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Neural mechanisms of social influence

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ABSTRACT

The present investigation explores the neural mechanisms underlying the impact of social influence on preferences. We socially tagged symbols as valued or not – by exposing participants to the preferences of their peers – and assessed subsequent brain activity during an incidental processing task in which participants viewed popular, unpopular, and novel symbols. The medial prefrontal cortex (mPFC) differentiated between symbols that were and were not socially tagged – a possible index of normative influence – while aspects of the striatum (the caudate) differentiated between popular and unpopular symbols – a possible index of informational influence. These results suggest that integrating activity in these two brain regions may differentiate objects that have become valued as a result of social influence from those valued for non-social reasons.

The iconic Lacoste green crocodile logo – initially created in honor of the 1920s French tennis star Rene Lacoste – has waxed and waned in popularity over the years, enjoying enormous popularity in the United States in the late 1970s and early 1980s while nearly disappearing from sight in the 1990s, only to reemerge in this decade as a desired status symbol. One reason to buy clothing featuring this crocodile might be to emulate Lacoste himself, of course, but we would be surprised if American teenagers have any awareness of the origins of the logo. Instead, such trends are often driven by the adoption – and rejection – of products by others: The value of little green crocodiles depends critically on the value that others attach to that symbol.

In this paper, we model the process by which social influence impacts preferences in a 1-h experimental session, using a paradigm in which we train participants to see symbols as socially valued or not by providing them with feedback about the preferences of others. We then examine the impact of this social feedback on the brain activity that participants exhibit while viewing objects that have been endorsed or rejected by their peers, exploring the neural processes underlying changes in valuation due to social influence.

Mechanisms of social influence

The notion that humans are influenced in their beliefs, preferences, and behaviors by the beliefs, preferences, and behaviors of others has become nearly axiomatic across the social sciences; the sheer number of terms used to describe this process is indicative of its ubiquity, from social influence to social proof to peer pressure to bandwagon effects to conformity to herding (Abrahamson, 1991; Asch, 1951; Banerjee, 1992; Bikhchandani, Hirshleifer, & Welch, 1992; see Cialdini & Goldstein, 2004; Sherif, 1936, for a review). Indeed, even non-human primates are quick to adhere to social norms (Whiten, Horner, & de Waal, 2005). The impact of social influence has been demonstrated in countless domains, including pain perception (Craig & Prkachin, 1978), littering (Cialdini, Reno, & Kallgren, 1990), voting (Gerber, Green, & Larimer, 2008), donating to charities (Reingen, 1982), expressing prejudice (Apfelbaum, Sommers, & Norton, 2008), choosing jobs (Higgins, 2001; Kilduff, 1990), investing in the stock market (Hong, Kubik, & Stein, 2004), and, most relevant to the current investigation, both adoption and rejection of consumer products (Berger & Heath, 2007). Judgment and decision-making researchers have also increasingly recognized the fundamental impact of social factors on human behavior: Investigations of such "social decision-making" (Sanfey, 2007) have the potential to speed the integration of psychologists with both neuroscientists and game theorists, offering a more complete account of human decision-making (Camerer, 2003).

From an early stage in research exploring the effects of social factors on behavior, researchers focused their attention on a fundamental question: the extent to which behavior influenced by peers indicated a true change in attitude such that social influence changed people's minds, or merely a desire to be publically consistent with the viewpoints of others. Following on Asch's (1951) classic

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conformity studies, in which participants gave obviously wrong answers to a simple line judgment task when confederates had given those wrong answers before them, Deutsch and Gerard (1955) varied whether responses to such tasks were visible to others or not; they showed that conformity was at its highest when responses were public – due to what they termed normative influence – but that even responses given in private could be influenced by the behavior of others – what they termed informational influence. In this and subsequent investigations, the extent to which behavior was influenced by true changes in belief as opposed to public desires to conform was inferred by comparing behavior influenced only by private factors (anonymous behavior) from behavior influenced by both private and public factors; subtracting the former from the latter results in the amount of private attitude change. While this strategy is experimentally elegant, the ideal evidence for this theory would be to assess the underpinnings of normative and informational influence simultaneously.

Brain imaging research offers just this potential. One of the key theoretical questions lingering from Asch's initial investigation, for example, was whether participants were merely conforming to the confederate's answers, or whether they came to literally see the wrong answers as correct. In a recent functional magnetic resonance imaging (fMRI) investigation of conformity in which confederates gave false answers to a mental rotation task, Berns et al. (2005) demonstrated that the erroneous responses of others altered activity in brain regions implicated in mental rotation, suggesting not just a social impact of conformity pressures, but a true change in perception (see Sherif, 1936). These results offer evidence that social influence can be indexed at the level of the brain, and suggest that examining different regions known to be implicated in different processes may be a fruitful avenue to examine two-factor theories of social influence.

While the research reviewed above has focused primarily on conformity to tasks (line judgments and mental rotations), we use brain imaging to explore these dynamics in the domain of preferences, examining how the brain responds when participants are confronted by symbols that they previously learned were socially valued or socially rejected by others. In the spirit of previous studies on social influence, we consider both normative and informational aspects of such pressures, assessing brain activity in (a) regions involved with processing the opinions and mental states of others – the normative aspects of social influence and (b) regions implicated in experienced utility or reward – the informational aspects of social influence.

Neural mechanisms of social influence

Normative influence

We expected the processing of ‘‘socially tagged” objects – objects about which participants had seen others express an opinion (i.e., endorse or reject) – to be associated with significantly greater activity in regions that play a role in representing and decoding the mental states (e.g., beliefs, desires and preferences) of other people. A large body of neuroimaging research points to the central role of the medial prefrontal cortex (mPFC) in intuiting other people's mental states and in social thinking more generally (for reviews see Amodio & Frith, 2006; Blakemore & Decety, 2001; Gallagher & Frith, 2003; Mason & Macrae, 2008). For example, enhanced activity in this region has been detected when people consider the motivations underlying other's actions (de Lange, Spronk, Willems, Toni, & Bekkering, 2008; Mason, Banfield, & Macrae, 2004), their feelings (Ochsner et al., 2004), and their fears (Olsson, Nearing, & Phelps, 2007). The region is also active when people reflect on the impression they have made on others (Izuma, Saito, & Sadato, 2008). Particularly relevant to the present investigation is fMRI evidence that the mPFC plays a role in the processing of social norms, including perceiving norm violations (Berthoz, Armony, Blair, & Dolan, 2002) and experiencing embarrassment or guilt for the social norm transgressions of others (Takahashi et al., 2004). Dovetailing with these brain imaging findings is neuropsychological evidence that patients with damage to regions of the mPFC exhibit social disinhibition due to a lack of awareness or concern for social norms (Beer, Heerey, Keltner, Scabini, & Knight, 2003; Eisenberg, 2000).

Taken together, previous research suggests that the mPFC plays a central role in representing and processing information about the beliefs, attitudes and feelings of other people. We therefore predicted that people would exhibit greater recruitment of the mPFC when exposed to objects that they had learned were socially valued and devalued, compared to objects that had not been similarly socially tagged.

Informational influence

We also explored whether social influence impacts the experienced utility – the reward value – of socially tagged objects. Brain imaging research (Delgado, Nystrom, Fissell, Noll, & Fiez, 2000; Elliott, Friston, & Dolan, 2000; Knutson, Adams, Fong, & Hommer, 2001; McClure, Laibson, Loewenstein, & Cohen, 2004a; O'Doherty, Deichmann, Critchley, & Dolan, 2002) and electrophysiological work with non-human primates (Schultz, Apicella, Scarnati, & Ljungberg, 1992; Tremblay, Hollerman, & Schultz, 1998) converge on a central role of the striatum – the nucleus accumbens (nACC), putamen, and caudate – in representing the value of primary reinforcers, or stimuli with inherent reward such as cocaine, but also secondary reinforcers, stimuli that are rewarding by association or that have acquired value through acculturation, such as art (Vartanian & Goel, 2004). Thus striatal regions are active not just when people view inherently attractive faces (Aharon et al., 2001), but also when they view their significant other, whether conventionally attractive or not (Aron et al., 2005).

Particularly relevant to the present investigation is recent evidence that recruitment of these regions is impacted by exposure to products that people have come to value as the result of marketing actions, even holding the objective utility of those objects constant. For instance, people exhibit significantly greater activity in reward regions when they consume a wine they believe to be expensive relative to when they consume that same wine priced more modestly (Plassman, O'Doherty, Shiv, & Rangel, 2008) due to their having learned the general rule that price is a signal of quality (Rao & Monroe, 1989). In addition, reward regions are more active when people consume drinks that they believe are made by a company whose brand they have learned to value than when they consume that same drink under a different brand name (McClure et al., 2004b). These results suggest that reward regions code not only for the inherent value of a product but also for the utility from learned associations like price and brand information. While both price and brand are in part socially constructed – people's preferences for expensive branded products is likely related to their desire for social utility – we explore whether these cortical areas are sensitive to value created solely and specifically from learning the opinions of others. Thus while we predicted that activity in the mPFC would track with whether objects had been socially *tagged* or not, we predicted that activity in reward areas such as the striatum (nACC, putamen, and caudate) would vary as a function of the valence of that tagging – whether participants had learned that objects were socially *valued* or not.

Overview of the experiment

Prior to collecting functional imaging data, we exposed participants to information about others' preferences for abstract sym-