Neuroendocrine and Cardiovascular Responses to Shifting Status

Daan Scheepers*

Leiden University / Utrecht University, the Netherlands

Erik L. Knight

Pennsylvania State University

*Please address correspondence to Daan Scheepers, Leiden University - Institute of Psychology, Social and Organizational Psychology section. P.O. Box 9555, 2300 RB Leiden, the Netherlands. Phone: +31(0)71-527 3642. Fax: +31(0)71-527 3619. E-mail: Scheepersdt@fsw.leidenuniv.nl

Abstract

We review recent work on human neuroendocrine and cardiovascular responses to stable and unstable status. We describe experiments examining inter-personal and inter-group contexts, involving both experimentally-created as well as naturalistic (gender, SES) status differences. Across studies the pattern of results is clear: Stable status differences are stressful for those low in status, which is evident from increased cortisol and a cardiovascular response-pattern indicative of threat (low cardiac output, high vascular resistance); however, when status differences are unstable the same effects are found among those high in status, while those low in status show challenge (low vascular resistance, high cardiac output). Potential status-loss also leads to increased testosterone. We discuss implications and suggestions for further research.

1. Introduction

Social rank is one of the key factors coloring social relationships and driving social behaviors [1]. It is therefore not surprising that social status also has a profound impact on biological processes, some of them mediating these behaviors [2-4]. Here we provide an overview of recent work on human neuroendocrine (cortisol, testosterone) and cardiovascular (CV) responses to status differences, with a particular focus on the role of status-stability [5].

1.1 Neuroendocrine and Cardiovascular Responses to Status

Cortisol has been the focus of extensive work on links between social status and stress. Cortisol is a steroid hormone released in response to stressors that helps coordinate systemic stress responses and modulate metabolism to fuel responses [6,7]. Although heightened cortisol is necessary for healthy responding to stress, over-production of cortisol over longer periods is a key factor linking chronic stress to negative health outcomes [8].

A second key hormone relevant to status is testosterone, a sex hormone that is theorized to motivate concern for social status and rises in response to threats to social status positions in order to direct status-maintaining behaviors [9]. Testosterone is also functionally linked to cortisol activity: Both neuroendocrine systems tend to inhibit each other at rest [10], but under conditions of status threat, testosterone and cortisol responses may be coupled [11-13], with some evidence indicating testosterone causes increased cortisol responses to stress (discussed further below) [14].

Research examining the influence of status on CV-responses has mainly applied the biopsychosocial model of challenge and threat (BPS-CT) [15-19]. This model describes specific CV-indices of challenge and threat states during motivated performance (e.g., negotiating, taking a test), when the heart starts working faster (increased Heart Rate, HR) and with more force (decreased Pre-Ejection Period, PEP). Under challenge this is coupled with decreased vascular resistance (Total Peripheral Resistance, TPR) leading to more oxygenated

blood pumped-out by the heart (i.e., increased Cardiac Output, CO). Threat, by contrast, is marked by *increased* TPR, leading to stable CO. The challenge CV-profile is a benign response that typically positively relates to performance; the threat CV-profile is a maladaptive response that is, over time, predictive of negative health outcomes.

1.2 The Importance of Status Stability

Work on status and cortisol generally suggests that high-ranking positions are associated with reduced levels of basal cortisol [20], and that objective societal status (i.e., socioeconomic status) may inhibit acute cortisol responses to stress [21,22; see also Fournier, this issue]. Similar results have been found for cardiovascular indices of stress, in that high status buffers against negative stress and sometimes even facilitates "positive stress" in the form of challenge [23-27; see also Rodríguez-Bailón, Sánchez-Rodríguez, García-Sánchez, Petkanopoulou, & Willis, this issue, for the psychosocial effects of status].

However, correlational work in nonhuman primates provided initial evidence that hierarchy instability may attenuate or reverse high status' association with reduced cortisol. Higher-ranking male olive baboons had lower cortisol levels than lower-ranking males when the hierarchy was stable but, during times of instability, higher-status males had higher cortisol levels compared to lower-ranking males [28]. Nonhuman primate research has also provided initial evidence that high-ranking positions correlate with increased testosterone concentrations compared to lower-ranking positions in unstable hierarchies; in stable hierarchies, social rank was not associated with differences in testosterone responses to stress [29,30]. Below we review recent work showing similar effects in humans.

2. Hormones and Hierarchy Instability

2.1. Endocrine Responses to Hierarchy Instability

In the first experimental test of human endocrine responses to hierarchy instability [11], men and women (n=118) were randomly assigned to be a manager (high status) or

builder (low status) in a stable hierarchy (in which their performance during a social-evaluative stressor [31] would not affect their status) or an unstable hierarchy (in which their position could change depending on their performance during the stressor). In a stable hierarchy, high-status positions caused reduced cortisol responses to the stressor compared to low-status positions; status-based differences in testosterone responses were not evident in a stable hierarchy. However, in an unstable hierarchy, high-status positions caused increased cortisol and testosterone responses to the stressor compared to low-status positions.

These experimental results are reflected in other research that did not explicitly manipulate hierarchical rank and stability. For example, men who lose social influence – a component of social status – demonstrate increases in cortisol compared to men who gain social influence [32]. In contrast to the experimental evidence, which did not find gender differences, the effect of loss of influence was only found among men in same-gender groups, and not in women or men working with women.

Other work has shown that testosterone levels increase in response to losing status in hierarchies that are implicitly unstable. Competitions are one way to establish hierarchies, with winning or losing representing gains or losses in rank (respectively). However, if a competition outcome is unclear or unexpected, the hierarchy may be considered unstable. Within this context, women who had narrowly lost a laboratory competition or who had lost after a period of uncertainty demonstrated greater increases in testosterone compared to women who won in these situations [33]. A later study found that this pattern of testosterone responses in close competitions was weaker in men and may depend on individual differences in basal cortisol levels [34]. This evidence is suggestive that testosterone responds to hierarchy instability but more work is necessary to clarify these potential gender differences.

2.2. Testosterone Heightens Responses to Hierarchy Instability

Although testosterone is typically thought to reduce stress responses [10], socially-threatening stimuli have been hypothesized to activate socio-emotional neural systems (e.g., the amygdala, hippocampus, and pre-frontal areas) that direct the co-activation of cortisol and testosterone responses to status threat [12, 13, 35]. Testosterone specifically heightens an array of responses to social threat, such as increasing neural activity and physiology in response to threatening social stimuli [36, 37]. This pattern suggests a positive feedback loop develops between testosterone and cortisol during social threat, in contrast to the mutually inhibitory relationships observed at rest. In animal models, coupling of testosterone and cortisol responses to status threat among dominant males has been linked to increased sympathetic nervous system activity, which directly reduces testicular sensitivity to cortisol's inhibitory effects (reviewed in [38]). This effect of the sympathetic nervous system on testosterone and cortisol responses to threat among dominant individuals, to our knowledge, has not been examined in humans.

Moreover, testosterone causes increased cortisol and negative affect responses to a social-evaluative stressor, especially in men high in trait dominance [14], a personality factor associated with increased awareness of, and reactivity to, threats to one's status [39]. Behaviorally, testosterone responses to explicit hierarchy instability have also been negatively associated with performance during the stressor and high basal testosterone has been linked to poor cognitive performance under conditions of status threat [40]. In each of these studies, testosterone may intensify responses to social threat–and thus to hierarchy instability–because of testosterone's role motivating concern for status.

3. Hierarchy Instability and Cardiovascular Reactivity

Using a similar interpersonal paradigm as in the study by Knight and Mehta [**Error! Reference source not found.**], a study by Scheepers, Röell, and Ellemers [41] found that when status was stable, low-status persons showed CV signs of threat, while high-status

persons showed challenge. However, when status was unstable, high-status individuals were threatened–things could seemingly only go "downhill"–while low status individuals were challenged, as status improvement seemed possible (see also [42]).

Another study found that members of a high status group (White Americans) were threatened when they interacted with members of a low status group (Latino Americans) who had a high socioeconomic status, while they were challenged when the interaction partner had a low socioeconomic status [43]. This effect can be interpreted as the high SES person representing a cue for a changing status quo, which may be threatening for members of high-status groups.

Research using minimal group paradigms has more systematically investigated the influence of the stability of inter-group status-differences on challenge and threat responses in members of low and high status groups. In this research, participants were assigned to a relatively meaningless social category (e.g., "holistic perceivers" or "detailed perceivers"). As a group-status manipulation, participants then received (bogus) feedback about their group's performance on a task. Stability was manipulated by providing information about the predictive value of performance on this first task for performance on subsequent tasks; in the stable condition, performance on the first task was said to be a good predictor for performance on the second task; in the unstable condition performance on the first task was said to be a weak predictor of performance on the second task. Analyses of CV reactivity during the second task revealed the members of the low status group were threatened in the stable condition. In the unstable condition, by contrast, members of the low status groups were challenged and members of the high status group were threatened [44,45]. Similar results have been found when the security of the hierarchy was not based on status-stability cues, but on (more psychological) *legitimacy* appraisals: Legitimate group-status differences are threatening for members of low status groups while illegitimate group-status differences are

threatening for members of high status groups [46].

Cardiovascular evidence for "stability threat" among members of high-status groups has also been demonstrated in the context of changing gender-roles. One study showed that when discussing *traditional* gender roles women had higher blood pressure than men, but when discussing *changing* gender roles men had higher blood pressure than women [47]. These effects were found irrespective of the gender-composition of the debating dyad although they were particularly strong when a man discussed the issues with a woman. A related effect was found in a study where white men engaged in a (simulated) job interview procedure [31]. When the company was presented as one that values diversity, the men showed a CV threat pattern, which was not the case when the company was not explicitly presented as one that valued diversity [48].

4. Conclusions

The research described above shows that those low in status show neuroendocrine and CV stress-responses when status differences are stable, but that those high in status show similar responses when status differences are unstable. Under the latter circumstances those low in status show CV-signs of challenge, as for them there is scope to improve their position. These effects have been shown for both interpersonal and inter-group status differences. Below we discuss implications and make suggestions for further research.

4.1. Implications

Research on social hierarchies and health tends to focus on the chronic, negative impact of low status in relatively stable hierarchies (i.e., socioeconomic status) on stress and health [22]. However, in experimental settings, high unstable status seems to elicit the strongest neuroendocrine responses to acute threat [**Error! Reference source not found.**]. However, this instability will likely resolve at some point (though no research to our knowledge has specifically examined the half-life of hierarchy instability), whereas the stable

low-status position, by definition, may represent a longer-term threat akin to a chronic stressor [49]. This pattern implies that longitudinal research on social hierarchies could include indices of status instability to more clearly understand status-based differences in stress and health outcomes.

The current research on status stability stress has implications for understanding how people respond to social change. Current societies all over the world face substantial changes due to economic, political, demographic (migration), and cultural factors (e.g., changing gender identities). Members of high status groups, like "white men" can respond quite defensively to such changes, which has been related to voting behaviors and attitudes towards policies like affirmative action [44,50] research described here suggests that physiological stress may underlie such defensive behaviors, and that addressing this threat–more than just to suggest to "stop whining"–may help alleviate problematic defensive behaviors, such as supporting divisive political ideals and candidates.

4.2. Future Directions

Since the initial experimental test in humans, hierarchy instability among high-ranking managers has been found to be associated with increased self-reported stress levels in one study, particularly among individuals with high levels of trait dominance [52]. Other work indicates that status mobility–i.e., changes in social rank as indexed by socioeconomic status–is associated with cortisol measures that index chronic stress [53]. However, no studies have examined the effect of perceived hierarchy instability on endocrine or CV responses in real world settings like workplace or community settings. Examining status, perceived hierarchy instability, and physiological responses across multiple time-points may be especially insightful for understanding pathways linking intra-individual changes in status and instability to downstream biological and behavioral responses.

Moreover, more work is necessary that integrates among physiological and endocrine responses to stress. Cortisol and testosterone have been examined as predictors or covariates of autonomic responses to stress [37,53], but no studies have examined coordination among these responses in humans in status-threatening situations specifically. Future work could also examine wider arrays of physiological responses to stress that may be better indicators of the combined impact of social status and instability on health, such as inflammatory immune responses.

In conclusion, hierarchy instability potently modulates the links between social status and physiological responses to stress. Continued examination of hierarchy instability may provide insights for understanding the physiology, health, and behavior of those who perceive their status to be in flux.

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