The Neuroscience of Consumer Decision-Making

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ABSTRACT

While there is an extensive history of neuroscience, only recently has the theory and the methods of this discipline been applied to answer questions about decision making, choice, preference, risk and happiness. This new area of research, coined neuroeconomics, seeks to reveal more about the neural functioning and associated implications for economic and consumer behavior. In this paper are some of the key developments in neuroeconomics research as they relate to consumer decision-making, culminating with a discussion of possible future research areas in marketing where this type of research could be applied with important managerial, policy and academic implications.

This paper is a review of some of the key developments in a new area of research called neuroeconomics which combines methods and theory from economics, psychology and neuroscience. Neuroeconomics research examines how people make choices and attempts to determine the underlying neural basis for these choices and decisions. Until now, there has been very little integration of this new approach with current behavioral marketing research. This review will examine some of the seminal studies in neuroeconomics as it relates to consumer decision-making and offer future research areas in marketing where this type of research could be applied.

WHAT NEUROSCIENCE CAN REVEAL ABOUT CONSUMER DECISION-MAKING

Decision-making is a fundamental part of human behavior. We all make decisions everyday that influence our health, well-being, finances, and future prospects among other things. Researchers have become increasingly interested in why we make the decisions we do, especially when in many cases these decisions do not appear rational or to benefit us in the long run. While neoclassical economics has traditionally looked at how people *should* behave, other disciplines, such as psychology and cognitive science, have tried to answer the question of *why* people act the way they do. A new discipline, referred to by some as neuroeconomics, has sought to meld theory and methodology from diverse areas such as economics, psychology, neuroscience, cognitive science, cognitive neuroscience, mathematics, statistics, behavioral finance and decision theory in order to create a model of human behavior that not only explains but also predicts how people make decisions (Glimcher and Rustichini 2004).

Decision theory integrates mathematics, statistics, economics, philosophy, management, and psychology to better understand how decisions such as choices between incommensurable commodities, choice under uncertainty, intertemporal choice, and social choice are made. It has been assumed in decision theory that agents respond rationally in forming their choices and preferences. Essentially, consumers should follow a utility maximization function:

$$v(p,m) = \max u(x) \quad (p_1,p_2, \ldots, p_n) * (x_1, x_2,\ldots, x_n) = m$$

$$\text{such that } px = m.$$

The function $v(p,m)$ gives the maximum utility achievable at a given level of prices (p) and income (m), and a utility maximizing bundle x* meets the budget constraint of the consumer with equality (Varian 1978). Expected Utility Theory states:

$$\text{Max E(U)} = \sum_{i=1}^{n} probability_i \times utility_i$$

This theory finds that any “normal” preference relation over a finite set of states can be expressed as an expected utility equation.

However, the introduction of prospect theory, which suggests the possibility that other factors may impact behavioral decision-making for the individual, has generated an interest in understanding the underlying mechanisms of preference, judgment, and choice (Kahneman and Tversky 1979). The significance of these findings can have important implications for the marketing discipline. To understand the critical drivers of consumer behavior, a better understanding of the decision-making processes used by consumers is important.

Psychology has sought to investigate the “black box” of the human mind (Camerer et al. 2003). Cognitive psychology, and more recently cognitive neuroscience, has introduced new tools that allow researchers to capture and measure data from brain activity related to a specific function and behavior. This new type of data has created new directions of research that combine neuroscience, psychology, and decision theory to better understand the complexities of human decision-making.

Neuroscience looks at the structure, function and development of the nervous system and brain, while cognitive neuroscience studies how behavior and the nervous system work together in humans and animals. In other words, cognitive neuroscience is the study of the neural mechanisms of cognition (Gazzaniga 2002). At the nexus of neuroscience, economics and psychology, there is an area that has tentatively been coined neuroeconomics which uses neuroscience techniques to look specifically at how human subjects make choices. Neuroeconomics is not only interested in exposing brain regions associated with specific behavior, but also in identifying neural circuits or systems of specialized regions which control choice, preference, and judgment (Camerer et al. 2003)

One such technique borrowed from neuroscience is functional magnetic resonance imaging (fMRI) which may reveal how humans and animals use the neural substrates of the brain to process and evaluate decisions, weigh risk and reward, and learn to trust others in transactions. Brain imaging techniques that can be used on human subjects include:

(INSERT TABLE 1)

Another technique borrowed from neuroscience is transcranial magnetic stimulation (TMS) which is used to produce a magnetic pulse that can temporarily interfere with normal brain activity. For example, TMS can produce sudden movements in motor areas. While it has not yet been used for neuroeconomic studies, TMS has been used successfully for cognitive neuroscience studies and could potentially be used in the future to study decision-making. In addition, there are invasive techniques of monitoring brain activity in animals including single cell recording, where an electrode is passed through the skull into the brain. Neuroeconomics studies can also use non-imaging techniques. For example, some studies have been conducted using patients with brain lesions. Additionally, in order to determine central nervous system (CNS) response, studies can measure hormone levels, galvanic skin response, sweat gland activity and heart rate (Carter and Tiffany 1999; Frackowiak et al. 2004).

Before imaging technology made it possible to examine the “black box” of cognition, much of economic theory relied on the rational choice model. Current models of decision-making only partially explain human behavior. Neuroeconomics examines higher level cognitive functions of personal choice and decision-making, demonstrating how these are expressed at the neuronal and biochemical level. The analysis of this newest form of data which more closely examines brain processing hopes to bring us closer to answering questions as to why people consume, have addictions, save and hoard, in addition to understanding what makes people happy, risk seeking or adverse, trusting or trustworthy, and what drives preference and choice.

The Evolution of Neuroscience and Behavioral Decision-making

Over the past 50 years, scientists have experimented with a number of hypothetical game scenarios in order to determine models of how people make choices in economic situations. Before imaging technology, it was not possible to accurately investigate the influence of emotions and cognition on these economic models of decision-making. However, behavioral economists have begun to challenge the assumptions of the rational agent and have found that psychological and emotional factors do indeed play an important role in people’s economic decision-making process. Essentially, neuroeconomics looks at two branches of choice: solitary choice and strategic choice (Zak 2004).

In their paper on neuroeconomics, Camerer, Loewenstein and Prelec argued for the fundamental insights that neuroscience could offer economics (Camerer et al. 2003). They argue that economic theory has assumed that agents can ‘mentalize’, or infer from the actions of others, what their preferences and beliefs are. However, accumulating evidence from individuals with autism, Asperger’s syndrome, and brain lesions shows that mentalizing is a specialized skill modularized in specific brain regions. More importantly, the ability to mentalize exists in varying degrees from person to person (Camerer et al. 2003).

Traditional economic theory has maintained that humans are rational decision-making entities, that each individual has a clear sense of his/her own preferences and try to maximize his/her own well being and make consistent choices over time (Huang 2005). However, this model is more often violated than upheld as people and animals attempt to outwit evolution and destiny. Neuroscience gives researchers the opportunity to look into the ‘black box” of cognitive processing to reveal empirical indications of how the brain really processes choice, risk and preferences. The goal is to create “a complete neuroeconomic theory of the brain” (Glimcher 2003).

The Neuroscience of Game Playing

Games give neuroeconomists a useful way to isolate decision and choice variables in experimental studies. Most of these studies look at either behavior, autonomic reactions (such as hormone levels or heart rate) or brain activity while subjects are engaged in strategic games, thus revealing how the neuronal system processes fairness, reward, loss, trust, distrust, revenge, discounting and choice. Specific brain regions have been implicated in how judgments are made about perceptual stimuli received from our environment (Adolphs 2003). Some of these brain regions involved in judgment include the amygdala, which is central in the processing and memory of emotions, the insula, believed to be involved with feelings of disgust and unease, and the anterior cingulate cortex, which is implicated in reward anticipation, decision-making and empathy, among other important regions (Frackowiak et al. 2004) (see Appendix A and B).

Neural Calculations of Decisions

The idea that people seem prone to violate expected utility theory has led to the development of alternative models on how choices are made under risk. One of these alternatives, prospect theory, exhibits a series of effects that alter the value assigned to gains and losses (Kahneman and Tversky 1979). Phenomena such as the certainty effect, which states that people are prone to underweight probable versus certain outcomes, or the isolation effect which finds inconsistent preferences for identical outcomes based on how the outcomes are framed, or anchoring, biases and correlation illusion effects challenge the notion that utility theory holds in real life cases of human judgment (Kahneman and Tversky 1982).

Interestingly, Camerer makes clear in his paper on neuroeconomics that all the violations of the utility theory that humans commit have been replicated in animal studies (Camerer et al. 2003). For example, rats have also committed that same patterned violations in addition to other expected utility properties (Kagel et al. 1995).

Probability is how animals and humans calculate associations between events and predict outcomes critical to survival and understanding their environment. One study found evidence that dopamine neurons of the primate ventral midbrain may act to predict reward by specifically coding errors (Fiorillo et al. 2003). It was found that dopamine levels increase during gambling, which indicates that uncertainty may be the mechanism that induces this dopamine rush. It is hypothesized that this may explain the reward people feel when gambling, which cannot be explained by the monetary gain of gambling since losses usually outnumber gains. This uncertainty induced increase in dopamine may act to reinforce risk taking behavior, while the phasic response after predication error may serve to mediate the reward reinforcement itself. Gold and Shadlen (2002) build a relationship between the theoretical framework developed by codebreakers during World War II and how decisions are computing in the brain. They hypothesize that decisions are reached when evidence reaches a threshold value, this value being controlled by neural circuits that calculating the rate of reward (Gold and Shadlen 2002).

Trust and Cooperation

Imaging studies have revealed more about how social interaction shapes neural response, allowing us to choose mutual cooperation and shared gains over self interested choices to create a sense of stability in longer term game scenarios (McCabe et al. 2001). Increased activity in players who were more trusting and cooperative was shown in Brodmann area 10 (believed to be the locus of mentalizing) and in the limbic system, where emotions are believed to be processed (Camerer et al. 2003).

One study used the trust game to demonstrate how the brain processes decisions that involve cooperation and trust. Using the trust game, McCabe, et al. (2003b) found that subjects who were receivers violated the rational response which would be to accept any amount of money offered to them by the givers. Interestingly, when a similarly low offer was offered by a computer player instead of a human, the response in the receivers was not as extreme (McCabe 2003b). Half of the subjects in the study could be characterized as cooperators and had a common pattern of divergent activation in the prefrontal cortex where simultaneous attention to mutual gains and inhibition of immediate gratification allow for cooperative choices. The social brain hypothesis says that brain growth is due to adaptation caused by increasingly sophisticated social interaction.

Another version of the trust game found that in a multi-round game, the reciprocity of one player was a strong predictor of trusting behavior in future rounds from the other player (King-Casas et al. 2005). This study sought to understand how trust is developed over multiple rounds and over time, which is based in the concept of reciprocity. Specifically, reciprocity was defined as "a fractional change in money sent across rounds by one player in response to a fractional change in money sent by their partner. By scanning both participants simultaneously, an analysis of both within and between brain differences was able to show two differing neural responses. One was encoded by response magnitude, which was correlated with "intention to trust" on the next round of play and the other was encoded by response timing, which shifted by 14 seconds as the reputation of the player developed. Neural response was found in the dorsal striatum, the head of the caudate nucleus located in the basal ganglia (Purves et al. 1997). The researchers proposed that the caudate nucleus may be the area that received and computed information about the fairness of the other player's actions and the intention to reciprocate the action with trust. This may be similar to shifts in the reward prediction error signals in reinforcement learning.

In a similar study, fMRI scans found that the when responders were offered low amounts ($1 or $2 out of $10 possible) there was more activation in the prefrontal cortex, anterior cingulate (ACC) and the insula cortex (Sanfey et al. 2003). When monetary offers were low, the receivers had increased activity in the insula, which is often associated with feelings of pain and disgust (Wright et al. 2004). The ACC receives input from a number of other areas and is thought to resolve conflict among these areas. A player refusing an offer could be predicted by the level of activation in the insula. The author speculates that the insula may be the neural area responsible for distaste for inequality or unfair conditions. This has also been posited by social utility models which have attempted to explain ultimatum rejections, public goods contributions and trust, and gift exchange results.

Zak and his colleagues looked at the hormonal response during trust games to determine if there was a specific hormone that could be connected to feelings of trust and distrust (Zak et al. 2005; Zak et al. 2004). Using the trust game, subjects' blood was tested after each round for levels of oxytocin (OT), which has been associated in facilitating social behaviors, social recognition, maternal attachment, pair bonding, and the feeling of falling in love. The study found that when money was returned to the first player, OT did indeed increase to twice the levels of the random draw. This means that if people felt they were being trusted, increased OT levels made them more likely to trust back. Interestingly, ovulating women were less likely than non ovulating women or men to give money back even if they received the full amount from the other player. This, Zak believes, is due to the fact that progesterone, which increases during ovulation, binds with OT to inhibit its affect. In looking at distrust, Zak looked at dihydrotestosterone (DHT) and testosterone in both men and women to see if levels increased during low trust games. The study found that testosterone did not significantly increase in either women or men and DHT levels did not increase for women. However, there was a significant increase in the level of DHT in men when the other player signaled distrust. Zak hypothesizes that this may be related to the increased feelings of aggression that men reported when engaged in a low trust game.

In a further study, Zak worked with researchers in Switzerland to test whether trust levels could be manipulated with the administration of oxytocin in subjects (Kosfeld et al. 2005). The experimenters used the trust game, where subjects were paired as investor and trustee, and the investor could send the trustee as much of the original endowment which was tripled once the trustee received it. The trustee had the choice of keeping the full amount or any subset, or sending the full amount back to the investor for another round of investment. The subjects were given a nasal spray of the neuropeptide oxytocin prior to the initiation of the game. The study found that the oxytocin increased the trust behavior in the investor demonstrated in the larger amounts invested, but did not affect the trustworthiness of the trustee. It was hypothesized that while oxytocin modulates trusting behavior in humans by possibly increasing approach behavior, the mechanism that underlies trustworthiness or reciprocity is a different one and possibly not susceptible to the effects of oxytocin, which has also been found in animal studies.

McCabe hypothesizes that a theory of mind module allows subjects to imagine the mind set of another and may increase trusting behavior among agents. Because there is attention placed on the mutual gains, this may in turn activate the executive systems located in the frontal lobes that inhibit the impulse for immediate gratification and facilitate cooperation (McCabe 2003b).

While cooperation is an important component in human society, the desire to punish is the flip side of cooperation which may be how society is able to enforce social norms. An interesting study that looked at the neural basis for altruistic punishment or revenge found that people feel satisfaction from punishing violations of societal norms (de Quervain et al. 2004). Using PET scans, researchers found greater activation in the dorsal striatum which is usually “implicated in the processing of rewards that accrue as a result of goal-directed actions.” In addition, those subjects with stronger responses in the dorsal striatum were willing to incur greater costs in order to punish the violators.

Fairness

Humans tend to reject inequality even if it means walking away from a reward, which does not seem to indicate a rational agent in all situations (Powell 2003). In a study that looked at the neural substrates of cognitive and emotional processing, specifically fairness and unfairness activated during the Ultimatum Game, 19 subjects were scanned using fMRI (Sanfey et al. 2003). The Ultimatum Game is based on one player offering the other a split of a sum of money which the responder can either reject or accept. Players were paired with others who offered various split amounts of $10. The responders were scanned as they decided whether they would choose fair or unfair proposals. Previous behavioral research on the Ultimatum Game found that low offers are rejected 50% of the time even though a rational maximizing solution would be for the responder to accept any amount of money, since some money should be better than no money. Subjects usually report that low offers are often rejected because it provokes an angry response. In Sanfey, et al.'s study, brain imaging revealed that unfair offers activated the bilateral anterior insula, dorsolateral prefrontal cortex (DLPFC) and anterior cingulate cortex (ACC). The anterior insula is often implicated in negative emotional responses, more specifically in disgust (Krolak-Salmon et al. 2002; Wright et al. 2004). The DLPFC is often implicated in executive function and goal maintenance, which may stem from the responder actively maintaining the cognitive goal of acquiring as much money as possible. Increased activation of the insula was biased toward rejection of the offer and increased activation of the DLPFC was biased to accepting the offer. ACC has been implicated in cognitive conflict and may be a result of conflict between emotional and goal motivation during the game. Interestingly, the experiment was also run with both human and computer partners who acted in offering the split. The response in these brain areas was stronger when unfair offers were made by the human partner versus the computer, suggesting that the response was not just to the monetary amount offered, but also to the contextual factor that the unfair offer was made by another human.

Even monkeys seem to adhere to this notion of fairness. Brosnan and de Waal found that cooperation may have developed through evolution where individuals must compare their own efforts to the payoff they receive with those of others (Brosnan and De Waal 2003). Brown capuchin monkeys responded negatively when offered unequal rewards from experimenters and even refused to participate when they witnessed other monkeys receiving more attractive rewards for the same amount of effort. The researchers posit that this inequity aversion may have an evolutionary origin in our neurological development.

The Neural Substrates of Reward and Loss

Kahneman and Tversky found that loss is judged by people as being more painful than an equivalent gain is pleasurable as is evidenced in the convex utility curve for losses and concave utility curve for gains in the value function (Kahneman and Tversky 1979).

How valuation of gain and loss is calculated in the brain is an area under investigation by neuroscientists. Montague and Berns have looked at a number of experiments to develop a computational model, the predictor-valuation model (PGM) which anticipates a class of single-unit neural responses in the orbitofrontal and striatal neurons (Montague and Berns 2002). Other brain imaging studies have found that the brain processes gains and losses differently (Smith et al. 2002). PET imaging has revealed that there are two separate but functionally integrated choice systems, both in anatomical structure and in processing, each sensitive to loss. The dorsomedial system processes loss when deliberating risky gambles. When subjects make a choice that results in loss, there is a greater use of the dorsomedial system which serves to calculate versus the visceral representations in the more primitive ventromedial system which animals most likely use to make decisions. Choice processing seems to be centered in the more medial structures with more ventral than dorsal distribution.

Another animal study looking at reward valuation has found that reward valuation in monkeys can be predicted in a simple model based on reward history that duplicates foraging behavior. Sugrue, Corrado and Newsome found that neurons in the parietal cortex represent the relative value of competing actions (Sugrue et al. 2004).

Animal studies, mainly using monkeys, are revealing new information about how animals estimate the value of specific actions. For example, in a series of experiments Shultz looked at the neuronal response in the substantia nigra and the ventral tegmental area of the monkey brain in order to determine activity when a monkey pressed levers for juice rewards (Schultz 1998; Schultz et al. 1997). Another animal study looked at whether specific neuronal activation can be correlated to the probability that the animal expects of gain (Platt and Glimcher 1999).

How we respond to monetary reward has also been investigated using fMRI. The neural substrates of financial reinforcement overlap with areas that deal with primary reinforcers, such as food (Elliott et al. 2003). Gold has made an argument for reward expectation to be linked to the basal ganglia (Gold 2003).

Breiter, et al. have used fMRI to analyze the neural response to expectation and experience of gains and loss (Breiter et al. 2001). The study found that that there may be a common circuitry of neurons that process different types of rewards. In studies conducted with monkeys, it was found that the rhinal cortex was important for creating the associations between visual stimuli and their motivational significance (Liu et al. 2000; Liu and Richmond 2000). Monkeys whose rhinal cortex had been removed were not able to adjust their motivation to changes in a reward schedule, while unaffected monkeys were able to adjust their motivation. The complexity of how motivation works to cause action is not clearly understood, but it is believed that a limbic-striatal-pallidal circuit forms the basis for the translation of motivation into action (Liu et al. 2000).

Closely related to the question of reward is addiction. Neural activity drives the search for food in both animals and humans. These same neuronal networks may also drive behavior to seek other kinds of substances that rate high on the reward evaluation. When the brain is strongly activated by, for example, sugar, food or drugs, it can lead to abuse which is often called addiction (Hoebel et al. 1999).

The neural substrate association with time discounting was investigated using fMRI, and it was found that human subjects use different regions in the brain to calculate short and long term monetary rewards (McClure et al. 2004a). The limbic system associated with the midbrain dopamine system tended to be activated when decisions which would bring immediate gratification were contemplated. On the other hand, the lateral prefrontal cortex and posterior parietal cortex was activated by intertemporal choices regardless of whether the delay was short or long. There was greater fronto-parietal activity when the choice made by the subjects was longer term.

Addictive Behavior

A critical issue in behavioral decision theory is why people and animals would choose to engage in behavior that is detrimental or harmful. This issue is related to the question of addictive behavior and the endeavor to understand the neural underpinnings of reinforcement and inhibition of behavior. In an early neuroeconomic paper dealing with this issue, Bernheim and Rangel (2002) proposed a mathematical theory of addiction that sought to explain irrational addictive behavior in terms of decision theory and economics (Bernheim and Rangel 2002a; Bernheim and Rangel 2002b). The model is based on the idea that cognitive processes like attention can affect behavioral outcomes regardless of initial preference. If a person is subject to "hot cognition" (or affect laden thinking), for example, he/she may engage in consumption behavior that conflicts with preference because the focus is on usage and "the high" (Bernheim and Rangel 2002a).

The theory of cue reactivity is another theory that might serve to explain why addiction levels remain high even though subjects self report that they are striving to quit and they do not enjoy the consumption of their addictive substance (Carter and Tiffany 1999; Laibson 2001). In a recent study that used fMRI to analyze neural response in adolescents to alcohol related imagery, researchers found that adolescents with even a short usage history of alcohol had significantly higher blood oxygen response in areas of the brain associated with reward, desire, positive affect and episodic recall (Tapert et al. 2003).

There are various types of addictive behaviors that are under investigation by researchers. A type of consumption addiction involves the dispensation of products. The neural basis of collecting and hoarding in humans was analyzed using patients with prefrontal cortex lesions (Anderson et al. 2005). In addition to judgments of use and consequences of discarding possessions, other cognitive processing going on at the time of the decision to save may be important. Compulsive hoarders appear to have a peculiar perspective with regard to possessions. When deciding whether or not to discard a possession, they spend most of their time thinking about being without the possession (the cost of discarding) and little time thinking about the cost of saving it, or the benefit of not having it. This notion is similar to an observation made by Smith (1990) about animal hoarding. Smith (1990) speculated that the sight of a nut (by a squirrel) puts the squirrel 'in touch with' the feeling of being hungry and without the nut. For the hoarder, the sight of the possession puts them 'in touch with' the feeling of being without the possession and needing it. This feeling dominates their consideration of whether the possession should be discarded (Frost and Hartl 1996).

There are many other types of addictive behavior being investigated using theories developed from neuroscientific techniques, with relevance for neuroeconomics and behavioral decision theory. Examples include pathological gambling, substance abuse including nicotine, heroin, cocaine, alcohol, shopping, credit card use, and internet use (Carter and Tiffany 1999; Chambers et al. 2003; Due et al. 2002; Margolin and Kelly 1992; Potenza et al. 2003; Robinson and Berridge 1993; Spinella et al. 2004; Warren and McDonough 1999; Wilson et al. 2004).

Risk Judgment and Choice

Aversion to risk is linked to the amygdala and is driven by the ancient fear response (Camerer et al. 2004). Cortical override of the fear response is demonstrated in animal studies using shock. Over time, the response will be “extinguished.” If the connections between the amygdala and the cortex are severed, the fear response will return. This demonstrates that the amygdala does not “forget” but the cortex is suppressing the response.

Risky choice is different from risk judgment in that the subject must choose between risky gambles which force an interaction between cognition and affect. Patients with damage to the ventromedial prefrontal cortex seem to suffer from decision-making deficits. In a study which measured performance in gambling tasks, these patients continued to choose disadvantageously even after they knew the correct strategy (Bechara et al. 1997). Normal subjects used the advantageous strategy even before they consciously realized which strategy worked best. Additionally, normal subjects developed skin conductance responses (SCR) when facing a risky choice even before they knew that the choice was actually risky. For the patients with prefrontal damage, these SCRs never developed. This suggests that there might be a nonconscious, autonomic bias that guides risky decision-making that is based in the ventromedial prefrontal cortex, responding even before conscious cognition is aware of the risk. Bechara, et al. hypothesize that this covert bias activation is dependent on past reward and loss experiences and the emotions that go with them, with damage to the ventromedial cortex interfering with access to this knowledge.

A recent study looked at how emotion affects perceptions of risk in investment behavior (Shiv et al. 2005). Using patients with stable focal lesions in the brain regions associated with emotion, Shiv, et al. compared investment decisions over 20 rounds to those made by patients with lesions in areas unrelated to emotion (control) and normal subjects. They hypothesized that the patients with damage to the emotional regions would be able to make better investment decisions since they would not be subject to emotional reactions that could lead to poor choices. This hypothesis was based on the case of a patient with ventromedial prefrontal damage who was able to avoid an accident on an icy road while others skidded out of control. The patient revealed later that because he felt a lack of fear, he was able to calmly react to the road conditions by thinking rationally about the appropriate driving response (Damasio 1994). This led the researchers to wonder whether a lack of normal emotional reactions might allow people to make more advantageous decisions. The study found that normal participants and control patients became more conservative in the investment strategy after a win or loss, whereas the lesion patients made more advantageous decisions and ultimately earned more money from their investment decisions (Shiv et al. 2005). Other studies have found that even low levels of negative emotions can result in loss of self control which can have less than optimal outcomes for the subjects. For example, as the result of myopic loss aversion people exhibit high levels of loss aversion when gambles are presented one at a time rather than all at once (Benartzi and Thaler 1995).

The Neural Foundations of Preferences

One of the most interesting papers with specific implications for marketing research is a twist on the Coke and Pepsi taste test done by neuroscientists at Baylor (McClure et al. 2004b). This study looks at the effect of brand cues over behavioral preference, finding that what consumers say they prefer in terms of taste is not what the brain reveals is their preference. Even more specifically, it seems that cultural cues such as brand, which are a top down process, may have a significant biasing effect on bottom up preferences such as taste, and that people do not make choices based solely on sensory stimuli processing systems such as gustation, olfaction, visual, etc. This study looks at whether consumers look at immediate gratification differently from delayed rewards (McClure et al. 2004a).

Kahneman (1994) outlined four types of utilities that influence utility: remembered utility, anticipated utility, choice utility and experienced utility. Camerer discusses that these different types of utilities often contradict and conflict with each other (Camerer et al. 2003).This may signify that there are different brain areas that calculate these utilities independently and then compete for dominance. In fact, Berridge and Robinson (1998) found that there are distinct neural regions for wanting and liking which is analogous to choice utility and experienced utility. A good example of this is the conflict that addicts feel between craving or wanting and consuming or choosing which does not necessarily give the addict a positive experience.

GENERAL DISCUSSION

Limitations

It is not necessarily a new concept that brain science offers insights into economic and behavioral phenomena. While not universally embraced by all economists, some behavioral economists have been using constructs from psychology in order to attempt to build more descriptive and realistic models of behavior (Huang 2005). However, for the first time, imaging technology such as fMRI offers the type of tools that can effectively explore the subtleties of the human brain while being noninvasive, relatively safe for human subjects and providing results that are robust and revealing. However, fMRI studies have been questioned by critics because of the use of small sample sizes (typically less than 40 subjects), the ambiguity in human neuroanatomy mapping, lagtime of the hemodynamic response, image distortion due to signal dropoff, motion artifacts, and susceptibility, poor temporal resolution and the debate over functional definitions of neural areas (Savoy 1998; Savoy 1999; Wald 2005). Despite the limitations and difficulties in analyzing the results produced by fMRI, significant improvements in brain mapping, imaging power and resolution (there are now 3T, 4T and 7T scanners being used to gain improved imaging resolution) have indicated that at least some of these shortcoming may be reduced with the next generation of equipment.

Implications for Marketing

An example of how neuroeconomics could be applied to an important marketing research area deals with the question of consumption addiction. This is especially true in developing effective marketing communications for vulnerable consumers such as children and adolescents. Pechmann et al. (2006) presented evidence from the addiction and neuroscience literature that adolescents were more vulnerable to advertising and promotions due to the unique structure of their neural development (Pechmann et al. 2005). This may indicate that the decision-making process for adolescents is significantly different from that of children and adults. While there has been evidence from empirical social psychology studies to support this assertion, increasing definitive evidence based on neuroimaging studies has been developed by researchers from psychology, neuroscience, and medicine. This important development could offer a strong basis for marketing research that seeks to investigate how and why adolescents respond to marketing communications and advertising differently. Furthermore, marketing research could begin to develop ways to protect vulnerable adolescents from detrimental product categories such as cigarettes and alcohol, while enhancing the relevance and efficacy of marketing that is crucial to adolescents such as health messages. In this way, neuroeconomics methods can offer marketing researchers a valuable suite of methods that will allow a more refined and revealing understanding of the neural basis of consumer choice for a developmentally unique segment of the population, adolescents.

Managerial Implications

This paper shows the diverse questions that can be addressed using neuroeconomic techniques and methods. How consumers make decisions is important for marketers in developing consumer and financial products. Thus, the application of neuroeconomics to important marketing issues can be of vital importance to marketers. However, marketers must be sensitive to the public concern that many neuroscientific techniques may be considered invasive and ill applied to many of the marketing concerns of marketers especially when they are used as a means of selling more product to a consumer society. For that reason, this paper suggests that the best application of neuroeconomic principles may be for marketing issues that are related to important public policy issues such as consumption addiction, protection of vulnerable consumers and aiding consumers to make better decisions (Petty and Cacioppo 1996). Nonetheless, neuroeconomics could serve as an important new area for tackling many of the fundamental questions about consumer decision-making that have been difficult to explain theoretically.

Controversy Related to “Neuromarketing”

Using tools developed in neuroscience to look into consumer preferences has been called “neuromarketing” by some, although this term is still not universally used. The popular press has run a number of articles on the subject of neuroeconomics and neuromarketing (Begley 2002; Blakeslee 2003; Blakeslee 2004; D'Antonio 2004; Hotz 2005; Marketing Week 2005; The Economist 2004). In addition, some corporate marketing departments have set up their own neuroscience labs in order to test consumer response to product designs, marketing stimuli, etc. Specialized marketing consultants have also used theories developed in neuroscience studies to create tools that attempt to reveal preferences, choices and responses to specific products and campaign ideas.

Some have voiced a concern that neuroscience may reveal too much about the brain to those who would seek to use that information to their advantage. In particular, some consumer advocacy groups such as Commercial Alert have lobbied Congress and other federal institutions in order to attempt to stop activities that are deemed to be neuromarketing in nature (Commerical Alert 2004). The major concern is that the everyday person could be made vulnerable to mechanisms of persuasion that neuroscience reveals.

However, there is an opportunity to use the insights gleaned through neuroscientific techniques to enhance the consumer experience. A better understanding of the effect of environmental cues on addictive behavior could protect vulnerable populations, such as adolescents and children, from exposure to detrimental marketing influences. In addition, a better understanding of the decision-making and preference process of consumers could allow for the creation of better decision-making tools for consumers in addition to helping firms to tailor their marketing strategies to aid consumer decision-making.

CONCLUSION

Neuroeconomics offers the potential for insights into the neurological processes that underlie human and animal behavior. Using experimental methodologies combined with imaging and other neuroscience tools can better help us understand the mechanisms of decision-making, choice, preference, risk seeking or avoidance, valuation, bias, weighting, conflict, gain and loss. While neuroeconomics as a field of study is in a relatively early phase, there are a growing number of researchers who are establishing new theoretical constructs that could potentially inform economics, behavioral decision theory, management, marketing, and psychology.

Within neuroeconomics, there are a number of intriguing areas of research that have not yet been fully explored and could prove of further interest. Such future areas of research might include:

- How do neural systems work together to create decision-making behavior?
- How wide is the variation in brain patterns between different population groups?
    - subgroups (age, race, gender, individual variation)
    - vulnerable populations
- How do cultural differences between population groups demonstrate differential neural response to experiments in judgment, choice, conflict, risk, etc.
- How does free will play into neural responses to decision-making variables?
- What factors influence the development of addictive behavior and what factors could act to discontinue these addictions?

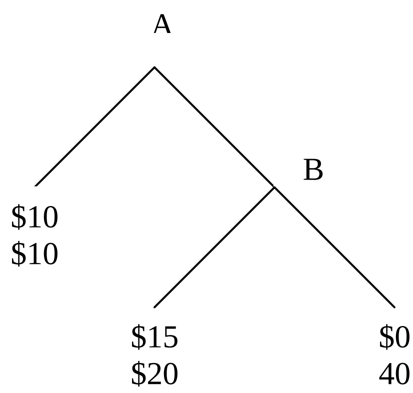
While the application of neuroscientific methods to economics and other related fields may cause continuing controversy and debate among scientists and the public, the results gleaned thus far from neuroeconomic research have revealed valuable insights into the neural substrates that affect human and animal decision-making. It seems reasonable to think that these insights may allow for new, more revealing models of decision-making that will take into account the underlying neurological mechanisms that drive behavior, emotion and choice.

Table 1

Methodology	What Is Imaged	How
Electroencephalography (EEG)	Changes in electrical brain current	Electrodes are placed on scalp to measure electrical brain waves coming from the brain
Computerized Tomography (CT or CAT)	X-ray images of brain structures	Multiple images (tomograms) of the brain are taken by rotating X-ray tube
Positron Emission Tomography (PET)	Emissions from radioactive chemicals in blood	Radioactive isotopes injected into blood stream are detected like X rays
Nuclear Magnetic Resonance Imaging (MRI)	Changes in electrical brain current	Magnet creates strong magnetic field to which molecules align, radio pulses knock out of alignment
Magnetoencephalography (MEG)	Changes in electrical brain current	Similar to EEG but instead magnetic fields are measures instead of electric fields
Functional Magnetic Resonance Imaging (fMRI)	Blood flow, specifically oxyhemoglobin to deoxyhemoglobin ratio	Relies on magnetic properties of blood to map blood flow; show brain function

Figure 1

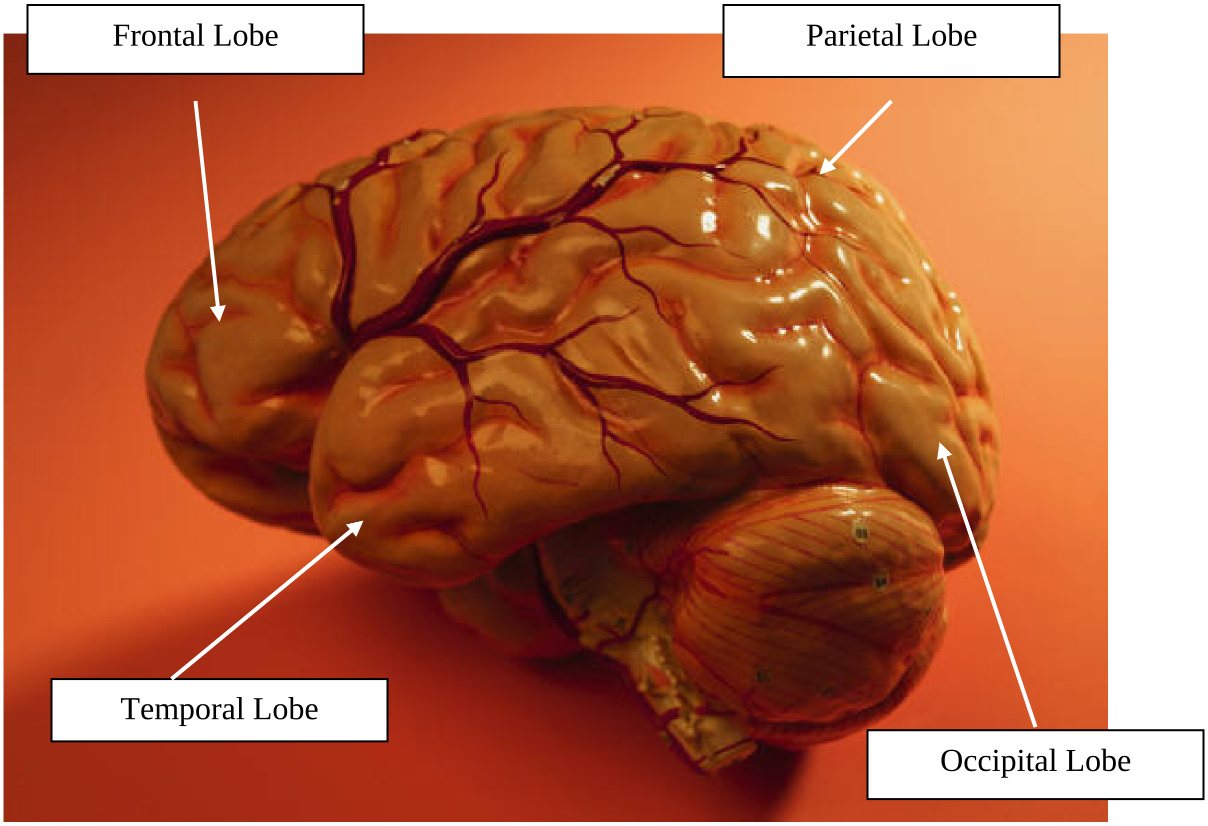
The Trust Game



At node A, player 1 has the option of either path. Moving left ends the game with the outcomes: top goes to player 1 and bottom to player 2. Moving right allows player 2 to move. Player 2 can choose either path at node B. Once player 2 moves the game ends and payoffs are distributed (McCabe 2003a).

Appendix A: Four Lobes of the Cerebral Cortex

Figure A-1



Frontal Lobe: Planning and production of body and eye movements, speech, cognition, emotions, organizing behavior, thoughts and memories

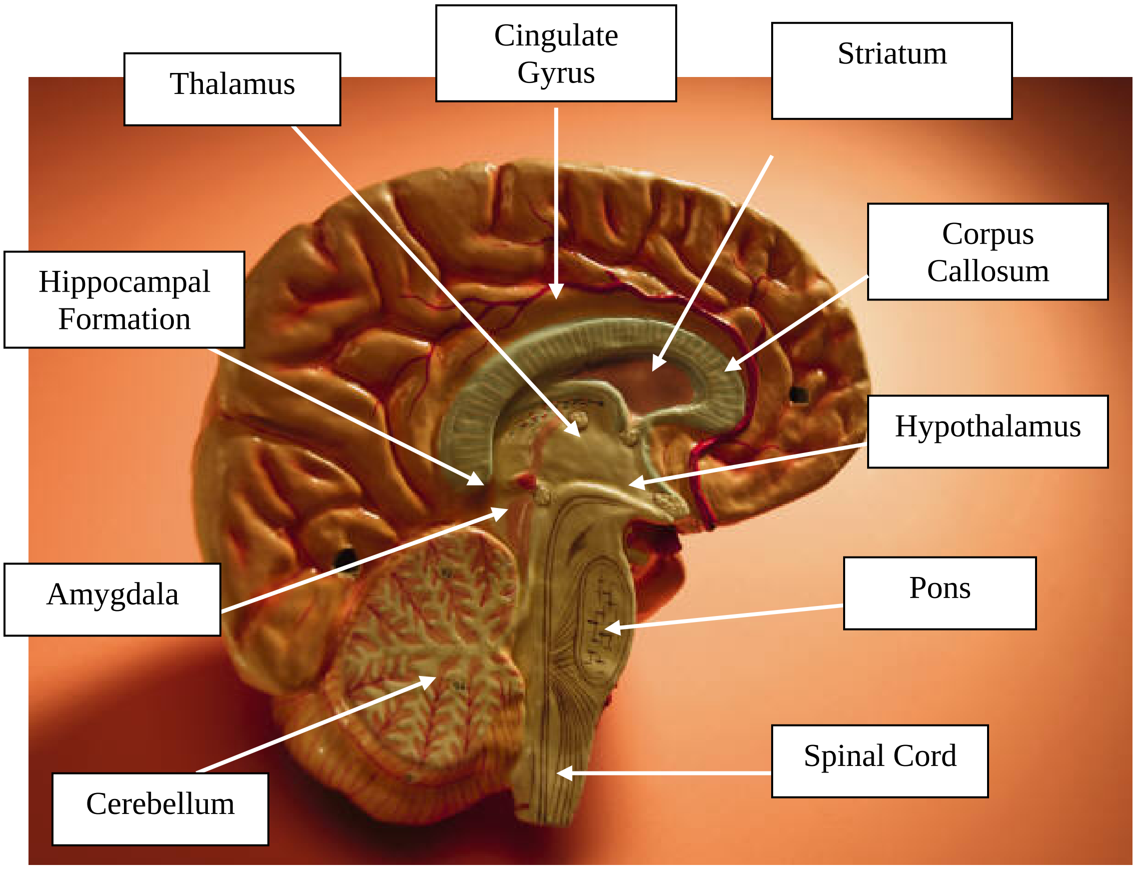
Parietal Lobe: Mediates perceptions of touch, pain and limb position, integrates sensory information for perception and language, mathematical thought and visuospatial cognition

Occipital Lobe: Location of the primary visual cortex

Temporal Lobe: Mediates sensory function and participates in memory and emotions; location of the primary auditory cortex (Martin 2003)

Appendix B: Medial Surface of the Cerebral Hemisphere

Figure A-2



Amygdala: Lies in front of hippocampus in the anterior pole of the temporal lobe and is important in the control of emotional behavior.

Cerebellum: Prominent hindbrain structure that governs motor coordination, posture and balance.

Cingulate Gyrus: Lies just superior to corpus callosum and forms part of the limbic system; important in emotional functions.

Corpus Callosum: Large midline fiber structure that contains axons that connect the cortex on the two sides of the brain.

Hippocampal Formation: A cortical structure in the temporal lobe; important to a variety of functions including short term declarative memory.

Hypothalamus: Part of the diencephalon which integrates functions from the autonomic nervous system and controls endocrine hormone release of the pituitary gland; governs reproductive, homeostatic and circadian functions.

Insular Cortex (not shown): Part of the cerebral cortex found in the depths of the lateral fissure; important in taste, internal body senses and some aspects of pain.

Pons: Component of the brain stem which plays key role in eye movement

Spinal Cord: Portion of the central nervous system that extends from the lower end of the brainstem.

Striatum: Made up of the caudate and putamen and is part of the basal ganglia; involved in planning and modulation of movement but also involved in other cognitive processes including executive function and processing of reward, aversion, novel or unexpected stimuli.

Thalamus: A part of the diencephalons which is a key structure for transmitting sensory information to the cerebral hemispheres from the lower centers. (Martin 2003; Purves et al. 1997)

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