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Consumer Neuroscience: Past, Present, and Future

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Abstract

In this article, we give an overview of the growing field of consumer neuroscience and discuss when and how it is useful to integrate neurophysiological data into research conducted in business fields. We first discuss the foundational elements of consumer neuroscience and showcase a range of studies that highlight the ways that neuroscientific research and theory can add to existing lines of research in marketing. Next, we discuss the new domains and questions that brain data allow us to address, such as an emerging ability to predict market-level behavior in a range of decision types. We conclude by providing insights about the emerging frontiers in the field that we think will have an important impact on our understanding of marketing behavior, as well as organizational behavior.

Keywords

marketing, neuroscience, consumer neuroscience, consumer behavior, decision neuroscience, neuroeconomics

In recent years, research in fields such as finance, management, and marketing has seen a significant increase in the use of experimental methods that measure physiological and/or neural signals. In particular, consumer neuroscience research—which applies tools and theories from neuroscience to better understand decision making and related processes—has shown some of the most growth and development (Ariely & Berns, 2010; Camerer, Loewenstein, & Prelec, 2004, 2005; Plassmann, Ramsøy, & Milosavljevic, 2012; Plassmann, Yoon, Feinberg, & Shiv, 2010; Venkatraman, Clithero, Fitzsimons, & Huettel, 2012).

Consumer psychology is a field that has integrated theories and tools from neuroscience for more than a decade. Thus, in this article we use consumer neuroscience as a specific exemplar of

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management-related research more generally and make links to how organizational research could potentially benefit from using neurophysiological markers wherever possible. The central brain-based methods are electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). However, the field extends to a range of physiological tools including eye tracking and facial emotion coding together with measures of arousal such as heart rate and galvanic skin responses.

Though it entails a more restrictive experimental setting, fMRI is by far the most commonly used neurophysiological technique in academic consumer neuroscience research (Plassmann & Karmarkar, 2015). However, the range of methods available offers researchers the ability to target their experiments to the specific question of interest. For example, eye tracking offers one of the best measures of visual attention, while EEG can be used to measure arousal and engagement responses to information that changes quickly over time. Table 1 offers a broad overview of the techniques featured in this review (adapted from Plassmann & Karmarkar, 2015; see Cacioppo, Tassinary, & Berntson, 2007, for a detailed scientific review and Plassmann, Ambler, Braeutigam, & Kenning, 2007, for a more applied review).

The brief but dense history of work presented in this article illustrates a number of ways in which these methods can expand our understanding of how people make decisions in real-world situations as they unfold over time. One factor that has attracted significant attention is that many neural (and physiological) methods require no conscious effort on the part of the participants. As a result, they have been used to measure implicit, automatic, and/or unconscious processes that might be more challenging to detect via behavioral measures. Furthermore, they offer a measurement pathway that may avoid some of the confounds and biases that can be introduced by survey and interview methods (Feldman & Lynch, 1988). These elements make neural measures particularly compelling for understanding the contributions of emotional or affective processing to individuals' marketplace behavior (but see also Barrett, 2017).

The goals of this article are to offer an overview of the consumer neuroscience field and to discuss when and how it is useful to integrate findings from these methods and approaches into our understanding of behavior more generally. In service of these goals, we first introduce studies that demonstrate the measurable neural correlates of marketing constructs. We then showcase studies that offer strong examples of how neural and physiological research can expand consumer psychology theory and offer pathways to behavioral predictions. The next sections introduce some of the emerging opportunities and directions for consumer neuroscience. We conclude with some thoughts on how the trajectory of consumer neuroscience might best relate to organizational research, and the importance of these advances in improving our overall understanding of behavior in economic and social settings.

Past: Neural Correlates of Consumer Behavior

One of the earliest studies mixing neural methods with marketing-based constructs was research examining the relative preference for two types of "culturally familiar" drinks—namely, Coke and Pepsi (McClure et al., 2004). One of the hallmark findings of this work was that it offered evidence for neural activity in specific areas associated with memory processes (the hippocampus and dorsolateral prefrontal cortex) that was correlated with the Coke brand, but not the Pepsi brand. This opened the possibility that marketing actions could be measured in meaningful ways using neural techniques, and that these techniques could generate novel insights.

Initial consumer neuroscience studies similarly identified neural correlates of marketing-relevant behavior (see also Plassmann, Venkatraman, Huettel, & Yoon, 2015, for a review). A number of these brain areas are illustrated in Figure 1. As one example, Erk and colleagues found more activity in corticostriatal reward circuitry such as the nucleus accumbens (NAcc) and ventromedial prefrontal cortex (vmPFC) in response to consumer preferences for high image sports

Table 1. Examples of Commonly Used Consumer Neuroscience Methods (adapted from Plassmann & Karmarkar, 2015).

Tool	Benefits	Limitations	Management-Relevant Uses
Electroencephalography (EEG)[a]	• Can be used to measure rapid changes in neural activity on the millisecond scale • Minimally invasive and/or commercial research packages available • Possible for participants to move around and engage in enriched/social environments	• Difficult to pinpoint neural signals from particular brain areas (poor spatial resolution) • Does not measure from deep brain structures (e.g., nucleus accumbens)	• Can be used to monitor experience in stores and in social settings • Can detect positive/negative arousal, decision conflict, attention, language processing, some memory effects • Common in neuromarketing (applied) research
Functional magnetic resonance imaging (fMRI)	• Ability to resolve activity in small structures • Differentiates signal from neighboring areas • Whole-brain measurement	• Physically restrictive; participants lie on their backs in the scanner and cannot move around • Expensive and equipment intensive	• Response to marketing stimuli such as brands and price • Localization of neural processing during decision making, consumption experiences, socially relevant stimuli, and value learning • Prediction of market-level and/or population-level behavior
Eye tracking	• Offers strong nuanced data on visual attention and gaze pathways, and can be integrated with pupillometry	• Does not measure inferences, valence of the response, thoughts, or emotions	• Evidence of overt attention • Shelf layout and packaging and advertising • Website usability • Can be applied to attention and information seeking in interpersonal communication and social scenes
Transcranial magnetic stimulation (TMS)/tDCS	• Can be used to show causality	• Limited to investigating function of surface brain areas • Can only generally lower (TMS/tDCS) or raise (tDCS) neural activity generally; cannot test for specific "levels" of activity or influence specific circuits	• Studying causality of specific brain regions for specific mental processes (e.g., preferences, brand choice) by temporarily taking them "offline" • Can be used to upregulate and downregulate brain areas relevant to self-control and social conformity

(continued)

Table 1. (continued)

Tool	Benefits	Limitations	Management-Relevant Uses
Biometrics: skin conductance response (SCR), heart rate, pupil dilation	• Simple; well validated • Unobtrusive equipment; allows for more natural interactions with environment	• Cannot distinguish between positive and negative arousal	• Response to communication stimuli (e.g., commercials and/or persuasive and signaling messages) • Inferences of emotional engagement/arousal during choice processes • Inferences of emotional engagement/arousal during interpersonal interactions with others of varying status
Facial electromyography (fEMG), facial affective coding	• Dynamic tracking of emotional (potentially unconscious) responses to ongoing stimuli/information • Available automatic facial encoding software/algorithms	• Requires attaching electrodes directly to the face (in a lab)	• Valence of response to marketing stimuli, in particular commercials • Inferences of emotional valence of information processing during choice and processes like negotiations
Pharmacology	• Allows better understanding of (physiological) state-dependent effects	• Cannot measure fast/immediate changes • Individual chemicals have multiple effects that can be difficult to isolate; specific effects can be unclear	• Oxytocin: stress, cooperation, social interactions • Testosterone: impulsiveness, risk behavior, aggression, social interactions, power • Cortisol: stress, conflict, general arousal

[a]Additional techniques such as single-neuron recording, research in patient (e.g., neural lesion) populations, and magnetoencephalography have been used to address management-related questions. However, because of their limited availability and/or limited scope of current research in the field, we do not provide details here.

cars compared to more boring vehicles (Erk, Spitzer, Wunderlich, Galley, & Walter, 2002). Though there was a Coke-specific pattern of activity in the hippocampus and dorsolateral prefrontal cortex (dlPFC) on average in the McClure et al. (2004) study, Deppe and colleagues also found that their subject's favorite brand activated significantly more of the vmPFC compared to other brands from the same category that were less liked (Deppe, Schwindt, Kugel, Plassmann, & Kenning, 2005).

Building on this, Knutson and colleagues investigated which brain areas responded most strongly to specific elements of retail-type yes/no purchasing decisions. They found that activity in the NAcc correlated with product preferences, or "liking" for the product. Interestingly, this was distinct from medial prefrontal cortex (mPFC) activity that was more associated with consumer surplus, or perceptions of monetary value related to both the product and its price. In addition, their findings implicated insula activity as representing the negative impact or negative emotions associated with disliked prices (Knutson, Rick, Wimmer, Prelec, & Loewenstein, 2007). Plassmann and colleagues complemented these investigations by considering individuals' willingness to pay (WTP)

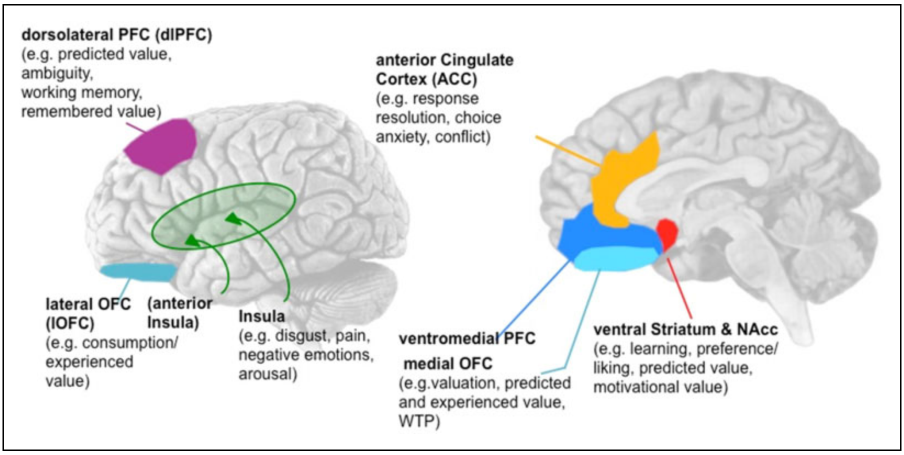

Figure 1. Brain areas important for investigations into consumer decision making (adapted from Plassmann & Karmarkar, 2015).

as measured by incentive compatible Becker-DeGroot-Marschak auctions (Becker, DeGroot, & Marschak, 1964). They found that vmPFC and dlPFC activity encoded WTP for not only appetitive products, but also for aversive ones (Plassmann, O'Doherty, & Rangel, 2010, 2007).

The importance of these areas was reinforced by a broader meta-analysis of fMRI studies that involved decision-making paradigms across a range of fields (Bartra, McGuire, & Kable, 2010). In particular, "rewards" were consistently associated with the striatum, and "subjective value" was consistently associated with activity in prefrontal (and orbitofrontal) cortex. In addition to products and prices, later work explored more strategic marketing elements such as packaging attractiveness and brand preferences (Esch et al., 2012; Reimann, Zaichkowsky, Neuhaus, Bender, & Weber, 2010; Schaefer & Rotte, 2007). Many of these findings also converged on the important role of the mesolimbic system, specifically the striatum/NAcc and vmPFC, in encoding different facets of an individual's value perceptions (e.g., preferences, utility, WTP) for not only products but also specific product features.

Present: Integrating Neuroscience and Behavior in Consumer Research

While these findings offered a necessary foundation for the study of consumer neuroscience, from a management perspective, it could be argued that they tell us more about the brain than they do about behavior. In a recent survey conducted by this article's authors, consumer neuroscience academics listed the publications in the field that they perceived as most influential (Plassmann & Karmarkar, 2015). Of the top five, three fell into this "brain-focused" first-step category. In particular, 61% of the individuals who answered the question indicated Plassmann, O'Doherty, Shiv, and Rangel's 2008 study on the pricing of wine, 48% listed the McClure et al. (2004) Coke/Pepsi study, and 30% named the Knutson et al. (2007) article on the neural predictors of purchases described above. Notably, all three of these articles were published in neuroscience journals.

In contrast, the other two articles in the top five were both published in marketing journals (Yoon, Gutchess, Feinberg, & Polk, 2006, 32%, and Berns & Moore, 2012, 20%; discussed below). This could be an indicator of where such research is headed. While it was initially important to establish the relevance of neural data for marketing questions, the discipline has progressed to the point where it can offer rigorous study of consumer psychology directly. This transition is likely an important one for many applied and/or business fields. When considering organizational behavior and management specifically, it is possible that the significant growth of fields such as neuroeconomics and social and affective neuroscience can already offer a strong theoretical foundation. In particular, social neuroscience has generated a number of findings related to trust, competition, social norms, and empathy (see Rilling & Sanfey, 2011, for a review). However, as with consumer neuroscience, it may be that initial steps for "neuro-management" will need to test the neural correlates of foundational field-specific constructs to establish reference data that both neuroscience and non-neuroscience researchers can build on.

Moving beyond what has been accomplished already, neurophysiological techniques have a role in offering distinct data that can complement what is measured by other research methods in the field. This can allow us to strengthen the foundations of consumer psychology as well as advance its boundaries. In the following sections, we highlight a number of studies that speak to three areas of neuroscience-based research that are having a significant impact on our understanding of consumer psychology: additions and expansions to behavior-based theory, as well as a novel science of predicting behavior.

Additions: Resolving Conflicts and Adding Insight Into Existing Decision-Making Theories

Research models and methods. One of the productive ways that neural and physiological methods can be applied in consumer psychology is to refine current models, assumptions, or hypotheses related to certain behavioral outcomes and patterns. As one example, a seminal assumption in psychology and some fields of business research is that responses to hypothetical scenarios and choice situations offer good approximations for everyday behavior. This clashes with practices in economics that rely on revealed preference theory and require "real" and/or incentivized choices.

Research by Kang and colleagues approached this conflict directly by using fMRI to compare whether hypothetical and incentive compatible (or "real") choices involve the same neural circuits. They found that the two situations involve similar brain areas, suggesting that the same mechanisms and value calculations are occurring whether or not a choice is incentivized. However, they also showed that the levels of activation were stronger for real choices than for hypothetical ones (Kang, Rangel, Camus, & Camerer, 2011). This takes on additional relevance in the context of organizational behavior research, which can involve complex and difficult social relationships. It may offer a caveat in considering whether null results arise from the difficulty of recreating these complexities in the lab. However, it also suggests that the patterns of neural activity arising from hypothetical situations can indeed be generalized. A further provocative prediction to consider from this work might be that "weaker" hypothetical choices could be more malleable or have lesser long-term and/or carryover effects than fully incentivized decisions.

fMRI findings can also support consumer behavior theories related to the question of whether consumers' preferences for an item rely on the awareness of a decision-making context, or the need to make a choice. Social psychology research would suggest that preferences are formed and/or retrieved automatically, and without conscious control (Duckworth, Bargh, Garcia, & Chaiken, 2002; Fazio, Sanbonmatsu, Powell, & Kardes, 1986; Zajonc, 1980). A number of recent fMRI articles have addressed this issue and have found evidence that the brain encodes preferences even when participants are unconcerned with, or unaware of, any need to make a decision (Lebreton, Jorge, Michel, Thirion, & Pessiglione, 2009; Levy & Glimcher, 2011; Smith, Bernheim, Camerer, & Rangel, 2014; Tusche, Bode, & Haynes, 2010). In several of these studies, incidental encoding of preference is predictive of subsequent decision making. Such findings also suggest that there may be some element of preference that is represented similarly regardless of when and how the target is encountered (see also Karmarkar, Shiv, & Knutson, 2015). This convergence of neural and behavioral data in support of automatic unconscious preference formation bridges theories across different disciplines and offers a useful background for understanding what elements of business practice are more or less susceptible to contextual effects.

Resolution of competing hypotheses. The addition of neural data can resolve competing theories regarding one particular type of behavior. Prior research has shown that information about a product, such as brand or price, can induce expectations about the product's quality in ways that have meaningful downstream effects on consumption (Allison & Uhl, 1964; Lee, Frederick, & Ariely, 2006; Shiv, Carmon, & Ariely, 2005; for a review, see Plassmann & Wager, 2014). It is possible that marketing actions could actually be changing consumers' sensory experiences—a high quality expectation engendered by a high price could make a product taste better. But it is also possible that these effects could come from a form of motivated reasoning, in which people interpret or filter new experiences and information to match a belief or perception they already hold (Kunda, 1990).

In addition, people could be influenced by explicitly or implicitly felt social pressures related to the marketing signal. Plassmann and colleagues tested this directly using fMRI, having their participants consume identical wines with different price tags while being brain scanned. They found that higher prices enhanced the actual tasting experience—that is, how the product quality was perceived and/or how "tasty" the individuals found the wine to be (Plassmann et al., 2008). These findings offer an interesting complement to the ones on hypothetical scenarios; here they suggest that the effects of marketing actions on product experiences are as "real" as the effects of more tangible or physical attributes. These findings might relate to ways that signaling works in an organizational research setting. For example, looks or other nonverbal behaviors serving as "quality signals" from a leader might work similarly to quality cues from marketers by changing how employees encode their work experiences in their brains (Rule et al., 2010; Rule et al., 2011; Todorov, Baron, & Oosterhof, 2008).

Social and interpersonal effects in business contexts. Neuroscientific investigations have also been able to refine existing marketing theories in directions that are important for understanding interpersonal and person–firm relationships. For example, the brand personality framework is a central pillar of both consumer research and marketing practice (Aaker, 1997). This work developed dimensions of brand personality that are analogous to the "big five" human personality dimensions (Costa & McCrae, 1985), though they are defined distinctly. These parallels raise the question of whether brand personalities are indeed perceived in the same way as human ones are. Yoon and colleagues (2006) addressed this question directly in an fMRI study, finding that judgments about brands and people recruited mostly dissociable neural systems. This suggests that despite apparent similarities in the constructs, individuals process information about brands and humans using fundamentally different mechanisms.

While the Yoon et al. article established boundaries around the perceptions of brand personality, fMRI research by Chen, Nelson, and Hsu (2015) offered evidence validating the dimensions that compose the brand personality framework. Their research first identified maps of neural activity across the whole brain that were associated with each of the five dimensions of brand personality (excitement, competence, sincerity, ruggedness, and sophistication). They were then able to use these neural dimension maps to "predict" the type of brand a person was seeing. More specifically, by examining the degree to which each of the brand personality neural maps correlated with the brain map arising from a particular brand, it was possible to appropriately infer the kind of brand the person had viewed (Chen et al., 2015). These results show that brand personality dimensions do indeed represent perceptions that accurately relate to the way that the brain codes its responses to individual brands. These ideas could potentially also extend to how firms are perceived by their employees or other organizational stakeholders, with meaningful personalities that might parallel the personalities of brands (Haack, Pfarrer, & Scherer, 2014).

Beyond direct branding, marketers often use celebrity endorsements to endow a product with the ability to engage consumers socially. However, the mechanisms by which these “faces of the firm” exert their influence remain unclear. One neuroimaging study focused on celebrity as a form of recognized expertise, showing that when celebrity spokespeople were credible experts, they could create deeper processing and trust and possibly more integrated encoding for the target product than nonexpert celebrities could (Klucharev, Smidts, & Fernández, 2008). Focusing on the specific benefits of “being famous,” work by Stallen and colleagues confirmed that there is a transfer of positive affect from the individual celebrity to the product that arises from a recipient’s (positive) memories and thoughts about the celebrity (Stallen et al., 2010). These findings offer interesting possibilities for organizational research on the persuasive abilities of company and/or team “rockstars.” More generally, the range of mechanisms identified in these studies suggest that neural data could provide insights into the processes by which various leaders within an organization are more or less successful in motivating and communicating with their teams.

Expansions: Revealing New Mechanisms Underlying Consumer Decision Making

Since neurophysiological measures can dynamically track neural activity and processes such as attention without overt interruption of people’s behavior, they offer multiple new dimensions of data. It is possible to use this information to identify entirely new models of consumer behavior, or to reveal new mechanisms involved in how people approach choice scenarios and information processing.

A recent fMRI study by Karmarkar and colleagues illustrates how the temporal dynamics of consumer neuroscience methods can reveal new insights. In this work, the authors examined how the timing of price information did, or did not influence product value and purchasing decisions (Karmarkar et al., 2015). Medial prefrontal cortex activity (correlated with perceptions of monetary value) showed different patterns of activity depending on whether participants saw prices before or after seeing the associated product. The neural data suggested that when the product appeared first, participants were making the purchase decision by asking “Do I like this?” But under “price primacy,” when prices appeared first, the decision question seemed to shift to “Is this worth it?” A timing-based shift in mind-set had not been suggested in previous research, nor was it obvious from the behavioral data during the task. However, with the insights revealed by the neural findings, it was possible to target behavioral consequences of price primacy. A second experiment showed that price-first situations increased purchases of products with a clearly defined “worth” or functional value.

Combining time with space, neurophysiological measures have dramatically increased our understanding of the contribution of visual attention to choice (Milosavljevic & Cerf, 2008). Eye-tracking research has shown that the time people spend looking at a product is predictive of their likelihood of purchase (Krajbich, Armel, & Rangel, 2010). While this seems relatively uncontroversial, further research has shown that this relationship between visual attention and purchase is bidirectional and can be causal. In two-option choice experiments with generally desirable items, both theoretical models and eye-tracking experiments showed that the longer a particular item was shown, the more likely participants were to choose it (Armel, Beaumel, & Rangel, 2008; Krajbich et al., 2010; Krajbich, Lu, Camerer, & Rangel, 2012; Krajbich & Rangel, 2011).

Complementing these studies is work that looks at the visual salience of products and promotional material (Milosavljevic, Navalpakkam, Koch, & Rangel, 2012; Pieters & Wedel, 2004; Towal, Mormann, & Koch, 2013). For example, one set of studies has shown that when people are making very fast decisions and/or choices when they are under cognitive load, the visual salience of a product can override their true preferences (Milosavljevic et al., 2012). Furthermore, eye tracking can be used to explore branding and how it influences the subjective meaning of stimuli (Philiastides

& Ratcliff, 2013; Pieters, Rosbergen, & Wedel, 1999; Wedel & Pieters, 2000). Eye tracking can also offer more targeted and detailed recommendations about how to use specific design elements in domains such as food packaging (Piqueras-Fiszman, Velasco, Salgado-Montejo, & Spence, 2013) and shelf placements (Chandon, Hutchinson, Bradlow, & Young, 2013), thus offering insights that span theory and practice.

In addition to marketing applications, eye tracking and computational models of visual attention could potentially offer insights for management and organizational researchers. Eye tracking can be a powerful method for detecting implicit social associations (e.g., Fiedler, Glöckner, Nicklisch, & Dickert, 2013), and tracking visual attention might offer another path to understanding power dynamics in team behavior and negotiations (e.g., Kleinke, 1986). This tool opens up a new dimension of data, allowing us a richer understanding of management-related behaviors.

Neural-based predictions of behavior. Above, we described consumer neuroscience contributions to preexisting topics and concepts in marketing. Going beyond this, neural data may have a unique ability to directly predict consumer behavior. Measures such as EEG and fMRI can track nuances of a person's response to various attributes of a decision, or decision target, as the choice process unfolds, even before a conscious decision is actually made. Taking advantage of this, several studies have shown that it is possible to predict an individual's future patterns of behavior from his or her own brain activity (Chua et al., 2011; Demos, Heatherton, & Kelley, 2012; Ersner-Hershfield, Wimmer, & Knutson, 2008; Falk, Berkman, Mann, Harrison, & Lieberman, 2010; Mitchell, Schirmer, Ames, & Gilbert, 2011). Expanding the generalizability of such results, recent findings have shown that it is possible to use fMRI and/or EEG data from small groups of people to predict the future marketplace behavior of larger populations (see also Knutson & Karmarkar, 2014, for a review).

Predicting preferences. In one of the first such studies, Berns and Moore (2012) compared fMRI scans of people listening to novel music clips found online to the popularity of those songs three years later. The authors found that the participants' average neural activity in the NAcc during a song was a significant predictor of the song's sales. In contrast, participants' survey ratings of how much they liked the songs were *not* significant predictors, highlighting the distinct contribution of the brain data (Berns & Moore, 2012). Prediction of sales success has also been achieved using EEG recordings: In an experiment involving individuals watching movie trailers (Boksem & Smidts, 2015), activity measured by EEG in one group of individuals was significantly correlated with the U.S. box office results for those movies. These ideas and approaches are applicable to organizational research, which often relies on survey methods. For some organizational research questions neural data could be a better predictor of organizational behavior and policy-related behaviors than predictors based on survey data (Antonakis, 2017).

Another methodological approach that can be used for prediction is intersubject correlation (ISC). ISC examines the degree of similarity among the neural responses recorded from multiple individuals as they are experiencing the same stimulus. The degree of this correlation has been shown to reflect the fidelity of information transmission, or how consistent and/or similar consumers' level of engagement is with visual media such as movies (Hasson, 2004; Hasson & Honey, 2012; Hasson et al., 2008). Recent work measured the ISC of EEG traces from a small group of individuals while they were watching a popular television program; the researchers were able to use that data to successfully predict the moment-to-moment viewership of that program across the population (Dmochowski et al., 2014). This analytical technique can be applied to both EEG and fMRI data and could offer insights not only into the likely popularity of various media, but also into the kinds of situations or elements that generate the most viewer engagement. Furthermore, because social interactions and being "in sync" with each other is important to the efficiency of group work and negotiations, such intersubject-correlation models could potentially offer insightful findings for existing organizational theories.

Predicting persuasion. Beyond predicting preferences, neural data can also offer insight into the efficacy of consumer-focused communications in persuading their targets and/or influencing behavior. In one example, a "neural focus group" underwent fMRI scanning while watching various antismoking campaigns. Participants' prefrontal cortex activity levels outperformed survey measures in predicting the national success of the campaigns in encouraging call volumes to "quitting hotlines" (Falk, Berkman, & Lieberman, 2012).

In a second example, a study of a small sample of individuals (18) analyzed fMRI data taken while people viewed various promotional materials for chocolates, focusing on a preselected set of neural regions based on the consumer neuroscience literature (Kühn, Strelow, & Gallinat, 2016). The experimenters found that the neural data significantly predicted the ranking of which display materials would elicit the highest to lowest purchase rates of the chocolate in a real grocery store location.

In a study of particular interest to organizational researchers, fMRI was used to examine responses to individuals' loan requests as posted on the microfinance website Kiva.org. Neural activity from the participants was significantly predictive of the true success of those requests in being funded (Genevsky & Knutson, 2015). Framing this more broadly, one interpretation could be that neural data can be used to study the conditions that engage altruistic behavior and/or trust-dependent behavior, as well as the types of situations that engender positive social relationships, particularly in online contexts.

The largest-scale demonstration of predicting market-level behavior to date has been a collaborative effort among academics, companies, and the Advertising Research Foundation. This group examined responses to ads from multiple brands using a range of traditional and "neuromarketing" methods (Venkatraman et al., 2015). The research tested how well data from these measures linked to market-level sales elasticities (the percentage change in sales/market share due to a 1% change in the amount of advertising). They found that fMRI data were uniquely able to explain variance beyond traditional measures such as survey responses. This specific benefit of neural data, present in the majority of the research studies in these sections, underpins the important contribution that neurophysiological research can make to enhance existing methodologies, even when the measure of central interest relates to behavior.

Overall, by measuring a distinct set of signals from consumers, neural methods offer novel dimensions of insights into consumer preferences, message receptivity, and behavior at individual and market levels. A growing number of studies support the ability of these data to potentially outperform the data gathered by more commonly used behavioral measures. While this has been most commonly demonstrated in transactional or personal-reward-based situations, such predictive power could possibly be applied to interpersonal decisions and/or understanding and predicting social rewards based on the inclusion of a wider network of brain regions (e.g., Behrens, Hunt, & Rushworth, 2009; Ruff & Fehr, 2014). An important feature of this type of research is thus likely to involve expanding such experiments from investigating the behavior of individuals around self-motivated goals to having people make decisions with distinct interpersonal consequences, engage in negotiations, and/or work toward collaborative team goals.

Challenges of Applying Neural Findings to Management Disciplines

One caveat of using neuroscientific methods, particularly those such as fMRI that localize neural activity in specific brain regions, is that the extent to which psychological processes can be inferred from neural data is limited. Over the past two decades, a growing number of fMRI studies have contributed to our better understanding of the relationships between a brain structure and a certain function. These data allow some inferences about the role of particular brain regions during the manipulated psychological process of interest. For researchers interested in consumer or organizational behavior it is tempting to employ “reverse inference,” whereby the engagement of a particular mental process is inferred from the activation of a particular brain region based on past findings (Poldrack, 2006, 2011). Reverse inference is problematic for two central reasons. The first is that psychological processes and concepts do not necessarily map directly onto specific brain regions. The second is that individual brain regions are usually involved in more than one function. For example, the anterior insula has been involved in the feeling of pain. However, it is also involved in disgust, psychological arousal, and the feeling of love. Hence, a one-to-one mapping of brain activation coordinates to a brain function is rarely valid.

This issue raises the question of whether a reverse inference can be justified. This depends on how well brain activation tends to match the psychological concepts used by researchers and how specific and selective the concept–region mapping is. It is also still a source of active debate. Meta-analyses across thousands of neuroimaging studies (e.g., Yarkoni, Poldrack, Nichols, Van Essen, & Wager, 2011) provide statistical measures of the validity of reverse inferences; correspondence can be very strong for some relationships (e.g., activation in the striatum and reward processing; Bartra et al., 2010) but much weaker for others (e.g., activation in the insula and love). Failure to recognize the statistical properties of reverse inference can lead to false conclusions; a particularly notorious example was an erroneous claim made that iPhone usage elicits feelings of love based on activation in the anterior insula (Lindstrom, 2011).

Future: New Avenues and Domains

The work described in this article covers several ways that neurophysiological techniques have already proven useful for understanding people in business situations, and how they might be transferred to the study of organizational research. These examples also reveal how consumer neuroscience is developing its own integrated field of study rather than simply a loose collection of brain science related to decision making. The pace of this development is quite fast, creating a widening platform to which insights can be added by using more neurophysiological markers of consumer and organizational behavior (Smidts et al., 2014). It has been further accelerated by connections to other thriving academic communities, such as neuroeconomics, that have advanced frameworks on the neural mechanisms underlying decision-making processes and individual perceptions of value. Looking to the future, disciplines such as social and affective neuroscience offer an important way to expand the scope of this research to include the contributions of social influences and settings as well as interpersonal interactions. For example, recent research suggests that there may be multiple value systems that trade off between social rewards and individually defined rewards (e.g., Jenke & Huettel, 2016). These types of studies are also likely to offer significant insight for organizational research, and ideally would help integrate more consumer-focused and organization-focused findings into a larger framework of human behavior in management contexts.

In the following sections, we outline other developing domains that push beyond the scaffolding built by behavioral work in consumer psychology to offer new tools and directions that are intrinsically derived from the data offered by neural measures. We can broadly divide them into two areas: (1) better understanding individual differences in consumer behavior and (2) better understanding state-dependent differences in consumer behavior.

Individual Differences

While it is often useful to understand the principles that can govern behavior in general, the moderating effects of individual differences are of significant interest to consumer researchers and can be a powerful source of insight in applied human resource work, such as hiring practices and team building. First, we can start with known psychological or demographic individual differences of interest and use consumer neuroscience to expand our understanding of them. Below we showcase examples that integrate more holistically known individual differences in economic behavior due to socioeconomic status, age, and culture. Second, it is possible to uncover measurable individual differences in the brain and translate those into psychological or socioeconomic individual differences such as personality traits. The same approach could be useful for better understanding individual differences across company cultures and organizational roles.

Expanding the understanding of known demographics of interest and their impact on neurophysiological markers. Evidence exists that individual differences in sociodemographic status can be linked to differences in neurophysiological markers to explain economic behavior. For example, Haushofer and Fehr (2014) used measures (and manipulations) of the stress hormone cortisol to identify links between poverty and stress and to then connect those to changes in risk-taking behavior. Notably, this work was done in countries beyond western/European ones, broadening the scope of our understanding of how these factors operate across different types of societies.

Advanced age is a ubiquitous individual difference that cuts across all kinds of groups and has been shown to influence consumer behavior (Carpenter & Yoon, 2012; Carstensen et al., 2011; Drolet, Schwarz, & Yoon, 2010; Yoon, Cole, & Lee, 2009). The neuroscience of age-dependent behavior has generated a number of new perspectives on consumption patterns (Halfmann, Hedgcock, & Denburg, 2013; Hedden & Gabrieli, 2004; Mohr, Li, & Heekeren, 2010; Samanez-Larkin, Li, & Ridderinkhof, 2013). In a nutshell, these studies find that aging and the biological maturation that occurs with it alter the cortical-subcortical brain networks underlying consumer decision making (and their regulation by neurotransmitters such as dopamine and serotonin). These in turn alter behaviors encoded in such networks such as risk-taking behavior during financial decision making, cognitive control, and intertemporal choice tasks (Cassidy, Hedden, Yoon, & Gutchess, 2014; Denburg et al., 2007; Samanez-Larkin et al., 2011; Samanez-Larkin & Knutson, 2015; Samanez-Larkin, Kuhnen, Yoo, & Knutson, 2010; Samanez-Larkin, Robertson, Mikels, Carstensen, & Gotlib, 2009).

As a last example, another new area of study has been dubbed "cultural neuroscience" (see Chiao, Cheon, Pornpattananangkul, Mrazek, & Blizinsky, 2013, for a review). Studies in this area have allowed researchers to better identify links among culture and psychological processes using neural data as a mediator (e.g., Kitayama & Park, 2010; Kitayama & Uskul, 2011). Cultural neuroscience allows researchers to discriminate between individual differences or variations that occur within groups as well as differences in how groups behave across cultures (Na et al., 2010). In other words, this suggests that neural data might potentially be useful to dissociate whether a particular difference in a psychological variable, such as representations of the self, should be considered an individual-level difference or a group-level difference. All of these factors—socioeconomic status, age, and culture—are also established individual differences of interest in management research. Thus, the application of neuroscience similarly holds a unique potential to shed light on *why* those individual variables change organizational behavior.

Using neurophysiological markers to rethink individual differences. We can also approach individual differences from the "bottom up," looking at neurophysiological markers that can inform differences at behavioral levels. As one example, individual brain anatomy such as gray matter volume (GMV) can be linked to individual differences in brain function, personality, and behavior (DeYoung et al., 2010; Newman, Trivedi, Bendlin, Ries, & Johnson, 2007; Peinemann et al., 2005). Such individual anatomical differences in dopaminergic pathways have been linked to significant differences in effects on reward-guided behaviors and variation of reward-related personality traits (Depue & Collins, 1999; Wansink, Payne, & North, 2007).

In a recent consumer neuroscience study taking this approach, the authors used automated structural brain imaging in combination with traditional experiments to determine individual differences in expectancy or placebo effects of marketing actions such as pricing and branding (Plassmann & Weber, 2015). They found evidence that consumers high in reward seeking and higher GMV in a reward-related brain region, high in need for cognition and higher GMV in one of the brain's cognitive integration hubs, and low in somatosensory awareness and lower GMV in the brain somatosensory cortex are more responsive to expectancy effects of marketing actions.

These correlational results provide emerging evidence for stable biomarkers for responsiveness to influence by marketing actions. Similar results suggest that GMV of a specific brain area (right posterior parietal cortex) could provide a marker for individual risk attitudes (Gilaie-Dotan et al., 2014). Biomarkers such as these could serve as a simple measurement of economically relevant behaviors that could be easily extracted from the wealth of existing medical brain scans, and could potentially offer policy makers and businesses a characteristic distribution of these attitudes across the population.

Connectivity between different brain systems offers another new approach to measuring individual differences relevant for consumer behavior but also for leadership roles and collaborative team interactions. Such measures can investigate either structural connectivity or intrinsic functional connectivity (see Kable & Levy, 2015, for a more detailed review). The former measures individual differences in how the brain is wired (i.e., the range and strength of white matter connectivity assessed by a technique called diffusion tensor imaging); the latter measures the brain's ongoing activity when participants are asked to do nothing (the so-called resting-state activity; Raichle, 2015).

As an example of how this information could be applied, both approaches have advanced our understanding of delay discounting. Van den Bos and colleagues found that the extent of delay discounting was negatively correlated with the strength of connection between a region involved in self-control (the dorsolateral prefrontal cortex) and a region involved in reward prediction and motivation (the striatum; van den Bos, Rodriguez, Schweitzer, & McClure, 2014). In addition, a study by Li and colleagues found evidence for a negative correlation between delay discounting and the functional connectivity among regions that have been implicated in self-control and reward-related structures important for the choice process (Li et al., 2013). Taken together these findings support the notion that there are multiple paths involving structural and functional connections by which preference for immediate rewards can be increased.

"Within-Individual" Differences

Beyond differences among segments of consumers, neuroscience can also reveal variability in one individual's decision-making processes depending on his or her particular (temporary) state. For example, specific states such as sleep deprivation and hunger (or satiety) can have temporary but significant influences on choices and preferences. Pharmacological interventions and measurements offer ways of reliably characterizing, detecting, and inducing these states to examine their specific contributions to behavior through the study of neuromodulators. Neuromodulators include chemicals that allow neurons to communicate with each other (e.g., neurotransmitters) as well as brain hormones. Neurotransmitters such as dopamine relate to reward processing, motivation, and learning, while serotonin relates to regulation of mood, appetite, and sleep as well as social preferences, memory, and learning. This field of study further includes hormones such as testosterone, cortisol, and oxytocin, the latter of which is important for social preferences and bonding (Crockett & Fehr, 2014; Kable, 2011).

The levels of neuromodulators in the brain and body are regulated in response to specific inner states and events in the environment. So, for example, being stressed is characterized by increased levels of the neuromodulator cortisol. Thus, neuromodulators can be thought of as encoding a context, whether that is features of the external environment (e.g., competitors, potential mates, negotiation partners, or challenging bosses) or internal states (e.g., mood, reproductive status, high arousal, or hunger levels); note that group-dependent differences in cortisol responses were also useful for indicating individual differences in stress responses, as discussed earlier (e.g., Haushofer & Fehr, 2014). Furthermore, these state-dependent varying levels of neuromodulators can then influence information processing in related brain systems (Cooper, Bloom, & Roth, 2003; Crockett & Fehr, 2014; Robbins & Arnsten, 2009).

The functioning of neuromodulators could be integrated in consumer and organizational research in multiple ways. A recent study demonstrates one of these ways: establishing correlations between peripheral levels of a neuromodulator and attitudinal or behavioral measures. The authors investigated the link between participants' testosterone levels (measured from their saliva) and impulsivity related to preferences for smaller sooner over larger later rewards (Takahashi, Sakaguchi, Oki, Homma, & Hasegawa, 2006). This study found an inverted-U relationship between impatience for gains and salivary testosterone levels, regardless of individual differences in base levels of impulsivity. Measures of this neuromodulator are related to several behaviors that are critical for interpersonal relationships and affect organizational behavior. For example, testosterone and cortisol levels have been linked to social rank behaviors and status signaling (e.g., Mehta & Josephs, 2010). Previous work has also shown that arousal related to affiliation motivation and arousal related to power can have detectably differing effects across genders on hormones such as testosterone and progesterone (Schultheiss, Wirth, & Stanton, 2004).

A second way to integrate neuromodulators into management research is to manipulate them. This is a powerful approach because it offers causal evidence for neurophysiological marker–behavior relationships. But it is important to note the restriction that the link between levels of neuromodulators in the body outside and inside the brain is not generally straightforward (except for testosterone and cortisol), because most of these molecules cannot cross the blood–brain barrier. Hence it is difficult to quantify how an oral administration of a neuromodulator might affect the brain levels of that chemical. For some neuromodulators, such as oxytocin, a nasal administration has been posited to bypass the blood–brain barrier, rather than an oral or dermal administration. However, the mechanisms by which such intranasally administered neuromodulators might enter the brain remain unclear (Chumbley et al., 2014). A more direct way to pursue a manipulation of the level of neuromodulators in the brain is by blocking or stimulating the respective neuromodulator's *receptors* with pharmacological agents. These can be antagonists that impair neuromodulator functioning or agonists that increase neuromodulator functioning.

A successful example of manipulating neuromodulators that involved directly administering testosterone found that consumers' preferences for luxury brands does increase with higher testosterone (T) levels (Nave, Nadler, Dubois, Camerer, & Plassmann, 2015). For consumers, luxury goods represent social markers that elevate them in the social hierarchy by increasing either status or power. Across two large-scale studies, these findings are the first to show a causal relationship between increased preference for luxury goods and single-dose testosterone administration. In addition, the study also showed that status-seeking—but not power-seeking—behavior during consumers' product evaluations can be caused by increased T levels.

As these findings illustrate, understanding the pharmacology underlying individual behavior can generate exciting new avenues for neuroscience to establish causal links between brain and behavior in a range of social and organizational settings.

Conclusions

In parallel with academic advances, practitioners' interest in applying neurophysiological methods to company-specific market research has also advanced. The number of "neuromarketing" research companies has been growing steadily (Plassmann et al., 2012), and most of the largest marketing research companies currently have neuromarketing divisions or partnerships (e.g., Nielsen, Millward Brown, GfK, TNS). Thus, the impact of using neuroscientific techniques is not limited to the theoretical, but extends into shaping how companies approach, relate to, and design their offerings for consumers.

For many questions in theory or practice it can be helpful to choose the single measurement method that best speaks to the question of interest. For example, to study visual attention, eye tracking can provide more directly relevant answers than fMRI. However, to provide definitive evidence supporting a particular theory or explanation of behavior, programs of research involving multiple complementary methods offer significant benefits. Combined methods can offer researchers the ability to measure correlation and also to establish the causality of hypothesized neural mechanisms. In particular, the field could benefit significantly by better incorporating approaches that examine whether loss of a particular brain structure causes loss of the hypothesized function. One traditional route to doing so is conducting experiments with populations of patients who have lesions in focal brain areas of interest.

Alternatively, for cortical structures, "functional lesions" and other changes in neural activity can be caused temporarily and noninvasively by techniques such as transcranial magnetic stimulation (TMS) or transcranial direct current stimulation (tDCS). As an illustration of the benefits of these methods, work by Klucharev and colleagues has shown that using TMS to downregulate activity in the posterior medial prefrontal cortex can reduce the degree to which people exhibit socially conforming behavior (Klucharev, Munneke, Smidts, & Fernández, 2011). This is relevant for better understanding the functioning of these brain pathways and for future consumer research related to social conformity pressures in marketing (e.g., brand responses and adoption), and clearly shows great promise for studying conformity pressure in organizational settings with a variety of power structures. Employing these "functional lesion" approaches as part of the full portfolio of available methodologies allows us to build a strong scientific pathway with convergent evidence building from neural circuits all the way up to consumer behavior.

Speaking more broadly, the neuroscientific techniques that can be applied to consumer psychology—and by extension organizational behavior—are exciting and extremely powerful. However, they are not independently all-powerful. They are most useful as a complement to existing investigations, offering data, models, theories, and analyses that can be integrated with current research in the social sciences. Specific methods may be well suited to providing insight into one type of question but inappropriate for others. This philosophy can be further expanded to the discipline level. Business-related research already embraces an interdisciplinary approach that draws from economics, psychology, communication, and several other fields. The use of neurophysiological techniques offers an additional set of bridges to the enormous (also interdisciplinary) field of neuroscience, and the potential for improving theory that ties to biology, genetics, and other fields. As this article demonstrates, an interdisciplinary approach to this science offers the possibility to enrich theorizing in consumer psychology and broaden the impact and scope of business research.

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References

Aaker, J. L. (1997). Dimensions of brand personality. *Journal of Marketing Research*, *34*(3), 347-356.

Allison, R. I., & Uhl, K. P. (1964). Influence of beer brand identification on taste perception. *Journal of Marketing Research*, *1*(3), 36-39.

Antonakis, J. (2017). On doing better science: From thrill of discovery to policy implications. *Leadership Quarterly*, *28*(1), 5-21.

Ariely, D., & Berns, G. S. (2010). Neuromarketing: The hope and hype of neuroimaging in business. *Nature Reviews Neuroscience*, *11*(4), 284-292.

Armel, K. C., Beaumel, A., & Rangel, A. (2008). Biasing simple choices by manipulating relative visual attention. *Judgment and Decision Making*, *3*(5), 396-403.

Barrett, L. F. (2017). *How emotions are made*. Boston, MA: Houghton Mifflin Harcourt.

Bartra, O., McGuire, J. T., & Kable, J. W. (2010). The valuation system: A coordinate-based meta-analysis of BOLD fMRI experiments examining neural correlates of subjective value. *NeuroImage*, *76*, 1-16. http://doi.org/10.1016/j.neuroimage.2013.02.063

Becker, G. M., DeGroot, M. H., & Marschak, J. (1964). Measuring utility by a single-response sequential method. *Behavioral Science*, *9*(3), 226-232. http://doi.org/10.1002/bs.3830090304

Behrens, T. E. J., Hunt, L. T., & Rushworth, M. F. S. (2009). The computation of social behavior. *Science*, *324*(5931), 1160-1164. http://doi.org/10.1126/science.1169694

Berns, G. S., & Moore, S. E. (2012). A neural predictor of cultural popularity. *Journal of Consumer Psychology*, *22*(1), 154-160.

Boksem, M. A. S., & Smidts, A. (2015). Brain responses to movie trailers predict individual preferences for movies and their population-wide commercial success. *Journal of Marketing Research*, *52*(4), 482-492. http://doi.org/10.1509/jmr.13.0572

Cacioppo, J. T., Tassinary, L. G., & Berntson, G. (2007). *Handbook of psychophysiology*. Cambridge, UK: Cambridge University Press.

Camerer, C. F., Loewenstein, G., & Prelec, D. (2004). Neuroeconomics: Why economics needs brains. *Scandinavian Journal of Economics*, *106*(3), 555-579. http://doi.org/10.1111/j.0347-0520.2004.00377.x

Camerer, C., Loewenstein, G., & Prelec, D. (2005). Neuroeconomics: How neuroscience can inform economics. *Journal of Economic Literature*, *43*(1), 9-64.

Carpenter, S. M., & Yoon, C. (2012). Aging and consumer decision making. *Annals of the New York Academy of Sciences*, *1235*(1), E1-E12. http://doi.org/10.1111/j.1749-6632.2011.06390.x

Carstensen, L. L., Turan, B., Scheibe, S., Ram, N., Ersner-Hershfield, H., Samanez-Larkin, G. R., ... Nesselroade, J. R. (2011). Emotional experience improves with age: Evidence based on over 10 years of experience sampling. *Psychology and Aging*, *26*(1), 21-33. http://doi.org/10.1037/a0021285

Cassidy, B. S., Hedden, T., Yoon, C., & Gutchess, A. H. (2014). Age differences in medial prefrontal activity for subsequent memory of truth value. *Frontiers in Psychology*, *5*, 87. http://doi.org/10.3389/fpsyg.2014.00087

Chandon, P., Hutchinson, J. W., Bradlow, E. T., & Young, S. H. (2013). Does in-store marketing work? Effects of the number and position of shelf facings on brand attention and evaluation at the point of purchase. *Journal of Marketing*, *73*(6), 1-17. http://doi.org/10.1509/jmkg.73.6.1

Chen, Y.-P., Nelson, L. D., & Hsu, M. (2015). From "where" to "what": Distributed representations of brand associations in the human brain. *Journal of Marketing Research*, *52*(4), 453-466. http://doi.org/10.1509/jmr.14.0606

Chiao, J. Y., Cheon, B. K., Pornpattananangkul, N., Mrazek, A. J., & Blizinsky, K. D. (2013). Cultural neuroscience: progress and promise. *Psychological inquiry*, *24*(1), 1-19.

Chua, H. F., Ho, S. S., Jasinska, A. J., Polk, T. A., Welsh, R. C., Liberzon, I., ... Strecher, V. J. (2011). Self-related neural response to tailored smoking-cessation messages predicts quitting. *Nature Neuroscience*, *14*(4), 426-427. http://doi.org/10.1038/nn.2761

Chumbley, J. R., Krajbich, I., Engelmann, J. B., Russell, E., Van Uum, S., Koren, G., ... Fehr, E. (2014). Endogenous cortisol predicts decreased loss aversion in young men. *Psychological Science*, *25*(11), 2102-2105. http://doi.org/10.1177/0956797614546555

Cooper, J. R., Bloom, F. E., & Roth, R. H. (2003). *The biochemical basis of neuropharmacology*. Oxford, UK: Oxford University Press.

Costa, P. T., & McCrae, R. R. (1985). *The NEO Personality Inventory manual*. Odessa, FL: Psychological Assessment Resources.

Crockett, M. J., & Fehr, E. (2014). Pharmacology of economic and social decision making. In P. W. Glimcher & E. Fehr (Eds.), *Neuroeconomics* (pp. 259-279). London, UK: Elsevier. http://doi.org/10.1016/B978-0-12-416008-8.00014-0

Demos, K. E., Heatherton, T. F., & Kelley, W. M. (2012). Individual differences in nucleus accumbens activity to food and sexual images predict weight gain and sexual behavior. *Journal of Neuroscience*, *32*(16), 5549-5552. http://doi.org/10.1523/JNEUROSCI.5958-11.2012

Denburg, N. L., Cole, C. A., Hernandez, M., Yamada, T. H., Tranel, D., Bechara, A., ... Wallace, R. B. (2007). The orbitofrontal cortex, real-world decision making, and normal aging. *Annals of the New York Academy of Sciences*, *1121*, 480-498. http://doi.org/10.1196/annals.1401.031

Deppe, M., Schwindt, W., Kugel, H., Plassmann, H., & Kenning, P. (2005). Nonlinear responses within the medial prefrontal cortex reveal when specific implicit information influences economic decision making. *Journal of Neuroimaging*, *15*(2), 171-182. http://doi.org/10.1177/1051228405275074

Depue, R. A. R., & Collins, P. F. P. (1999). Neurobiology of the structure of personality: Dopamine, facilitation of incentive motivation, and extraversion. *Behavioral and Brain Sciences*, *22*(3), 491-469.

DeYoung, C. G., Hirsh, J. B., Shane, M. S., Papademetris, X., Rajeevan, N., & Gray, J. R. (2010). Testing predictions from personality neuroscience: Brain structure and the big five. *Psychological Science*, *21*(6), 820-828. http://doi.org/10.1177/0956797610370159

Dmochowski, J. P., Bezdek, M. A., Abelson, B. P., Johnson, J. S., Schumacher, E. H., & Parra, L. C. (2014). Audience preferences are predicted by temporal reliability of neural processing. *Nature Communications*, *5*, 1-9. http://doi.org/10.1038/ncomms5567

Drolet, A. L., Schwarz, N., & Yoon, C. (2010). *The aging consumer*. London, UK: Routledge.

Duckworth, K. L., Bargh, J. A., Garcia, M., & Chaiken, S. (2002). The automatic evaluation of novel stimuli. *Psychological Science*, *13*(6), 513-519.

Erk, S., Spitzer, M., Wunderlich, A. P., Galley, L., & Walter, H. (2002). Cultural objects modulate reward circuitry. *NeuroReport*, *13*(18), 2499-2503. doi:10.1097/01.wnr.0000048542.12213.60

Ersner-Hershfield, H., Wimmer, G. E., & Knutson, B. (2008). Saving for the future self: Neural measures of future self-continuity predict temporal discounting. *Social Cognitive and Affective Neuroscience*, *4*(1), 85-92. http://doi.org/10.1093/scan/nsn042

Esch, F. R., Möll, T., Schmitt, B., Elger, C. E., Neuhaus, C., & Weber, B. (2012). Brands on the brain: Do consumers use declarative information or experienced emotions to evaluate brands? *Journal of Consumer Psychology*, *22*(1), 75-85.

Falk, E. B., Berkman, E. T., & Lieberman, M. D. (2012). From neural responses to population behavior: Neural focus group predicts population-level media effects. *Psychological Science*, *23*(5), 439-445. http://doi.org/10.1177/0956797611434964

Falk, E. B., Berkman, E. T., Mann, T., Harrison, B., & Lieberman, M. D. (2010). Predicting persuasion-induced behavior change from the brain. *Journal of Neuroscience*, *30*(25), 8421-8424. http://doi.org/10.1523/JNEUROSCI.0063-10.2010

Fazio, R. H., Sanbonmatsu, D. M., Powell, M. C., & Kardes, F. R. (1986). On the automatic activation of attitudes. *Journal of Personality and Social Psychology*, *50*(2), 229-238.

Feldman, J. M., & Lynch, J. G. (1988). Self-generated validity and other effects of measurement on belief, attitude, intention, and behavior. *Journal of Applied Psychology*, *73*(3), 421-435.

Fiedler, S., Glöckner, A., Nicklisch, A., & Dickert, S. (2013). Social value orientation and information search in social dilemmas: An eye-tracking analysis. *Organizational Behavior and Human Decision Processes*, *120*(2), 272-284.

Genevsky, A., & Knutson, B. (2015). Neural affective mechanisms predict market-level microlending. *Psychological Science*, *26*(9), 1411-1422.

Gilaie-Dotan, S., Tymula, A., Cooper, N., Kable, J. W., Glimcher, P. W., & Levy, I. (2014). Neuroanatomy predicts individual risk attitudes. *Journal of Neuroscience*, *34*(37), 12394-12401. http://doi.org/10.1523/JNEUROSCI.1600-14.2014

Haack, P., Pfarrer, M. D., & Scherer, A. G. (2014). Legitimacy-as-feeling: How affect leads to vertical legitimacy spillovers in transnational governance. *Journal of Management Studies*, *51*(4), 634-666. http://doi.org/10.1111/joms.12071

Halfmann, K., Hedgcock, W., & Denburg, N. L. (2013). Age-related differences in discounting future gains and losses. *Journal of Neuroscience, Psychology, and Economics*, *6*(1), 42-54. http://doi.org/10.1037/npe0000003

Hasson, U. (2004). Intersubject synchronization of cortical activity during natural vision. *Science*, *303*(5664), 1634-1640. http://doi.org/10.1126/science.1089506

Hasson, U., & Honey, C. J. (2012). Future trends in neuroimaging: Neural processes as expressed within real-life contexts. *NeuroImage*, *62*(2), 1272-1278. http://doi.org/10.1016/j.neuroimage.2012.02.004

Hasson, U., Landesman, O., Knappmeyer, B., Vallines, I., Rubin, N., & Heeger, D. J. (2008). Neurocinematics: The neuroscience of film. *Projections*, *2*(1), 1-26. http://doi.org/10.3167/proj.2008.020102

Haushofer, J., & Fehr, E. (2014). On the psychology of poverty. *Science*, *344*(6186), 862-867. http://doi.org/10.1126/science.1232491

Hedden, T., & Gabrieli, J. D. E. (2004). Insights into the ageing mind: A view from cognitive neuroscience. *Nature Reviews Neuroscience*, *5*(2), 87-96. http://doi.org/10.1038/nrn1323

Jenke, L., & Huettel, S. A. (2016). Issues or identity? Cognitive foundations of voter choice. *Trends in Cognitive Sciences*, *20*(11), 794-804.

Kable, J. W. (2011). The cognitive neuroscience toolkit for the neuroeconomist: A functional overview. *Journal of Neuroscience, Psychology, and Economics*, *4*(2), 63-84. http://doi.org/10.1037/a0023555

Kable, J. W., & Levy, I. (2015). Neural markers of individual differences in decision-making. *Current Opinion in Behavioral Sciences*, *5*, 100-107. http://doi.org/10.1016/j.cobeha.2015.08.004

Kang, M. J., Rangel, A., Camus, M., & Camerer, C. F. (2011). Hypothetical and real choice differentially activate common valuation areas. *Journal of Neuroscience*, *31*(2), 461-468. http://doi.org/10.1523/JNEUROSCI.1583-10.2011

Karmarkar, U. R., Shiv, B., & Knutson, B. (2015). Cost conscious? The neural and behavioral impact of price primacy on decision making. *Journal of Marketing Research*, *52*(4), 467-481. http://doi.org/10.1509/jmr.13.0488

Kitayama, S., & Park, J. (2010). Cultural neuroscience of the self: Understanding the social grounding of the brain. *Social Cognitive and Affective Neuroscience*, *5*(2-3), 111-129. http://doi.org/10.1093/scan/nsq052

Kitayama, S., & Uskul, A. K. (2011). Culture, mind, and the brain: Current evidence and future directions. *Annual Review of Psychology*, *62*(1), 419-449. http://doi.org/10.1146/annurev-psych-120709-145357

Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin*, *100*(1), 78-100. http://doi.org/10.1037/0033-2909.100.1.78

Klucharev, V., Munneke, M. A. M., Smidts, A., & Fernández, G. (2011). Downregulation of the posterior medial frontal cortex prevents social conformity. *Journal of Neuroscience*, *31*(33), 11934-11940. http://doi.org/10.1523/JNEUROSCI.1869-11.2011

Klucharev, V., Smidts, A., & Fernández, G. (2008). Brain mechanisms of persuasion: How “expert power” modulates memory and attitudes. *Social Cognitive and Affective Neuroscience*, *3*(4), 353-366.

Knutson, B., & Karmarkar, U. (2014). Appetite, consumption, and choice in the human brain. In S. D. Preston, M. L. Kringelbach, & B. Knutson (Eds.), *The interdisciplinary science of consumption* (pp. 163-184). Cambridge, MA: MIT Press.

Knutson, B., Rick, S., Wimmer, G. E., Prelec, D., & Loewenstein, G. (2007). Neural predictors of purchases. *Neuron*, *53*(1), 147-156. http://doi.org/10.1016/j.neuron.2006.11.010

Krajbich, I., Armel, C., & Rangel, A. (2010). Visual fixations and the computation and comparison of value in simple choice. *Nature Neuroscience*, *13*(10), 1292-1298. http://doi.org/10.1038/nn.2635

Krajbich, I., Lu, D., Camerer, C., & Rangel, A. (2012). The attentional drift-diffusion model extends to simple purchasing decisions. *Frontiers in Psychology*, *3*, 193. http://doi.org/10.3389/fpsyg.2012.00193

Krajbich, I., & Rangel, A. (2011). Multialternative drift-diffusion model predicts the relationship between visual fixations and choice in value-based decisions. *Proceedings of the National Academy of Sciences*, *108*(33), 13852-13857. http://doi.org/10.1073/pnas.1101328108

Kühn, S., Strelow, E., & Gallinat, J. (2016). Multiple "buy buttons" in the brain: Forecasting chocolate sales at point-of-sale based on functional brain activation using fMRI. *NeuroImage*, *136*(C), 122-128. http://doi.org/10.1016/j.neuroimage.2016.05.021

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, *108*(3), 480-498.

Lebreton, M., Jorge, S., Michel, V., Thirion, B., & Pessiglione, M. (2009). An automatic valuation system in the human brain: Evidence from functional neuroimaging. *Neuron*, *64*(3), 431-439. http://doi.org/10.1016/j.neuron.2009.09.040

Lee, L., Frederick, S., & Ariely, D. (2006). Try it, you'll like it: The influence of expectation, consumption, and revelation on preferences for beer. *Psychological Science*, *17*(12), 1054-1058.

Levy, D. J., & Glimcher, P. W. (2011). Comparing apples and oranges: Using reward-specific and reward-general subjective value representation in the brain. *Journal of Neuroscience*, *31*(41), 14693-14707. http://doi.org/10.1523/JNEUROSCI.2218-11.2011

Li, N., Ma, N., Liu, Y., He, X.-S., Sun, D.-L., Fu, X.-M., ... Zhang, D. R. (2013). Resting-state functional connectivity predicts impulsivity in economic decision-making. *Journal of Neuroscience*, *33*(11), 4886-4895.

Lindstrom, M. (2011, September 30). You love your iPhone. Literally. *New York Times*. Retrieved from http://www.nytimes.com/2011/10/01/opinion/you-love-your-iphone-literally.html

McClure, S. M., Li, J., Tomlin, D., Cypert, K. S., Montague, L. M., & Montague, P. R. (2004). Neural correlates of behavioral preference for culturally familiar drinks. *Neuron*, *44*(2), 379-387. http://doi.org/10.1016/j.neuron.2004.09.019

Mehta, P. H., & Josephs, R. A. (2010). Testosterone and cortisol jointly regulate dominance: Evidence for a dual-hormone hypothesis. *Hormones and Behavior*, *58*(5), 898-906. http://doi.org/10.1016/j.yhbeh.2010.08.020

Milosavljevic, M., & Cerf, M. (2008). First attention then intention: Insights from computational neuroscience of vision. *International Journal of Advertising Research*, *27*(3), 381-398.

Milosavljevic, M., Navalpakkam, V., Koch, C., & Rangel, A. (2012). Relative visual saliency differences induce sizable bias in consumer choice. *Journal of Consumer Psychology*, *22*(1), 67-74. http://doi.org/10.1016/j.jcps.2011.10.002

Mitchell, J. P., Schirmer, J., Ames, D. L., & Gilbert, D. T. (2011). Medial prefrontal cortex predicts intertemporal choice. *Journal of Cognitive Neuroscience*, *23*(4), 857-866. http://doi.org/10.1162/jocn.2010.21479

Mohr, P. N. C., Li, S.-C., & Heekeren, H. R. (2010). Neuroeconomics and aging: Neuromodulation of economic decision making in old age. *Neuroscience & Biobehavioral Reviews*, *34*(5), 678-688. http://doi.org/10.1016/j.neubiorev.2009.05.010

Na, J., Grossmann, I., Varnum, M. E., Kitayama, S., Gonzalez, R., & Nisbett, R. E. (2010). Cultural differences are not always reducible to individual differences. *Proceedings of the National Academy of Sciences*, *107*(14), 6192-6197.

Nave, G., Nadler, A., Dubois, D., Camerer, C., & Plassmann, H. (2015, November). *Peacocks, testosterone and luxury goods: Single-dose testosterone administration increases preference for status goods*. Paper presented at the annual meeting of the Society for Judgment and Decision Making, Chicago, IL.

Newman, L. M., Trivedi, M. A., Bendlin, B. B., Ries, M. L., & Johnson, S. C. (2007). The relationship between gray matter morphometry and neuropsychological performance in a large sample of cognitively healthy adults. *Brain Imaging and Behavior*, *1*(1-2), 3-10. http://doi.org/10.1007/s11682-007-9000-5

Peinemann, A., Schuller, S., Pohl, C., Jahn, T., Weindl, A., & Kassubek, J. (2005). Executive dysfunction in early stages of Huntington's disease is associated with striatal and insular atrophy: A neuropsychological and voxel-based morphometric study. *Journal of the Neurological Sciences*, *239*(1), 11-19. http://doi.org/10.1016/j.jns.2005.07.007

Philiastides, M. G., & Ratcliff, R. (2013). Influence of branding on preference-based decision making. *Psychological Science*, *24*(7), 1208-1215. http://doi.org/10.1177/0956797612470701

Pieters, R., Rosbergen, E., & Wedel, M. (1999). Visual attention to repeated print advertising: A test of scanpath theory. *Journal of Marketing Research*, *36*(4), 424-438.

Pieters, R., & Wedel, M. (2004). Attention capture and transfer in advertising: Brand, pictorial, and text-size effects. *Journal of Marketing*, *68*(2), 36-50.

Piqueras-Fiszman, B., Velasco, C., Salgado-Montejo, A., & Spence, C. (2013). Using combined eye tracking and word association in order to assess novel packaging solutions: A case study involving jam jars. *Food Quality and Preference*, *28*(1), 328-338.

Plassmann, H., Ambler, T., Braeutigam, S., & Kenning, P. (2007). What can advertisers learn from neuroscience? *International Journal of Advertising*, *26*(2), 151-175.

Plassmann, H., & Karmarkar, U. R. (2015). Consumer neuroscience. In M. I. Norton, D. D. Rucker, & C. Lamberton (Eds.), *The Cambridge handbook of consumer psychology* (pp. 122-151). Cambridge, UK: Cambridge University Press.

Plassmann, H., O'Doherty, J., & Rangel, A. (2007). Orbitofrontal cortex encodes willingness to pay in everyday economic transactions. *Journal of Neuroscience*, *27*(37), 9984-9988. http://doi.org/10.1523/JNEUROSCI.2131-07.2007

Plassmann, H., O'Doherty, J. P., & Rangel, A. (2010). Appetitive and aversive goal values are encoded in the medial orbitofrontal cortex at the time of decision making. *Journal of Neuroscience*, *30*(32), 10799-10808. http://doi.org/10.1523/JNEUROSCI.0788-10.2010

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

Plassmann, H., Ramsøy, T. Z., & Milosavljevic, M. (2012). Branding the brain: A critical review and outlook. *Journal of Consumer Psychology*, *22*(1), 18-36. http://doi.org/10.1016/j.jcps.2011.11.010

Plassmann, H., Venkatraman, V., Huettel, S., & Yoon, C. (2015). Consumer neuroscience: Applications, challenges, and possible solutions. *Journal of Marketing Research*, *52*(4), 427-435. http://doi.org/10.1509/jmr.14.0048

Plassmann, H., & Wager, T. D. (2014). How expectancies shape consumption experiences. In S. D. Preston, M. L. Kringelbach, & B. Knutson (Eds.), *The interdisciplinary science of consumption* (pp. 219-240). Cambridge, MA: MIT Press.

Plassmann, H., & Weber, B. (2015). Individual differences in marketing placebo effects: Evidence from brain imaging and behavioral experiments. *Journal of Marketing Research*, *52*(4), 493-510. http://doi.org/10.1509/jmr.13.0613

Plassmann, H., Yoon, C., Feinberg, F. M., & Shiv, B. (2010). Consumer neuroscience. In J. Sheth & N. Malhotra (Eds.), *Wiley international encyclopedia of marketing* (pp. 115-122). Chichester, UK: John Wiley. http://doi.org/10.1002/9781444316568.wiem03051

Poldrack, R. A. (2006). Can cognitive processes be inferred from neuroimaging data? *Trends in Cognitive Sciences*, *10*(2), 59-63. http://doi.org/10.1016/j.tics.2005.12.004

Poldrack, R. A. (2011). Inferring mental states from neuroimaging data: From reverse inference to large-scale decoding. *Neuron*, *72*(5), 692-697. http://doi.org/10.1016/j.neuron.2011.11.001

Raichle, M. E. (2015). The brain's default mode network. *Annual Review of Neuroscience*, *38*, 433-447.

Reimann, M., Zaichkowsky, J., Neuhaus, C., Bender, T., & Weber, B. (2010). Aesthetic package design: A behavioral, neural, and psychological investigation. *Journal of Consumer Psychology*, *20*(4), 431-441.

Rilling, J. K., & Sanfey, A. G. (2011). The neuroscience of social decision-making. *Annual Review of Psychology*, *62*(1), 23-48. http://doi.org/10.1146/annurev.psych.121208.131647

Robbins, T. W., & Arnsten, A. F. T. (2009). The neuropsychopharmacology of fronto-executive function: Monoaminergic modulation. *Annual Review of Neuroscience*, *32*(1), 267-287. http://doi.org/10.1146/annurev.neuro.051508.135535

Ruff, C. C., & Fehr, E. (2014). The neurobiology of rewards and values in social decision making. *Nature Reviews Neuroscience*, *15*(8), 549-562. http://doi.org/10.1038/nrn3776

Rule, N. O., Freeman, J. B., Moran, J. M., Gabrieli, J. D. E., Adams, R. B., & Ambady, N. (2010). Voting behavior is reflected in amygdala response across cultures. *Social Cognitive and Affective Neuroscience*, *5*(2-3), 349-355. http://doi.org/10.1093/scan/nsp046

Rule, N. O., Moran, J. M., Freeman, J. B., Whitfield-Gabrieli, S., Gabrieli, J. D. E., & Ambady, N. (2011). Face value: Amygdala response reflects the validity of first impressions. *NeuroImage*, *54*(1), 734-741. http://doi.org/10.1016/j.neuroimage.2010.07.007

Samanez-Larkin, G. R., & Knutson, B. (2015). Decision making in the ageing brain: Changes in affective and motivational circuits. *Nature Reviews Neuroscience*, *16*(5), 278-289. http://doi.org/10.1038/nrn3917

Samanez-Larkin, G. R., Kuhnen, C. M., Yoo, D. J., & Knutson, B. (2010). Variability in nucleus accumbens activity mediates age-related suboptimal financial risk taking. *Journal of Neuroscience*, *30*(4), 1426-1434. http://doi.org/10.1523/JNEUROSCI.4902-09.2010

Samanez-Larkin, G. R., Li, S.-C., & Ridderinkhof, K. R. (2013). Complementary approaches to the study of decision making across the adult life span. *Frontiers in Neuroscience*, *7*, 243. http://doi.org/10.3389/fnins.2013.00243

Samanez-Larkin, G. R., Mata, R., Radu, P. T., Ballard, I. C., Carstensen, L. L., & McClure, S. M. (2011). Age differences in striatal delay sensitivity during intertemporal choice in healthy adults. *Frontiers in Neuroscience*, *5*, 126. http://doi.org/10.3389/fnins.2011.00126

Samanez-Larkin, G. R., Robertson, E. R., Mikels, J. A., Carstensen, L. L., & Gotlib, I. H. (2009). Selective attention to emotion in the aging brain. *Psychology and Aging*, *24*(3), 519-529. http://doi.org/10.1037/a0016952

Schaefer, M., & Rotte, M. (2007). Favorite brands as cultural objects modulate reward circuit. *NeuroReport*, *18*(2), 141-145. http://doi.org/10.1097/WNR.0b013e328010ac84

Schultheiss, O. C., Wirth, M. M., & Stanton, S. J. (2004). Effects of affiliation and power motivation arousal on salivary progesterone and testosterone. *Hormones and Behavior*, *46*(5), 592-599.

Shiv, B., Carmon, Z., & Ariely, D. (2005). Placebo effects of marketing actions: Consumers may get what they pay for. *Journal of Marketing Research*, *42*(4), 383-393.

Smidts, A., Hsu, M., Sanfey, A. G., Boksem, M. A. S., Ebstein, R. B., Huettel, S. A., . . . Yoon, C. (2014). Advancing consumer neuroscience. *Marketing Letters*, *25*(3), 257-267. http://doi.org/10.1007/s11002-014-9306-1

Smith, A., Bernheim, B. D., Camerer, C. F., & Rangel, A. (2014). Neural activity reveals preferences without choices. *American Economic Journal: Microeconomics*, *6*(2), 1-36. http://doi.org/10.1257/mic.6.2.1

Stallen, M., Smidts, A., Rijpkema, M., Smit, G., Klucharev, V., & Fernández, G. (2010). Celebrities and shoes on the female brain: The neural correlates of product evaluation in the context of fame. *Journal of Economic Psychology*, *31*(5), 802-811. http://doi.org/10.1016/j.joep.2010.03.006

Takahashi, T., Sakaguchi, K., Oki, M., Homma, S., & Hasegawa, T. (2006). Testosterone levels and discounting delayed monetary gains and losses in male humans. *Neuroendocrinology Letters*, *27*(4), 439-444.

Todorov, A., Baron, S. G., & Oosterhof, N. N. (2008). Evaluating face trustworthiness: A model based approach. *Social Cognitive and Affective Neuroscience*, *3*(2), 119-127. http://doi.org/10.1093/scan/nsn009

Towal, R. B., Mormann, M., & Koch, C. (2013). Simultaneous modeling of visual saliency and value computation improves predictions of economic choice. *Proceedings of the National Academy of Sciences*, *110*(40), E3858-E3867. http://doi.org/10.1073/pnas.1304429110

Tusche, A., Bode, S., & Haynes, J. D. (2010). Neural responses to unattended products predict later consumer choices. *Journal of Neuroscience*, *30*(23), 8024-8031. http://doi.org/10.1523/JNEUROSCI.0064-10.2010

van den Bos, W., Rodriguez, C. A., Schweitzer, J. B., & McClure, S. M. (2014). Connectivity strength of dissociable striatal tracts predict individual differences in temporal discounting. *Journal of Neuroscience*, *34*(31), 10298-10310. http://doi.org/10.1523/JNEUROSCI.4105-13.2014

Venkatraman, V., Clithero, J. A., Fitzsimons, G. J., & 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*(1), 143-153. http://doi.org/10.1016/j.jcps.2011.11.008

Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., . . . Winer, R. S. (2015). Predicting advertising success beyond traditional measures: New insights from neurophysiological methods and market response modeling. *Journal of Marketing Research*, *52*(4), 436-452. http://doi.org/10.1509/jmr.13.0593

Wansink, B., Payne, C. R., & North, J. (2007). Fine as North Dakota wine: Sensory expectations and the intake of companion foods. *Physiology & Behavior*, *90*(5), 712-716. http://doi.org/10.1016/j.physbeh.2006.12.010

Wedel, M., & Pieters, R. (2000). Eye fixations on advertisements and memory for brands: A model and findings. *Marketing Science*, *19*(4), 297-312.

Yarkoni, T., Poldrack, R. A., Nichols, T. E., Van Essen, D. C., & Wager, T. D. (2011). Large-scale automated synthesis of human functional neuroimaging data. *Nature Methods*, *8*(8), 665-670. http://doi.org/10.1038/nmeth.1635

Yoon, C., Cole, C. A., & Lee, M. P. (2009). Consumer decision making and aging: Current knowledge and future directions. *Journal of Consumer Psychology*, *19*(1), 2-16. http://doi.org/10.1016/j.jcps.2008.12.002

Yoon, C., Gutchess, 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*(1), 31-40.

Zajonc, R. B. (1980). Feeling and thinking: Preferences need no inferences. *American Psychologist*, *35*(2), 151-175. http://doi.org/10.1037/0003-066X.35.2.151

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