

Disclosing information about the self is intrinsically rewarding

Diana I. Tamir¹ and Jason P. Mitchell

Department of Psychology, Harvard University, Cambridge, MA 02138

Edited by Michael S. Gazzaniga, University of California, Santa Barbara, CA, and approved March 27, 2012 (received for review February 7, 2012)

Humans devote 30–40% of speech output solely to informing others of their own subjective experiences. What drives this propensity for disclosure? Here, we test recent theories that individuals place high subjective value on opportunities to communicate their thoughts and feelings to others and that doing so engages neural and cognitive mechanisms associated with reward. Five studies provided support for this hypothesis. Self-disclosure was strongly associated with increased activation in brain regions that form the mesolimbic dopamine system, including the nucleus accumbens and ventral tegmental area. Moreover, individuals were willing to forgo money to disclose about the self. Two additional studies demonstrated that these effects stemmed from the independent value that individuals placed on self-referential thought and on simply sharing information with others. Together, these findings suggest that the human tendency to convey information about personal experience may arise from the intrinsic value associated with self-disclosure.

self-reference | social cognition | reward | functional MRI

Studies of human conversation have documented that 30–40% of everyday speech is used to relay information to others about one's private experiences or personal relationships (1–4), and recent surveys of Internet use indicate that upwards of 80% of posts to social media sites (such as Twitter) consist simply of announcements about one's own immediate experiences (5). Although other primates do not generally attempt to communicate to others what they know—for example, by pointing out interesting things or modeling behaviors for others to imitate—by 9 mo of age, human children begin trying to draw others' attention to aspects of the environment that they find important (6), and adults in all societies make consistent attempts to impart their knowledge to others (7). Recently, a number of commentators have argued that such unusually high rates of disclosure derive from a species-specific motivation to share one's beliefs and knowledge about the world (6, 7), suggesting that our species may have an intrinsic drive to disclose thoughts to others. This account suggests the following hypothesis: To the extent that humans are motivated to propagate the products of their minds, opportunities to disclose one's thoughts should be experienced as a powerful form of subjective reward. Here, across five studies, we used a combination of neuroimaging and cognitive methods to demonstrate empirical support for this possibility.

Over the past two decades, researchers have characterized a system of neural regions that responds to the anticipation and receipt of reward (8–11). In both humans and animals, the mesolimbic dopamine system—which includes the nucleus accumbens (NAcc) and the ventral tegmental area (VTA)—responds robustly to primary rewards such as food (12–15); secondary rewards such as money or other tokens that can be exchanged for primary rewards (16–22); and even social rewards such as learning that others share one's opinion, experiencing humor, or catching a brief glimpse of an attractive member of the opposite sex (23–27).

In the current studies, we capitalized on the consistency of such findings to examine whether these same brain regions are engaged by opportunities to disclose information about one's self. In these studies, participants underwent functional magnetic resonance imaging (fMRI) scanning while alternately disclosing their own beliefs and opinions or speculating about the beliefs and opinions of another person. To the extent that revealing one's own thoughts is intrinsi-

cally rewarding, we expected greater activity in the NAcc and VTA to accompany trials in which participants answered such questions about themselves than when they answered questions about others.

In addition, we assessed the value associated with opportunities for self-disclosure behaviorally. To do so, we developed a modified version of the “pay-per-view” task introduced by Deaner, Platt, and colleagues (28, 29). In this task, participants make a series of choices between stimuli with fixed value (such as money) and a second category of stimuli with unknown subjective value. For example, Deaner et al. (28) had macaques choose between variable amounts of a primary reinforcer (juice) and brief visual displays of a high-status groupmate. Monkeys waived significant amounts of juice for the opportunity to view a dominant male, suggesting that such displays have high subjective value. In much the same way, Hayden et al. (29) quantified the reward associated with beauty and sexual attraction by measuring the amount of money that university students would forgo to view brief visual displays of attractive members of the opposite sex. Here, we used similar logic to assess the value associated with self-disclosure. To the extent that revealing one's own thoughts is intrinsically rewarding, we expected participants to forgo more money to answer questions about themselves than about others.

Results

In study 1a, participants ($n = 78$) alternately disclosed their own opinions or judged the opinions of others (30, 31). In study 1b, participants ($n = 117$) alternately disclosed their beliefs about their own personality traits or judged the traits of another person (Fig. S1). For both sets of data, we conducted two parallel analyses to examine whether neural regions associated with reward—specifically, the NAcc and the VTA—were engaged by the opportunity to disclose one's own beliefs or opinions more than by considering those of another person. First, we conducted a whole-brain random-effects contrast to identify regions that were more active for *self* > *other* trials ($P < 0.05$, corrected; see Tables S1 and S2 for full results). Replicating earlier work, this contrast revealed an extensive region of medial prefrontal cortex (MPFC), a region that has consistently been associated with self-referential thought (32–34). More importantly for the current hypothesis, this analysis also revealed robust activity in those neural regions implicated in reward processing. In study 1a, significantly greater response was observed in the NAcc bilaterally when disclosing one's own opinions and attitudes than when judging those of another person (Fig. 1A). In study 1b, both the NAcc bilaterally and the VTA (cluster extent = 22 voxels) responded more strongly when disclosing beliefs about one's own personality traits than when judging the traits of others (Fig. 1B).

To confirm that these regions overlapped with those responsive to rewarding stimuli, we independently defined neural regions from a task in which a separate sample of participants ($n = 14$) received monetary rewards [the Monetary Incentive Delay (MID) task] (18). Replicating earlier research, we observed greater activity in bilateral

Author contributions: D.I.T. and J.P.M. designed research, D.I.T. and J.P.M. performed research; D.I.T. analyzed data; and D.I.T. and J.P.M. wrote the paper.

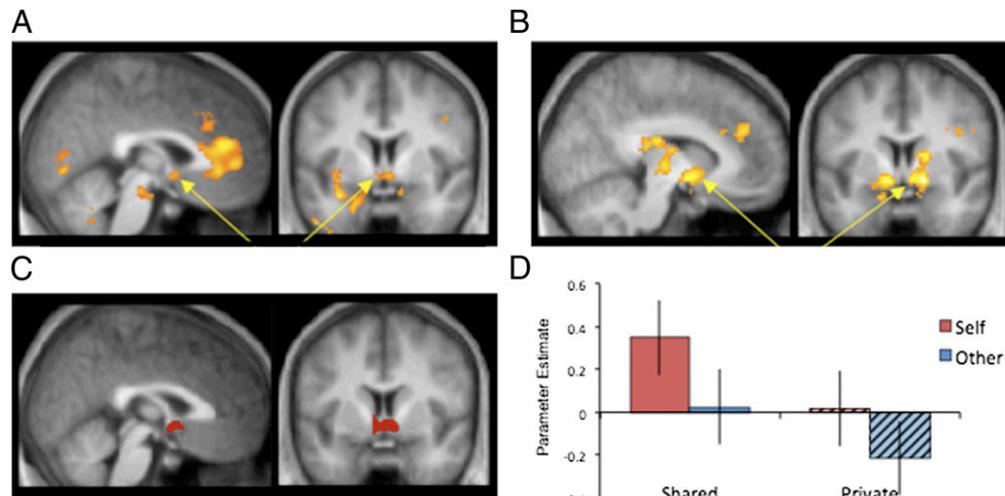
The authors declare no conflict of interest.

This article is a PNAS Direct Submission.

¹To whom correspondence should be addressed. E-mail: dtamir@fas.harvard.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1202129109/-DCSupplemental.

Fig. 3. Introspecting about the self and disclosing that information to others serve as independent sources of reward. Whole-brain random-effects contrasts comparing (A) *self* > *other* and (B) *shared* > *private* from study 3 reveal significant reward activity in bilateral NAcc ($P < 0.05$, corrected; indicated by arrows). (C) A region of interest in bilateral NAcc, defined using the Monetary Incentive Delay task in the same set of subjects. (D) Parameter estimates from this independently defined region are graphically depicted for all four trial types: *self shared* (solid red), *self private* (dashed red), *other shared* (solid blue), and *other private* (dashed blue). Analyses of these parameter estimates confirmed that bilateral NAcc showed responses consistent with two independent sources of reward from self-disclosure: introspection about the self and sharing with others. Error bars depict SE calculated for within-subject designs.



proton-density-weighted anatomical image. In addition to providing an independent way of localizing reward regions of interest, such an analysis also allows for interrogation of activity in the VTA, the small size of which ($\sim 60 \text{ mm}^3$) makes it difficult to localize functionally. Results of this analysis were consistent with the previous two analyses: A 2×2 repeated-measures ANOVA of activity in the NAcc revealed greater activity during *self* than during *other* trials [$F(1,16) = 4.05, P = 0.061, d = 0.50$], significantly greater activity during *shared* than during *private* trials [$F(1,16) = 21.74, P = 0.0003, d = 1.17$], but no interaction between the two factors [$F(1,16) = 0.21, P = 0.65, d = 0.11$]. Likewise, a 2×2 repeated-measures ANOVA of activity in the VTA revealed significantly greater response during *self* trials than *other* trials [$F(1,16) = 7.38, P = 0.015, d = 0.68$] and during *shared* than during *private* trials [$F(1,16) = 5.94, P = 0.027, d = 0.61$], but no interaction between the two factors [$F(1,16) = 0.40, P = 0.53, d = 0.16$]. Together, these results suggest that the value of self-disclosure may derive from two independent sources: both introspecting about the self and communicating information to other people. Because both factors robustly activate neural regions associated with reward and do not interact, each of these factors appears to contribute independently to the motivation for self-disclosure.

In study 4, we replicated the findings from study 3 using the same behavioral assay used in study 2. On each of the 240 trials, participants ($n = 41$) chose between a passive 5-s delay and answering one of four types of question: (i) a *self shared* trial in which participants disclosed their opinions to another person; (ii) a *self private* trial in which participants privately introspected about their opinions; (iii) an *other shared* trial in which participants judged the attitudes of another person and disclosed their answer to another person; or (iv) an *other private* trial in which participants judged another person's attitudes privately. This design diverged slightly from the previous studies in that comparisons were made to a passive delay rather than an active task (i.e., questions about others or facts). We were concerned about the possibility that participants might have valued self-referential thought simply because thinking about the self is relatively easier or entails more certainty than answering questions about other people or about trivia facts (although this concern does not likely apply to the *share* > *private* effects of study 3). To examine this possibility, we included a maximally easy condition: passive delay. If participants were choosing to answer questions merely on the basis of relative ease, then they should place the greatest value on the opportunity to simply rest passively for several seconds. However, if the act of self-disclosure itself represents an intrinsically rewarding option, participants should still be willing to forgo money to self-disclose, despite it being the more difficult of two options.

Payoff amounts varied (between \$0.01 and \$0.04) across trials, as did the option for which participants received the larger payoff. As in study 2, we quantified the relative monetary value of each

question type by calculating the PSE between that question type and the delay option by fitting a cumulative normal distribution curve to each participant's choices and finding the monetary value at which the participant was indifferent to the two options (Fig. 2C).

Consistent with the results of study 3, participants showed a consistent preference for answering questions about the self, and this preference was augmented when participants knew they were communicating their answers to another person. When payoff amounts were equal, participants chose to answer a *self shared* question 69% of the time, an *other shared* question 67% of the time, and a *self private* question 62% of the time. Only on *other private* questions did participant choice behavior not differ significantly from chance (57%). Analysis of PSE scores revealed both a main effect of *self* over *other* [$F(1,40) = 5.08, P = 0.03, d = 0.36$] and a main effect of *sharing* over *private* [$F(1,40) = 8.71, P = 0.005, d = 0.47$] but no interaction between the two factors [$F(1,40) = 0.37, P = 0.55, d = 0.10$]. As displayed in Fig. 2D, this pattern of results was strikingly similar to that obtained using neural data in study 3: participants were willing to forgo money to introspect about the self, and even more money when they were able to disclose the results of such introspection to another person. Indeed, this drive for self-disclosure led to an average loss of $\sim 25\%$ of potential earnings on *self shared* trials. As it happened, participants valued sharing a response about the self at just under one cent (0.97¢), putting a new twist on the old phrase “a penny for your thoughts.”

Discussion

Despite the frequency with which humans disclose the contents of their own thoughts, little has been known about the proximate mechanisms that motivate this behavior. Here, we suggest that humans so willingly self-disclose because doing so represents an event with intrinsic value, in the same way as with primary rewards such as food and sex. Intriguingly, findings also suggested that both parts of “self-disclosure” have reward value. Although participants were willing to forgo money merely to introspect about the self and doing so was sufficient to engage brain regions associated with the rewarding outcomes, these effects were magnified by knowledge that one's thoughts would be communicated to another person, suggesting that individuals find opportunities to disclose their own thoughts to others to be especially rewarding.

The present research follows from a rich history of investigations into self-disclosure and serves to both validate and extend these previous findings. For example, cognitive research into self-disclosure has identified factors that affect the likelihood that individuals will self-disclose, such as one's feeling toward the audience (50) or the intimate nature of the disclosure (2). Other studies have suggested a number of instrumental reasons that people might choose to self-disclose, including expectations for reciprocation

(51, 52), benefits to personal well-being (53, 54), and increased liking between relationship partners (50). Interestingly, a number of earlier researchers have put forward the hypothesis explicitly tested here—that self-disclosure will act as an intrinsic reward (51, 55, 56); however, despite calls to do so (56), this notion has not previously been tested empirically. As such, the current study validates a long-standing hypothesis that self-disclosure arises—at least in part—from the subjective value associated with it.

In an ultimate sense, the tendency to broadcast one's thoughts and beliefs may confer an adaptive advantage in individuals in a number of ways: by engendering social bonds and social alliances between people (50, 57, 58); by eliciting feedback from others to attain self-knowledge (59); by taking advantage of performance advantages that result from sharing one's sensory experience (60); or by obviating the need to discover firsthand what others already know, thus expanding the amount of know-how any single person can acquire in a lifetime. As such, the proximate motivation to disclose our internal thoughts and knowledge to others around us may serve to sustain the behaviors that underlie the extreme sociality of our species.

Materials and Methods

Studies 1a and 1b. Seventy-eight individuals participated in study 1a and 117 individuals participated in study 1b. Informed consent was obtained from all participants in a manner approved by the Human Studies Committee of the Massachusetts General Hospital or by the Committee on the Use of Human Subjects at Harvard University. Studies 1a and 1b collectively comprise 14 separate data collections, including 4 published previously (Table S3). In study 1a, participants alternately disclosed their own opinions or judged the opinions of others (30, 31). On each trial, participants first saw a cue for 500 ms that indicated the target of the judgment: either a chalk outline of a head used to indicate self or a photograph of another person. The identity of the *other* varied across data collections, but was always a fictional, unfamiliar target. The visual cue was presented above a brief phrase that interrogated opinions and dispositions (e.g., "prefer coffee over tea" or "get frustrated sitting in traffic"). Participants used a 4- or 5-point Likert scale to indicate how well the statement described their own opinion or that of the other person within a response window of 3,500 ms.

In study 1b, participants alternately disclosed their beliefs about their own personality traits or judged the traits of another person. The other person was the President of the United States at the time of data collection (George W. Bush or Barack Obama), a choice guided by earlier behavioral (61, 62) and neuroimaging (63) studies of self-referential thought (for review, see ref. 34). On each trial, participants saw a cue for 500 ms that indicated the target of the judgment ("self," "Bush," "Obama") above a personality trait (e.g., "curious" or "ambitious"), and used a Likert scale to indicate how well the trait described the target within a response window of 3,500 ms.

In both studies, trials were separated by a variable intertrial interval (ITI) of 0–10 s (64). Functional data were acquired using a gradient-echo echo-planar pulse sequence [repetition time (TR) = 2,000 ms; echo time (TE) = 35 ms; 1.5T Siemens Sonata or 3T Siemens Trio scanners; 26 or 31 axial, interleaved slices, 5 mm thick; 3.75×3.75 or 3×3 in-plane resolution; see Table S3 for design features of all data acquisitions]. Functional images were preprocessed and analyzed using Statistical Parametric Mapping (SPM) (Wellcome Department of Cognitive Neurology). Data were preprocessed to correct for slice time acquisition differences in each whole-brain volume and spatially realigned to correct for head movement. Images were normalized to a standard anatomical space (2-mm isotropic voxels) on the basis of the ICBM 152 brain template (Montreal Neurological Institute) and then spatially smoothed using an 8-mm FWHM Gaussian kernel. Preprocessed images were analyzed using a general linear model in which trials were modeled as an event with no duration that onset at the presentation of the cue. Trials were conditionalized on the basis of the target: *self* or *other*. Events were modeled using a canonical hemodynamic response function and its temporal derivative. Analyses included covariates of no interest (session mean and linear trend, no response trials, and their temporal derivative). Analyses were performed individually for each participant, and contrast images were subsequently entered into a second-level analysis treating participants as a random effect. At the group level, analyses were conducted using a statistical criterion of 57 or more contiguous voxels at a voxel-wise threshold of $P < 0.001$, providing an experiment-wise threshold of $P < 0.05$, corrected for multiple comparisons per Slotnick and Schacter's (65) specifications.

Study 3. Seventeen individuals participated in study 3. Informed consent was obtained from all participants in a manner approved by the Committee on the Use of Human Subjects at Harvard University. Participants in this study alternately disclosed their own opinions and attitudes (*self* trials) or judged the opinions of another person, Barack Obama (*other* trials). Participants

arrived at the laboratory in the company of a friend or relative, and their answers to half the questions were shared with that other person (*shared* trials), whereas answers to the other half remained private (*private* trials). On each trial, participants first saw a two-word cue for 1,500 ms that indicated both the target of the judgment (*self* or *other*) and whether the answer would be shared or would remain private (*share* or *private*), followed by a 3,500-ms response window. Participants answered 48 of each of the four possible trial types: *self shared*, *self private*, *other shared*, and *other private*. Questions generally asked about fairly mundane opinions, such as those involving food preferences or everyday activities, and avoided issues that were controversial or potentially embarrassing to participants.

Functional data were acquired using a gradient-echo echo-planar pulse sequence (TR = 2,500 ms; TE = 30 ms; 3T Siemens Trio scanners; 42 axial, interleaved slices, 0 skip; 2-mm isotropic voxels). Data acquisition was optimized for signal extraction from the brain regions of interest: the NAcc and the VTA. These acquisition parameters allowed for partial brain coverage; the volumes acquired excluded only the most dorsal/posterior extent of the occipital and parietal cortex. Trials were separated by a variable ITI of 0–12.5 s. Functional images were preprocessed and analyzed using SPM (Wellcome Department of Cognitive Neurology) as for studies 1a and 1b. At the group level, an experiment-wise threshold of $P < 0.05$ corrected for multiple comparisons per Slotnick and Schacter's (65) specifications; because of the limited field of view and smaller voxel size, Monte Carlo simulations indicated use of a statistical criterion of 15 or more contiguous voxels at a voxel-wise threshold of $P < 0.01$.

To enable an analysis of native space anatomical regions of interest, a proton-density-weighted image (TR 6,000 ms, TE 8.6 ms, flip angle 180°, echo spacing 8.62 ms) was acquired with the same orientation and slice thickness as the functional images (42 slices, 2 mm thick, 0.9 mm in-plane spatial resolution) immediately following acquisition of functional data. These images were used to localize the VTA and bilateral NAcc individually for each subject using the manual segmentation tool in the ITK-SNAP segmentation software. Anatomical regions of interest were then aligned with the functional data by applying parameters from the coregistration of the anatomical image to the first image of the functional task. To functionally localize brain regions associated with the processing of rewarding stimuli, participants completed a MID task (66). We defined ROIs by comparing trials on which participants won money to trials in which participants could not earn any reward (See *SI Materials and Methods* for further details). We extracted parameter estimates (β s) from the anatomically defined reward regions for the *self shared*, *self private*, *other shared*, and *other private* trials in study 3, and from the functionally defined NAcc regions for the *self* and *other* trials in studies 1a and 1b, and for the *self shared*, *self private*, *other shared*, and *other private* trials in study 3.

Studies 2 and 4. Thirty-seven individuals participated in study 2 and 41 individuals participated in study 4. Informed consent was obtained from all participants in a manner approved by the Committee on the Use of Human Subjects at Harvard University. The PSE for each question type was calculated individually for each participant by fitting a cumulative normal distribution to the participant's choice behavior. In study 2, at each value for the relative payoff between two question types, we first calculated the percentage of trials in which participants chose (i) to answer a question about the self over a question about a fact, (ii) to answer a question about the self over a question about another person, and (iii) to answer a question about another person over a question about a fact. The other person in studies 2 and 4 was always the current head of state at the time of data collection, Barack Obama. In study 4, at each value for the relative payoff between waiting and answering one of the four question types (*self share*, *self private*, *other share*, and *other private*), we calculated the percentage of trials in which a participant chose to answer that question type over waiting. This resulted in a total of 7 data points per subject, one at each of the relative payoffs between the two options, as relative payoffs ranged between $-\$0.03$ and $+\$0.03$. Cumulative normal curves were fit to these values by implementing a Nelder-Mead simplex search algorithm in Matlab. Cumulative normal distributions are defined on the basis of the following probability density function:

$$\frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Starting values for this estimation were set at a mean of 0 and an SD of 1, and the search continued for 10,000 iterations, or until a solution was achieved. Final solutions of PSE were limited to a range of $-\$0.03$ and $+\$0.03$.

ACKNOWLEDGMENTS. The authors thank Zach Alexander, Kimberlee D'Ardenne, Juan Manuel Contreras, Richard Hackman, Joe Moran, Kenneth Parreno, Emma Templeton, Adam Waytz, and Jamil Zaki for helpful advice and assistance. D.I.T. was supported by a graduate research fellowship from the National Science Foundation.

1. Dunbar RIM, Marriott A, Duncan NDC (1997) Human conversational behavior. *Hum Nat* 8:231–246.
2. Emler N (1990) A social psychology of reputation. *Eur Rev Soc Psychol* 1:171–193.
3. Emler N (1994) Gossip, reputation, and social adaptation. *Good Gossip*, eds Goodman R, Ben Ze'ev A (Kansas University Press, Lawrence, KS), pp 117–133.
4. Landis MH, Burt HE (1924) A study of conversations. *J Comp Psychol* 4(1):81–89.
5. Naaman M, Boase J, Lai CH (2010) Is it really about me?: Message content in social awareness streams. *Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work* (Association for Computing Machinery), Savannah, GA, pp 189–192.
6. Tomasello M (1999) *The Cultural Origins of Human Cognition* (Harvard University Press, Cambridge, MA).
7. Csibra G, Gergely G (2011) Natural pedagogy as evolutionary adaptation. *Philos Trans R Soc Lond B Biol Sci* 366:1149–1157.
8. Schultz W (2002) Getting formal with dopamine and reward. *Neuron* 36:241–263.
9. Montague PR, Berns GS (2002) Neural economics and the biological substrates of valuation. *Neuron* 36:265–284.
10. McClure SM, York MK, Montague PR (2004) The neural substrates of reward processing in humans: The modern role of FMRI. *Neuroscientist* 10:260–268.
11. Haber SN, Knutson B (2010) The reward circuit: Linking primate anatomy and human imaging. *Neuropsychopharmacology* 35:4–26.
12. D'Ardenne K, McClure SM, Nystrom LE, Cohen JD (2008) BOLD responses reflecting dopaminergic signals in the human ventral tegmental area. *Science* 319:1264–1267.
13. Small DM, Zatorre RJ, Dagher A, Evans AC, Jones-Gotman M (2001) Changes in brain activity related to eating chocolate: From pleasure to aversion. *Brain* 124:1720–1733.
14. O'Doherty JP, Deichmann R, Critchley HD, Dolan RJ (2002) Neural responses during anticipation of a primary taste reward. *Neuron* 33:815–826.
15. Hernandez L, Hoebel BG (1988) Food reward and cocaine increase extracellular dopamine in the nucleus accumbens as measured by microdialysis. *Life Sci* 42:1705–1712.
16. Schott BH, et al. (2008) Mesolimbic functional magnetic resonance imaging activations during reward anticipation correlate with reward-related ventral striatal dopamine release. *J Neurosci* 28:14311–14319.
17. Knutson B, Taylor J, Kaufman M, Peterson R, Glover G (2005) Distributed neural representation of expected value. *J Neurosci* 25:4806–4812.
18. Knutson B, Adams CM, Fong GW, Hommer D (2001) Anticipation of increasing monetary reward selectively recruits nucleus accumbens. *J Neurosci* 21:159–159.
19. McClure SM, Laibson DI, Loewenstein G, Cohen JD (2004) Separate neural systems value immediate and delayed monetary rewards. *Science* 306:503–507.
20. Koeppe MJ, et al. (1998) Evidence for striatal dopamine release during a video game. *Nature* 393:266–268.
21. Cohen MX, et al. (2009) Neuroelectric signatures of reward learning and decision-making in the human nucleus accumbens. *Neuropsychopharmacology* 34:1649–1658.
22. Breiter HC, Berke JD, Kennedy WA, Rosen BR, Hyman SE (1996) Activation of striatum and amygdala during reward conditioning: An FMRI study. *Neuroimage* 3:5220.
23. Aharon I, et al. (2001) Beautiful faces have variable reward value: fMRI and behavioral evidence. *Neuron* 32:537–551.
24. Mobbs D, Greicius MD, Abdel-Azim E, Menon V, Reiss AL (2003) Humor modulates the mesolimbic reward centers. *Neuron* 40:1041–1048.
25. Fehr E, Camerer CF (2007) Social neuroeconomics: The neural circuitry of social preferences. *Trends Cogn Sci* 11:419–427.
26. Klucharev V, Hytönen K, Rijpkema M, Smidts A, Fernández G (2009) Reinforcement learning signal predicts social conformity. *Neuron* 61:140–151.
27. Sabatinelli D, Bradley MM, Lang PJ, Costa VD, Versace F (2007) Pleasure rather than salience activates human nucleus accumbens and medial prefrontal cortex. *J Neurophysiol* 98:1374–1379.
28. Deaner RO, Khera AV, Platt ML (2005) Monkeys pay per view: Adaptive valuation of social images by rhesus macaques. *Curr Biol* 15:543–548.
29. Hayden BY, Parikh PC, Deaner RO, Platt ML (2007) Economic principles motivating social attention in humans. *Proc Biol Sci* 274:1751–1756.
30. Mitchell JP, Macrae CN, Banaji MR (2006) Dissociable medial prefrontal contributions to judgments of similar and dissimilar others. *Neuron* 50:655–663.
31. Tamir DI, Mitchell JP (2010) Neural correlates of anchoring-and-adjustment during mentalizing. *Proc Natl Acad Sci USA* 107:10827–10832.
32. Northoff G, Bermpohl F (2004) Cortical midline structures and the self. *Trends Cogn Sci* 8:102–107.
33. Northoff G, et al. (2006) Self-referential processing in our brain: A meta-analysis of imaging studies on the self. *Neuroimage* 31:440–457.
34. Mitchell JP (2009) Social psychology as a natural kind. *Trends Cogn Sci* 13:246–251.
35. Schmitz TW, Rowley HA, Kawahara TN, Johnson SC (2006) Neural correlates of self-evaluative accuracy after traumatic brain injury. *Neuropsychologia* 44:762–773.
36. Pfeifer JH, Lieberman MD, Dapretto M (2007) "I know you are but what am I?": Neural bases of self- and social knowledge retrieval in children and adults. *J Cogn Neurosci* 19:1323–1337.
37. Gutchess AH, Kensinger EA, Schacter DL (2007) Aging, self-referencing, and medial prefrontal cortex. *Soc Neurosci* 2:117–133.
38. Macrae CN, Moran JM, Heatherton TF, Banfield JF, Kelley WM (2004) Medial prefrontal activity predicts memory for self. *Cereb Cortex* 14:647–654.
39. Jenkins AC, Mitchell JP (2011) Medial prefrontal cortex subserves diverse forms of self-reflection. *Soc Neurosci* 12:1–8.
40. O'Doherty JP, Dayan P, Friston K, Critchley H, Dolan RJ (2003) Temporal difference models and reward-related learning in the human brain. *Neuron* 38:329–337.
41. Litt A, Plassmann H, Shiv B, Rangel A (2011) Dissociating valuation and saliency signals during decision-making. *Cereb Cortex* 21:95–102.
42. Nicola SM (2010) The flexible approach hypothesis: Unification of effort and cue-responding hypotheses for the role of nucleus accumbens dopamine in the activation of reward-seeking behavior. *J Neurosci* 30:16585–16600.
43. Seymour B, Daw N, Dayan P, Singer T, Dolan R (2007) Differential encoding of losses and gains in the human striatum. *J Neurosci* 27:4826–4831.
44. Zink CF, Pagnoni G, Martin ME, Dhamala M, Berns GS (2003) Human striatal response to salient nonrewarding stimuli. *J Neurosci* 23:8092–8097.
45. Epley N, Whitchurch E (2008) Mirror, mirror on the wall: Enhancement in self-recognition. *Pers Soc Psychol Bull* 34:1159–1170.
46. Greenwald AG, et al. (2002) A unified theory of implicit attitudes, stereotypes, self-esteem, and self-concept. *Psychol Rev* 109:3–25.
47. Pelham BW, Mirenberg MC, Jones JT (2002) Why Susie sells seashells by the seashore: Implicit egotism and major life decisions. *J Pers Soc Psychol* 82:469–487.
48. Kahneman D, Knetsch JL, Thaler RH (1991) Anomalies: The endowment effect, loss aversion, and status quo bias. *J Econ Perspect* 5:193–206.
49. Morewedge CK, Shu LL, Gilbert DT, Wilson TD (2009) Bad riddance or good rubbish? Ownership and not loss aversion causes the endowment effect. *J Exp Soc Psychol* 45:947–951.
50. Collins NL, Miller LC (1994) Self-disclosure and liking: A meta-analytic review. *Psychol Bull* 116:457–475.
51. Cozby PC (1972) Self-disclosure, reciprocity and liking. *Sociometry* 35:151–160.
52. McAllister HA (1980) Self-disclosure and liking: Effects for senders and receivers. *J Pers* 48:409–418.
53. Ko HC, Chen TK (2009) Understanding the continuous self-disclosure of bloggers from the cost-benefit perspective. *Proceedings of the Second Conference on Human Systems Interactions* (Institute of Electrical and Electronics Engineers), Cantania, Italy, pp 520–527.
54. Niederhoffer KG, Pennebaker JW (2002) Sharing one's story: On the benefits of writing or talking about emotional experience. *Handbook of Positive Psychology*, eds Snyder CR, Lopez SJ (Oxford University Press, New York).
55. Cozby PC (1973) Self-disclosure: A literature review. *Psychol Bull* 79:73–91.
56. Omarzu J (2000) A disclosure decision model: Determining how and when individuals will self-disclose. *Pers Soc Psychol Rev* 4:174–185.
57. Dunbar RIM (1996) *Grooming, Gossip, and the Evolution of Language* (Harvard University Press, Cambridge, MA).
58. Dindia K (2000) Sex differences in self-disclosure, reciprocity of self-disclosure, and self-disclosure and liking: Three meta-analyses reviewed. *Balancing the Secrets of Private Disclosures*, ed Petronio S (Lawrence Erlbaum Associates, Mahwah, NJ), pp 21–36.
59. Cooley CH (1902) *Human Nature and the Social Order* (Charles Scribner's, New York), pp 136–178.
60. Bahrami B, et al. (2010) Optimally interacting minds. *Science* 329:1081–1085.
61. Bowers GH, Gilligan SG (1979) Remembering information related to one's self. *J Res Pers* 13:420–432.
62. Rogers TB, Kuiper NA, Kirker WS (1977) Self-reference and the encoding of personal information. *J Pers Soc Psychol* 35:677–688.
63. Kelley WM, et al. (2002) Finding the self? An event-related fMRI study. *J Cogn Neurosci* 14:785–794.
64. Dale AM (1999) Optimal experimental design for event-related fMRI. *Hum Brain Mapp* 8:109–114.
65. Slotnick SD, Schacter DL (2004) A sensory signature that distinguishes true from false memories. *Nat Neurosci* 7:664–672.
66. Knutson B, Westdorp A, Kaiser E, Hommer D (2000) FMRI visualization of brain activity during a monetary incentive delay task. *Neuroimage* 12:20–27.