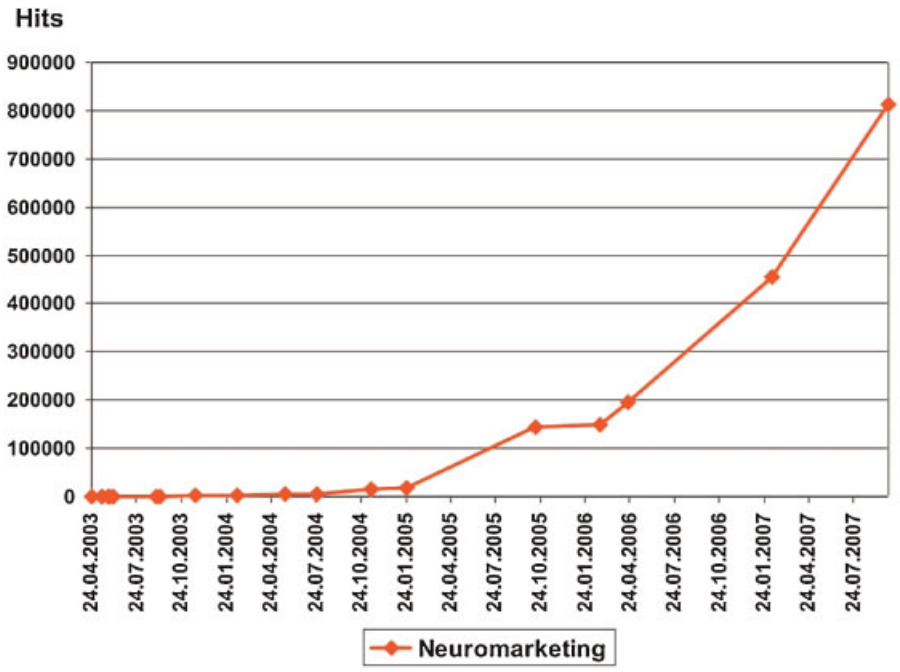

Figure 1. Development of google hits on neuromarketing 2003–2007.

DOI: 10.1002/cb

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

DOI: 10.1002/cb

Table 1. Overview of selected studies in alphabetical order

Study	Subject	Problem	Method	Experimental set-up	*N*	Results
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 brain stem → processing of emotional stimuli
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

DOI: 10.1002/cb

Deppe *et al.*, 2007	Distribution policy	What influence does the "framing effect" have on neural activation in case of intuitive decisions?	fMRI	Evaluation of the attractiveness of print ads 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 anterior cingulate cortex was measured → evaluation of the relevance of the framing stimulus
Erk *et al.*, 2002	Product policy	Is there a neural representation of product attractiveness?	fMRI	Ranking of attractiveness of sports cars, limousines, and small cars with scanner and questionnaire	$n = 12$	Products that symbolize wealth and prestige lead to a higher activation in areas that are associated with the perception of rewards
Kenning *et al.*, 2007b	Communication policy	Can the perceived attractiveness of an advertisement be associated with specific neural activations?	fMRI	The subjects had to evaluate different advertisements by their attractiveness while their brain activity was measured	$n = 22$	Attractive ads lead to a stronger activation in - The VMPFC → integration of emotions in the decision-making process - Nucleus accumbens → attractive ads can work as reward stimulus
Knutson *et al.*, 2007	Price policy	Which impact does the price have on product preferences and neural activity?	fMRI	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	$n = 26$	- Activation in the nucleus accumbens correlates with product preferences - The activation of the insula cortex is evoked by high prices - The medial prefrontal cortex (MPFC) reacts to reduced prices → prices can be perceived differently and can evoke different neural reactions.

(Continues)

DOI: 10.1002/cb

Table 1. (Continued)

Study	Subject	Problem	Method	Experimental set-up	*N*	Results
Koenigs and Tranel, 2007	Brand research	Is it possible to receive the same results as McClure *et al.* 2004a, through the observation of people with lesions in the MPFC?	Lesion-study	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	Groups 1. $n = 16$ 2. $n = 16$ 3. $n = 12$	The results from McClure *et al.* 2004a could be validated: - Only persons with lesions in the VMPFC did not show preference bias when exposed to brand information - The other groups were susceptible to brand information - The results show that the VMPFC seem to play a key role in developing brand preferences
McClure *et al.*, 2004a	Brand research	What effect does brand information have on the sensory perception of similar products (Coca Cola/Pepsi)?	fMRI	Anonymous and semi-anonymous taste tests of Coca Cola and Pepsi inside and outside the scanner	$n = 67$	- 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
Plassmann *et al.*, 2005	Brand research	What are the neural correlates of brand choice under risk?	fMRI	Subjects participated in a brand choice task where they had to choose between 16 travel brands to a risky and a less risky destination	$n = 15$	- "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

DOI: 10.1002/cb

Plassmann *et al.*, 2007b	Distribution policy	What are the neural correlates of brand loyalty?	fMRI	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	$n = 22$	- Loyal customers probably integrate emotions more intensively in the decision-making process - For loyal customers the favorite brand can be a rewarding stimulus
Plassmann *et al.*, 2007d	Price policy	Is there a neural correlate for the individual willingness to pay?	fMRI	They presented hungry subjects food, while measuring their brain activity. The participants had to evaluate their individual willingness to pay	$n = 19$	- 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)
Plassmann *et al.*, 2007e	Price policy	Is a high price able to change the experienced utility and the corresponding neural activity?	fMRI	The subjects tasted different kinds of wine with the explicit price information, while their brain activity was measured	$n = 20$	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
Rossiter and Silberstein, 2001	Communication policy	Is it possible to derive how well ads are remembered from neural activation pattern?	EEG	The subjects watched different commercials and were asked which single scenes they remembered	$n = 35$	Scenes that evoked a fast response in the left hemisphere were better remembered

(Continues)

DOI: 10.1002/cb

Table 1. (Continued)

Study	Subject	Problem	Method	Experimental set-up	*N*	Results
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

DOI: 10.1002/cb

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''

DOI: 10.1002/cb

— 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

DOI: 10.1002/cb

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

DOI: 10.1002/cb

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 precuneus, 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 Tranel (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 biases 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 degreed, 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''

DOI: 10.1002/cb

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

DOI: 10.1002/cb

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.

DOI: 10.1002/cb

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

DOI: 10.1002/cb

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 neuroethic 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

DOI: 10.1002/cb

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 counterargument 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

Mirja Hubert completed undergraduate studies in business at Humboldt-University, Berlin, majoring in Marketing and International Management. Since September 2007, she is a Research Assistant to Professor Peter Kenning at Zeppelin University, Friedrichshafen, Germany.

Peter H. Kenning is a Professor of Marketing at Zeppelin University, Germany. His primary research interests are consumer behavior, consumer neuroscience, neuroeconomics, and marketing management. His work has been widely published, for example, in *International Journal of Advertising*, *Management Decisions*, *Journal of Product and Brand Management*, *Advances in Consumer Research*, *Journal of Neuroimaging*, *NeuroReport*, and *Brain Research Bulletin*. He has presented papers at numerous conferences including AMA-Conference EMAC, and ACR. For his work he received several best paper awards and grants.

References

Aaker JL. 1997. Dimensions of brand personality. *Journal of Marketing Research* **34**(3): 347–356.

Aharon I, Etcoff N, Ariely D, Chabris C, O'Connor E, Breiter H. 2001. Beautiful faces have variable reward value-fMRI and behavioral evidence. *Neuron* **32**(3): 537–551.

Ailawadi KL, Keller KL. 2004. Understanding retail branding: conceptual insights and research priorities. *Journal of Retailing* **80**(4): 331–342.

Ambler T, Burne T. 1999. The impact of affect on memory of advertising. *Journal of Advertising Research* **39**(2): 25–34.

Ambler T, Ioannides A, Rose S. 2000. Brands on the brain: neuro-images of advertising. *Business Strategy Review* **11**(3): 17–30.

Anderson EW, Fornell C, Lehmann DR. 1994. Customer satisfaction, market share, and profitability: findings from Sweden. *Journal of Marketing* **58**(3): 53–66.

Bagozzi RP. 1991. The role of psychophysiology in consumer research. In *Handbook of Consumer Behavior*, Robertson TS, Kassarjian HH (eds). Prentice-Hall: Englewood Cliffs, NY; 124–161.

Bailetti AJ, Litva PF. 1995. Integrating customer requirements into product designs. *Journal of Product Innovation Management* **12**(1): 3–15.

Bechara A, Damasio AR. 2005. The somatic marker hypothesis: a neural theory of economic decision. *Games and Economic Behavior* **52**: 336–372.

Bechara A, Damasio H, Damasio AR. 2000. Emotion, decision making and the orbitofrontal cortex. *Cerebral Cortex* **10**: 295–307.

Bijou Y, Spinella M, Lester D. 2004. Credit card use and prefrontal cortex dysfunction: a study in neuroeconomics. *Psychological Reports* **94**(3): 1267–1268.

DOI: 10.1002/cb

Blakeslee S. 2004. If you have a ''Buy Button'' in your brain, what pushes it? *New York Times* **154**: 5.

Bloch PH. 1995. Seeking the ideal form: product design and consumer response. *Journal of Marketing* **59**(3): 16–29.

Braeutigam S. 2005. Neuroeconomics—from neural systems to economic behavior. *Brain Research Bulletin* **67**: 355–360.

Breiter H, Aharon I, Kahneman D, Dale A, Shizgal P. 2001. Functional imaging of neural responses to expectancy and experience of monetary gains and losses. *Neuron* **30**: 619–639.

Cacioppo JT, Berntson GG, Lorig TS, Norris CJ, Rickett E, Nusbaum H. 2003. Just because you're imaging the brain doesn't mean you can stop using your head: a primer and set of first principles. *Journal of Personality and Social Psychology* **85**(4): 650–661.

Camerer C, Loewenstein G, Prelec D. 2005. Neuroeconomics: how neuroscience can inform economics. *Journal of Economic Literature* **43**: 9–64.

Choi SC. 1991. Price competition in a channel structure with a common retailer. *Marketing Science* **10**(4): 271–296.

Chorvat TR, McCabe K, Smith V. 2004. Law and neuroeconomics, George Mason Law and Economics Research Paper.

Constantinides E. 2006. The marketing mix revisted: towards the 21st century marketing. *Journal of Marketing Management* **22**: 407–438.

Cooper RG. 1979. The dimensions of industrial new product success and failure. *Journal of Marketing* **43**(3): 93–103.

Deppe M, Schwindt W, Krämer J, Kugel H, Plassmann H, Kenning P, Ringelstein EB. 2005a. Evidence for a neural correlate of a framing effect: bias-specific activity in the ventromedial prefrontal cortex during credibility judgments. *Brain Research Bulletin* **67**: 413–421.

Deppe M, Schwindt W, Kugel H, Plassmann H, Kenning P. 2005b. Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision-making. *Journal of Neuroimaging* **15**: 171–182.

Deppe M, Schwindt W, Pieper A, Kugel H, Plassmann H, Kenning P, Deppe K, Ringelstein EB. 2007. Anterior cingulate reflects susceptibility to framing during attractiveness evaluation. *NeuroReport* **18**(11): 1119–11123.

Eliashberg J, Steinberg R. 1987. Marketing-production decisions in an industrial channel of distribution. *Management Science* **33**(8): 981–1000.

Erk S, Spitzer M, Wunderlich AP, Galley L, Walter H. 2002. Cultural objects modulate reward circuitry. *NeuroReport* **13**(18): 2499–2503.

Evanschitzky H, Kenning P, Vogel V. 2004. Consumer price knowledge in the German retail market. *Journal of Product and Brand Management* **13**(6): 390–405.

Fugate DL. 2007. Neuromarketing: a layman's look at neuroscience and its potential application to marketing practice. *Journal of Consumer Marketing* **24**(7): 385–394.

Gabor A, Granger CWJ. 1979. Price sensitivity of the consumer. *Management Decisions* **17**(8): 569–575.

Groeppel-Klein A. 2005. Arousal and consumer in-store behavior. *Brain Research Bulletin* **67**: 428–437.

Howard JA, Sheth JN. 1969. *The Theory of Buyer Behavior*. John Wiley & Sons: New York.

Kenning P, Plassmann H. 2005. NeuroEconomics: an overview from an economic perspective. *Brain Research Bulletin* **67**: 343–354.

Kenning P, Plassmann H, Ahlert D. 2007a. Applications of functional magnetic resonance imaging for market research. *Qualitative Market Research: An International Journal* **10**(2): 1352–2752.

Kenning P, Plassmann H, Deppe M, Kugel H, Schwindt W. 2002. The discovery of cortical relief. *Field of Research: Neuromarketing* **1**: 1–26.

Kenning P, Plassmann H, Kugel H, Schwindt W, Pieper A, Deppe M. 2007b. *Neural correlates of attractive ads, FOCUS-Jahrbuch 2007, Schwerpunkt: Neuroökonomie, Neuromarketing, Neuromarktforschung*, Koschnick WJ (ed.). FOCUS Magazin Verlag: Munich; 287–298.

Knutson B, Peterson R. 2005. Neurally reconstructing expected utility. *Games and Economic Behavior* **52**: 305–315.

Knutson B, Rick S, Wimmer GE, Prelec D, Loewenstein G. 2007. Neural predictors of purchase. *Neuron* **53**(1): 147–156.

Koenigs M, Tranel D. 2007. Prefrontal cortex damage abolishes brand-cued changes in cola preference. *Social Cognitive and Affective*

DOI: 10.1002/cb

Neuroscience Advance Access (published online on 18 September 2007): 1–6.

Kotler P, Keller KL. 2006. *Marketing Management*. Prentice-Hall International: New Jersey.

Lee E, Staelin R. 1997. Vertical strategy interaction: implications for channel pricing strategy. *Marketing Science* **16**(3): 185–207.

Lee N, Broderick AJ, Chamberlain L. 2007. What is ''neuromarketing''? A discussion and agenda for future research. *International Journal of Psychophysiology* **63**: 199–204.

Lichtenstein DR, Ridgway NM, Netemeyer RG. 1993. Price perceptions and consumer shopping behavior: a field study. *Journal of Marketing Research* **30**(2): 234–245.

McClure SM, Li J, Tomlin D, Cypert KS, Montague LM, Montague PR. 2004a. Neural correlates of behavioral preference for culturally familiar drinks. *Neuron* **44**: 379–387.

McClure SM, York MK, Montague PR. 2004b. The neural substrates of reward processing in humans: the modern role of fMRI. *The Neuroscientist* **10**(3): 260–268.

Meenaghan T. 1995. The role of advertising in brand image development. *Journal of Product and Brand Management* **4**(4): 23–34.

Milgrom P, Roberts J. 1986. Price advertising signals of product quality. *The Journal of Political Economy* **94**(4): 796–821.

O'Doherty JP. 2004. Reward representations and reward-related learning in the human brain: insights from neuroimaging. *Current Opinion in Neurobiology* **14**: 769–776.

Pasternack PA. 1985. Optimal pricing and return policies for perishable commodities. *Marketing Science* **4**(2): 166–176.

Pitt LF, Berthon P, Caruana A, Berthon J-P. 2005. The state of theory premier, advertising journals: a research note. *International Journal of Advertising* **24**(2): 241–291.

Plassmann H, Ambler T, Sven B, Kenning P. 2007a. What can advertisers learn from neuroscience? *International Journal of Advertising* **26**(2): 151–175.

Plassmann H, Kenning P, Ahlert D. 2007b. Why companies should make their customers happy: the neural correlates of costumer loyalty. *Advances in Consumer Research* **34**: 1–5.

Plassmann H, Kenning P, Pieper A, Schwindt W, Kugel H, Deppe M. 2007c. Neural correlates of ad liking. *Proceedings of the Society for Consumer Psychology Conference*, Las Vegas.

Plassmann H, Kenning P, Schwindt W, Kugel H, Deppe M. 2005. The role of the medial prefrontal cortex in risk modulated processing of brand information. *Poster presented on the OHBM-Annual Meeting 2005*, Toronto.

Plassmann H, O'Doherty J, Rangel A. 2007d. Orbitofrontal cortex encodes willingness to pay in everyday economic transactions. *The Journal of Neuroscience* **27**(37): 9984–9988.

Plassmann H, O'Doherty J, Shiv B, Rangel A. 2008. Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of National Academy of Sciences of the United State of America* **105**(3): 1050–1054.

Rao VR. 1984. Pricing research in marketing: the state of the art. *The Journal of Business* **57**(1): 39–60.

Ridderinkhof KR, Illsperger M, Crone EA, Niewenhuis S. 2004. The role of the medial frontal cortex in cognitive control. *Science* **306**: 443–447.

Rossiter JR, Silberstein RB. 2001. Brain-imaging detection of visual scene encoding in long-term memory for TV commercials. *Journal of Advertising Research* **41**: 13–21.

Sanfey AG. 2007. Social decision-making: insights from game theory and neuroscience. *Science* **318**: 598–602.

Sanfey AG, Loewenstein G, McClure SM, Cohen JD. 2006. Neuroeconomics: cross-currents in research on decision-making. *TRENDS in Cognitive Sciences* **10**: 108–116.

Sanfey AG, Rilling JK, Aronson JA, Nystrom LE, Cohen JD. 2003. The neural basis of economic decision-making in the ultimatum game. *Science* **300**: 1755–1758.

Schaefer M, Berens H, Heinze H-J, Rotte M. 2006. Neural correlates of culturally familiar brands of car manufactures. *NeuroImage* **31**: 861–865.

Selnes F. 1993. An examination of the effect of product performance on brand reputation, satisfaction and loyalty. *European Journal of Marketing* **27**(9): 19–35.

Seymore B, Singer T, Dolan R. 2007. The neurobiology of punishment. *Naturereviews Neuroscience* **8**: 300–311.

Shocker AD, Ben-Akiva M, Boccara B, Nedungadi P. 1991. Consideration set influences on consumer decision-making and choice: issues, models,

DOI: 10.1002/cb

and suggestions. *Marketing Letters* **2**(3): 181–197.

Simon H, Dolan RJ. 1998. Price Customization. *Marketing Management* **7**(3): 11–17.

Singer T, Fehr E. 2005. The neuroeconomics of mind reading and empathy. *The American Economic Review* **95**(2): 340–345.

The Lancet. 2004. *Neurology* **3**: 71.

The Texas Heart Institute Website: http://www.texasheartinstitute.org/HIC/Topics/Meds/betameds.cfm [4.3.2008].

Tversky AD, Kahneman, D. 1971. Belief in the law of small numbers. *Psychological Bulletin* **76**(2): 105–110.

Vanhuele M, Drèze X. 2002. Measuring the price knowledge shoppers bring to the store. *Journal of Marketing* **66**(4): 72–85.

Völckner F. 2007. The dual role of price: decomposing consumers' reactions to price. *Journal of the Academy of Marketing Science*, online publication date 25 September 2007.

Winer RS. 1986. A reference price model of brand choice for frequently purchased products. *Journal of Consumer Research* **13**: 250–256.

Wood JN, Grafman J. 2003. Human prefrontal cortex: processing and representational perspectives. *Nature Reviews* **4**: 139–147.

Yoon C, Gutchess AH, Feinberg F, Polk TA. 2006. A functional magnetic resonance imaging study of neural dissociations between brand and person judgments. *Journal of Consumer Research* **33**: 31–40.

Zaltman G. 2000. Consumer researchers: take a hike!. *Journal of Consumer Research* **26**(4): 423–428.

DOI: 10.1002/cb