



HHS Public Access

Author manuscript

Neuropsychologia. Author manuscript; available in PMC 2016 July 06.

Published in final edited form as:

Neuropsychologia. 2014 April ; 56: 140–146. doi:10.1016/j.neuropsychologia.2014.01.009.

How Social Neuroscience Can Inform Theories of Social Comparison

Jillian K. Swencionis and
Princeton University

Susan T. Fiske
Princeton University

Abstract

Social comparison pervades our interactions with others, informing us of our standing and motivating improvement, but producing negative emotional and behavioral consequences that can harm relationships and lead to poor health outcomes. Social neuroscience research has begun to illuminate some mechanisms by which status divides lead to interpersonal consequences. This review integrates core findings on the neuroscience of social comparison processes, showing the effects of comparing the self to relevant others on dimensions of competence and warmth. The literature converges to suggest that relative status divides initiate social comparison processes, that upward and downward comparisons initiate pain- and pleasure- related neural responses, and that these responses can predict people's kindly or aggressive intentions toward one another. Across different types of comparisons, brain regions involved in mentalizing are also sometimes involved. Along with future work, the research reviewed here may inform efforts to mitigate negative outcomes of constant social comparisons.

Keywords

social comparison; social neuroscience; status; power; envy; Schadenfreude

Why Study Social Comparison?

A longstanding literature in social psychology tells us that humans are never done comparing. Status hierarchies are ever-present, and not only in obvious places like military organizations and corporations; even non-human primates organize themselves hierarchically, and easily interpret signs of social rank (Fiske, 2010). By Festinger's (1954) account, there is good reason why it might be unavoidable for people to compare constantly: judging our own abilities and beliefs relative to others' provides information about where we stand, and motivates us to change. Although we might prefer more objective indicators of

Please direct correspondence to: Jillian K. Swencionis, Princeton University, Department of Psychology Princeton, NJ 08540, jswencio@princeton.edu.

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

our own standing for purposes of accurate self-evaluation, in many parts of social life our standing may have meaning only in a comparative sense.

However, these constant social comparisons can be dangerous. Judging ourselves relative to others high in social status has known consequences, especially for members of stigmatized groups, who endure social stress as a result of hierarchies. Social stress involved in cross-status and cross-race interactions engenders a physiological threat response, hindering performance on tasks in the short term (Mendes, Blascovich, Lickel, & Hunter, 2002; Mendes, Blascovich, Major, & Seery, 2001; Richeson et al., 2003) and gradually amassing negative health effects through emotional and physiological processes in the long term (Gallo & Matthews, 2012; Mays, Cochran, & Barnes, 2007; McEwen, 2000; Sapolsky, 2005). Understanding the processes of social comparison involved in status hierarchies is thus an important goal in psychology, and social cognitive affective neuroscience has a critical role to play in figuring out how status hierarchies operate. This review addresses neuroscience advances in our understanding of how social comparison processes begin, and how comparisons initiate the sequence of emotional and behavioral consequences that result from status divides (see Fiske, 2011, for an earlier, broader review).

Critical in formulating social comparisons between self and other, two dimensions, competence and warmth (or liking) drive both evaluations of the self (e.g., Tafarodi & Swann, 1995) and evaluations of others (Fiske, Cuddy, & Glick, 2006; Fiske, Cuddy, Glick, & Xu, 2002). As described in various models in social cognition including the stereotype content model (SCM), competence and warmth consistently appear in our judgments of individuals and groups (Abele & Wojciszke, 2007; Fiske et al., 2006, 2002; Wojciszke, 2005). In regard to others, dimensions of warmth and competence may have evolved to answer two basic survival questions regarding another person: Does the other person intend to help or harm? Is the other person capable of acting on those intentions? (Fiske et al., 2006) Directly relating to social hierarchies, the degree of interdependence between people predicts perceived warmth, and their status predicts perceived competence (Fiske et al., 2006). Because these dimensions are so fundamental in assessing the self and others, this review is organized around social comparisons on dimensions of competence and warmth (and closely related dimensions).

For a process so universal and so fundamental to how we think about ourselves and others, little integrated theory describes the neural processes involved in social comparisons. Focusing on the last decade of social neuroscience research using neuroimaging methods in humans, this review seeks to integrate findings on how we compare ourselves to others along competence and warmth dimensions, and how neural signatures of different comparison types may relate to the emotional and behavioral consequences of social comparisons. The review focuses on studies that investigate comparing the self to another person, as opposed to studies that involve comparing other people to each other, because comparisons that involve the self are instrumental in gaining information to assess or improve the self, and in generating other-regarding feelings such as envy (for a review that focuses on neural processes involved in inferring ordinal rank, see Chiao, 2010). Of the studies reviewed here, the majority use “social comparison” to mean comparing one’s own competence, ability, possessions, status, or literal hierarchical rank to those of others, whether those others rank

higher or lower on a relevant dimension. We will argue that these types of comparisons are involved in thinking about others in terms of power, or control over valuable resources or outcomes (for a detailed discussion of different concepts of power and status, see Fiske, 2010). While comparison processes related to resource control may be the prototype of social comparison as people typically conceive it, we will argue for the equal importance of considering how humans compare ourselves to others on other social dimensions.

Specifically, the SCM finds interpersonal warmth/trustworthiness in addition to competence to be critical in comparative social cognition (Fiske et al., 2006, 2002). When seeking truth or validation by comparing ourselves to others, the good or ill intentions of those others should matter at least as much as their competence, or ability to act on those intentions, in determining how we respond to the comparison (“Am I as liked as that other person?” “Am I as trusted?”). The studies that do take a comparison target's warmth, or morality, into consideration are mostly investigations of interpersonal empathy, taking on somewhat different tasks than those that involve more straightforward comparisons of abilities or possessions.¹ Before making that jump, however, the review will begin by discussing the social neuroscience of ability and resource comparisons, and then will move on to the more limited literature investigating comparisons more closely related to interpersonal warmth, or a combination of the two dimensions.

In interpreting results involving social comparisons on both competence and warmth dimensions, we have focused on neural responses that tend to accompany experiences of social reward and social pain, as well as mentalizing and self/other processing. Refining our understanding of how people experience and respond to rewarding and painful experiences, discussions between economists and psychologists have framed many questions about how people assign value in absolute versus relative terms. Research in social neuroscience provides a new angle from which to ask these questions. Framed in terms of pleasure and pain-related processes in the human brain, these studies compare how different social scenarios activate the brain's reward network, including the ventral striatum (VS) and orbitofrontal cortex (OFC), known to respond to rewards such as money and food (for a review, see Berridge & Kringelbach, 2008); and the pain-affect network, including dorsal anterior cingulate cortex (dACC) and insula, known to respond to noxious stimuli (Rainville, 1997; Sawamoto et al., 2000). These brain regions have similarly been implicated in social pleasures and pains (Eisenberger & Lieberman, 2004; Eisenberger, 2012; Lieberman & Eisenberger, 2009), extending the range of interpretations from brain activity in pleasure and pain networks.

Across studies reviewed here, considering one's relative social standing does appear to influence pleasure- and pain- related responses. To make an especially useful contribution to theories of social comparison and its consequences, some of the studies reviewed here use brain activations as predictors of subsequent emotional or behavioral outcomes resulting

¹Moral status, or morality, is part of the warmth dimension in work on the SCM (Fiske, Xu, Cuddy, & Glick, 1999), is part of related dimensions like communality in Wojciske and colleagues' work on social perception (e.g., Wojciszke & Abele, 2008; Wojciszke, 2005), and is noted to fall on the same general dimension as warmth, though it may be considered a subset of all characteristics that tend to fall under warmth (Leach, Ellemers, & Barreto, 2007).

from upward and downward comparisons, showing these responses may play an integral role in kind or aggressive intentions toward others.

In addition to responses related to social pleasures and pains, social comparisons also engender responses implicated in mentalizing, or considering another person's mental state, particularly both dorsal and ventral medial prefrontal cortex (dmPFC and vmPFC) and precuneus/PCC (Amodio & Frith, 2006; Mitchell, 2009; Van Overwalle, 2009). In particular, bolstering social psychological theories of resource control, competition and impression formation (e.g., Erber & Fiske, 1984; Neuberg & Fiske, 1987; Ruscher & Fiske, 1990) people may focus more on the intentions of others who are higher versus lower in power and status (Ames & Fiske, 2013; Muscatell et al., 2012). In addition to elaborating on the role of social standing in impression formation, these regions are also involved in various other studies reviewed here, and future work will be needed to continue to elucidate their roles. For a simplified overview of findings summarized in this review, see Table 1.

Sizing Up: Comparing on Competence

Recent studies have investigated the brain networks involved in interpersonal comparisons of competence, resource control, or social hierarchies assigned numerical ranks. Beginning with ability and resources, in a clear manipulation of comparing based on resource ownership, Fliessbach and colleagues (2007) had two participants at a time compete in a dot estimation game during fMRI scanning in two separate scanners (hyperscanning). On each trial, both participants found out whether they and their partner had answered correctly or incorrectly, and how much money they both had won, allowing direct comparison of their estimation abilities and monetary rewards. Important for replicating past work on value and reward, absolute gains in participants' pay did produce expected activity in ventral striatum (VS; in addition to occipital lobe, angular gyrus, precuneus, and medial prefrontal cortex), as shown in previous studies implicating VS in reward processing.

More centrally for social comparison theories, the VS activation scaled up as participants earned *relatively* more than their partners in trials when both partners answered correctly. Additionally, the variability in VS response to relative reward correlated with subjects' individual tendencies to reciprocate kind and unkind actions, assessed in a questionnaire – implicating social comparisons and resulting reward responses in reciprocal behavior.² Thus, Fliessbach and colleagues' study shows important new evidence for valuation and subsequent helping behavior based on comparing resource outcomes with others. Here, differences in reward responses in the brain provide new evidence for processes leading to differences in interpersonal outcomes.

Further probing the emotional responses to social comparisons between the self and others who win or lose money, Dvash, Gilam, Ben-Ze'ev, Hendler, and Shamay-Tsoory (2010) showed that VS responds not only to relative gains when participants win more money in a game of chance, but even when they *lose less* money than their comparison target (believed

²Notably participants in this study were comparing winnings that were larger or smaller based on chance, not based on ability (i.e., to analyze brain responses to relative gains, the researchers looked only at trials in which *both* participants answered correctly, and could receive different payouts). Thus, judgments of fairness may be an important part of judging these relative gains.

to be participating simultaneously, although this study had no other participant). Elaborating on why this reward response might occur even during absolute losses, participants in their study expressed envy when they won less than another person, and joy and Schadenfreude (malicious glee) when they won more. Surprisingly, participants reacted with envy and Schadenfreude even though the differences in outcomes were due purely to chance (as in Fliessbach et al., 2007); that the differences were not related to ability may explain why the differences in envy and gloating ratings, though significant, were small between the upward and downward comparison conditions. Emotion ratings were completed in a separate behavioral study, and not in the fMRI study showing VS response to comparisons, so it is also unclear exactly what role envy and Schadenfreude might have played in reacting to social comparisons of participants' winnings; possibly, upward and downward comparisons produced these emotions in one study and produced different VS activations in a separate study.

Filling in some of these gaps—further specifying types of comparisons that produce different emotional responses and also show different activations in pleasure/pain circuitry—Takahashi and colleagues (2009) had the same participants complete two separate fMRI tasks, in which they considered scenarios involving three different people: one with greater abilities in domains important to the participant, one with greater abilities in irrelevant domains, and one with average abilities in irrelevant domains. As classic work in self-evaluation maintenance in social comparisons has shown, upward comparisons can be especially threatening when the comparison domain is more relevant to the self (e.g., Tesser & Collins, 1988).

Accordingly, in the first task, Takahashi and colleagues found greater activation in dACC in response to superior, relevant targets compared to superior irrelevant targets (with average, irrelevant targets as a contrast for both conditions). The dACC activations correlated with participants' envy ratings of the different types of targets, bolstering the interpretation of envy as “social pain” resulting from threatening upward comparisons, though the authors point to response conflict as an additional possible interpretation for increased dACC activity (for example, being faced with a superior person in a relevant domain may complicate participants' normally positive self-concepts).³

In the second task, participants responded to situations in which misfortunes befell the superior relevant and average irrelevant targets, and rated greater pleasure at the downfall of the superior, more-envied targets. Responding to the downfall of these same envied targets, in addition to greater ratings of pleasure, participants also showed activity in dorsal and ventral striatum and OFC, and VS activity in response to these targets correlated with pleasure ratings – further supporting the account of Schadenfreude when superior comparison targets in self-relevant domains fail. Tying the ends together, VS activity to the more-envied targets in the second task also correlated with dACC activity to these targets in

³In addition to its interpretation as reflecting social pain as corroborated by behavioral measures of envy or displeasure, dACC activity may also reflect response conflict to some extent. It is possible that these two interpretations work in concert as a sort of neural “alarm system” that something is wrong, whether that something is more affective or cognitive. For a detailed discussion of these interpretations, see Eisenberger, 2012.

the first task – in other words, the stronger the social pain response in response to an envied target, the stronger the reward response when that target falls from grace.

Activity in VS does not always accompany downward comparisons felt as rewarding, however: In one study, participants played a speed and accuracy-based computer game against (fictitious) three-star-rated, high-skilled players and one-star-rated, low-skilled players. Participants showed activity in VS, bilateral occipital/parietal cortex, parahippocampal cortex, and dlPFC, when viewing the high-skilled versus low-skilled players—a finding the authors attribute to heightened attentional and associative processing to superior players (Zink et al., 2008). A second study changed the nature of the hierarchy, such that players' star ratings could change during the game (i.e., a more unstable hierarchy). Zink et al. replicated the same activations in a contrast between viewing high-skilled versus low-skilled players, and additionally observed activity in bilateral thalamus, right amygdala, posterior cingulate/precuneus, mPFC, and motor areas. These results are a challenge to reconcile with some of the experiments described previously, which map more simply onto the social pains and pleasures of envy and Schadenfreude. Some of the differences in Zink et al.'s findings may have to do with the other players' rank not bearing on the computer game outcomes, or with the fact that brain activity was observed during passive viewing of other players; it is unclear exactly what participants were thinking while observing other players' faces.

So far, brain activity in VS and OFC tends to respond to gains relative to others around us, not just to absolute gains, and such reward responses may be especially likely when those others' threatening qualities lead us to envy them. Moreover, dACC, implicated in response conflict and social pain, tends to respond to envied others. But if social comparison functions to give us more information about ourselves in a social context, then how might these comparisons actually impact our behavior, beyond how we feel about comparison targets?

Consistent with earlier results, Bault, Joffily, Rustichini, and Coricelli (2011) showed that VS responds more strongly to relative gains than absolute gains, and also that VS responds more strongly to absolute personal gains than to relative losses, when comparing to a supposed other participant playing a series of gambles.⁴ Extending the implications of such comparisons to decision scenarios, the authors also found that VS sensitivity to social gains (i.e., the extent of VS response to relative gains when choosing gambles in a social context) predicted the extent of mPFC activity in subsequent trials where participants made gambling choices in a social context. Recruited across a wide variety of tasks in social cognition, activity in mPFC and PCC is thought to index mentalizing, defined as actively considering another person's thoughts and feelings, or thinking about the self and others more broadly (Amodio & Frith, 2006; Mitchell, 2009; Van Overwalle, 2009). In this context, those participants who tend to experience winning relatively more money than others as especially rewarding, may focus especially intently on subsequent social trials, trying to assess others' intentions in efforts to optimize outcomes. Corroborating this story with behavioral evidence, participants who experienced greater relative social gains early in the experiment

⁴In this study, the absolute gains were not in a social context.

were more likely to choose the riskier, higher-payoff option in the gambles, trying to outperform their partner. Comparing to others may yield information that shapes behavior, but as this study shows, high sensitivity to relative gains in social contexts may lead down a riskier path. Like Fliessbach et al.'s study, Bault et al.'s investigation gives new information about how the brain's response to rewards relative to others' may impact future behavior, with heightened social rewards influencing impression formation and social behavior.

In addition to Bault et al. (2011)'s evidence tracing differential mPFC activity and social behavior to differential responses to social comparisons, the social context itself may impact our focus on others' intents. For example, if mere differences in resources or social status implies comparison (e.g., Chiao, 2010), we may consider others' intents differently depending on the implied comparison. In an ecologically rich experiment, Ames and Fiske (2013) had participants collaborate on a task designing educational games with one partner whose performance mattered to the participant's potential reward (i.e., outcome dependency), and one partner whose performance on the task was outcome-independent. Here, the partner who mattered for the participant's outcome was in a position of relative power; the other partner was not. Accordingly, participants were especially attuned to forming detailed impressions of the high-power partner, showing greater mPFC activity to impression-inconsistent (versus consistent) information about this partner, but showing greater mPFC activity to consistent (versus inconsistent) information about the partner with less impact on outcomes. These results suggest a mechanism by which relatively low-power individuals in a collaborative setting may form more detailed impressions of high-power others, and by which inconsistent information about low-power others may go relatively ignored.

In a related set of studies that focused on subjective social status rather than power, Muscatell et al. (2012) demonstrated that lower-status participants show greater activity in the mentalizing network, identified as mPFC (in addition to dmPFC and precuneus), in social compared to non-social situations, than do higher-status participants. In Muscatell et al.'s first study, college students rated their perceived social status within the college community, an environment with plentiful opportunities for comparison, and in their second study, adolescents' parents' ratings of socioeconomic status predicted dmPFC and amygdala reactions to threatening versus neutral faces. The authors suggest lower social status, much like relatively low power in Ames and Fiske's study, may be related to a greater need to understand high-status or high-power others' thoughts and feelings, because these higher-ups may be especially important in determining outcomes. In both cases, relative social standing matters for impression formation, whether that standing is randomly assigned at the beginning of the experiment, or observed as the participant's subjective report of social status – with standing determining the extent of impression formation.

Beyond these two studies that draw specifically on the role of social standing in impression formation, several other studies reviewed here also observe activity in mPFC and precuneus/PCC, identified as core regions in social cognition that respond to a range of stimuli related to the self and others (Amodio & Frith, 2006; Denny, Kober, Wager, & Ochsner, 2012; Mitchell, 2009; Van Overwalle, 2009). Given the likelihood that initial impressions of others draw on social comparison processes, and given that these regions respond to the self and

others, involvement of mPFC in social comparison may not be a surprise, but future work is needed to provide a consistent interpretation of this network's involvement in social comparison. Considering that the mPFC responds to both the self and others, its involvement in social comparisons may reflect processing of the self, or of the comparison target, or some combination while comparing the self to another person. Variations in mPFC response may also depend on task differences, including the extent to which a comparison has social implications, as opposed to merely sizing up the person in question. When playing a game against a partner to win money, a participant already knows the partner's intention, so it may not be necessary to try to infer the partner's thoughts. However, in more complicated situations, it may be more necessary to figure out what an interaction partner's intentions are in addition to figuring out how able they are to act on them.⁵ As the literature on other kinds of social comparisons continues to develop, comparisons on dimensions like interpersonal warmth or morality may depend more heavily on focusing on others' intents. If so, such studies may show more of a role of mPFC in these kinds of comparisons. In any case, more research is needed to continue to elucidate the mPFC's role in comparison processes.

Taking these studies together, comparing the self to others on competence-related dimensions elicits reward- and pain- related responses in the brain, sometimes to a greater extent than absolute judgments not related to others, and sometimes predicting subsequent interpersonal outcomes. Even within the confines of social comparisons based on competence or ability, the tasks used in this series of experiments vary widely, accounting for some of the variation in brain networks observed. Future work in this area might untangle some of these differences.

Inferring Intentions: Comparing on Interpersonal Warmth

This section will briefly review the beginnings of work investigating social comparisons on dimensions other than competence or resource control, and speculate about new directions that may pursue further questions about comparisons on warmth, morality, and other intent-related dimensions.

In a path-breaking study, Beer and Hughes (2010) had students make many different types of comparisons with “the average University of Texas student,” on a wide range of dimensions, including some like competence, and others like warmth. Following the idea that social comparisons may serve to inform and improve ourselves, some comparers were more realistic than others in their self/social judgments: Replicating the typical “better than average” effect, in which raters tend to exaggerate their own qualities and abilities compared to others', Beer and Hughes showed a negative correlation between this overestimation effect and activity in OFC and dACC. One interpretation is that these regions assist in making useful, realistic judgments from such social comparisons. Another is that people who acknowledge that they are not better than average are facing a discrepancy between self-esteem and reality, consistent with other work implicating the dACC in social pain and in

⁵As another example, two other studies of social comparisons on the intelligence dimension do observe activation in mPFC as central findings, but these studies both contrasted brain activity during relative intelligence judgments with activity during judgments of relative height, so activations in areas such as mPFC and precuneus should be expected from the contrast between a social versus non-social comparison (Kedia et al., 2013; Lindner et al., 2008).

discrepancy detection more generally (Botvinick, Cohen, & Carter, 2004; Eisenberger & Lieberman, 2004). Although these social comparisons all were grouped together, future work might see whether any effects differed by comparison dimension.

A more recent study did not make social comparisons explicit, but did separate participants' evaluations of different targets' social status into dimensions of status and morality (Cloutier, Ambady, Meagher, & Gabrieli, 2012). Participants responded to faces of targets who were presented as having either low or high socioeconomic status (i.e., their salary was presented), or high or low moral status (e.g., hedge fund manager vs. inventor of green technologies). In line with Chiao's work on determining numerical status (e.g., Chiao, 2010), Cloutier and colleagues found the intraparietal sulcus (IPS) responded to SES information, while vmPFC responded to moral status, in line with much previous work on thinking about the self and similar others, especially with respect to considering another person's intentions (Amodio & Frith, 2006; Denny et al., 2012; Mitchell, 2009; Van Overwalle, 2009). Although dimensions of morality/warmth and status/competence tend to be relevant for the self as they are for evaluating others, and though comparisons are persistent and automatic, it may be that the lack of direct, explicit social comparisons in this study may be why participants did not show the typical responses reflecting reward or social pain in upward and downward comparisons. However, one aspect of comparing the self to others certainly involves merely assessing where the other person stands, and involvement of IPS and vmPFC in status and morality judgments is likely an important component of direct social comparisons as well.

In a study more squarely focused on warmth comparisons, Singer et al. (2006) had participants react to others' painful experiences after observing their economic-game behavior. After playing a prisoner's dilemma game with two confederate opponents, one who was relatively more generous (warm) and one who was relatively less generous, participants and opponents received painful and non-painful electric shocks. Squaring with the results of the resource-comparing studies mentioned earlier (Dvash et al., 2010; Fliessbach et al., 2007; Takahashi et al., 2009), participants in this study showed neural responses in response to negative events involving the self and both opponents that fit an account of social pain and pleasure. However, in this study, the dACC and insula activation were observed in response to the generous opponent's pain, interpreted as reflecting empathy for the generous opponents (i.e., "feeling their pain;" see discussion below on different possible interpretations of pain affect network activation). In male subjects (but not female subjects), these activations in dACC and insula were significantly attenuated in response to the less generous opponents' pain, and additionally VS activity was observed, interpreted as less empathy and even a sense of reward (Schadenfreude) corresponding to pain experienced by the relatively less generous opponent.

In a study allowing comparisons of positive versus negative outcomes for favored, rival, and neutral teams, Cikara, Botvinick, and Fiske (2011) measured participants' responses to baseball players' successes and failures. Critically, this study, which recruited participants on the basis of being ardent fans of either the New York Yankees or Boston Red Sox, enables the authors to compare responses to events that happen to ingroup versus outgroup members. When viewing their own team's failures or rival team's successes, participants showed

activity in dACC and insula, correlated with their own ratings of pain during these experiences; when viewing their own team's successes or rival team's failures, participants showed VS activity correlated with their pleasure ratings of these events. The VS activity in response to rival team's failures when playing a third team, interpreted as Schadenfreude, also predicted participants' rated likelihood of harming fans of the rival team. In addition to observing dramatic inverse responses to successes and failures based on group membership, this study gets at some of the mechanisms involved in how these kinds of events can result in intergroup harm.

These last two studies raise a question about “painful” experiences during social comparisons. One popular interpretation of activity in dACC and insula during social exclusion is that participants experience social pain in much the same way as they experience physical pain (for a review, see Eisenberger, 2012). Adding to this interpretation, the experience of envying another person, and the very different experience of empathizing with another person's pain, also reliably recruit dACC and insula (on empathy: Decety & Ickes, 2009). What might it mean for these different experiences to share neural circuitry – are these processes actually similar, and if so, how? Though all may be experienced as painful in some sense, physical pain, exclusion, envy, and empathy are distinct experiences with distinct causes and motivational consequences, and future work will be needed to explore their common interpretation as painful. One important aspect that bolsters the social pain interpretation of both envy and empathy for pain is that ACC and insula responses in empathy appear to be limited to empathy for others' pain, as opposed to other types of emotional experiences (Morelli & Lieberman, 2013), suggesting that pain, in any of these forms, may be the common experience. Experiences related to social pain may be especially relevant to comparisons involving interpersonal warmth, and this consideration should play a part in future studies about social comparison on warmth dimensions.

Conclusion

As we have seen, humans can hardly avoid comparing themselves to others in the ubiquitous situations where status divides are present. Beyond their effects on interpersonal attitudes and behavior, status hierarchies have wide-ranging effects on health, motivation, and well being (Smeeding, 2005; Wilkinson & Pickett, 2009). A fuller understanding of the mechanisms through which comparisons produce emotional and behavioral responses may yield constructive information about *how* status differences produce long-range outcomes, and possibly improve some of comparison's negative consequences. Social neuroscientific methods provide one way of learning about these mechanisms: reward- and pain-related brain responses that result from social comparisons, and relate to downstream emotional and behavioral consequences, yield new insight into how status divides can produce resentment and conflict. Studies showing mentalizing responses in certain social comparisons are beginning to elaborate on existing theories of social standing and impression formation. Many open questions remain, from disentangling interpretations of different kinds of social pains, to the social and interpersonal factors that maintain social hierarchies, to discerning how relative differences in social status and their accompanying differences in impression formation may be involved in negative downstream consequences. Social neuroscience

investigations are a relatively new addition to the study of social comparison processes, making it an exciting enterprise.

References

- Abele AE, Wojciszke B. Agency and communion from the perspective of self versus others. *Journal of personality and social psychology*. 2007; 93(5):751–63. DOI: 10.1037/0022-3514.93.5.751 [PubMed: 17983298]
- Ames DL, Fiske ST. Outcome dependency alters the neural substrates of impression formation. *NeuroImage*. 2013; 83:599–608. DOI: 10.1016/j.neuroimage.2013.07.001 [PubMed: 23850465]
- Amodio DM, Frith CD. Meeting of minds: the medial frontal cortex and social cognition. *Nature reviews Neuroscience*. 2006; 7(4):268–77. DOI: 10.1038/nrn1884 [PubMed: 16552413]
- Bault N, Joffily M, Rustichini A, Coricelli G. Medial prefrontal cortex and striatum mediate the influence of social comparison on the decision process. *Proceedings of the National Academy of Sciences of the United States of America*. 2011; 108(38):16044–9. DOI: 10.1073/pnas.1100892108 [PubMed: 21896760]
- Beer JS, Hughes BL. Neural systems of social comparison and the “above-average” effect. *NeuroImage*. 2010; 49(3):2671–9. DOI: 10.1016/j.neuroimage.2009.10.075 [PubMed: 19883771]
- Berridge KC, Kringelbach ML. Affective neuroscience of pleasure: reward in humans and animals. *Psychopharmacology*. 2008; 199(3):457–480. DOI: 10.1007/s00213-008-1099-6 [PubMed: 18311558]
- Botvinick MM, Cohen JD, Carter CS. Conflict monitoring and anterior cingulate cortex: an update. *Trends in cognitive sciences*. 2004; 8(12):539–46. DOI: 10.1016/j.tics.2004.10.003 [PubMed: 15556023]
- Chiao JY. Neural basis of social status hierarchy across species. *Current opinion in neurobiology*. 2010; 20(6):803–9. DOI: 10.1016/j.conb.2010.08.006 [PubMed: 20850964]
- Cikara M, Botvinick MM, Fiske ST. Us versus them: social identity shapes neural responses to intergroup competition and harm. *Psychological science*. 2011; 22(3):306–13. DOI: 10.1177/0956797610397667 [PubMed: 21270447]
- Cloutier J, Ambady N, Meagher T, Gabrieli JDE. The neural substrates of person perception: spontaneous use of financial and moral status knowledge. *Neuropsychologia*. 2012; 50(9):2371–6. DOI: 10.1016/j.neuropsychologia.2012.06.010 [PubMed: 22732489]
- Decety, J.; Ickes, W., editors. *The Social Neuroscience of Empathy*. Cambridge, MA: MIT Press; 2009.
- Denny BT, Kober H, Wager TD, Ochsner KN. A meta-analysis of functional neuroimaging studies of self- and other judgments reveals a spatial gradient for mentalizing in medial prefrontal cortex. *Journal of cognitive neuroscience*. 2012; 24(8):1742–52. DOI: 10.1162/jocn_a_00233 [PubMed: 22452556]
- Dvash J, Gilam G, Ben-Ze'ev A, Hendler T, Shamay-Tsoory SG. The envious brain: the neural basis of social comparison. *Human brain mapping*. 2010; 31(11):1741–50. DOI: 10.1002/hbm.20972 [PubMed: 20205244]
- Eisenberger NI. The pain of social disconnection: examining the shared neural underpinnings of physical and social pain. 2012; May 2011. doi: 10.1038/nrn3231
- Eisenberger NI, Lieberman MD. Why rejection hurts: a common neural alarm system for physical and social pain. *Trends in cognitive sciences*. 2004; 8(7):294–300. DOI: 10.1016/j.tics.2004.05.010 [PubMed: 15242688]
- Erber R, Fiske ST. Outcome dependency and attention to inconsistent information. *Journal of Personality and Social Psychology*. 1984; 47(4):709–726. DOI: 10.1037//0022-3514.47.4.709
- Festinger L. A Theory of Social Comparison Processes. *Human Relations*. 1954; 7(2):117–140. DOI: 10.1177/001872675400700202
- Fiske, ST. Interpersonal Stratification. In: Fiske, ST.; Gilbert, DT.; Lindzey, G., editors. *Handbook of Social Psychology*. 5th. New York, NY: McGraw-Hill; 2010. p. 941-982.
- Fiske, ST. *Envy Up, Scorn Down: How Status Divides Us*. New York, NY: Russell Sage; 2011.

- Fiske ST, Cuddy AJC, Glick P. Universal dimensions of social cognition: warmth and competence. *Trends in cognitive sciences*. 2006; 11(2):77–83. DOI: 10.1016/j.tics.2006.11.005 [PubMed: 17188552]
- Fiske ST, Cuddy AJC, Glick P, Xu J. A model of (often mixed) stereotype content: Competence and warmth respectively follow from perceived status and competition. *Journal of Personality and Social Psychology*. 2002; 82(6):878–902. DOI: 10.1037//0022-3514.82.6.878 [PubMed: 12051578]
- Fiske ST, Xu J, Cuddy AC, Glick P. (Dis)respecting versus (Dis)liking: Status and Interdependence Predict Ambivalent Stereotypes of Competence and Warmth. *Journal of Social Issues*. 1999; 55(3): 473–489. DOI: 10.1111/0022-4537.00128
- Fliessbach K, Weber B, Trautner P, Dohmen T, Sunde U, Elger CE, Falk a. Social comparison affects reward-related brain activity in the human ventral striatum. *Science*. 2007; 318(5854):1305–8. DOI: 10.1126/science.1145876 [PubMed: 18033886]
- Gallo LC, Matthews KA. Understanding the Association Between Socioeconomic Status and Physical Health: Do Negative Emotions Play a Role? *Psychological bulletin*. 2012; 129(1):10–51. DOI: 10.1037/0033-2909.129.1.10 [PubMed: 12555793]
- Kedia G, Lindner M, Mussweiler T, Ihssen N, Linden DEJ. Brain networks of social comparison. *Neuroreport*. 2013; 24(5):259–64. DOI: 10.1097/WNR.0b013e32835f2069 [PubMed: 23407275]
- Leach CW, Ellemers N, Barreto M. Group virtue: the importance of morality (vs. competence and sociability) in the positive evaluation of in-groups. *Journal of personality and social psychology*. 2007; 93(2):234–49. DOI: 10.1037/0022-3514.93.2.234 [PubMed: 17645397]
- Lieberman MD, Eisenberger NI. Pains and pleasures of social life. *Science*. 2009; 323:890–891. [PubMed: 19213907]
- Lindner M, Hundhammer T, Ciaramidaro A, Linden DEJ, Mussweiler T. The neural substrates of person comparison--an fMRI study. *NeuroImage*. 2008; 40(2):963–71. DOI: 10.1016/j.neuroimage.2007.12.022 [PubMed: 18234521]
- Mays VM, Cochran SD, Barnes NW. Race, Race-Based Discrimination, and Health Outcomes Among African Americans. *Annual review of psychology*. 2007; 58:201–225. DOI: 10.1146/annurev.psych.57.102904.190212
- McEwen BS. The neurobiology of stress: from serendipity to clinical relevance 1. *Brain Research*. 2000; 886:172–189. [PubMed: 11119695]
- Mendes WB, Blascovich J, Lickel B, Hunter S. Challenge and Threat During Social Interactions With White and Black Men. *Personality and Social Psychology Bulletin*. 2002; 28(7):939–952. DOI: 10.1177/014616720202800707
- Mendes WB, Blascovich J, Major B, Seery M. Challenge and threat responses during downward and upward social comparisons. *European Journal of Social Psychology*. 2001; 31(5):477–497. DOI: 10.1002/ejsp.80
- Mitchell JP. Social psychology as a natural kind. *Trends in cognitive sciences*. 2009; 13(6):246–51. DOI: 10.1016/j.tics.2009.03.008 [PubMed: 19427258]
- Morelli, Sa; Lieberman, MD. The role of automaticity and attention in neural processes underlying empathy for happiness, sadness, and anxiety. *Frontiers in human neuroscience*. 2013 May. 7:160.doi: 10.3389/fnhum.2013.00160 [PubMed: 23658538]
- Muscattell KA, Morelli Sa, Falk EB, Way BM, Pfeifer JH, Galinsky AD, et al. Eisenberger NI. Social status modulates neural activity in the mentalizing network. *NeuroImage*. 2012; 60(3):1771–1777. DOI: 10.1016/j.neuroimage.2012.01.080 [PubMed: 22289808]
- Neuberg SL, Fiske ST. Motivational influences on impression formation: outcome dependency, accuracy-driven attention, and individuating processes. *Journal of personality and social psychology*. 1987; 53(3):431–44. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/3656080>. [PubMed: 3656080]
- Rainville P. Pain Affect Encoded in Human Anterior Cingulate But Not Somatosensory Cortex. *Science*. 1997; 277(5328):968–971. DOI: 10.1126/science.277.5328.968 [PubMed: 9252330]
- Richeson, Ja; Baird, Aa; Gordon, HL.; Heatherton, TF.; Wyland, CL.; Trawalter, S.; Shelton, JN. An fMRI investigation of the impact of interracial contact on executive function. *Nature neuroscience*. 2003; 6(12):1323–8. DOI: 10.1038/nn1156 [PubMed: 14625557]

- Ruscher JB, Fiske ST. Interpersonal Competition Can Cause Individuating Processes. *Journal of Personality and Social Psychology*. 1990; 58(5):832–843. [PubMed: 2348371]
- Sapolsky RM. The influence of social hierarchy on primate health. *Science (New York, N Y)*. 2005; 308(5722):648–52. DOI: 10.1126/science.1106477
- Sawamoto N, Honda M, Okada T, Hanakawa T, Kanda M, Fukuyama H, et al. Shibasaki H. Expectation of pain enhances responses to nonpainful somatosensory stimulation in the anterior cingulate cortex and parietal operculum/posterior insula: an event-related functional magnetic resonance imaging study. *The Journal of neuroscience*. 2000; 20(19):7438–45. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/11007903>. [PubMed: 11007903]
- Singer T, Seymour B, Doherty JPO, Stephan KE, Dolan RJ, Frith CD. Empathic neural responses are modulated by the perceived fairness of others. *Nature*. 2006; 439:10–13. DOI: 10.1038/nature04271 [PubMed: 16397473]
- Smeeding TM. Public Policy, Economic Inequality, and Poverty: The United States in Comparative Perspective. *Social Science Quarterly*. 2005; 86:955–982.
- Tafarodi RW, Swann WB. Tafarodi-Swann-1995-JPA95.pdf. *Journal of personality assessment*. 1995; 65(2):322–342. [PubMed: 8656329]
- Takahashi H, Kato M, Matsuura M, Mobbs D, Suhara T, Okubo Y. When Your Gain Is My Pain and Your Pain Is My Gain: Neural Correlates of Envy and Schadenfreude. *Science*. 2009 Feb.323:937–939. [PubMed: 19213918]
- Tesser A, Collins JE. Emotion in social reflection and comparison situations: intuitive, systematic, and exploratory approaches. *Journal of personality and social psychology*. 1988; 55(5):695–709. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/3210140>. [PubMed: 3210140]
- Van Overwalle F. Social cognition and the brain: a meta-analysis. *Human brain mapping*. 2009; 30(3): 829–58. DOI: 10.1002/hbm.20547 [PubMed: 18381770]
- Wilkinson RG, Pickett KE. Income Inequality and Social Dysfunction. *Annual Review of Sociology*. 2009; 35(1):493–511. DOI: 10.1146/annurev-soc-070308-115926
- Wojciszke B. Morality and competence in person- and self-perception. *European Review of Social Psychology*. 2005; 16:155–188. DOI: 10.1080/10463280500229619
- Wojciszke B, Abele AE. The primacy of communion over agency and its reversals in evaluations. 2008 May.1147:1139–1147. DOI: 10.1002/ejsp
- Zink CF, Tong Y, Chen Q, Bassett DS, Stein JL, Meyer-Lindenberg A. Know your place: neural processing of social hierarchy in humans. *Neuron*. 2008; 58(2):273–83. DOI: 10.1016/j.neuron.2008.01.025 [PubMed: 18439411]

Highlights

- We review neuroimaging studies of social comparison and its consequences
- Upward comparisons activate brain networks implicated in envy and social pain
- Downward comparisons activate networks involved in perceiving reward
- Both types of comparisons sometimes recruit areas involved in mentalizing
- Brain activations sometimes predict friendly or aggressive intentions toward

Table 1

Area(s) activated

Type of comparison Study	Study	VS	OFC	ACC	Insula	dIPFC	dmPFC	vlPFC	vmPFC	PCC/precuneus	IPS/IPL	TPJ	AMG
Competence													
Dominance; ordinal hierarchy	Chiao, 2010 (review)				X			X			X		
Game ability	Zink et al., 2008	X			X	X			X				X
Intelligence	Kedia et al., 2013		X	X		X			X		X		
Intelligence	Lindner et al., 2008		X			X		X				X	
Perceived social status; SES	Muscattell et al., 2012					X			X				X
Power; outcome dependency	Ames & Fiske, 2013					X							
Relative lottery outcomes	Bault et al., 2011	X				X							
Relative lottery outcomes	Dvash et al., 2010	X	X						X				
Relative rewards; competence	Fliessbach et al., 2007	X											
Self-relevance; Competence	Takahashi et al., 2009	X		X									
Warmth													
Generosity; Pain received	Singer et al., 2006	X	X	X	X								
Both Warmth and Competence													
Group membership; Competence	Cikara et al., 2011	X	X	X	X								
Moral status; SES	Cloutier et al., 2012								X				X
Warmth and competence traits	Beer & Hughes, 2010		X	X									