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In this Issue

Using neuroimaging techniques to explore the relationship between social status and health

In the 1980s and early 1990s, a puzzle began to emerge among those concerned with health outcomes: why do individuals with higher social status live longer and have better health than those with lower social status? In one of the most compelling demonstrations of this socioeconomic status (SES)-health gradient, Marmot and colleagues (1984) showed that, among approximately 18 000 British civil servants, men in the lowest socioeconomic group had three times the mortality rate (over a 10-year period) than those in the highest group. Moreover, these effects were not confined to those at the very top and very bottom of the SES hierarchy; rather, each step up in occupational status conferred additional health benefits over those a step below, in a graded fashion. Follow-up research has suggested that this relationship does not seem to be solely due to differences in health behaviors (e.g. smoking) or access to health care among different socioeconomic groups (Adler *et al.*, 1994). In addition, subjective social status has been shown to be just as strong, if not a stronger, predictor of health outcomes than objective social status (Singh-Manoux *et al.*, 2005).

To unravel the puzzle of the SES-health gradient, researchers have taken different approaches, including examining the qualities of the social environment that differ by SES (e.g. presence of toxins, noise), the psychological tendencies of those at different SES levels (e.g. perceived control, optimism), the cognitive appraisal strategies that might differ by class (e.g. making more hostile attributions for ambiguous behaviors) or the biological responses to stressors, which may vary as a function of SES (e.g. long-term *vs* short-term exposure to stressors) (Adler and Snibbe, 2003). In this issue, Gianaros and colleagues (2007) add a novel perspective on exploring the relationship between SES and health by examining neural differences that might occur as a function of perceived social status.

In their paper, Gianaros and colleagues (2007) used structural neuroimaging techniques to investigate, whether certain neural regions vary in size as a function of "perceived social standing," a self-report measure that captures the subjective perception of being lower in social status. Participants were shown an image of a 10-rung ladder and were asked to mark the rung that corresponds to where they think, they 'stand' compared to others in the United States based on income, education and occupational status. The authors found that self-reported social status correlated with gray matter volume in only one region in the entire brain, the perigenual anterior cingulate cortex (pACC). Specifically, low perceived social status was associated with reduced gray matter volume in the pACC. These findings remained significant after controlling for demographic, psychological (e.g. depressive symptoms, recent life stress) and conventional SES measures (e.g. income, education).

These findings are important for several reasons. First, the region of the pACC that Gianaros and colleagues identify as varying in size based on perceived social standing is almost exactly the same region that Pezawas and colleagues (2005) identify as varying in size based on the 5-HTTLPR polymorphism. In that study, individuals with a copy of the short (s) allele of the 5HTTLPR gene, who are at heightened risk for anxiety and depression (Hariri and Holmes, 2006), also show significantly reduced gray matter volume in the pACC (and amygdala) compared to those with two copies of the long (l) allele. Thus, both low perceived social status and the s-allele of the 5HTTLPR gene are associated with smaller pACC volumes. The fact that the same neural region correlates with both perceived social status and a serotonin-related gene fits nicely with previous work showing relationships between serotonin levels and social status, such that, in mammals, those with lower serotonergic functioning have lower social status whereas those with higher serotonergic functioning tend to have higher social status (Edwards and Kravitz, 1997).

Second, these findings provide additional insight into the mechanisms that may link social status and health. Identifying a neural region whose size correlates with perceived social standing allows researchers to narrow the realm of possible ways in which social standing links to health and instead, probe the specific computations of this region that may contribute to the SES-health link. Along these lines, recent research has demonstrated a role for the pACC in emotion regulation and cognitive control. For example, increased pACC activity is associated with reductions in amygdala activation (an affect-related neural structure) while viewing emotional faces (Das *et al.*, 2005;

Etkin *et al.*, 2006), and patients with damage to the pACC fail to recruit cognitive control during a cognitive conflict task (Di Pellegrino *et al.*, 2007). These findings fit with the suggestion that this region (pACC; Brodmann area 32) is a 'cingulofrontal transition' area, which has features of both cingulate cortex and adjacent frontal areas (Vogt *et al.*, 1995). Indeed, in the rhesus monkey, BA 32 is considered to be a part of the prefrontal cortex rather than a part of the cingulate cortex (Vogt *et al.*, 1987), and thus may be more strongly linked with prefrontal regulatory processes.

Based on this, one intriguing possibility is that individuals with higher perceived social status may show better emotion and/or cognitive regulatory processes, possibly resulting in lower levels of stress-related physiological responses and better health outcomes as a result. Additional research would be needed to determine the direction of this relationship as many questions arise from such an association. For instance, do poor regulatory skills lead to lower social standing (e.g. through drops in social standing based on poor impulse control)? Does lower social standing lead to less effective regulatory skills, perhaps because threats, among those with lower social standing are more legitimate and thus need to be attended to rather than regulated?

Last, these findings represent a novel way of probing the SES-health gradient. In the past two decades, the SES-health gradient has been explored primarily by investigating psychological (e.g. cognitive appraisals, perceived control), behavioral (e.g. smoking, drug use), physiological (e.g. physiological stress reactivity) and societal mechanisms (e.g. differential access to health care). With the widespread use of neuroimaging techniques, an additional method of investigation can now be added to this arsenal. The study by Gianaros and colleagues highlights a new way of investigating links between social standing and health and may provide additional insight into this relationship. Indeed, the cognitive neuroscience of health psychology is a wide-open area of investigation that would no doubt benefit from neural investigations such as the present one. This study represents one of the first forays into this emerging area.

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