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## Decision neuroscience and consumer decision making

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**Abstract** This article proposes that neuroscience can shape future theory and models in consumer decision making and suggests ways that neuroscience methods can be used in decision-making research. The article argues that neuroscience facilitates better theory development and empirical testing by considering the physiological context and the role of constructs such as hunger, stress, and social influence on consumer choice and preferences. Neuroscience can also provide new explanations

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for different sources of heterogeneity within and across populations, suggest novel hypotheses with respect to choices and underlying mechanisms that accord with an understanding of biology, and allow for the use of neural data to make better predictions about consumer behavior. The article suggests that despite some challenges associated with incorporating neuroscience into research on consumer decision processes, the use of neuroscience paradigms will produce a deeper understanding of decision making that can lead to the development of more effective decision aids and interventions.

**Keywords** Consumer neuroscience · Decision neuroscience

Neuroscience has become both a useful tool and a source of theory development and testing in decision-making research. Some researchers express high hopes that a neuroscience perspective will provide a deeper understanding of marketing and consumer decision making, whereas other researchers appear more skeptical. In this paper, we tackle two related questions. How can insights from neuroscience shape future theory and models in consumer decision making? How should neuroscience methods be integrated into the research methodology of consumer decision making? We argue that neuroscience provides constraints to facilitate better theory development, provides new empirical tests of standard theoretical claims, can provide explanations for observed heterogeneity within and across populations, and can provide a mechanism for considering the physiological context and the role of constructs such as hunger, stress, and social influence on consumer choices and preferences. We present a few key arguments and examples of how the use of neuroscience paradigms can illuminate our understanding of decision processes. Our primary goal is to appeal to a broad audience and to stimulate further study in this important area. Readers, who want background on specific measures, paradigms, methods, and reviews of recent findings related to decision neuroscience, should consult Glimcher et al. (2009) or Vartanian and Mandel (2011).

## 1 The role of neuroscience in consumer decision making

The prospect of turning to the biological variables of neuroscience to inform models of marketing and consumer decision making may, at first, seem far-fetched. Indeed, some economists (e.g., Gul and Pesendorfer 2008) have argued that because economic and decision-making models tend to be silent about the underlying biological mechanisms, neuroscience and biological variables would be irrelevant in theory testing. We categorically disagree with this view.

Decision-making research has benefited from the revealed preferences perspective, which follows the behaviorist tradition of focusing on the observation of what people actually choose (or state that they will choose). This perspective has gone a long way in promoting empirically testable theory. In its extreme form, the revealed preference approach ignores the black box in which decisions are made. However, this view has been somewhat limiting. Many researchers build models about the processes

occurring inside the black box, but under the revealed preferences approach those models are evaluated using data from the output stage only. While some decision scientists have been reluctant to consider data in addition to choice, others, including many in marketing, consider additional variables (e.g., attitudes, memory, stated intentions, willingness to pay, response time, and priming manipulations) to be important in theory development and empirical observation. These additional variables can facilitate insights because they provide context and testable constraints. As judgment and decision-making research has demonstrated, there can be empirically testable hypotheses about the workings and mechanisms inside the black box, especially when coupled with a revealed preferences approach.

We propose that neuroscience adds value to decision-making research by enhancing the ability to make inferences beyond our usual variables and paradigms. We assert that more comprehensive theories—those making empirically testable claims about both decision processes and their output, for example, or about both biological and social variables—will be useful as the decision neuroscience field continues to develop. Two decision behaviors may be identical but may have different underlying neural circuitry. One may ask why the circuitry is relevant if at the end of the day the choice is the same. But if one understands the underlying mechanism that led to the observed choice, then one is in a better position to (a) generalize this knowledge, (b) understand contextual influences that may interact with the different neural circuitry leading to different choices, and (c) create interventions or influence those decisions more effectively. Such process knowledge can be important in many domains including policy, marketing, legal decisions, and medical decisions. In much the same way that eyetracking or verbal self-report can provide additional information about potential process, the tools of decision neuroscience can yield valuable information that can provide additional constraints on the interpretation of choice data.

Many of us have naïve intuitions about biology being fixed and unmalleable. One of the lessons from modern neuroscience is that biological variables are instead plastic and malleable. In recent years, it has become increasingly clear that although the brain is biologically based, it is also shaped by environmental, cultural, and contextual factors. Armed with knowledge of how these variables interact, decision research scholars and practitioners may be in a better position to develop more effective, more personalized and more tailored interventions and decision aids that can improve decision making.

## 2 Understanding heterogeneity

Understanding both inter- and intra-personal sources of heterogeneity remains a core goal of consumer behavior research, as seen in the emphasis on improving the efficiency of marketing campaigns through population segmentation (for related ideas, see Venkatraman et al. 2012). Neuroscience provides a framework in which to study and ultimately account for individual differences. Specifically, individual differences in choice need not be arbitrary or idiosyncratic. Instead, they could reflect predictable interactions between genetic markers that code for brain function (e.g., genes that shape our dopamine system), hormone and neurotransmitter levels that fluctuate with disease and state variation (e.g., sleep deprivation), and environmental

variation (e.g., stressors and life events). Many of these variables are simply outside the scope of standard models but may be highly relevant for consumer behavior.

Recent work at the interaction of biology and social sciences suggest that genes can play important roles in shaping response tendencies in dynamic interaction with the environment. Research in gene  $\times$  environment interactions and in epigenetics suggest that it is not genes alone, but the interactions between the genetic code and environment that are associated with our behaviors. For example, prior studies have found that DRD4—a dopamine receptor gene that is implicated in ADHD and other behavioral disorders—functions differently depending on the quality of parenting. Long-allele versions of the gene are associated with sensation-seeking, high-intensity pleasure seeking, and impulsivity, but only in children who were subjected to poor quality parenting (Sheese et al. 2007). There is promise in exploring genetics and gene  $\times$  environment interactions in decision-making research; examples of recent studies include Krugel et al. (2009) and Doll et al. (2011).

Functional magnetic resonance imaging (fMRI) could inform hypotheses about heterogeneity in decision processes. There could be sub-groups of individuals that approach the same decision problem using different strategies, suggesting that these different sub-groups may exhibit different patterns of brain activation. Neuroscientists have been developing techniques that discriminate brain activity in groups of subjects performing different tasks (Poldrack et al. 2009); these techniques could be used to test whether sub-groups of subjects exhibit different brain activations in the same task. This kind of approach is analogous to the market segmentation approaches familiar to consumer researchers.

Decision theorists talk much about heterogeneity in decision-making parameters (such as utility function parameters or temporal discounting parameters), and the field has developed good models to understand that heterogeneity. Neuroscience can take that understanding to a new level by adding a biological substrate to the explanation. Take for example the role of stress on decision making. Decision-making researchers may get more mileage from their paradigms if they also examine additional biological variables related to stress, e.g., hormones like cortisol. Fluctuations in cortisol can be related to decisions and so can fluctuations (possibly experimental manipulations) of the stressor. In this case, the researcher can go beyond merely examining the association of the stressor to the choice (the black box model) and say something about the underlying mechanism in the sense that the stressor initiates a biological response, which can in turn be related to the choice. For example, Mehta et al. (2010) show that fluctuations in cortisol have implications for economic decision making during negotiation and bargaining games. Stress has not typically been seen as relevant to consumer decision making. However, we believe it is an important factor in some decisions such as food choice under time or budget constraints, which may be associated with stress (e.g., grocery shopping after a stressful day at work when cortisol levels may be high). Furthermore, the cortisol variable can also act as a “manipulation check” on the experimental stressor, and could provide additional information about other processes such as habituation to the stressor. Biological data could provide evidence that the participant is habituating to the stressor, and thus provide one way to interpret an observed change in the choices the participant makes in the face of a repeated stressor. This is a type of intrapersonal heterogeneity for which biological variables can provide additional explanatory power.

A biological variable like cortisol can also elucidate why one participant did not change their choices in the presence of a stressor but another participant did. If the participant who changed her choices responded to the stressor with elevated cortisol levels but the other participant's cortisol did not fluctuate in response to the stressor, then this points to a type of heterogeneity in, say, the effect the stressor has on the participant. If the cortisol levels are the same in the two participants, then the potential explanation that each responded to the stressor differently (at least in terms of a biological response) can be ruled out. In these examples, we have focused on cortisol as the biomarker for the stress response but there could be other biological variables and measurements, such as fMRI, that could also be informative about the heterogeneity. As can be seen through these examples, the inclusion of biological information in our behavioral decision-making models may go a long way toward accounting for the observed heterogeneity, at both intrapersonal and interpersonal levels, in decision behavior.

### 3 Understanding value and its computation

A major question in decision neuroscience has involved understanding how goods are represented and valued by consumers. A number of studies have documented the key role of the orbitofrontal cortex in the valuation process (e.g., Kringelbach 2005; Kable and Glimcher 2009). An open question in the neuroscience of decision making has been whether the brain has implemented a system that tracks the subjective value of items for choice, how these systems are at play when consumers “miscompute” their subjective value resulting in disadvantageous decision-making outcomes such as obesity, and whether brain activity in these systems can be consciously regulated. Answers to these questions have potentially important implications for understanding the underlying neuropsychological mechanisms of consumer decision making and for designing public policy interventions.

We illustrate with an example investigating brain systems that track decision values of hungry subjects using fMRI. Based on the results of several previous studies using monkey electrophysiology and human fMRI, one can hypothesize a priori that activity in the medial orbitofrontal cortex (mOFC) would be involved in decision value (DV) computations. To test this hypothesis, Plassmann et al. (2007, 2010) used fMRI to scan hungry people's brains while they placed bids for the right to eat 50 different junk foods (e.g., chips and candy bars) in a Becker–DeGroot–Marshak auction. The participants placed bids for the right to eat a snack at the end of the experiment in 100 different bidding trials. In each trial, they were allowed to bid \$0, \$1, \$2, or \$3 for each food item.

Plassmann et al. (2010) found that right mOFC and ventromedial prefrontal cortex (VMPFC) and right dorsolateral prefrontal cortex (DLPFC) encode for DV during choice between unhealthy but appetitive food items. However, DV computations occur when choosing among appetitive and aversive items. Since dissociations between appetitive and aversive components of value signals have been shown in other domains such as anticipatory and outcome values, it is an important question as to whether appetitive and aversive DVs are computed in similar brain regions, or in separate ones. In a follow-up study, the investigators found that activity in a common area of the mOFC/VMPFC and DLPFC correlated positively with appetitive DVs and

negatively with aversive DVs. These findings suggest that the mOFC might comprise a common valuation region that encodes for both appetitive and aversive DVs (Litt et al. 2011). These results and related ones using monetary gambles and trinkets (Chib et al. 2009), or immediate and delayed rewards (Kable and Glimcher 2007, 2010) provide evidence that the brain encodes a “common currency” that allows for a shared valuation for different categories of goods (see Kable and Glimcher 2009, for a review).

#### 4 Understanding strategic contributions to choice

The assignment of subjective values during decision making constitutes one of the fundamental computations supporting human behavior. However, different sorts of computations may be evoked under different circumstances. Individuals may have difficulty overcoming immediate hedonic concerns to achieve a long-term goal, as in the case of decision-making disorders such as obesity, addiction, and pathological gambling, suggesting that this process may sometimes be more sensitive to immediate hedonic concerns than to long-term goals and outcomes. When this happens, strategies such as cognitive reappraisal and regulation may be required in order to modulate the computations of the value system. Different decision contexts may allow individuals more or less flexibility. Some choices may demand a rapid decision and are best suited to a simplifying, heuristic approach, while other decisions may allow for a more considered, analytic choice process. Across these and many other cases, decision makers are faced with the challenge of selecting the decision *strategy* that maximizes outcomes in the face of constraints.

Recent neuroscience work has provided insight into how individuals engage cognitive strategies to shape their decision process to modify the computations involved in determining the preference for a food, and can also diminish their motivation to obtain a food through activation of regions involved in executive control and behavioral inhibition. Similarly, there may be different roles for conscious and unconscious mechanism in our decisions, and for the role of mood, emotions, and stress. These findings may have important implications for how public policy interventions are designed to fight obesity, and also how health information on food packaging could be more effectively presented. Admittedly, there is much more research needed before we fully understand the policy implications and can develop new interventions and policies based on information from neuroscience studies.

Inter- and intra-individual variation in decision strategies can result from different underlying processes. For example, a study by Venkatraman et al. (2009) investigated how people selected between multi-attribute monetary gambles whose outcomes varied from very good (e.g., win \$100) to very bad (e.g., lose \$80). Because of the complexity of the problem—which has parallels in the multi-attribute nature of many consumer decisions—different individuals approached this decision with different strategies. Some individuals generally used information about outcomes in a largely compensatory manner consistent with standard economic models, whereas others often adopted a simpler, aspiration-level rule: “Choose the gamble that maximizes my overall chance of winning.” The authors found that these inter-individual differences were well-correlated with the response of the brain’s reward system to gains and losses, with those individuals whose reward system were most sensitive to the



valence of outcomes also showing the greatest tendency toward using the simplifying rule (i.e., choosing based on valence but ignoring magnitude). Moreover, switches from one sort of strategy to the other were associated with increased activation in the dorsomedial prefrontal cortex (DMPFC), a region broadly associated with the strategic control of behavior.

Finally, the very concept of subjective value can be parsed into distinct components, each potentially associated with distinct underlying mechanisms. Decision theory has recently been exploring the role of different types of utility in decision making (e.g., experienced utility, decision utility, remembered utility, and anticipated utility). For example, recent work indicates that rewarding visual images (e.g., photographs of attractive faces) simultaneously generate two sorts of subjective value signals within the VMPFC (Smith et al. 2010): an experienced value signal associated with the attractiveness of the face being viewed, and a DV signal proportional to an individual's relative willingness to pay small amounts of money to see attractive faces. Neuroscience can provide a framework for these different definitions and components of utility that can supplement the information that emerges from traditional the revealed preference paradigm. Neuroscience can help assess whether there is more to value than what is expressed in action. Similarly, neuroscience can inform our understanding of the mechanisms of temporal discounting, and its relation to other constructs such as impulsivity and other paradigms such as delay of gratification.

## 5 Hypothesis generation and constraints

A subtle detail in the previous section is that neuroscience can lead to new predictions and new paradigms for dissociating processes that may not be so easy to separate using nothing more than behavioral data and traditional research designs. It is not the case that imaging data merely lead to a search for high correlations. The food example above drew on a body of prior work to generate testable hypotheses about food choice.

More generally, neuroscience provides constraints on hypotheses that can be used to account for choice data. For example, we can reject a hypothesis about decision making that implies an unrealistic biological mechanism. A model about decision making under stress that does not have fidelity with respect to our biological understanding of the stress response would not go very far in furthering our understanding or in suggesting successful interventions for responding to stress that lead to effective decision making. Similarly, a decision-making model for stress or a model for pathological decision making that accords with our understanding of biological mechanism, but does not adequately represent decision-making processes is unlikely to yield a useful model.

Neuroscience can suggest new hypotheses, whether they be about the prediction of choices or about underlying mechanisms. One such recent example is by Ho and Spence (2009) who predicted that behavioral responses by drivers to in-car warning signals will be facilitated by designing warning systems that incorporate insights about constraints of the brain. Drawing on neuroscientific findings that humans (and other animals) pay greater attention and respond more rapidly to sensory stimuli occurring in peripersonal (i.e., close to the body) than extrapersonal space, they find support for the idea that peripersonal warning signals, compared with traditional

warning signals, afford significant performance advantages. In another example, Wadhwa et al. (2008) generated novel hypotheses, based on physiological theories of “reverse alliesthesia” and neuroscience research on the dopamine system, that consumption cues that are high in incentive value (such as sampling a food or brief experiences with hedonic cues) can strengthen subsequent goal pursuit of reward-seeking behaviors (defined as a representation of an internal state associated with a desirable outcome). The authors found support for their predictions, which ran counter to common views held by marketing practitioners and health experts, that sampling a food generally leads to lower subsequent consumption. Neuroscience also brings into decision-making research variables that have not been traditional key variables in behavioral models or paradigms. For example, recall our previous examples about the examination of hunger on our choice of food or the role of stress in decision making. The use of new hypotheses, variables, and paradigms can enrich decision-making research and potentially lead to interesting new findings.

The concept of optimization, held so dearly by many decision theorists, can also be extended by taking a biological approach. Biology may provide additional concepts and other objective functions that may lead to different predictions and conceptions of optimality. So, for example, models for foraging may provide new intuitions and predictions for food decisions. Or, a series of decisions that may not appear optimal when viewed in isolation may become evident as optimal when viewed in the context of a broader system where there are additional objectives and constraints. Behaviors and decisions leading to long-term gene propagation at the expense of the immediate and direct benefit to the individual, might not appear locally optimized but make sense from an evolutionary perspective and thus might be driven by specific biological mechanisms. New insights may come into play when analyzing the biological mechanisms underlying different strategies that a decision maker may employ (not only the usual strategy of maximizing a utility integral, but other strategies such as choosing the option with maximum probability to win or minimize maximum loss).

## 6 Hypothesis testing

An important issue in decision and consumer neuroscience is whether neuroscience evidence can be used to test a psychological or behavioral hypothesis, or can only speak to hypotheses about neural processes. Many have argued, quite correctly, against the validity of “reverse inference” in fMRI (e.g., Poldrack 2006). Reverse inference is concluding that participants were using a particular psychological process or experiencing a particular psychological state because of the presence of activation in a certain brain region. An example would be concluding that participants felt fear because the amygdala was active during the task. While we agree that researchers should guard against reverse inferences, such thinking can play a role in generating hypotheses for further testing.

More importantly, reverse inference is not the only way that functional imaging can be used to test hypotheses about psychological processes. Functional MRI can validly speak to whether two tasks use identical psychological processes—because if they do, they should result in similar brain activation. It is the similarity/difference of the brain activation, not the anatomical location, that is crucial here. Yoon et al. (2006) used this logic to show that thinking about brands does not engage the same

psychological processes as thinking about people since the brain activity for brand judgments was quite different from that involved in person judgments. Kable and Glimcher (2010) used similar logic to argue that people do not value immediate and delayed monetary rewards using fundamentally different mechanisms since the brain networks activated by both kinds of rewards were almost identical.

## 7 New types of predictions

The use of neural data in models of consumer decision making holds the promise of better predictions about consumer behavior across different time scales. Knutson et al. (2007), for example, distinguished between purchased-item trials and non-purchased-item trials, and found significant differences in nucleus accumbens (NAcc) activation during preference formation, and both MPFC and insula deactivation during price processing. In line with their a priori hypotheses, they then estimated brain activity in these three regions of interests and entered them as covariates in a logistic regression, along with self-report measures of preference and net value, to predict subsequent purchasing decisions. The results indicated that the full model (i.e., including the neural measures) provided significantly better predictive power, albeit one offering a small advantage over a model including only self-report measures (see also Tusche et al. 2010).

Berns and colleagues demonstrated that neural responses can be used to predict purchases that are made several years later. Berns et al. (2010) conducted a study with adolescents, from October 2006 to August 2007, in which behavioral measures of preferences and neural responses were collected while participants listened to 15-s clips of songs downloaded from <http://MySpace.com>. They found that likability ratings of songs were highly correlated with activity in the caudate nucleus (an area implicated in reward and valuation). The researchers also found that the tendency among participants to change their evaluations of a song in line with its popularity (i.e., reference group's ratings) was positively correlated with activation in the anterior insula and anterior cingulate (ACC). In a subsequent study, the investigators found that the individual neural responses (in OFC and NAcc) to songs in their initial study predicted purchase decisions by the general population assessed via total number of units sold through May 2010 (Berns and Moore 2012).

## 8 Multiple methods are advised

Neuroscience offers a wide range of variables and paradigms. Our suggestion is that researchers use multiple methods and paradigms from multiple disciplines. Of course, within the neuroscience domain fMRI has received much attention lately because of the compelling images it produces of the functionally related blood oxygen level-dependent responses, which reflects metabolic changes associated with neuronal activity. But, there are many other techniques within the neuroscience domain that may be useful to decision researchers. Measurements of brain structure, including diffusion tensor imaging, can provide insight into differences across individuals; e.g., as when examining changes in brain regions or their connecting pathways over the lifespan. Recordings of changes in brain electrical activity, such as electroencephalography and magnetoencephalography, provide better temporal resolution at the expense of poorer spatial resolution. Newer methods based on infrared technology

show good temporal and spatial resolution (though currently limited to recording near the surface of the cortex) in a more mobile context than fMRI.

Multiple methods not only have different strengths, in terms of the biological variables they can measure, they can also permit fundamentally different inferences. None of the techniques above allow one to infer that a neural process is necessary for a decision or that it plays a causal role in generating behavior. Lesion studies, in contrast, do test necessity. One can use lesion studies and animal models of decision making to test process and mechanism. There is also a way to mimic a lesion study by temporarily disrupting a particular brain region using repetitive transcranial magnetic stimulation (rTMS) or transcranial direct current stimulation. Further, there are psychopharmacological manipulations, the multisensory nature of perception, psychophysiological variables and genetics that can be added to the decision researcher's toolbox, each providing different paradigms, variables and constructs. Of course, there are startup and transaction costs in adopting these technologies in one's research paradigm, but those costs should be judged against the potential benefit in the more pointed theory testing that emerges from considering the interplay of biological, cognitive, affective, and behavioral variables.

An example of multiple methods comes from work by Plassmann et al. (2010) who observed decision-making-related value signals in the mOFC and DLPFC. But these value signals could be an output of decision making rather than an input. If these value signals are used in decision making, then individuals with damage to this area should behave less like value maximizers. This is exactly what Fellows and Farah (2007) observed in a choice experiment with food, famous people and colors. Patients with damage to mOFC and VMPFC were more inconsistent in their choices. Plassmann et al. (2010) demonstrated that the signals in DLPFC play an important causal role in valuation. Using rTMS while participants were involved in an economic valuation task involving the consumption of real foods, they found that applying transient disruption of the DLPFC resulted in a decrease in the values assigned to the stimuli relative to a control group. The results are consistent with the possibility that the DLPFC plays a causal role in the computation of DV at the time of choice. These results show that a manipulation of brain activity encoding DV can alter behavioral preferences of consumers.

Our general point is that the field of decision making has much to gain by taking a multidisciplinary approach to its research questions. Neuroscience is a natural discipline to add to the list of disciplines that relate to the field of judgment and decision making.

## 9 The neurobiology of social influence

Consumer decision making hardly ever occurs in isolation. Implicitly or explicitly, consciously or unconsciously, the social context influences choice. People demonstrate various forms of herding—alignments of the thoughts or behaviors of individuals in a group (herd) without centralized coordination (Raafat et al. 2009). The conformity literature has focused on the influence of descriptive norms, which provide information about the behavior of relevant others (such as one's peers) and are distinguished from injunctive norms that specify what "ought" to be done (e.g., "do not drink and drive"). Although the phenomenon of social conformity and the

power of descriptive norms have been studied extensively in traditional behavioral research paradigms, recent evidence points to relevant neural mechanisms. For example, Klucharev et al. (2009) used fMRI to reveal that social conformity follows principles of reinforcement learning. The results indicate that a conflict with group opinion triggers a neuronal response in the NAcc and the rostral cingulate zone (RCZ), a dorsal aspect of the MPFC similar to the 'prediction error' signal suggested by neuroscientific models of reinforcement learning (Schultz et al. 1997). Moreover, the amplitude of this neural response predicted the magnitude of the subsequent conforming behavioral change, and the overall size of the neural signal was related to individual differences in behavioral conformity. A follow-up study by Klucharev et al. in which they down-regulated the RCZ by means of rTMS indeed reduced conforming behavior, thus providing strong evidence of the causal role of the RCZ in social influence.

As discussed already, Berns et al. (2010) demonstrated that participants changed their opinion about a music clip when receiving information about the popularity of that clip; and that tendency to change the opinion due to the perceived opinion in their reference group was positively correlated with activation in the ACC and anterior insula. Furthermore, the MPFC was also found to be central to learning about social information (advice) and for determining the extent to which it guides behavior (Behrens et al. 2008).

The hypothesis that social conformity has a basic neural mechanism generates relevant insights for consumer behavior and marketing. First, an automatic response to deviating behavior from others makes it difficult for consumers to resist such an influence. For social norm campaigns such as encouraging people to eat healthy, drive safely, or donate their organs, one may expect that providing descriptive social norm information will generate the automatic tendency to conform. Second, understanding the dopamine system as well as conflict/error processing and its pathologies may inform us about when and for whom large effects of social influence can be expected. We speculate that if aging affects the dopamine system by weakening the reward prediction signals, then the elderly may be less affected by descriptive norm information and exhibit less social conformity. Of course, one needs to be careful making inferences about neurotransmitter systems from imaging studies and, likewise, about drawing policy implications from relatively preliminary evidence. We assert that a neuroscience perspective to the problem provides novel insights and directions for testing hypotheses, and suggests new interpretations that can be tested in subsequent studies. This is exactly the kind of generative process one likes to see in research programs.

## 10 Consumer neuroscience concerns

Our enthusiasm for the promise of adding neuroscience approaches to the traditional study of consumer decision making is tempered by some concerns. First, we recognize that the startup costs in terms of training are exceptionally high. Researchers and graduate students need proper training. It is more than merely learning about a new variable or a new paradigm. Doing this research properly requires a new way of thinking that must be incorporated into one's overall theoretical perspective. This will require a change to an already over-cramped graduate school curriculum. Some of the

startup cost can be absorbed through careful collaboration but there is no substitute for the behavioral researcher learning the basic paradigms, models and analysis issues in neuroscience, and likewise for the neuroscientist collaborator to learn about the basic behavioral paradigms, models and analytic issues. Furthermore, the research is relatively expensive and requires a different type of infrastructure than is common in decision-making research.

Second, we should calibrate expectations for what the field can realistically deliver, especially for practitioners. This nascent field should not promise the royal road to perfect (or better) prediction of choice. Some people can get seduced by the dramatic brain images in *Time Magazine* and the like, and think that it must be “real science,” which they assume is better than the usual behavioral work (Weisberg et al. 2008).

The fields of decision neuroscience and consumer neuroscience are academic disciplines that use a multidisciplinary and multimodal perspective to tackle its research questions. There is no magic: one cannot peek inside a decision maker's head and predict individual's selection of toothpaste or tomorrow's visit to the grocery store. We must be mindful of the limits of the techniques we use. For example, fMRI methodology cannot allow definitive inferences about the neurotransmitter system in play for a particular activation. But, our general point is that what is going on inside the head as measured by various imaging and biological correlates like genes and hormones can provide new insights and new ways to test theory. This is a great opportunity for the decision-making researcher.

Where do we go next? As the field of consumer neuroscience moves into the mainstream, we need to develop publication standards, establish training centers to educate graduate students and provide additional training for faculty who want to retool. Most importantly, the field needs to tackle the exciting research questions that are now possible with the new tools in our research toolbox. Unprecedented research opportunities are now available by adopting a multidisciplinary perspective on decision making that incorporates biological approaches.

## References

- Behrens, T. E. J., Hunt, L. T., Woolrich, M. W., & Rushworth, M. F. S. (2008). Associative learning of social value. *Nature*, *456*, 245–U245.
- Berns, G. S., & Moore, S. (2012). A neural predictor of cultural popularity. *Journal of Consumer Psychology*, *22*, 154–160.
- Berns, G. S., Capra, C. M., Moore, S., & Noussair, C. (2010). Neural mechanisms of the influence of popularity on adolescent ratings of music. *NeuroImage*, *49*, 2687–2696.
- Chib, V. S., Rangel, A., Shimojo, S., & O'Doherty, J. (2009). Evidence for a common representation of decision values for dissimilar goods in human ventromedial prefrontal cortex. *Journal of Neuroscience*, *29*(39), 12315–12320.
- Doll, B., Hutchison, K., & Frank, M. (2011). Dopaminergic genes predict individual differences in susceptibility to confirmation bias. *Journal of Neuroscience*, *31*, 6188–6198.
- Fellows, L. K., & Farah, M. J. (2007). The role of ventromedial prefrontal cortex in decision making: judgment under uncertainty or judgment per se? *Cerebral Cortex*, *17*(11), 2669–2674.
- Glimcher, P., Camerer, C., Fehr, E., & Poldrack, R. (2009). *Neuroeconomics: decision making and the brain*. Amsterdam: Elsevier.
- Gul, F., & Pesendorfer, W. (2008). The case for mindless economics. In A. Caplin & A. Shotton (Eds.), *The foundations of positive and normative economics*. Oxford: Oxford University Press.

- Ho, C., & Spence, C. (2009). Using peripersonal warning signals to orient a driver's gaze. *Human Factors*, *51*, 539–556.
- Kable, J., & Glimcher, P. (2007). The neural correlates of subjective value during intertemporal choice. *Nature Neuroscience*, *10*, 1625–1633.
- Kable, J., & Glimcher, P. (2009). The neurobiology of decision: consensus and controversy. *Neuron*, *63*, 733–745.
- Kable, J., & Glimcher, P. (2010). An “as soon as possible” effect in human intertemporal decision making: behavioral evidence and neural mechanisms. *Journal of Neurophysiology*, *103*, 2513–2531.
- Klucharev, V., Hytonen, K., Rijpkema, M., Smidts, A., & Fernandez, G. (2009). Reinforcement learning signal predicts social conformity. *Neuron*, *61*, 140–151.
- Knutson, B., Rick, S., Wimmer, G. E., Prelec, D., & Loewenstein, G. (2007). Neural predictors of purchases. *Neuron*, *53*, 147–156.
- Kringelbach, M. L. (2005). The human orbitofrontal cortex: Linking reward to hedonic experience. *Nature Reviews Neuroscience*, *6*, 691–702.
- Krugel, L., Biele, G., Mohr, P., Li, S.-C., & Heekeren, H. (2009). Genetic variation in dopaminergic neuromodulation influences the ability to rapidly and flexibly adapt decisions. *Proceedings of the National Academy of Science*, *106*, 17951–17956.
- Litt, A., Plassmann, H., Shiv, B., & Rangel, A. (2011). Dissociating valuation and saliency signals during decision-making. *Cerebral Cortex*, *21*, 95–102.
- Mehta, P.H., Yap, A., & Mor, S. (2010). The biology of bargaining: dynamic hormone changes during negotiation predict economic profit. *Talk presented at the conference for the Social and Affective Neuroscience Society*, Chicago, IL.
- Plassmann, H., O'Doherty, J., & Rangel, A. (2007). Orbitofrontal cortex encodes willingness to pay in everyday economic transaction. *Journal of Neuroscience*, *27*(37), 9984–9988.
- Plassmann, H., O'Doherty, J., & Rangel, A. (2010). Aversive goal values are negatively encoded in the medial orbitofrontal cortex at the time of decision-making. *Journal of Neuroscience*, *30*(32), 10799–10808.
- Poldrack, R. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, *10*, 59–63.
- Poldrack, R., Halchenko, Y., & Hanson, S. (2009). Decoding the large-scale structure of brain function by classifying mental states across individuals. *Psychological Science*, *20*, 1364–1372.
- Raafat, R. M., Chater, N., & Frith, C. (2009). Herding in humans. *Trends in Cognitive Sciences*, *13*, 420–428.
- Schultz, W., Dayan, P., & Montague, P. R. (1997). A neural substrate of prediction and reward. *Science*, *275*, 1593–1599.
- Sheese, B. E., Voelker, P. M., Rothbart, M. K., & Posner, M. I. (2007). Parenting quality interacts with genetic variation in dopamine receptor D4 to influence temperament in early childhood. *Development and Psychopathology*, *19*, 1039–1046.
- Smith, D., Hayden, B., Truong, T.-K., Song, A., Platt, M., & Huettel, S. (2010). Distinct value signals in anterior and posterior ventromedial prefrontal cortex. *Journal of Neuroscience*, *30*(7), 2490–2495.
- Tusche, A., Bode, S., & Haynes, J.-D. (2010). Neural responses to unattended products predict later consumer choices. *Journal of Neuroscience*, *30*(23), 8024–8031.
- Vartanian, O., & Mandel, D. (2011). *Neuroscience of decision making*. New York: Psychology Press.
- Venkatraman, V., Payne, J., Bettman, J., Luce, M., & Huettel, S. (2009). Separate neural mechanisms underlie choices and strategic preferences in risky decision making. *Neuron*, *62*, 593–602.
- Venkatraman, V., Clithoro, J. A., Fitzsimons, G. A., & Huettel, S. A. (2012). New scanner data for brand marketers: how neuroscience can help better understand differences in brand preferences. *Journal of Consumer Psychology*, *22*, 143–153.
- Wadhwa, M., Shiv, B., & Nowlis, S. M. (2008). A bite to whet the reward appetite: the influence of sampling on reward-seeking behaviors. *Journal of Marketing Research*, *45*, 403–413.
- Weisberg, D., Keil, F., Goodstein, J., Rawson, E., & Gray, J. (2008). The seductive allure of neuroscience explanations. *Journal of Cognitive Neuroscience*, *20*, 470–477.
- Yoon, C., Gutches, A. H., Feinberg, F., & Polk, T. A. (2006). A functional magnetic resonance imaging study of neural dissociations between brand and person judgments. *Journal of Consumer Research*, *33*, 31–40.