frontiers in
HUMAN NEUROSCIENCE

OPINION ARTICLE
published: 08 May 2012
doi: 10.3389/fnhum.2012.00123

Neuroimaging evidence for social rank theory

Marian Beasley[1]*, Dean Sabatinelli[2] and Ezemenari Obasi[1]

[1] Hwemudua Alcohol and Health Disparities Laboratory, Department of Counseling and Human Development Services, The University of Georgia, Athens, GA, USA
[2] Department of Psychology, I BioImaging Research Center, The University of Georgia, Athens, GA, USA
*Correspondence: mbeasle5@uga.edu

Recent advances in imaging have enabled the study of social rank, which refers generally to an individual's social standing as either dominant or subordinate in a group, in relation to brain structure and function. From an evolutionary perspective, the mind is a modular structure from which various psychological traits and processes evolved in order to promote the success of the individual and the species. Gilbert (2000) argues that social rank theory explains responses reflecting such a system, which appears to have functional underpinnings linking limbic, prefrontal, and striatal structures (Levitan et al., 2000). Researchers argue that this evolved system for responding to status information during social exchanges serves to facilitate cohesion in social rank encounters; namely, competition and/or cooperation for access to resources (Gilbert, 2000; Levitan et al., 2000).

Several questions emerge from this evolutionary perspective when considered in the context of social rank: How does social rank manifest behaviorally in humans? What environmental conditions might change how the brain uses rank to navigate social landscapes successfully? Furthermore, what are the underlying neural processes associated with these evolved systems?

The present discussion briefly discusses social rank as a theoretical construct, explores the behavioral manifestations of social rank, and reviews the neuroimaging support for social rank theory as a conceptual framework in which neural processes reflect an evolved psychological process. While a wealth of research provides conceptual support for this process in the animal model (Blanchard et al., 2001; Sapolsky, 2005; Morrison et al., 2011), here we review recent evidence for the neural basis of social rank in humans.

SOCIAL RANK: THEORY AND BEHAVIOR

Social rank can be conceptualized as a function of several related factors, including resource inequity, maintenance and stability of the hierarchy, subordinate coping strategies, mating style, personality variability, and culture (Sapolsky, 2004, 2005). In humans, organizational hierarchies such as those found in employment settings serve to create natural dominants (i.e., employers) and subordinates (i.e., employees).

Empirical evidence for behavioral manifestations of social rank (i.e., the extent to which submissive versus dominant rank is associated with particular behaviors) implicates threat (i.e., feeling criticized) and inferiority as central to the social rank system (Fournier et al., 2002; Zuroff et al., 2010). According to Gilbert (2005) social rank in humans, wherein perceived rank impacts the individual as much as actual rank (Adler et al., 2000), reflects the ability to attract the attention, admiration, and investment of others; when this goal is thwarted or unattainable, hopelessness and depression ensue.

How does social rank operate within a hierarchy in humans (i.e., what behaviors can be expected from dominant and subordinate individuals during rank contests)? Fournier et al. (2002) corroborated findings from primate studies (de Waal, 1989) and found that threat appraisals elicit escalation behaviors toward subordinates and de-escalation behaviors toward dominant superiors. Specifically, findings suggest that individuals in a workplace setting displayed higher levels of dominance (e.g., stated an opinion) when confronted by subordinates and higher levels of submissiveness (e.g., withheld opinions; gave in) toward higher status others. Levels of agreeableness (e.g., words/gestures of affection) and quarrelsomeness (e.g., confrontation; sarcasm) followed a similar pattern, suggesting a complex system for behavioral responses to rank contests as a function of affiliation and control.

Social rank processes can also predict group performance as a function of group leaders' and members' levels of coalition building (e.g., finding value in teamwork), dominant leadership (e.g., comfort in leadership roles; self-promotion), and ruthless self-advancement (e.g., concealing personal agendas; disloyalty; competition). Groups perform better when group leaders and members are both high in coalition building, while groups with leaders and members all exhibiting high levels of ruthless self-advancement appear to perform the worst (Kelly et al., 2011).

The complementarity hypothesis suggests social rank might also be a function of perceived non-verbal cues. That is, individuals display dominance through postural expansion (i.e., extending limbs) when their equal-status though unfamiliar counterpart displays submission through postural constriction (i.e., bringing limbs inward; Tiedens and Fragale, 2003). In friendships, we see evidence that insecure attachment sensitizes individuals to defend against shame and rejection from others through submissive behaviors (i.e., failing to defend oneself to criticism; avoiding direct eye contact; Irons and Gilbert, 2004). While the models differ in approach, research seems to support the premise that individuals tend to behave in ways that will ultimately create the most comfortable relationships (Fournier et al., 2002).

An empirical question emerges: what are the underlying neural mechanisms orchestrating social rank responses? An evolutionary perspective suggests that if social rank theory applies to modern human behavior, there may be evidence of relevant neural activation to facilitate these processes. Levitan et al. (2000) theorizes that a neural circuit linking limbic, prefrontal cortex, and striatal structures reflect the emotional, cognitive, and behavioral components of rank-related social interactions. Recent investigations examining the structure and function of brain areas associated with social rank offers preliminary support for this neural mechanism of a human social rank system.

NEUROANATOMY OF SOCIAL RANK

LIMBIC AND PREFRONTAL CORTEX

In an investigation of the neural mechanisms responsible for processing social superiority and inferiority cues in both stable and unstable hierarchies, Zink et al. (2008) used fMRI to measure brain activation in participants presented with an interactive game in which simulated players were manipulated to be either superior or inferior in game-related skills. The simulated players' statuses were held constant in a contrived "stable hierarchy" condition and allowed to vary periodically during a contrived "unstable hierarchy" condition. Results indicated that in a stable hierarchy, viewing a superior, relative to an inferior player activates bilateral occipital/parietal cortex, striatum, parahippocampal cortex, and dorsolateral prefrontal cortex. No unique activation associated with viewing an inferior player was identified. Specific to the unstable hierarchy condition, several additional brain areas were recruited when viewing the superior player. These include the bilateral thalamus, right amygdala, posterior cingulate, medial prefrontal cortex, premotor cortex, somatosensory cortex, and supplementary motor area. The findings of this study suggest that stability of the hierarchy differentially affects the neural processing of social status cues and supports the hypothesized role of corticolimbic and prefrontal cortex in social rank processing.

Gianaros et al. (2007) investigated the effects of perceived social status on neurological health using MRI data to uncover structural changes involved in the stress of lower social status. Results showed that self-reported low social status predicted reduced gray matter volume in the perigenual area of the anterior cingulate cortex, a paralimbic brain region implicated in adaptive emotional and physiological responding to psychosocial stressors. This pattern held even when accounting for other demographic (e.g., age, sex), psychological (e.g., depressive symptomatology), and conventional (e.g., SES) variables. Contrary to expectations, no associations were found between subjective SES and amygdala gray matter volume, which the authors interpret to be a result of methodological limitations (i.e., failure of voxel-based morphometry to uncover neuronal and cellular changes). Such reduced gray matter volume, particularly in the brain areas responsible for responding to psychosocial stressors, might be associated with mood and stress dysregulation (Sapolsky, 2004, 2005; Gesquiere et al., 2011).

STRIATUM

Based on previous work identifying the ventral striatum as a primary structure involved in processing social status information, Ly et al. (2011) investigated the relationship between one's own hierarchical status and brain activation during processing of status information. Specifically, the authors examined striatal activity using fMRI in individuals with varying levels of perceived rank, by presenting participants with pictures of individuals labeled as comparatively high and low status relative to the participant. Results showed that striatal activity was dependent on the participant's perceived status. High-status individuals exhibited a greater striatal response to images of higher status people, and low status participants exhibited a greater striatal response to images of lower-status people. The authors note that self-similarity and actual rank status are likely not solely responsible for explaining the observed effect of relative hierarchical status on striatal activation.

CONCLUSION

The neuroimaging evidence discussed here provides preliminary support for the role of limbic, prefrontal, and striatal pathways in human social rank processing. However, other brain structures may also be implicated, including visual associative processing areas (i.e., intraparietal sulci; Chiao et al., 2009).

In summary, these findings suggest that social hierarchy stability and perceived rank differentially impact the neural activation of relative status processing. It should also be noted that no empirical study to date has specifically examined the neural bases of involuntary defeat strategies (IDS) associated with social rank, and this gap in the literature offers fertile ground for future investigations. While the empirical understanding of the behavioral manifestations of social rank in various social strata (e.g., SES) is speculative, the link between a particular rank status and deleterious health outcomes is clear for subordinates (presumably low SES; Adler et al., 2000; Sapolsky, 2005) and highest ranking dominants (presumably high SES, Gesquiere et al., 2011) and future research might further shed light on these phenomena. What can be concluded from the present literature is that extant neuroimaging research support social rank as a brain-based system for recognizing and interpreting social status and rank-related information, and that future work may reveal the relationship of a social rank brain network and its role in social interactions.

REFERENCES

Adler, N., Epel, E., Castellazzo, G., and Ickovics, J. (2000). Relationship of subjective and objective social status with psychological and physiological functioning: preliminary data in healthy white women. *Health Psychol.* 19, 586–592.

Blanchard, R., McKittrick, C., and Blanchard, D. (2001). Animal models of social stress: effects on behavior and brain neurochemical systems. *Physiol. Behav.* 73, 261–271.

Chiao, J., Harada, T., Oby, E., Li, Z., Parrish, T., and Bridge, D. (2009). Neural representations of social status hierarchy in human inferior parietal cortex. *Neuropsychologia* 47, 354–363.

de Waal, F. (1989). *Peacemaking Among Primates*. New York: Penguin.

Fournier, M., Moscowitz, D., and Zuroff, D. (2002). Social rank strategies in hierarchical relationships. *J. Pers. Soc. Psychol.* 83, 425–433.

Gesquiere, L., Learn, N., Simao, C., Onyango, P., Alberts, S., and Altmann, J. (2011). Life at the top: 220 rank and stress in wild male baboons. *Science* 333, 357–360.

Gianaros, P., Horenstein, J., Cohen, S., Matthews, K., Brown, S., Flory, J., Critchley, H., Manuck, S., and Hariri, A. (2007). Perigenual anterior cingulate morphology covaries with perceived social standing. *Soc. Cogn. Affect. Neurosci.* 2, 161–173.

Gilbert, P. (2000). "Varieties of submissive behavior as forms of social defense: their evolution and role in depression," in *Subordination and Defeat: An Evolutionary Approach to Mood Disorders and Their Therapy*, eds P. Gilbert and L. Sloman (Mahwah, NJ: Lawrence Erlbaum Associates), 3–45.

Gilbert, P. (2005). Evolution and depression: issues and implications. *Psychol. Med.* 36, 287–297.

Irons, C., and Gilbert, P. (2004). Evolved mechanisms in adolescent anxiety and depression symptoms: the role of the attachment and social rank systems. *J. Adolesc.* 28, 325–341.

Kelly, A., Zuroff, D., Leybman, M., and Martin, A. (2011). Leaders' and followers' social rank styles interact to predict group performance. *Soc. Behav. Pers.* 39, 963–978.

Levitan, R., Hasey, G., and Sloman, L. (2000). "Major depression and the involuntary defeat strategy: biological correlates," in *Subordination and Defeat: An Evolutionary Approach to Mood Disorders and Their Therapy*, eds P. Gilbert and L. Sloman (Mahwah, NJ: Lawrence Erlbaum Associates), 95–120.

Ly, M., Haynes, M., Barter, J., Weinberger, D., and Zink, C. (2011). Subjective socioeconomic status predicts human ventral striatal responses to social status information. *Curr. Biol.* 21, 794–797.

Morrison, K., Swallows, C., and Cooper, M. (2011). Effects of dominance status on conditioned defeat and expression of 5-HT1A and 5-HT2A receptors. *Physiol. Behav.* 104, 283–290.

Sapolsky, R. (2004). Social status and health in humans and other animals. *Annu. Rev. Anthropol.* 33, 393–418.
Sapolsky, R. (2005). The influence of social hierarchy on primate health. *Science* 308, 648–652.
Tiedens, L., and Fragale, A. (2003). Power moves: complementarity in dominant and submissive nonverbal behavior. *J. Pers. Soc. Psychol.* 84, 558–568.
Zink, C., Tong, Y., Chen, Q., Bassett, D., Stein, J., and Meyer-Lindenberg, A. (2008). Know your place: neural processing of social hierarchy in humans. *Neuron* 58, 273–283.
Zuroff, D., Fournier, M., Patall, E., and Leybman, M. (2010). Steps toward an evolutionary personality psychology: individual differences in the social rank domain. *Can. Psychol.* 51, 58–66.

Received: 15 December 2011; accepted: 18 April 2012; published online: 08 May 2012.

Citation: Beasley M, Sabatinelli D and Obasi E (2012) Neuroimaging evidence for social rank theory. Front. Hum. Neurosci. ***6****:123. doi: 10.3389/fnhum.2012.00123*