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Consumer neuroscience: an overview of an emerging discipline with implications for consumer policy

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Abstract In recent years, interest in the integration and application of neuroscientific theories, concepts, findings and methods to the research discipline of consumer behavior has been increasing. The sub-discipline of consumer neuroscience that has resulted from that interest belongs to the innovative approach of neuroeconomics. Consumer neuroscience investigates problems of consumption and marketing through methods and findings from neuroscience. Conventional research in consumer behavior and marketing necessarily looked at the human organism as being a "black box" which cannot be assessed directly, or physiologically. This was a time when research mainly used theoretical constructs to interpret these bodily processes and resulting behavior. More recently, however, modern techniques and methods in neuroscience have facilitated a far more direct look into the "black box" of the organism as the basis for the sub-discipline of consumer neuroscience. Consumer neuroscience, therefore, can significantly benefit research in the field of consumer behavior, particularly in the attempt to better understand human behavior in decision-making processes. Although consumer neuroscience is a fledgling discipline, it constitutes a complementing advancement toward more comprehensive testing and expansion of theory. Against this background, the primary goal of the paper is to provide an overview of methods, findings, and implications of selected studies in consumer neuroscience. Furthermore, we integrate aspects of consumer policy and neuroethics, discussing the possible implications of these insights for consumer protection.

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Consumer Neuroscience – Überblick über einen neuen transdisziplinären Ansatz mit verbraucherpolitischen Implikationen

Zusammenfassung In den letzten Jahren konnte eine sich verstärkende Integration neurowissenschaftlicher Theorien, Konzepte, Erkenntnisse und Methoden in die Konsumentenverhaltensforschung beobachtet werden. Die damit angesprochene Consumer Neuroscience ist ein Teilgebiet der Neuroökonomik und untersucht konsum- und marketingrelevante Probleme mit Methoden und Erkenntnissen der Hirnforschung. Die klassische Konsumentenverhaltens- und Marketingforschung betrachtete den menschlichen Organismus notgedrungen als eine „Black-Box", in welche kein direkter Einblick möglich ist. Stattdessen nutzte man hauptsächlich theoretische Konstrukte, um latente Prozesse und die mit ihnen verbundenen Verhaltensweisen beschreiben und erklären zu können. Ein direkterer Blick in die „Black-Box" des Organismus wird nun mit Hilfe moderner Techniken und Methoden der Hirnforschung möglich, die auf dem Gebiet Consumer Neuroscience zum Einsatz kommen. Vor diesem Hintergrund werden in vorliegendem Beitrag ausgewählte Methoden und Ergebnisse aus dem Bereich Consumer Neuroscience vorgestellt. Abschließend

werden verbraucherpolitische und neuro-ethische Aspekte integriert und mögliche Implikationen dieser Erkenntnisse für die Verbraucherpolitik diskutiert.

1 Introduction

In recent years, interest in the integration and application of neuroscientific theories, concepts, findings and methods to the research discipline of consumer behavior has been increasing. The sub-discipline of consumer neuroscience that has resulted from that interest belongs to the innovative approach of neuroeconomics (Camerer et al. 2005; Braeutigam 2005; Fehr et al. 2005; Kenning and Plassmann 2005; Singer and Fehr 2005). Consumer neuroscience investigates problems of consumption and marketing through methods and findings from neuroscience (Lee et al. 2007; Fugate 2007). Classical research in consumer behavior and marketing necessarily looked at the human organism as being a "black box", which cannot be assessed directly, or physiologically. As a consequence research used mainly theoretical constructs to interpret these bodily processes and resulting behavior (Howard and Sheth 1969).

More recently, however, modern techniques and methods in neuroscience have facilitated a more direct look into the "black box" of the organism as the basis for the sub-discipline of consumer neuroscience (Kenning et al. 2007a). Although the use of neurobiological methods such as the electroencephalography (EEG) are not new in marketing research, the direct observation of brain processes through methods such as positron emission tomography (PET) or functional magnetic resonance imaging (fMRI) provides a different perspective (Plassmann et al. 2007a).

The localization of cortical areas activated during processing of stimuli in consumers provides new options and possibilities that traditional methods could not. First, using the approach of consumer neuroscience enables testing of existing theories that are based on different neural mechanisms (e.g., theory of brain lateralization), by investigating the **actual processes occurring in the brain in vivo**. Second, observation of the entire brain has the potential to detect new mechanisms that are associated with consumer behavior (Kenning et al. 2007a). Third, observation of brain activity provides an objective perspective (Huettel et al. 2009b). Methods of self-assessment that rely on the ability of humans to reconstruct and describe their feelings and thoughts are often subjective, and many of the biological/physiological processes affecting behavior happen unconsciously (Kahneman 2003). Therefore, the cognitive filter of study participants can distort methods of self-assessment. Fourth, strategic behavior and social desirability can be eliminated, as study participants have little or no influence on their brain activity, as measured (Camerer et al. 2005). Fifth, consumer researchers using brain imaging techniques might be able to capture information about the brain simultaneous to the moments of perception, processing, and decision-making (Lee et al. 2007). Finally, the integration of neuroscientific tools and theories into consumer research might help to add a new theoretical perspective into consumer research—that of biology (Riedl et al. 2010a, b). Taken into account that (1) there is still a significant amount of unexplained variance in research on consumer behavior and (2) consumer behavior should—at least partly—be affected by human biology, this new perspective might help to increase explained variance.

From these primarily methodical advantages, we reason that consumer neuroscience can add to consumer behavior research towards a better understanding of human behavior. Based on this notion, it becomes possible to improve theories for marketing and consumer research, and to achieve a higher level of explained variance (Knutson et al. 2007). The scientific proceedings of this research approach is subsumed under the term "consumer neuroscience," whereas "neuromarketing" points to the application of the findings from consumer neuroscience within the scope of managerial practice (Hubert and Kenning 2008; Ariely and Berns 2010). With respect to managerial practice, these new insights may help to improve company strategies in such ways as generating a better understanding of customer needs, and developing better solutions for product marketing (e.g., more effective product labelling) (Möser et al. 2010). As well, consumer neuroscience may have implications for consumer policy, as is addressed by Oehler and Reisch (2008).

In contrast, the primary goal of the paper is to provide an overview of methods, and findings of consumer neuroscience and its implications for consumer research. In addition, we integrate aspects of consumer policy and neuroethics, discussing the possible implications of consumer neuroscience for consumer protection.

2 Relevant neuroscience tools for consumer research

Using neuroimaging tools in consumer research is a new and exciting development (Ariely and Berns 2010), but a general lack of in-depth knowledge creates the need to provide some explanation of these methods. On the basis of already existing overviews (Lee and Chamberlain 2007; Camerer et al. 2005; Kenning and Plassmann 2005; Kenning et al. 2007a; Lee et al. 2007; Shiv et al. 2005), the purpose here is to discuss selected neuroscience tools available to consumer research, rather than to discuss each tool extensively. (For an additional overview of costs and benefits, see, for example, Ariely and Berns 2010; Riedl et al. 2010a; Perrachione and Perrachione 2008.)

2.1 Psychophysiological measurements

Measurement of psychophysiological indicators is probably the oldest and simplest technique for measuring neurophysiological states (Camerer et al. 2005). Heart rate can be used to detect cognitive attention, because the heart rate changes as cognitive attention is directed to a situation (Cacioppo and Tassinary 1990; Cacioppo et al. 1990; Fridlund and Izard 1983). Facial electromyography (EMG) can be used to measure the emotional response by attaching sensors to different parts of the face. Increased activity in the smile muscle near the mouth has been linked to positive emotion, and increased activity in the frown muscle near the eye has been linked to negative emotion (Fridlund and Izard 1983). Skin conductance response (SCR)—essentially, perspiring—is an indicator of arousal; the more aroused an individual becomes, the more he or she sweats, regardless of whether the arousal is positive or negative (Damasio 1994). Thus, SCR is often combined with facial EEG to understand the direction and strength of emotion. Although these techniques do not directly measure brain activity, the captured indicators are closely related to the nervous system. Typically, psychophysiological responses to stimuli occur nearly instantaneously, while other neurological responses can require several seconds to occur. These techniques are highly appropriate for the investigation of a number of consumer research questions, in particular those studies related to confronting new products, or making product decisions (e.g., Groeppel-Klein 2005; Kroeber-Riel 1979).

2.2 Imaging of brain activation

Brain imaging techniques are currently the most popular neuroscientific tools (Camerer et al. 2005; Logothetis 2008; Logothetis et al. 2001). The logic of brain imaging is simple: it typically compares a person's brain activation under two conditions, a control condition and an experimental task condition. The differential activation indicates the brain areas that are involved with performing the task. In the following, we briefly describe four imaging methods which capture brain activation, and which we consider to be the most relevant for consumer neuroscience (see also, Kenning and Plassmann 2005): EEG, fMRI, magnetoencephalography (MEG) and PET. In addition, we describe another promising neuroscientific method as a potential experimental setting in consumer neuroscience—transcranial magnetic stimulation (TMS).

2.2.1 Electroencephalography

Electroencephalography measures voltage fluctuations on the scalp. Electrodes placed on the skin and attached to any part of the head detect electrical potentials, which are produced by the neurons in the brain. EEG measures the changes in these neuronal potentials. The main advantage of EEG is its high temporal resolution (i.e., milliseconds), and it is often used to follow the time course of neural activity. In contrast, however, spatial resolution is very limited. When applying EEG, it is necessary to distinguish between evoked potentials (EPs) and the spontaneous EEG. EPs are potential variations which occur synchronously to a certain stimulus. Averaging over a large sample minimizes non-phase-locked components, so that only components which are phase-locked remain (Regan 1989). In contrast, spontaneous EEG is non-phase-locked to a specific stimulus. It can also vary according to a stimulus and higher order techniques are necessary for analyzing the data and computing the relationship between the stimulus and EEG signals (Pfurtscheller and Lopes da Silva 1999). Therefore, many serious questions arise in the literature with regard to the suitability of this method (Knight 2004).

Although methodical problems might arise with the use of EEG, there are examples illustrating additional benefit for consumer research: Young (2002), for example, has used EEG to detect what he identifies as branding moments in television advertisements. He has found a high correlation between moments identified by brain waves and moments identified by use of a behavioral, attention-sensitive method of picture sorting. In this way, he supports the existence of moments in television advertisements that have special importance for marketing.

2.2.2 Functional magnetic resonance imaging

Functional magnetic resonance imaging tracks blood oxygenation in the brain and exploits the different magnetic properties of oxygenated and deoxygenated blood [the so-called blood–oxygen-level-dependent (BOLD) contrast] (Kwong et al. 1992). Changes between the two states of oxygenation in hemoglobin are measured to correlate regions and brain function to a particular stimulus or behavior. The BOLD signals are correlated with MRI (Purves et al. 2008). Simultaneous direct recording of neural processing and fMRI responses shows that the BOLD signal reflects the parameters of neural activity reasonably well (Logothetis 2008; Logothetis et al. 2001). In contrast to EEG, fMRI provides better spatial resolution (from 1 or 2 cm to a hundred micrometers); it does so, however, with a lower temporal resolution (differing by a few seconds). In a typical fMRI study, multiple trials per person are averaged for the statistical analysis (Kenning et al. 2007a; Huettel et al. 2009a). The development of fMRI technology is ongoing and will continue to improve (Camerer et al. 2005), but is already considered one of the most promising technologies in neuroscience (Shamoo 2010). fMRI is of particular importance for the social sciences because it is possible to simultaneously scan the brain of two or more participants engaged in a social exchange (the so-called "hyperscanning method") (Montague et al. 2002). In neuroeconomics, this new technique is especially important for the analysis of social concepts such as cooperation, trust, reciprocity, and related constructs.

One study by King-Casas et al. (2005), for example, observed brain activity as two subjects played an economic game, in order to study each participant's inferences regarding trust and trustworthiness of the other participant. Obviously, because trust is a central construct in consumer research (e.g., Kenning 2008), new technologies such as hyperscanning have exciting potential for advancing scientific progress in the field of consumer research. Due to its acknowledged potential and increasing use (Glimcher et al. 2009), most of the studies presented in Sect. 3 used fMRI in their experimental design.

2.2.3 Magnetoencephalography

Magnetoencephalography is sensitive to changes of the magnetic fields that are induced by electrical brain activity (Kenning and Plassmann 2005). The temporal and spatial resolution of MEG can be compared to that of EEG. This technique is, therefore, also suitable to resolve the temporal sequence of the different cortical processing stages involved in decision-making and other brain and/or human processes. In contrast to the EEG, however, MEG is able to depict activity in deeper brain structures (Braeutigam et al. 2001a, b, 2004). Nonetheless, several problems found with the use of EEG (e.g., the inverse problem described by Helmholtz 1853) apply to MEG as well.

The methodical problems related to MEG do not exclude this tool from the application in consumer research: MEG has already been used, for example, to study the neural responses of viewing advertisements (Ioannides et al. 2000), which demonstrates its potential use in consumer research. The results of Ioannides et al. (2000) seem to indicate that cognitive rather than affective advertisements activate cortical centers associated with the executive control of working memory, and with maintenance of higher-order representations of complex visual material. In conclusion that the inter-subject variability of neuronal responses to affective advertisements may be greater than the response to cognitive spots.

2.2.4 Positron emission tomography

Positron emission tomography is a nuclear medicine imaging technique and produces three-dimensional images of functional processes in the human body (Raichle 1983; Riedl et al. 2010a). Positrons are the antiparticles of electrons, and they are generated during the radioactive decay of specific radio-nuclides. As positrons are instantly destroyed upon generation (by encountering an electron), they dissipate into two high-energy gamma-quants that are emitted in diametrically opposed directions. These gamma-quants are detected by the PET scanner, which calculates their points of origin from their respective path differences. Typically, isotopes of the elements that are used enter into metabolically relevant molecules, such as sugars or alcohols. After injection or inhalation of these radioactive isotopes (e.g., modified glucose or neurotransmitters), their calculated spatial distribution allows inference of the blood flow or metabolic rate within the brain. Spatial resolution is relatively high (in the centimeter range), but temporal resolution is low (several minutes)

(Kenning and Plassmann 2005). As PET scanners expose participants to radiation, the application to healthy test persons is usually restricted (Shamoo 2010).

An example of a PET study with relevance for consumer research is an experiment performed by Haier et al. (1992). In this study, brain activity was measured twice in subjects playing the computer game Tetris, both before and after practice. After 4–8 weeks of daily practice on Tetris, brain activity decreased, despite a more than sevenfold increase in performance. This suggests that learning can result in a more efficient use of the brain, as reflected by a decrease in brain metabolism. Direct implications for consumer research become clear, for example, when comparing the effects of learning or experiencing different product attributes resulting in specific decision-making (e.g., Deppe et al. 2005a).

2.3 Transcranial magnetic stimulation

Transcranial magnetic stimulation is a method that stimulates the brain by sending electromagnetic impulses through the skull. This requires placing an electromagnetic coil directly over a specified location of the head and introducing a transient high intensity current. The magnetic field generated introduces additional currents in the concerned neurons, activating nerve cells that temporarily disrupt brain function in this area (Camerer et al. 2005; Lee and Chamberlain 2007; Shiv et al. 2005). The differences in cognitive and behavioral functioning that result from such disruptions allow determination of whether the region is, in fact, critical for a certain function. Theoretically, TMS permits a more causal testing of brain function, and adds external validity than do correlative measures such as fMRI and EEG (Camerer et al. 2005). However, TMS also has several disadvantages. First, the use of TMS is currently limited to the cortical areas close to the skull. Second, due to the interconnectedness of brain areas, the effects of TMS are not limited to the stimulated region, making causal interpretations difficult. Third, there is some evidence that TMS may have longer-lasting effects on neural tissue (e.g., Jones 2007). Though TMS is not physically invasive in the way that a surgical procedure is the radiation produced by TMS affects the body, with headaches and, rarely, even seizures having been reported (Heckman and Happel 2006).

Notwithstanding potential concerns related to TMS, it has the potential to better explain the occurrence of phenomena in consumer research: an example of a TMS study that would have relevance for consumer research is an experiment conducted by Basso et al. (2006). They used repetitive TMS to investigate the role of the prefrontal cortex in visuospatial planning. The results indicate that, in a visuospatial problem-solving task, the prefrontal cortex is involved in the switching between heuristics during the execution of a plan. Given the importance of the use of heuristics in decision-making tasks (Brandstätter et al. 2006; Gigerenzer 1991; Goldstein and Gigerenzer 2002), these findings likely have implications for consumer research. Another repetitive TMS-study was conducted by Plassmann et al. (2008). They addressed the question, what role the dorsolateral prefrontal cortex plays in so called decision values (DV). DV are subjective value computations of how much resources (e.g., money) one is willing to give up in order to obtain a reward (e.g., having candy) or avoid experiencing a punishment (e.g., staying hungry). From their results, Plassmann et al. (2008) conclude that repetitive TMS designed to suppress the function of the right dorsolateral prefrontal cortex downmodulates the computation of DVs during a simple economic decision-making task. This might be a first step to a better understanding of the brain structures responsible for the computation of value in simple everyday choices of consumers.

2.4 Combination of neuroscience tools and responsible conduct of research

Each individual neuroscience tool has its strengths and weaknesses (for overviews see Ariely and Berns 2010; Riedl et al. 2010a; Perrachione and Perrachione 2008). Therefore, combining two or even more methods may improve the validity of research findings. Like filling in rows and lines in sudoku games, clues from one tool help fill in what is learned from other tools. For example, fMRI and EEG can be used in combination. Using fMRI-compatible electrodes, EEG can be measured within an fMRI scanner, combining the high temporal resolution of EEG with the high spatial resolution of fMRI. An advantage of fMRI is that it allows identification of the neural generators or underlying neural substrates of different components of an EEG signal (Debener et al. 2006). Moreover, recent studies using TMS in combination with brain imaging techniques have found that TMS does affect the activation in several interconnected brain areas (e.g., Ruff et al. 2008), which indicates that there is often no simple causal relationship between activation in one specific brain area and behavioral performance (Huettel et al. 2009b). This complexity of causal relationship advocates the use of TMS with other imaging methods (Riedl et al. 2010a).

With respect to responsible research conduct when applying neuroscience-based technologies, Shamoo and Resnik (2009) describe principles for such a program generally, as well as especially in the field of behavioral technology (Shamoo 2010; see also Newland et al. 2003). The principles they specify—honesty, objectivity and respect for research subjects—should, beside others (e.g., World Medical Association Declaration of Helsinki), be adhered to as well, when using neuroscience tools in consumer research. The eight sub-guidelines or sub-principles referring to the research with human subjects (Shamoo 2010), especially, should be an essential basis for every researcher using neuroscience tools. Oversight by independent institutional review boards to ensure subject and consumer protection is critical for responsible research in consumer neuroscience. Their responsibility is to understand, and monitor for issues of ethical research conduct as identified in discussions from the fields of neuroethics (Shamoo 2010; Shamoo and Resnik 2009; Shamoo and Schwartz 2007; Murphy et al. 2008; Farah 2002, 2007; Farah and Wolpe 2004) and, especially, neuromarketing (Murphy et al. 2008; Perrachione and Perrachione 2008; Wilson et al. 2008; Ariely and Berns 2010).

3 Overview of selected studies in the field of consumer neuroscience

In order to show the close alliance between consumer neuroscience and established market research, we present in the following specific results and implications of selected model studies from this recent field of research (for an overview see Hubert and Kenning 2008). The subjective selection takes into account whether or not the study was related to marketing issues and/or consumer research. 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 these represent predominant and essential elements of marketing theory and operational marketing management (Winer 1986; Constantinides 2006; Meffert et al. 2008). In this connection, neural activation patterns evoked by stimuli of each mix instrument, as well as by stimuli of brand research are identified. Finally, we point out some limitations of consumer neuroscience regarding theory building and methodological application.

3.1 Product policy

Product policy includes all decisions that a company makes regarding the market-driven composition of its offered services (Kotler and Keller 2006) and is, therefore, often labelled as "the heart of marketing". Corporate policy depends on this fundamental element, because a product range that satisfies the needs, demands, and problems of the consumer are the key to sustainable corporate success (Cooper 1979; Selnes 1993; Anderson et al. 1994; Bailetti and Litva 1995; Ernst et al. 2010). Problems for researchers in the field of product policy arise with the application of conventional market research methods such as self-reports, which often do not yield the desired information about consumers' real opinions of a product. As subjects are not always able to reconstruct and interpret their thoughts and feelings retrospectively, self-reports are sometimes in contrast to their actual inner states (Bagozzi 1991). With this understanding, there is some reasoning to believe that consumer neuroscience is able to yield a more complete and objective understanding of the inner states of consumers in this area, and may, consequently, assist consumers in better reproducing their own decisions. For instance, one important aspect of product policy is the optimal design of a product according to the real preferences of consumers (Bloch 1995). Erk et al. (2002) provided first insights into how the brain responds to differently designed goods (e.g., small cars, sports cars, and limousines). The fMRI results of their investigations showed that reward-related brain areas are activated by objects that have gained a reputation as status symbols through cultural conditioning. 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 present 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; Glimcher et al. 2009). Erk et al. (2002) concluded 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. The activity changes in the reward system of the brain induced by an attractive product design can be applied in order to predict purchasing behavior, assuming a relation between product design and purchase decision. Knutson et al. (2007) found evidence for such a relation: results from their study showed that activation of the nucleus accumbens, which is located in the ventral striatum, correlates with individual product preferences, and that activation in this area during product presentation may predict, to some degree, subsequent purchasing decisions (Grosenick et al. 2008).

3.2 Price policy

As a central concept in marketing, price policy constitutes a fundamental factor of a company's sales and profits (Rao 1984; Pasternack 1985; Lichtenstein et al. 1993). A quite interesting phenomenon often observed in price policy is that a similar price level can be perceived by consumers in two different ways, relative to the product category. On the one hand, increased price levels can have a negative influence on demand and deter consumers from buying a product, because they create a perception of loss. On the other hand, high prices can be seen as an indicator of high quality, enhancing the product value and the probability that consumers will buy the goods due to the complementary rewarding function of a higher price (Lichtenstein et al. 1993; Völckner and Hofmann 2007). For researchers, however, problems arise with asking consumers about pricing issues. For instance, consumers are often unable to recall prices (Vanhuele and Drèze 2002; Evanschitzky et al. 2004; Ofir et al. 2008), and it is also very difficult for them to specify abstract economic concepts such as willingness to pay, experienced utility, or 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 were first shown the image of a product, and then the same image with the price information. From this, they had to decide whether or not to buy the product. The results matched with those 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; Samanez-Larkin et al. 2007). The activation of the nucleus accumbens (activated by the anticipation of gains) correlates with product preferences, the activation of the insula (activated by the anticipation of losses) corresponds to excessive prices, and the activation of the medial prefrontal cortex (activated by the processing of gains and losses) correlates with reduced prices. This result supports the hypothesis that activity changes in the insula might reflect the neural representation of a negative price effect. Looking forward, this information can be an important element for identification of price limits and/or thresholds. In this respect, Plassmann et al. (2008) examined the contrasting positive-skewing impact of price setting on the evaluation of a specific product. In their fMRI study, subjects consumed wine and were presented with explicit price information. Among other things, results demonstrated that the participants 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) carefully assumed that the experienced utility of a product is not only dependent on intrinsic aspects such as the taste of the wine or thirst, but it is also impacted by adjustable factors within the frame of marketing-mix instruments, such as price setting. It is possible, therefore, to conclude that under certain circumstances the product's price is positively correlated with the product's utility.

3.3 Communication policy

Besides product and price policy, communication policy is a cornerstone in the marketing-mix. For instance, in order to inform consumers, the budget of US companies spent on advertising grew about 40.9% from $115,878billion in 1998 to $163,260billion in 2007 (International Journal of Advertising 2010). Against this background one future challenge crucial for the increasingly important marketing-mix instrument of communication is the psychological differentiation of brands (Milgrom and Roberts 1986; Meenaghan 1995) and consumer specific advertising in a global marketplace (Backhaus et al. 2001). We expect that, especially within communication policy, consumer neuroscience can help to overcome the existing lack of theory with only few specific attempts to study the role of theory in advertising research (Pitt et al. 2005; Plassmann et al. 2007a). In this regard, the question of how the brain processes, learns, and stores advertising stimuli may have essential importance. Considering the short-term processing of advertisements, two studies by Kenning et al. (2009) and Plassmann et al. (2007c) examined the neural correlates of attractive advertisements. In order to measure brain activity, subjects lying in the fMRI scanner were asked to rate different advertisements according to their attractiveness. The primary results showed that advertisements perceived to be attractive led to higher 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), relative to those advertisements perceived to be unattractive (Fig. 1).

Kenning et al. (2009) concluded from these results that attractive ads resemble a rewarding stimulus. In addition, the studies revealed that highly attractive and unattractive advertisements led to increased ad recall compared to neutral ads as well as that positive facial expressions are an essential component of attractive advertisements. A possible explanation of the role of facial perceptions can be found in the experiment of Aharon et al. (2001), who showed that a female face that was perceived to be beautiful led to the activation of reward-related areas in the brains of heterosexual males. Future studies may provide further information about the effects of conventional advertising stimuli such as the devices of using childlike characteristics, puppies, or even rather new forms such as computerized humans (avatars) in advertisements. 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 combined with emotional images, in comparison to the use of exclusively rational arguments. In the main experiment, Ambler et al. (2000) applied MEG to prove that rational or 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 emotional or affective images, a significant activation was observed in the areas of ventromedial prefrontal and orbitofrontal cortex, as well as in the amygdala and the brain stem. Ambler et al. (2000) conclude from these results that consumers process the content of advertisements differently in relation to their cognitive or emotional design. Future studies might show which information, in which particular contexts, is important for consumers when remembering and dealing with different products.

3.4 Distribution policy

Distribution policy is concerned with all decisions leading to the optimal distribution of goods between manufacturer and retailer (Ahlert 2005). The optimal distribution of products can have a sustainable and prominent influence on the buying decisions of consumers (Ailawadi and Keller 2004; Kotler and Keller 2006). Therefore, in order to set the optimal frame for the presentation of a brand, a central aspect of this important marketing-mix instrument is the choice of product marketing channels and brand-adequate marketing channels (Pasternack 1985; Eliashberg and Steinberg 1987; Choi 1991; Lee and Staelin 1997). In three similarly constructed experiments, Deppe et al. (2005a), Deppe et al. (2007), and Hubert et al. (2009) examined the neural correlates of this "framing effect". A primary finding of their investigations was that, in particular, the medial prefrontal cortex and the anterior cingulate cortex play a central role for the integration of implicit

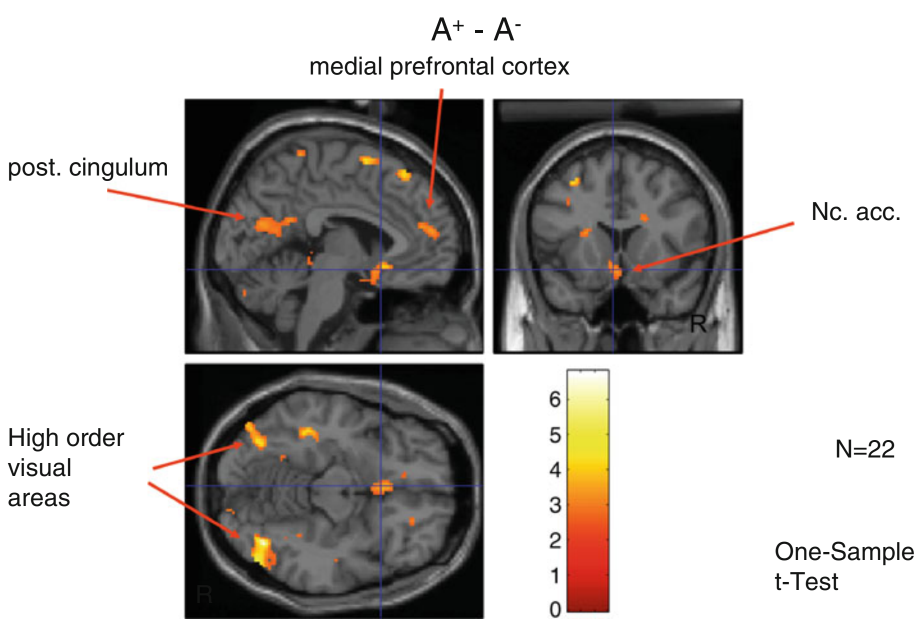

Fig. 1 Neural correlates of attractive advertisements (contrast attractive (A^+) vs. unattractive (A^-); $P < 0.01$, corrected for multiple comparisons). *Source* Kenning et al. (2007a, 2009)

framing information. This implicit framing information can consist of, 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 for the purchase of an identical garment, selecting the brand which they would prefer. With the results of that fMRI session and previously collected information about subjects' buying behavior, the researchers were able to identify the favorite retail brand of the participants. Next, subjects were divided into two groups, according to their average buying behavior. The group of "A" customers spent a minimum of 250 € on five or more shopping days per month at a certain retailer, and constituted the group of so-called "loyal customers." The group of "C" customers spent a maximum of 50 € and had only one shopping day per month at the same retailer, resulting in the group of labeled "disloyal customers." Data analysis showed that loyal customers integrate emotions into the decision-making process in a more intense way, through the activation in the ventromedial prefrontal cortex, and that the favorite retail brand can act as a relevant rewarding stimulus on a behavioral level. In contrast, a comparable activation in these regions was not measurable for disloyal participants. Plassmann et al. (2007b) developed an interesting conclusion from their results: the use of emotional reinforcers in marketing and within the distribution policy can constitute the base for sustainable, long-term customer retention. In this way, a learning process can be triggered, in which a customer's positive experiences are combined with the retail brand, then stored in the memory and recalled for future buying decisions (Kenning and Plassmann 2009).

3.5 Brand research

Brand research examines the 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 in the brain are involved during the processing of brand information. In their fMRI experiment, subjects had to make fictitious buying decisions, choosing between two very similar products that were differentiated only by brand information. The data analysis showed a significant difference in subjects' brain activity when a brand used in the fMRI experiment had been designated as their preferred brand. This group was labelled as the first choice brand (FCB) group. A closer look into the brain activities of the FCB group showed reduced activity in the dorsolateral prefrontal cortex, left premotor area, posterior parietal and occipital cortices—areas that are 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 as they are in comparison to diverse brands, so that the responsible brain region is deactivated and a "cortical release" occurs (Kenning et al. 2002). This effect is quite similar to those in the aforementioned Tetris study by Haier et al. (1992). In contrast, 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, in the recall of episodic memories, and in self-reflection. The increased activation in the ventromedial prefrontal cortex during decisions for 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 contradicts the well-established consideration-set concept. The consideration-set concept assumes that there is a set of goal-satisfying alternatives (Shocker et al. 1991), yet the results of Deppe et al. (2005b) provide evidence that only the favorite brand is able to trigger significant cortical activation patterns. These findings are in line with the neural activation patterns determined by McClure et al. (2004), providing evidence that consumer product brands employed as emotionalized stimuli can specifically modulate cortical activation in the ventromedial prefrontal cortex and, thus, can influence buying behavior. Accordingly, and analogous to the "Coca-Cola" test, McClure et al. (2004) described a consistent neural response in the ventromedial prefrontal cortex correlating with the subjects' behavioral preferences for different beverages (Coca-Cola® and Pepsi®). Intriguingly, a lesion study conducted by Koenigs and Tranel (2008) confirmed the suggestions of Deppe et al. (2005b) and McClure et al. (2004). According to their results, persons with damage within the ventromedial prefrontal cortex who exhibited irregularities in emotional processing did not show the normal preference biases when exposed to brand information. One potential reason for this might be that emotions could provide additional conscious or unconscious information to consumers' decision-making. Future studies might show, if consumers can use these insights to better understand and finally improve their buying decisions.

3.6 Limitations

As with any new approach, consumer neuroscience faces the challenge posed by limitations. For example, studies are very cost- and time-intensive (for an overview see Ariely and Berns 2010 or Riedl et al. 2010b). As well, the outcomes of experiments carried out to date need to be further validated and expanded (Vul et al. 2009) because of the complex data analysis required, the relatively small number of existing studies, and the relatively simple setting necessary for conducting brain imaging studies, which leads to a oversimplifying study design in the majority of cases (Plassmann et al. 2007a). Technical methods are steadily improving (see Sect. 2), but they still offer only 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 three assumptions: that the measured activation is not the result only of 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 participating subjects (Kenning and Plassmann 2005; Huettel et al. 2009b).

Another limitation could be the generalizability of the studies, which is often called into question. High costs precipitate the use of a limited number of participating subjects, and a small sample size increases the possibility of false positives and presents a higher probability of committing a Type II error, that is the error of failing to reject a null hypothesis when it is in fact not true (Tversky and Kahneman 1971). However, an argument supporting the validity of the results could be that several researchers investigating relevant marketing questions—in different national or cultural settings, applying various experimental approaches, and 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. 2004; Koenigs and Tranel 2008; Kenning et al. 2007c and Plassmann et al. 2007a; see Hubert and Kenning 2008 for an overview from an economic perspective). On the other hand, the robustness of neuroeconomic and consumer neuroscience findings may also constitute a counterargument for the validity. For example, 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 weak activations in the brain (Savoy 2005).

4 Discussion and concluding remarks

The selected overview of research in consumer neuroscience shows that a wide spectrum of traditional marketing-mix components and brand research has already been investigated in this new area (Hubert 2010; Hubert and Kenning 2008; Perrachione and Perrachione 2008; Kenning et al. 2007b). The application of neuroscience methods to marketing and consumption-relevant problems has yielded a number of theoretical contributions. First, neuroscience tools potentially lead to "objective" results, so that researchers can 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, neuroscience, and psychology. This transdisciplinary approach may assist all aforementioned disciplines in gaining innovative perspectives and in generating new ideas. In particular, it offers the opportunity for consumer neuroscience to confirm, reconfigure, or improve conventional theories of marketing theory (Fugate 2007, 2008). Therefore, one important contribution of consumer neuroscience is awareness of the influence of emotions on decision-making. At this point, the research has shown that, with emotions and unconscious processes playing a central role in generating behavior, consumers cannot be considered as completely rational in decision-making (Bechara and Damasio 2005; Camerer et al. 2005; Oehler and Reisch 2008). Another example of a contributing aspect is the strict distinction of marketing-mix instruments that is challenged by some of the studies presented. The exploration of the "framing effect" (Deppe et al. 2005a, 2007) yields important insights not only for distribution policy, but also for communication policy. As the consumer perceives the classical marketing-mix instruments simultaneously (Plassmann et al. 2008), there is a strong interaction between these elements, implying a possible new conceptualization of the classical approach, that marketing-mix instruments are strictly separated.

Although theoretically contributing to marketing research, the media has sensationalized many of the investigations in consumer neuroscience and neuromarketing, claiming that marketers found the "Buy Button" (Blakeslee 2004), that the public is in danger of being "brain scammed" (Editorial 2004), and that marketers desire to control consumer freedoms through unethical research. The use of neuroscience tools for marketing purposes is, therefore, criticized by consumer protection groups who fear the discovery of that "Buy Button," eventually turning consumers into buying robots (Commercial Alert 2003). Critics believe that the consumers' ability to make informed decisions about purchases might be compromised (Wilson et al. 2008). The rapid sprouting of firms offering neuroscientific marketing services (Reid 2006) could serve as an indicator for such a development. But of the approximately 90 firms worldwide claiming to work with methods from neuroscience, most only apply neuroscientific insights from publications. Only about 10% apply fMRI, which is the cornerstone of primary research in consumer neuroscience. This underscores how limited the real experiences with transferring insights from consumer neuroscience into corporate practice remain (Ariely and Berns 2010). The serious advice to handle findings from consumer neuroscience with care can be best conveyed by a skeptical comment in a 2004 *Nature Neuroscience* editorial, which noted that "neuromarketing is little more than a new fad, exploited by scientists and marketing consultants to blind corporate clients with science" (Editorial 2004, p. 683). This raises ethical issues and consumer neuroscience portrayed in this way could also damage the serious and significant work being produced by reliable researchers in the field.

Facing the critique aforementioned, serious consumer neuroscience researchers are aware of the concerns and address them directly. Advocates emphasize that the combination of marketing and neuroscience tools will allow consumers and marketers to better understand what products are desired, leading to a win–win situation for both parties (Wilson et al. 2008). That is why we respond assertively to the comment made in the Editorial (2004) of *Nature Neuroscience*, emphasizing the understanding that consumer neuroscience is primarily basic research used to better understand consumers' behavior and desires, providing selected practical implications to neuromarketing and consumer policy, but neither completely explaining nor controlling consumers. However, consumer neuroscience is still in its fledgling stages, and current investigations have been primarily targeted to basic research. A concrete deduction of practical implications will be very likely in the next few years though, as is indicated by Reid (2006). For that reason, direct practical recommendations for marketing, as well as for consumer policy purposes, should be derived very carefully (Plassmann et al. 2008; Ariely and Berns 2010). That said, it is essential to be aware of the fact that the technology of imaging techniques is limited so far: fMRI measures the brain blood flow correlation with the image of the brain. Computer software is then used to correlate the brain blood flow in the various parts of the brain with a specific function. In this sense, consumer researchers using neuroimaging techniques are not able to measure the function (e.g., the real behavior) itself, but only the physiological evidence of the function. That is why one can reject any concerns about finding a "Buy Button" or becoming "brain scammed," as the technology provides only a limited opportunity to *observe* the brain activity, not an ability to influence the brain. A worry that consumer neuroscience serves as an abusive method for "reading" consumers' minds and for manipulating their thoughts and behaviors, is an arbitrary concern at present. Due to the rapid development of the field of consumer neuroscience, ethical issues have also been discussed intensively (Farah 2002). In order to prevent the risk that neuromarketing might intervene in personal privacy to an unacceptable degree from becoming a reality (The Lancet N 2004), institutions and neuroethics conferences are already discussing the need for responsible use of the new techniques and the associated findings (e.g., Hain et al. 2007), and have already produced helpful guidelines (for an overview see, e.g., Ariely and Berns 2010; Shamoo 2010; for a "code of ethics" see Murphy et al. 2008). As a consequence, we believe that consumers will profit from the findings of consumer neuroscience. Moreover, they will be able to learn to better understand their own behaviors. For example, the examination of differences between the brain activity of compulsive buyers, compared with those who maintain appropriate levels of purchasing, helps to explain why these compulsive individuals tend to spend outside of their means (Reisch et al. 2004; Hubert et al. 2011).

With this understanding in mind, a specific example of the conflicting viewpoints is seen in the area of consumer protection policies. A central function of consumer policy is bringing more equilibrium and greater transparency into the relationship between consumers and suppliers (Klockenhoff 2009; Kunzmann 2010; Mitchell et al. 2001). In this context, knowledge gained from consumer neuroscience could be beneficial for consumers and suppliers, as it underscores the importance for companies to maintain their brand and price policies, thereby enabling a clearer and more transparent decision-making process for consumers. First, current regulatory policies such as competition law can use findings from consumer neuroscience to improve existing practices, which were previously based on theoretical assumptions like the idea that consumers make buying decisions on a rational basis (Chorvat et al. 2005). For instance, the finding (1) that high prices can positively affect product utility under certain circumstances and (2) that strong brands induce cortical releases in consumer brains might, perhaps, shed a new light on the interpretation of collaborations between manufactures and suppliers regarding price and brand maintenance. To date, these collaborations are often judged negatively with respect to paragraph 2 GWB (German Act Against Restraints of Competition), Article 101 (1) AEUV (The Treaty on the Functioning of the European Union) and Article 101 (3) AEUV (e.g., Olbrich and Buhr 2007). We think that this, perhaps, needs some revision if policy makers take into account recent findings from consumer neuroscience. Besides this, consumers can profit in a second way from these findings. They are the ultimate buying decision-makers, and consumer neuroscience can lead to a better understanding of which products they actually desire. Third, consumer neuroscience serves as a complementing information resource for consumer protection and education groups. Insofar as research results are published to a broader audience, this research might help to serve the "Consumer Bill of Rights" by increasing consumer awareness and by informing consumers (Oehler and Reisch 2008). Thereby, consumers can profit from the research developments by better meeting their own needs and by compelling suppliers to change design, quality, and price, which could even lead to an improvement in competitive efficiency and could enhance economic growth as well as consumer well-being. Fourth, and perhaps finally, consumer neuroscience discoveries may help consumers to protect themselves from their own emotions in the buying process. Investigations of addictive shopping behaviors (e.g., Hubert et al. 2011) or of how perceptions change with aging (e.g., Samanez-Larkin et al. 2007) might help consumers to make more reflective buying decisions, avoiding self-destructive compulsions in the buying context. To sum up, we support the idea that the use of consumer neuroscience is a win–win situation for both consumers and companies, enabling both to play their proper and balanced roles, and thereby contributing to the effective markets for goods and services that lead to economic growth, but without suppressing the decisive autonomy of consumers. That said, we hope that, ultimately, consumer neuroscience may lead to better equipped companies and consumers, who have the knowledge to be effective and informed participants in the economy, making decisions that are in their own best interest and reducing risks in a competitive marketplace.

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