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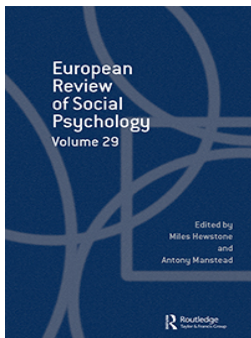
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## Stress and the stability of social systems: A review of neurophysiological research

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## Stress and the stability of social systems: A review of neurophysiological research

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### ABSTRACT

Current societies are characterised by unprecedented change in demographic, economic and political terms. These changes may be rather stressful, especially for those who have most to lose, that is members of (formerly) high-status groups. In this contribution, we review research on the influence of hierarchy stability on physiological stress, making a distinction between the cardiovascular correlates of negative stress (“threat”) and positive stress (“challenge”). Results from six studies reveal that when hierarchies are stable those low in rank show threat, while when hierarchies are unstable, those high in rank show threat and those low in rank show challenge. These effects occur independently of whether rank is based on power or status, or on interpersonal or inter-group comparisons. Results are discussed in terms of theories on power and identity, and implications for (interventions for) inter-group conflict and health.

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### Social rank and stress

Globalisation and technological developments in current human societies have resulted in unprecedented change in demographic, economic and political characteristics of social systems. These changes raise uncertainty for many, as they no longer know their position in the social order.

Policy makers and researchers addressing this problem have tended to focus on the plight of those who have few resources, are low in power, or seem otherwise deprived. Obviously, a lack of control and esteem makes people depend on the good intentions of others, and is generally considered to be stressful (Mendelson, Thurston, & Kubzansky, 2008; Scheepers, De Wit, Ellemers, & Sassenberg, 2012). Indeed, members of stigmatised groups, such as ethnic minority-group members or people low in social class, are

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more at risk of suffering from a range of negative health conditions (Adler et al., 1994). Importantly, the negative relation between social rank and health outcomes holds even after controlling for lifestyle differences between social classes. Instead, the *stress* of low status has been identified as a key explanatory factor in this relation, which causes long-term negative outcomes (Clark, Anderson, Clark, & Williams, 1999; Sapolsky, 2005).

Compared to those low in rank, those high in rank seem more fortunate, because they are more in control of a variety of material and social resources. This should make it possible for them to live a relatively stress-free and healthy life. Although there is an overall negative relation between social rank and stress, there are some important exceptions to this rule. This was clearly documented among primates, for instance in Robert Sapolsky's ground-breaking work on neuroendocrine stress responses in baboons. Sapolsky (1983) discovered that a baboon's rank within a group was only a weak predictor of the baboon's basal cortisol, which is one of the main stress hormones. Rather, it was rank in interaction with the *stability* of the group that best predicted the level of cortisol. When the group hierarchy was stable, highest cortisol was found in low-ranked baboons – as might have been expected. However, the relation between social rank and stress changed dramatically when the group became unstable. As positions of individuals within the hierarchy started to shift, the highly ranked baboons – rather than those low in rank – were the ones in whom the highest cortisol levels were observed. Similar observations have been made in other groups of primates (macaques, chimpanzees), for a range of neuroendocrine markers of stress, and for a variety of sources of hierarchy stability (e.g., animals leaving or entering the group, or the formation of a new group; Kaplan, Manuck, Clarkson, Lusso, & Taub, 1982; Sapolsky, 2004; Sapolsky, 2005)

These intriguing observations raise the question of whether similar physiological stress responses to shifts in social hierarchies might be observed among humans. Indeed, if the prospect of change induces stress among those who currently are well-off, this could help to explain why those who used to be in dominant positions, such as males, ethnic majority groups or people from the middle and higher social classes, appear to be particularly concerned about current changes in society, and how they respond to this, for example by supporting populist parties (Jetten, Mols, Healey, & Spears, 2017; Major, Blodorn, & Major Blascovich, 2018).

In this chapter, we provide an overview of neurophysiological research on “stability stress”, the stress that may emerge from shifting social ranks, in humans. At first sight it may only seem a small step to generalise Sapolsky's (1983, 2005) observations in primate groups to human social hierarchies. Indeed, the fact that these physiological stress processes operate in primates suggests a very basic and evolutionary adaptive process.

However, compared to primate groups, human social hierarchies tend to be more complex and dispersed, raising the question of whether such generalisations can be easily made (see also Ellemers, 2018). Indeed, human social hierarchies are based not only on interpersonal processes within groups, but also on relations *between* groups. Relatedly, human social hierarchies only partly reflect interpersonal differences or interdependencies that emerge in small interactive groups, but are often based on broad social categories (ethnicity, gender). Furthermore, human hierarchies are not only based on power, that is the asymmetric control over valued resources, but also on status, that is the extent to which an individual or group is respected or admired by others (Magee & Galinsky, 2008). Finally, insecurities in human social hierarchies stem not only from structural factors such as position instability, but also from more symbolic psychological concerns like the perceived legitimacy of status differences, or the perceived appropriateness of important values (Ellemers, 1993; Lammers, Galinsky, Gordijn, & Otten, 2008; Tajfel & Turner, 1979).

In this review, we address research that examines the influence of these more unique features of human social hierarchies (inter-group processes, status, identity, legitimacy) on the development of stability stress. Below we first provide a theoretical background and briefly summarise non-physiological research that provides initial – though indirect – evidence for the stability stress hypothesis. After this, we detail the main methodological background of our research programme: the biopsychosocial model of challenge and threat (Blascovich & Mendes, 2010). We then review research providing neurophysiological evidence for stability stress at three levels of human social hierarchies: the interpersonal level, the inter-group level, and the societal level. In the final section we indicate what can be concluded from this work and identify venues for future research.

## Background

### *Theoretical foundations*

The theoretical basis for explaining stability stress in human hierarchies can be found in two main areas of work: theory and research on *power*, and theory and research on *identity*. The prediction that an unstable hierarchy is threatening for those high in rank follows directly from Mulder's (1977) classic work on power distance. One of the central premises of this theory is that people are motivated to gain, and thereafter preserve, as much power as possible. As a consequence, the prospect of losing power should be rather threatening. Relatedly, more recent work on social motivation has identified the need for control over one's environment as one of the "core social motives" (Fiske, 2009).

However, as mentioned above, when we extend work on primates to human groups, research suggests we are not only driven by a need for control over tangible resources or outcomes. In social psychology there is a longstanding tradition pointing to the tendency for humans to rely on subjective comparisons rather than objective standards in the evaluation of important achievements and outcomes (Festinger, 1954). Relative deprivation theory further specifies that people not only compare individual outcomes but also outcomes of social groups, and monitor how the *relative* positions of these individuals or groups change over time (for an overview, see Walker & Smith, 2001). This explains why even those who compare favourably to others may feel dissatisfied with and concerned about their current standing, because they see the situation of others improving more rapidly, or realise that the extent of their advantage is shrinking.

Relatedly, humans also seek more symbolic forms of social status and aspire to achieve a subjective sense of positive social identity (Ellemers, 1993). According to social identity theory (Tajfel & Turner, 1979), people derive part of their identity from the groups to which they belong, i.e., their “social identity”. The motivational basis of the theory is that people generally strive for positive and meaningful social identities. This need is served by membership in groups that differ from relevant out-groups in a positive way. By making inter-group comparisons, and sometimes expressing in-group bias, a sense of such positive inter-group distinctiveness is created, leading to feelings of meaning, self-worth, and certainty – even if objective outcomes remain unchanged (see Ellemers & Haslam, 2011, for an overview).

As a result, people are generally attracted to, and identify with, groups with high social status (Ellemers, 1993). However, when status differences between groups become unstable, such differences in identification between members of low and high status groups disappear. This has been attributed primarily to an increased willingness of members of low status groups to identify as group members as they hope to collectively improve the group’s status (Boen & Vanbeselaere, 2000; Doosje, Spears, & Ellemers, 2002; Ellemers, Van Knippenberg, & Wilke, 1990).

A related, more recent perspective also emphasises the importance of social status for one’s identity. Destin, Rheinschmidt-Same, and Richeson (2017) focus on the subjective meaning that people ascribe to their social-economic status (SES) to define who they are. Destin et al. refer to this as their “status based identity”, and additionally introduce the concept of “status based identity uncertainty” to describe the threats and challenges that come with changes in individual SES. For example, upward mobility of low SES individuals improves the opportunities they have and can motivate them for status-relevant tasks. In a similar vein, individuals with high SES, who would seem to have nothing to worry about, might feel threatened

when they realise that the efforts and achievements of low SES individuals can threaten their positive-distinctive position. Thus, this analysis of status-based identity is in line with our reasoning that shifting positions within a status hierarchy can create both threats and challenges to the identities of those low and high in rank.

### *Behavioural and attitudinal effects of hierarchy stability*

Although the notion that hierarchy stability can be a source of positive and negative stress has not been directly tested at the psychophysiological level, prior research on the effects of hierarchy stability on behaviour and attitudes is certainly relevant to the focal studies in our review. Two strands of relevant research stand out. First, research on group dynamics and organisational psychology has examined the consequences of change within groups for group functioning. Second, research on societal change has examined how shifting status relations within a society affect prejudice and political voting behaviour. We briefly summarise the main conclusions from these two lines of work below.

#### *Group and organisational contexts*

Some work suggests that status instability in groups may carry certain motivational benefits. When primed with the possibility of status loss, people attach more value to status and are more willing to pay or work for status than when primed with the possibility of status gain (Pettit & Lount, 2010; Pettit, Yong, & Spataro, 2010). This type of reasoning also seems to guide management practices that favour flexible work contracts and possibilities for demotion to keep workers “on their toes”.

However, there may be a downside to such practices because a large body of research has documented the different ways in which position uncertainty and instability of team roles can undermine group functioning. For example, unethical work behaviour, such as cheating, is more likely to emerge when this can prevent a possible status loss than when it can result in a possible status gain (Pettit, Doyle, Lount, & To, 2016). Further, research on opinion-based groups has shown that when one’s position is no longer supported by others, and people experience a shift from majority to minority status, this undermines group attractiveness and identification (Prislin, Limbert, & Bauer, 2000). In general, this research suggests that insecurities about the continuation of one’s membership in a team, organisation, or social group cause individuals to become preoccupied with establishing their own worth and securing their position instead of working towards the achievement of common goals. It has been established, for instance, that position insecurity can cause individuals to ignore or neglect the valuable contributions of other group members, resulting in a suboptimal joint performance (Ellemers & Jetten, 2013; Rink, Kane, Ellemers, & Van der Vegt, 2013).

The negative consequences of hierarchical instability have also been shown for those most responsible for motivating and inspiring group members, and guiding innovation and performance, namely the leaders and power-holders within groups. For instance, Feenstra, Jordan, Walter, Yan, and Stoker (2017) found that managers who were high in social dominance reported more stress when their position was unstable than when their position was stable. Moreover, power-holders with a strong power motivation become more risk-avoidant when their decisions could result in loss of power or group-status (Maner, Gailliot, Butz, & Peruche, 2007; Scheepers, Ellemers, & Sassenberg, 2013; cf. Jordan, Sivanathan, & Galinsky, 2011). Such a preoccupation with maintaining the status quo is likely to undermine the group's ability to innovate and adapt, which ultimately threatens the performance or even the continuity of the group. A final way in which power instability undermines group functioning is that it leads to more negative views by power-holders of their subordinates (Georgesens & Harris, 2006). Concerns about the maintenance of power differences tend to elicit mutual distrust, leading to a dysfunctional spiral of deterrence measures by the power holder and non-compliance by subordinates (Mooijman, Van Dijk, Van Dijk, & Ellemers, 2015, 2017). Thus, research examining behavioural and attitudinal outcomes generally reveals that position instability in working groups undermines team climate and lowers joint performance.

### *Inter-group and societal level*

At the inter-group level, others have also noted that stability stress due to unstable social hierarchies plays a key role in current societal unrest, protest, and voting behaviour (Jetten et al., 2017; Major et al., 2018). An early demonstration of how such feelings may come about was obtained among Dutch shop-owners in Amsterdam. They overestimated the actual proportion of businesses owned by immigrants, and viewed the increase in the number of these shops as a threat to the identity of their neighbourhood (Ellemers & Bos, 1998). Importantly, this threat was not so much rooted in economic insecurities experienced by the native-Dutch shop-owners, as in the changing community identity.

A related finding can be found in the work by Jetten and Wohl (2012) on “collective angst”, that is the fear that one day one's group may cease to exist. This fear can be seen as one of the more extreme and dramatic forms of stability-stress. In the context of national identification, collective angst was shown to predict opposition to immigration. This effect was particularly strong among those high in national identification (Jetten & Wohl, 2012).

The stress of social change has also been identified as a chief determinant of negative responses to affirmative action policies in organisations. Likewise, it has been found to predict resistance to perceived racial progress

in society (Dover, Major, & Kaiser, 2016; Wilkins & Kaiser, 2014). For example in one study (Wilkins, Hirsch, Kaiser, & Inkles, 2017) white Americans experienced racial progress as a threat to their self-worth. This prompted them to perceive anti-white bias, which helped them restore feelings of legitimacy about their majority status (Wilkins & Kaiser, 2014). Racial progress has also been found to motivate whites to see biracial (i.e., black-white) people as black, as a way to protect the exclusive status of the white majority group (Cooley, Brown-Iannuzzi, Brown, & Polikoff, 2017).

Thus, research using attitudinal and behavioural outcome variables reveals feelings of subjective threat and the often defensive ways in which people respond to changing status hierarchies. In the work to be reviewed in more detail below, we extend these insights by examining responses to status stability using physiological measures of stress. Before reviewing these studies, we first outline our methodological approach.

### **Methodological approach: The biopsychosocial model of challenge and threat**

An important limitation of initial attempts to capture stress responses, using either self-reports or physiological measures, is that stress was considered in terms of generalised arousal. However, as already alluded to above, it is important to differentiate negative stress that is associated with defensive responses and disengagement (threat) from the positive stress that is needed to mobilise resources to address the situation (challenge). At a physiological level, this distinction can be made by applying the biopsychosocial model of challenge and threat (BPS-CT; Blascovich, 2008; Blascovich & Mendes, 2010; Seery, 2013). This model provides cardiovascular (CV) indices of threat (“negative stress”) and challenge (“positive stress”)<sup>1</sup> in the context of motivated performance (e.g., providing a speech, solving a math task, negotiating, parallel parking). According to the BPS-CT, threat emerges when the demands of the motivated performance situation (e.g., task difficulty, uncertainty, danger) outweigh the person’s resources to deal with these demands (e.g., skills, support). Challenge emerges when resources approach or exceed resources.

Importantly, the BPS-CT also describes the physiological response profiles underlying challenge and threat. In research applying the BPS-CT, four cardiovascular measures are typically used: Heart rate (HR; i.e., the *pace* with which the heart pumps), ventricular contractility (VC; the *force* with

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<sup>1</sup>The distinction between “negative stress” (threat) and “positive stress” (challenge) is reminiscent of Selye’s (1956) distinction between “distress” and “eustress”. However, unlike Selye’s work, the BPS-CT assumes *different physiological response-profiles* underlying positive (challenge) and negative (threat) states.

which the heart pumps), total peripheral resistance (TPR; a measure of vascular resistance), and cardiac output (CO, the amount of blood that is pumped-out by the heart in a single minute). Task-engagement, which is an indispensable characteristic of motivated performance, is indicated by increased HR and VC: that is the heart starts pumping faster and with more force. The distinction between challenge and threat can in turn be made on the basis of TPR and CO.

Threat is indicated by activation of the sympathetic-adrenal-medullary (SAM) axis in combination with activation of the hypothalamic-pituitary-adrenal (HPA) axis, of which cortisol – the main stress hormone – is the end-product. At the cardiovascular level, this leads to high vascular resistance (high TPR), low cardiac output, and typically also high blood pressure. The challenge-pattern is indicated by mere activation of the SAM-axis, leading, through the secretion of adrenaline, to *decreased* vascular resistance (TPR), and increased cardiac output. Thus, under threat TPR is relatively high, and CO relatively low, while under challenge TPR is relatively low and CO relatively high. Both for presentational reasons and in order to optimise the reliability of cardiovascular measurement, CO and TPR are often combined in a single “threat-challenge index” (TCI; Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004).

Although research on the BPS-CT has traditionally applied CV measures, there is a growing interest in neuro-endocrine markers of challenge and threat (Crum, Akinola, Martin, & Fath, 2017; Jamieson, Hangen, Lee, & Yeager, 2018; Yeager, Lee, & Jamieson, 2016). As indicated above, threat typically leads to increased secretion of the catabolic hormone cortisol. Challenge, by contrast, leads to increased secretion of the anabolic counterpart of cortisol, namely dehydroepiandrosterone-sulphate (DHEAS). There is now solid empirical evidence that a state of threat during motivated performance is marked by increased cortisol, while a state of challenge is marked by increased DHEAS (Crum et al., 2017; Yeager et al., 2016).

In the long run, the repeated activation of the CV threat response-profile leads to negative health outcomes (Blascovich, 2008b; Derks, Scheepers, Van Laar, & Ellemers, 2018). Under threat, the vasculature and the heart work in opposition, as the heart starts pumping faster and more strongly while at the same time the blood vessels constrict. Over time, this wears out the arteries, which can eventually lead to serious health problems like strokes and hypertension.

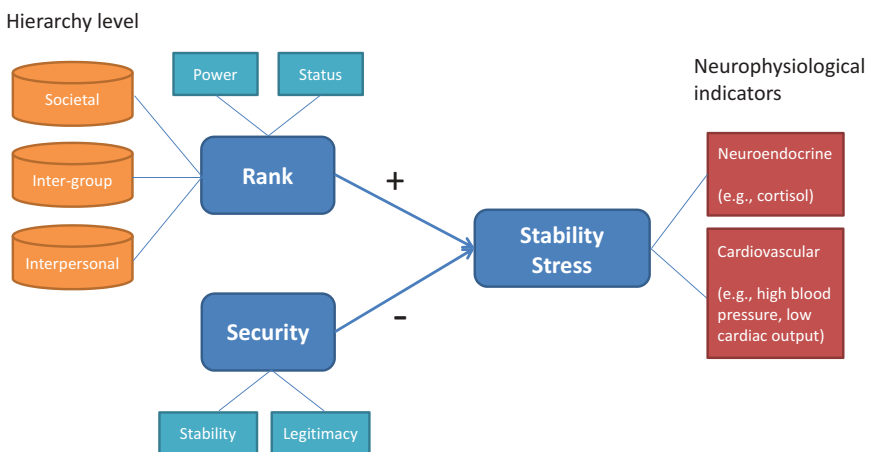
By contrast, the challenge profile is a more adaptive CV response profile, reflecting the efficient mobilisation and transportation of energy during motivated performance. Hence, the challenge state is typically associated with better performance than the threat state (Behnke & Kaczmarek, 2018; Hase, O’Brien, Moore, & Freeman, *in press*). Under particular circumstances, the enhanced blood flow when challenged can also be beneficial

for health-outcomes, for example when it facilitates the delivery of medication and the removal of waste (Blascovich, 2013).

The use of cardiovascular measures to index motivational states of challenge and threat has several methodological advantages. For example, these measures can be taken online, continuously and (relatively) unobtrusively. Moreover, these physiological activation patterns are part of the autonomic nervous system, meaning that they emerge without deliberate control, and are not necessarily visible to others. Nevertheless, they can influence self-reported attitudes and behaviours, even when people do not realise this is the case. Because of these properties, CV indicators of positive versus negative stress can offer valuable additional information about the way in which people experience and cope with status instability. This is why we set out to develop a programme of research in which these physiological measures constituted our primary dependent variable. This research will be described in the sections to follow. A conceptual overview is offered in Figure 1.

In the next section, we first discuss research on stability stress in interpersonal contexts. The research described there is relatively comparable to Sapolsky's research in primate groups. However, we then describe research on the stress of changing status relations *between* groups and social categories, and also discuss the role of social identity and status legitimacy. In terms of physiological stress, we differentiate between maladaptive physiological stress profiles ("threat") and more benign physiological stress profiles that are indicative of "challenge".

The main hypothesis addressed is that unstable social hierarchies evoke threat in those higher in rank, and challenge in those lower in rank. We predict



**Figure 1.** Schematic overview of determinants and physiological indicators of stability stress.

that unstable hierarchies will be challenging for people low in rank because for them there is “hope and scope” to improve their position while at the same time they do not have much to lose. This is different for those high in rank who do indeed have something to lose, which will increase uncertainty and thereby raise threat, even though they may eventually defend their position successfully.

### Interpersonal level

To what extent can primate research on neuroendocrine responses to (changing) social hierarchies be extrapolated to human populations? This question formed the basis of a recent experiment by Knight and Mehta (2017). Using a paradigm developed by Galinsky (Galinsky, Gruenfeld, & Magee, 2003; see also Jordan et al., 2011),<sup>2</sup> participants were placed in the role of “manager” (high power) or “builder” (low power) during a dyadic puzzle task. The manager would provide the builder with task-instructions about how to work on the task. Afterwards, the manager could evaluate the builder and divided a possible bonus between the two of them. After these role instructions, participants engaged in a Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), which is a standard public speech paradigm designed to elicit strong neuroendocrine (e.g., cortisol) stress responses. One of the phases of the test requires participants to “pitch” themselves as if they were applying for their ideal job. While delivering their speech, the participants are observed by two nonresponsive evaluators. To manipulate power stability, half of the participants learned that their role during the puzzle task could still change, based on their performance during the TSST; the other half was told that their position was fixed for the total session. At several moments during the experiment, cortisol and testosterone were measured using saliva samples: A baseline measure was taken before the TSST, and three post-measures were taken afterwards. Additionally, feelings of control were measured using a self-report measure and performance during the TSST was rated by two independent judges, who rated the participants’ dominance, warmth, and competence while delivering the speech.

Results indicated that under stable conditions, high power buffered against the strong cortisol response that the TSST typically produces. However, under unstable conditions this reversed: When power holders could potentially lose their dominant position, this resulted in strong cortisol and testosterone reactivity. In fact, in the unstable high power condition cortisol and testosterone reactivity was stronger than in the other three conditions (stable high, stable low, unstable low). Participants in the unstable high power condition also reported lower subjective feelings of control and performed less well

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<sup>2</sup>Knight and Mehta (2017) refer to their manipulation as a manipulation of “social status”. However, because the used paradigm they was initially developed to manipulate power (Galinsky et al., 2003; Jordan et al., 2011) we discuss it here as a study on power.

during the TSST than did participants in the other conditions. Finally, further analyses showed that all three responses were related: When high power was unstable, lower performance was mediated by increased testosterone, and decreased feelings of control.

These results suggest that Sapolsky's (1983; 2005) observations regarding the influence of hierarchy stability on cortisol responses in primates can indeed be extrapolated to similar responses in human hierarchies: Although having high power buffers against stress when one's position is secure, high power evokes strong neuroendocrine responses to conditions implying one's position is subject to change. The experiment conducted by Knight and Mehta (2017) also extends earlier (animal) studies by showing some of the psychological and behavioural consequences of neuroendocrine signs of stability stress. More specifically, the study shows that stability stress undermines feelings of control and impairs performance.

The results on cortisol are generally in line with what would be expected on the basis of the biopsychosocial model of challenge and threat (BPS-CT). The increased cortisol in the unstable high power condition fits the "threat" motivational state as detailed in the BPS-CT. The lower task-performance that was observed under threat is also in keeping with what is typically found in the context of the BPS-CT. The result for testosterone may be more difficult to directly relate to the BPS-CT, however, because testosterone is hypothesised to be higher after challenge than after threat (e.g., Jamieson et al., 2018). Nevertheless, this result fits with research showing increased testosterone levels in situations where one's status is at stake (e.g., Zilioli, Mehta, & Watson, 2014).

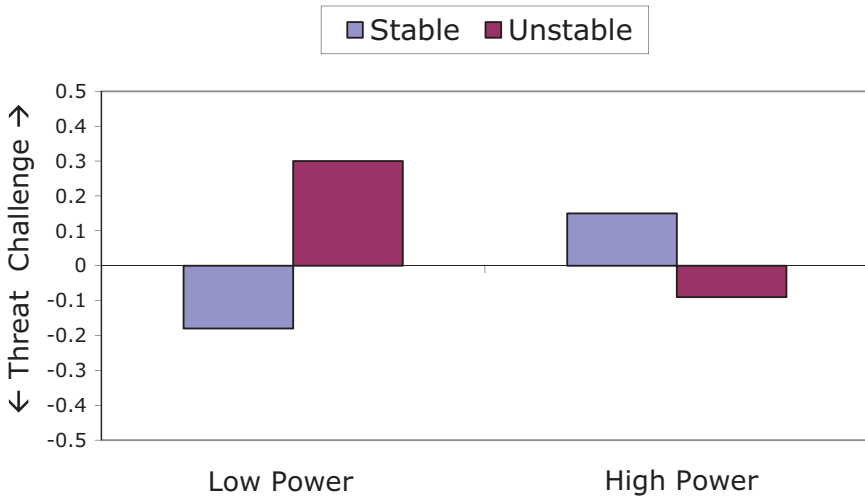
The analysis of behavioural performance during the TSST yielded yet another interesting effect in Knight and Mehta's (2017) study. Analysis of verbal performance during the speech revealed that participants in the low power condition behaved more dominantly when their position was unstable than when their position was stable. This is suggestive of a positive "challenge" response among low power individuals who anticipated a possible power gain. In our research, we sought to obtain cardiovascular evidence for such a challenge response among low power individuals who believed that their position could be improved.

The dyadic paradigm used in our study (Scheepers, Röell, & Ellemers, 2015) resembled the manipulations used by Knight and Mehta (2017), as described above. The main task consisted of first designing and then partly furnishing a house by employing the "SweetHome3D"® computer application. The two aspects of the task, first designing and then furnishing the house, were presented as two separate phases. Participants would ostensibly work on this task in dyads and communicate with each other via the computer system. One participant would be the "chief designer" (high power) and the other participant the "assistant" (low power). The chief

designer could design the house according to his or her wishes, and would then instruct the assistant to implement the designer's directives via the SweetHome3D® application. Moreover, the chief designer could select the dimensions on which the result would be evaluated and would also evaluate the assistant's performance. Participants were then randomly assigned to the low or high power role, ostensibly according to their scores on a "leadership" questionnaire. Moreover, participants in the unstable condition learned that on the basis of their performance during the first phase of the task (designing the house) their role during the second phase (furnishing the house) could possibly change. In the stable condition participants learned that their role would be fixed for the total duration of the session. Participants then were instructed to give a brief speech in front of a webcam. The objective of this speech would be for the chief designer to provide the assistant with directions, or for the assistant to offer his or her vision on the task. The assistant's speech would not be viewed by the chief designer but was just said to be recorded for "control purposes". The speech task constituted the motivated performance situation during which we monitored cardiovascular responses to differentiate challenge and threat motivational states.

In this experiment, as well as in the other threat-challenge experiments described below, we continuously measured ventricular contractility (VC), heart rate (HR), cardiac output (CO), and total peripheral resistance (TPR) using a combination of electrocardiography, impedance-cardiography, and continuous blood pressure assessments. At the start of the session, we asked participants to sit quietly and relax, allowing us to obtain individual baseline measurements of these indicators. We compared these baseline measures to responses during the speech task, to assess cardiovascular reactivity. We created individual reactivity scores by subtracting baseline cardiovascular scores from scores obtained during the speech task. We also created a combined threat-challenge index (TCI), as a summary indicator of the degree to which participant responses indicated relatively more threat (negative scores) or challenge (positive scores).

An ANOVA examining the impact of power and stability on the TCI score revealed a significant interaction (see [Figure 2](#)). As can be seen in the figure, participants in the low power condition displayed a response pattern in the direction of threat (high vascular resistance, low cardiac output) when power relations were stable, and a response pattern in the direction of challenge (low vascular resistance, high cardiac output) when power relations were unstable. A reverse pattern was found in the high power condition: Participants in the high power condition displayed a response pattern in the direction of challenge when power relations were stable, and a response pattern in the direction of threat when power differences were unstable.



**Figure 2.** Threat – Challenge Index (TCI) as a function of power and power stability (Scheepers et al., 2015). The TCI is based on mean standardised reactivity scores (i.e., task-baseline scores) of cardiac output and total peripheral resistance (multiplied with  $-1$ ). Lower scores indicate a stronger tendency towards threat and higher scores indicate a stronger tendency towards challenge.

The maladaptive cardiovascular stress pattern we found among those in the unstable high power condition is in line with findings from Sapolsky’s work with primates (1983, 2005) and Knight and Mehta’s (2017) neuroendocrine findings in humans. However, our results also go beyond these previous findings because they show a tendency towards positive stress (“challenge”) among those in the unstable low power condition. Thus, the results of this study demonstrate the added value of considering stability of power relations, in addition to power differences, because unstable power relations seem to reverse the standard and more straightforward pattern often reported in the literature, namely of discomfort among those with low power and comfort among those with high power.

Our experiment also revealed two other interesting findings regarding task engagement and optimism among those in the stable low power condition. First, the cardiovascular measures we included in our work indicate not only threat versus challenge but also task engagement. As noted above, task engagement is indicated by increased heart rate (HR) and ventricular contractility (VC), implying that the heart starts working faster and with more force. In the standard threat-challenge analysis the first step is to test for (sufficient) engagement across conditions, followed by a test of between-condition differences in challenge and threat. Thus, typically we do not examine between-condition differences in task engagement, because the presence of task engagement is needed to examine both challenge and threat.

However, when we explored between-condition differences in ventricular contractility in our study, we found a significant interaction between power position and power stability (Scheepers et al., 2015). This revealed less contractility in the stable low power condition compared to the unstable low power condition and the stable high power condition. This result is in line with the result of a self-report measure of optimism about the upcoming task. Analysis of this measure revealed that participants in the stable low power condition were less optimistic than participants in the other three conditions. Together, these results for engagement and optimism suggest that participants in the low power condition seemed to give up and stopped caring about the task, when they knew that their low power position was fixed. This disengagement response may be interpreted as a form of “learned-helplessness” which emerges when people do not see how they can improve a situation that is unfavourable for them (Seligman, 1972).

In summary, the available research on power differences in dyadic human contexts does indeed show the benefits of stable high power: Under stable conditions power buffers against negative stress, and during motivated performance it even facilitates *positive* stress in the form of challenge. Those low in status do not show these benefits of a secure system; on the contrary, they experience more negative stress or even disengage from the task when they know their position cannot change. When power is unstable, however, this pattern reverses: Those high in power show negative stress (threat) and those in low power show positive stress (challenge). When the powerless know they can improve their position, they become more optimistic, more dominant and, as a result, perform better.

In the next section, we move up one level of human social hierarchies, and examine whether similar patterns can be found in the context of inter-group relations. Moreover, we will examine stability stress as a function of status differences, rather than power differences.

### Inter-group level

Power is rooted in the ability to act, for example the ability of an alpha male baboon to make mating choices, or the ability of a manager to allocate bonuses to subordinates. These acts often involve real, tangible, resources. Compared to power, status, that is the respect and prestige that one enjoys, is more a reflective, psychological state. This reflection links to one’s self-esteem, making status closely tied to identity. Thus, status is a more uniquely human state, compared to power. Although we have no reason to believe that stability stress works differently depending on whether one’s power or status is at stake, the distinction between power and status is important for the generalisation of the stability-stress effect beyond interpersonal power hierarchies.

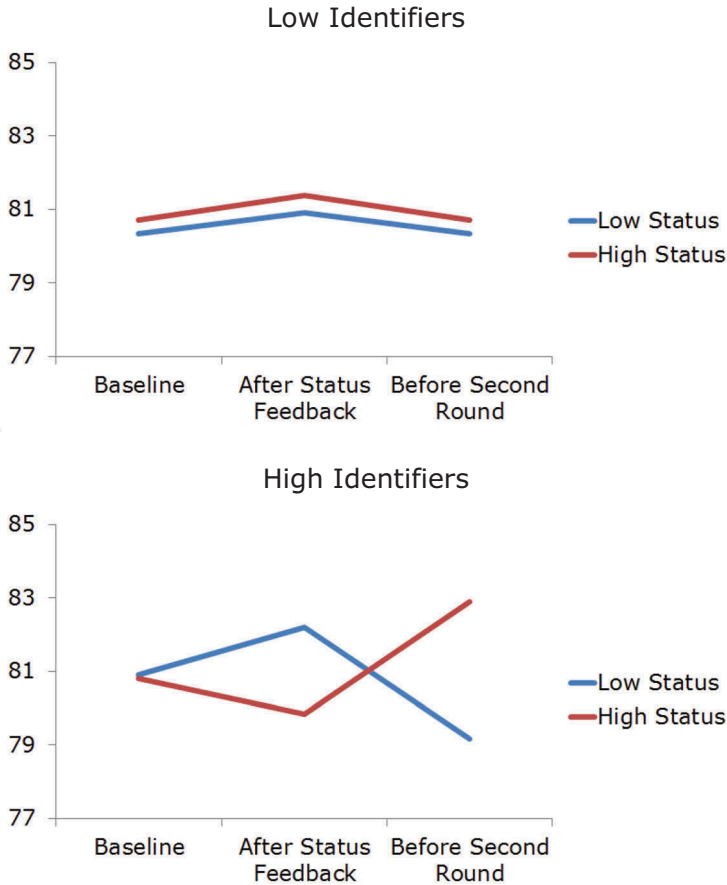
We obtained initial evidence for stability stress in inter-group status hierarchies in a relatively simple minimal group experiment (Scheepers & Ellemers, 2005). The experiment was presented as a study on “association style and reaction time”. Individual participants were separated from each other in cubicles, where they performed an association-style test, which ostensibly was used to categorise them as a member of the “holistic group” or “detailed group”. After this, participants completed a reaction time task on which they received group-level performance feedback. This served as our group-status manipulation. Then, unexpectedly, a second round of this status-defining task was announced. At three points in time we assessed the participant’s blood pressure (mean arterial pressure; MAP)<sup>3</sup>: at the beginning of the session (baseline measurement), after receiving the initial group-performance feedback, and after announcing the second round of the task, suggesting that group positions might still change. We also measured the participant’s subjective identification with their group.

A repeated-measures analysis of variance involving group status as a between-participants factor and blood pressure assessment as a within-participants factor revealed a significant interaction. After receiving the group-status feedback, participants in the low status group had higher blood pressure than participants in the high status group. We interpreted this response as resulting from the status quo, which should be more threatening for members of low status groups than for members of high status groups. However, just a few moments later, after announcing the second round of the task, this effect reversed. Now members of the high status group showed the highest blood pressure. This response seemed to reflect the anticipation of a possible *change* in the status quo during the second round of the task.

In order to test the role of social identification in producing these effects, we distinguished between participants who identified relatively weakly and participants who identified relatively strongly with their group, on the basis of their median identification score (Doosje et al., 2002). A follow-up repeated-measures ANOVA, including identification as an additional between-participants factor resulted in a significant three-way interaction (see Figure 3). As can be seen in the figure, the interaction between group status and blood pressure assessment only emerged for those participants who identified relatively strongly with the group. When identification was high, reflecting on the status quo was more threatening for members of the low status group, whereas anticipating a possible *change* in the status quo was more threatening for individuals who identified strongly with their high status group.

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<sup>3</sup>This study was the first psychophysiological study we ran in our lab, before the time we had a more sophisticated set-up to measure more advanced cardiovascular measures (VC, CO, TPR). However, according to the biopsychosocial model of challenge and threat, MAP is more indicative of threat than it is of challenge, as it is one of the determinants of TPR.



**Figure 3.** Mean Arterial Pressure (MAP, in mm Hg) as a function of group identification, group status and time of measurement (Scheepers & Ellemers, 2005).

This study, which focused on an inter-group context, conceptually replicates the studies on interpersonal hierarchies described in the previous section. However, it also has some important additional features. First, the minimal group context forms a less socially-meaningful context compared to the paradigms used in the interpersonal power studies; yet we showed the same physiological stress responses to (changes in) the status quo. This provides further evidence for the basic and generic nature of these effects. Second, in this study, the hierarchy was based on (symbolic) status which basically yielded the same effects as were found for (concrete) power, suggesting that it is not only the gain vs. loss of control over outcomes that matters but also the possible gain versus loss of less tangible resources, such as social standing or prestige. Finally, this study demonstrated the involvement of social identification in the threat posed by

lacking, or potentially losing, positive group-distinctiveness. This latter point is in line with social identity theory's notion that group outcomes mainly matter for individuals who define themselves in relation to the group (Branscombe, Ellemers, Spears, & Doosje, 1999; Ellemers, Spears, & Doosje, 2002; Tajfel & Turner, 1979). Here too, then, it is the emotional and symbolic value of group membership that is decisive, rather than the degree of formal outcome interdependence.

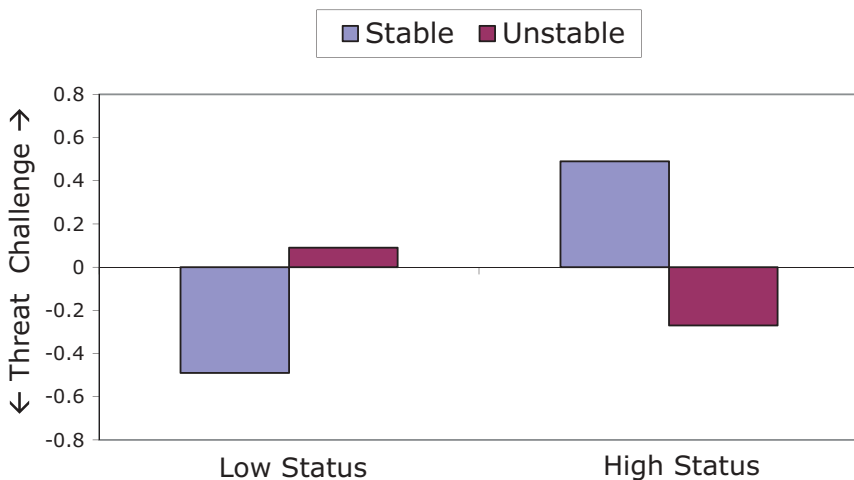
An obvious limitation of this study, compared to the interpersonal power studies, is that we did not randomly allocate participants to stable or unstable conditions. That is, we simply assumed that participants responded to the status quo after their scores were announced, and would infer a sense of instability when they discovered there would be a second round of the status-defining task. A second limitation is that we measured blood pressure in a relatively unsophisticated way, which does not unambiguously allow for an interpretation in terms of threat. Although the threat cardiovascular pattern is typically accompanied by high blood pressure (TPR typically correlates highly with MAP), blood pressure reactivity in itself has also been interpreted in terms of other psychological constructs, like mental effort (Brehm & Self, 1989). These two limitations were addressed in a follow-up experiment.

Participants in the experiment reported by Scheepers (2009) were categorised in minimal groups, after which they completed three tasks: a number-counting task, a letter-counting task, and a word-searching task. Group status was manipulated between-participants by providing group-level performance feedback on the first task. Status stability was then manipulated within-participants by providing explicit information about the predictive value of performance on the first task for performance on subsequent tasks. First, a stable situation was created by mentioning that performance on the first task was a good predictor of performance on the second task (i.e., the number-counting task). Thus, the second task served as a motivated performance situation for testing the relation between group status and challenge and threat during a stable situation. During the third task we created an unstable situation by mentioning that performance on the first two tasks was only a weak predictor of performance on this final task. The third task served as a motivated performance situation for testing the relation between group status and challenge and threat during an unstable situation. Throughout the experimental session, we took cardiovascular measures (HR, VC, CO, TPR) that allowed us to differentiate challenge from threat, and we again created reactivity scores by subtracting baseline scores from scores during the stable and unstable situation, respectively.

Repeated-measures ANOVAs again indicated strong interactions between status and stability for cardiovascular indicators of challenge and threat (CO, TPR, TCI). Results showed that when status differences were

stable, participants in the low status condition were relatively threatened (low CO, high TPR) compared to participants in the high status condition. However, when status differences were unstable, the threat evident in members of the low status group was turned into challenge (high CO, low TPR), while the members of the high status group now showed signs of threat. The pattern of results as summarised in a combined threat-challenge index is displayed in [Figure 4](#). As can be seen, the general pattern is in line with our reasoning: Members of the low status group initially showed signs of being relatively threatened while the situation was stable, but this threat pattern turned into a challenge one when status improvement became possible. By contrast, members of the high status group started out showing signs of being relatively challenged when their position seemed secure, but became threatened when they were informed they could potentially lose their dominant position.

A factor that bolsters the interpretation of the results in this experiment is that we used a straightforward and very explicit manipulation of status stability. In practice, however, such direct cues are often absent. At the same time, the motivation to challenge the status quo can be triggered by other, more psychological factors, such as its appraised legitimacy. For example ethnic minority-group members or feminists may decide to contest the overrepresentation of white males in high power roles in their organisation when they perceive these positions have been allocated unfairly, for example as a result of biased hiring procedures.

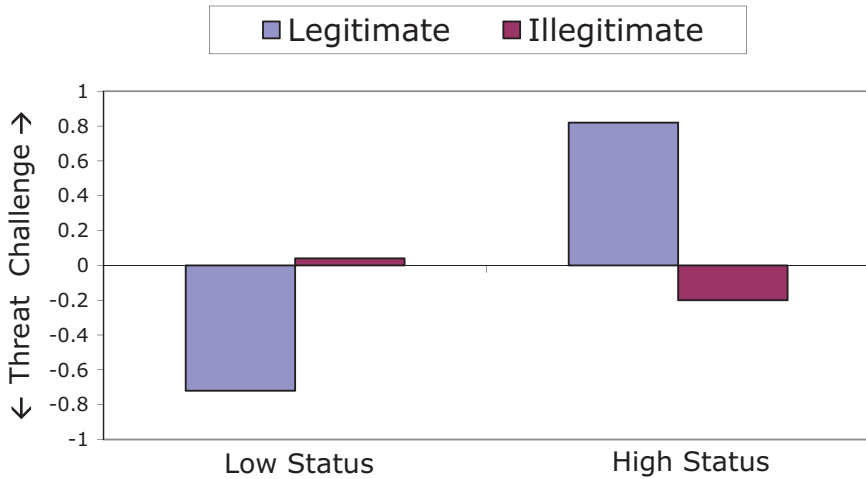


**Figure 4.** Threat – Challenge Index (TCI) as a function of status and status stability (Scheepers, 2009). The TCI is based on mean standardised reactivity scores (i.e., task-baseline scores) of cardiac output and total peripheral resistance (multiplied with  $-1$ ). Lower scores indicate a stronger tendency towards threat and higher scores indicate a stronger tendency towards challenge.

According to social identity theory, legitimacy appraisals can have the same motivational consequences as stability appraisals, because both make “cognitive alternatives” to the current status quo salient (Ellemers, 1993; Tajfel & Turner, 1979). For example research on the legitimacy of power differences shows that the relation between power and approach tendencies is moderated by power legitimacy (Lammers et al., 2008). In this latter study, the well-documented power-approach relationship was only found when power-differences were legitimate: The powerful showed approach (e.g., took risks) whereas the powerless showed avoidance behaviours (e.g., avoided risks). When power-differences were illegitimate, however, this relationship reversed; now the powerless showed approach and the powerful showed avoidance. The authors interpreted these effects in terms of the motivation to provoke (in the low power case) or prevent (in the high power case) social change.

In a recent experiment (Scheepers, 2017), the neurophysiological effects of (il)legitimate inter-group status differences were further tested using a minimal group procedure. Participants were categorised in groups and then performed a “mouse-click task” (Aarts, Gollwitzer, & Hassin, 2004) in which they had to click on a number of objects on their screen, in a prescribed order. Inter-group status differences were manipulated by providing group-level performance feedback on a first round of the task. Then, in anticipation of a second round of the task, participants were given the possibility to communicate with other members of their group, ostensibly to exchange tips and strategies to optimise performance during the second round. During this communication session, participants received a (manipulated) message from a fellow in-group member who claimed that performance had been assessed in a fair or in an unfair way. A manipulation check confirmed that this information influenced the participant’s own legitimacy appraisal in the intended way. The second round of the task served as the motivated performance situation we focused on for differentiating challenge and threat responses on the basis of cardiovascular reactivity. In addition to cardiovascular measures, we measured task-performance, in the form of the average speed with which the participant completed the trials of the mouse-click task.

There were significant interactions among status and legitimacy on CO, TPR, and the combined TCI. When status differences were legitimate, participants in the high status condition were relatively challenged, whereas participants in the low status condition were relatively threatened. When status differences were illegitimate, however, these differences disappeared (see Figure 5). Members of the high status group were also significantly more threatened when status differences were claimed to be unfair than when they were claimed to be fair, while for members of the low status group the opposite tendency was apparent.



**Figure 5.** Threat – Challenge Index (TCI) as a function of group status and status legitimacy (Scheepers, 2017). The TCI is based on mean standardised reactivity scores (i.e., task-baseline scores) of cardiac output and total peripheral resistance (multiplied with  $-1$ ). Lower scores indicate a stronger tendency towards threat and higher scores indicate a stronger tendency towards challenge.

Moreover, we found a significant interaction between status and legitimacy on performance. The pattern of means for performance followed the pattern for relative challenge. That is, when status differences were legitimate, participants in the high status condition performed better than participants in the low status condition; however, when status differences were illegitimate, there were no longer differences between the low and high status conditions. The latter effect was because members of the low status group performed better and members of the high status group performed worse when status was illegitimate than when status differences were legitimate. Mediation analysis confirmed that the effects on performance were mediated by a cardiovascular pattern indicative of relative challenge.

Thus, in line with previous theory and research (Ellemers, 1993; Lammers et al., 2008; Tajfel & Turner, 1979), the current results further illustrate that status (il)legitimacy appraisals have the same motivational implications as cues of status (in)stability: High status leads to challenge when status differences are legitimate but to threat and undermined performance when status differences are illegitimate. By contrast, low status leads to threat and relatively low performance when status differences are claimed to be fair, but to challenge and improved performance when status differences are claimed to be unfair.

In summary, the three studies on inter-group status differences reviewed in this section consistently demonstrate that secure differences are threatening for

those low in rank, whereas insecure status differences are threatening for those high in rank. Thus, the same response pattern that we saw in interpersonal hierarchies also emerged when hierarchies were defined at the group level. These studies also move beyond power as a primary and concrete basis for differences in social rank by showing similar effects in a more symbolic hierarchy based on status and identity.

In the next section, we move to a further level, and extend our discussion to motivational implications of social change at the societal level.

## Societal level

So far, we have considered hierarchies and position change pertaining to specific individuals or clearly interdependent groups. Can similar physiological responses also be evoked regarding broader social categories – which do not necessarily affect individual outcomes? To examine this, we focus on the changing roles of men and women in society, and the physiological stress responses that these changes may bring about among individual males and females. As we have shown above in the context of minimal groups, we predict that reflecting on traditional roles is particularly threatening for women because this reminds them of their history of low group status, whereas anticipating a change in gender roles should be particularly threatening for men.

Several previous studies have shown that losing personal control and influence elicits strong neurophysiological stress responses, especially among men. For instance, Knight and colleagues (2017) exposed men to a TSST that is, as noted earlier, a highly stressful situation that heavily taxes one's sense of control. Importantly, however, cortisol reactivity was especially high among men who had been administered testosterone (a hormone related to dominance behaviours) and especially among men high in trait dominance (who tend to be most susceptible to social-status threats, see Case & Maner, 2014; Mead & Maner, 2012). In a similar vein, a study by Taylor (2014) showed high cortisol reactivity among men (not women) who experienced a loss of influence within a group of men, but not when this happened in a group of women. This latter effect was explained by arguing that when men are “amongst themselves” they experience particularly high pressure to comply to the masculine stereotype of being powerful.

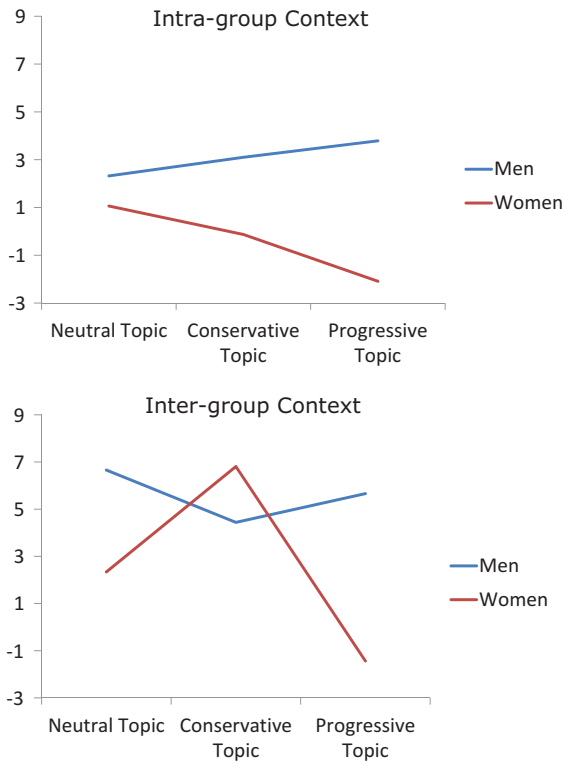
More direct evidence of the threat of social change among men comes from a study by Dover et al. (2016). Using a job interview paradigm, male participants played the role of applicant for a job in a company that did or did not explicitly stress the value of diversity. In the diversity condition, males had higher cardiovascular responses indicative of threat, performed less well, and had higher expectations of becoming the victim of discrimination within the company than did males in a neutral control condition.

This is in line with our reasoning that being reminded that the dominant position of one's group in society is being called into question may be threatening.

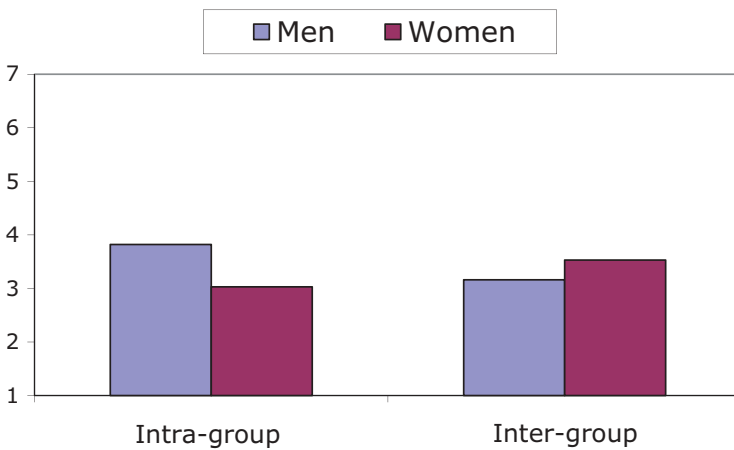
In a study conducted along these lines (Scheepers, Ellemers, & Sintemaartensdijk, 2009), we directly manipulated the salience of traditional versus changing gender roles, and examined its consequence for physiological stress among men and women. Participants discussed several topics in a dyadic setting. In the intra-group condition, participants debated with someone of the same sex; in the inter-group condition, participants debated with someone of the opposite sex. All participants debated the same three topics, in the same order. The first round of the debate was a "warming-up" round, to get used to the debating setting, and was on a gender-neutral topic (drugs legalisation). The second debate was on a conservative topic that aimed to make traditional gender roles salient ("After a child is born the mother [rather than the father] should stay at home to care for it"). The third topic was a "progressive topic", aimed at making changing gender roles salient ("More subsidies for day care centres should become available so that women can continue working after they have a child"). Directly after each debate we took blood pressure assessments. At the start of the session, we also took baseline blood pressure readings. For the analyses, we again created reactivity scores by subtracting baseline readings from the reading after each debate. After the third debate participants completed several self-report measures, including measures of modern sexism (Swim, Aikin, Hall, & Hunter, 1995) and attitudes towards affirmative action.

A repeated-measures ANOVA on blood pressure revealed an interaction between gender and topic: Women had higher blood pressure reactivity than men when discussing the conservative topic, whereas men had higher blood pressure than women when discussing the progressive topic (see [Figure 6](#)). This is in line with our expectation that the salience of traditional gender roles is particularly threatening for women, whereas the salience of changing gender roles is particularly threatening for men. Importantly, however, this interaction was only present in the inter-group condition – that is when discussing with someone of the opposite sex, but not in the intra-group condition – when discussing with someone of the same sex.

The analysis of the self-report measures complemented this interesting pattern (see [Figure 7](#)). Men in the intra-group condition ("men among themselves") scored higher on sexism and were less in favour of affirmative action than were women in the intra-group condition. However, in the inter-group condition this effect disappeared: In the presence of a woman, the men presented themselves as relatively low in sexism and more in favour of affirmative action. Thus, although men involuntarily displayed physiological signs of threat in the context of changing gender relations, at the same time they explicitly presented themselves as relatively low in sexism.



**Figure 6.** Systolic blood pressure (SBP, in mm Hg) reactivity (debate–baseline) as a function of condition, sex and debating topic (Scheepers, Ellemers, & Sintemaarstendijk, 2009).



**Figure 7.** Modern sexism as a function of condition and sex. Modern sexism scores can range between 1 and 7.

The combination of these implicit (threat) and explicit (sexism) responses seems even more remarkable because threat is often seen as a determinant of bias (e.g., Maass, Cadinu, Guarnieri, & Grasselli, 2003). The seemingly diverging findings of higher implicit threat and low explicit bias among men in the inter-group condition is likely explained by the strategic adaptation of the self-reports. It may be that the men in the inter-group condition became aware of the threat and how these feelings diverged from the social norm or their personal ideals. In turn, they compensated for this by reporting relatively low sexism. Another explanation follows the classic “reaction formation” defensive response, in which threat is regulated by claiming the opposite (“Me threatened? Not at all!”). In any case, the current results illustrate how implicit and explicit measures can diverge, thereby illustrating the added value of including both types of methodology in research on inter-group threat.

## General discussion

Together, the results reviewed in this paper attest to the value of extending Sapolsky’s observations about primates regarding stability and stress to inform our understanding of human social hierarchies. The overview of our programme of research also clarifies that this reasoning increases our understanding of (1) inter-group relations and societal changes; (2) status and identity as source of threat; and (3) legitimacy appraisals as a source of status insecurity. Moreover, we obtained converging evidence from groups with different status positions in society (i.e., men and women), as well as minimal groups (i.e., groups that have no social meaning outside the lab context). This attests to the basic nature of the processes involved: There is a generic tendency for those at the bottom of the hierarchy to be threatened when the hierarchy is stable. However, there is also a generic tendency for those at the top of the hierarchy to be threatened when the hierarchy is unstable. A summary of all evidence for the stability-stress effect is displayed in [Table 1](#).

## Theoretical implications

The research reviewed here is in line with previous theory and research on how humans and animal primates strive to obtain and protect their high rank in a social hierarchy (Mulder, 1977; Sapolsky, 2005). However, it also moves beyond prior work by showing the importance of status and identity in the stress that arises from the (in)stability of social hierarchies. We reviewed research examining different types of hierarchies (interpersonal, inter-group, and societal). Moreover, in our review, we moved from work on concrete power-differences and interpersonal outcome interdependence to more symbolic status-differences and from concrete stability cues to



**Table 1.** Evidence for the stability-stress hypothesis among different types of species, hierarchies, and ranks.

Species	Hierarchy based on	Rank based on	Main findings	Source
Animal studies	Intra-group context	Power	<ul style="list-style-type: none"> <li>Diverse sources of instability within different type of primate groups leads to neuroendocrine (e.g., cortisol) response among those high in rank</li> </ul>	<ul style="list-style-type: none"> <li>Sapolsky (2004; Sapolsky, 2005)</li> </ul>
Human	Interpersonal context	Power	<ul style="list-style-type: none"> <li>Unstable dyadic task situations are stressful for the high power person (cardiovascular threat/cortisol response)</li> </ul>	<ul style="list-style-type: none"> <li>Knight and Mehta (2017)</li> </ul>
Human	Inter-group context	Status	<ul style="list-style-type: none"> <li>Unstable or illegitimate group status is threatening for high-status group members (cardiovascular threat response)</li> </ul>	<ul style="list-style-type: none"> <li>Scheepers and Ellemers (2005)</li> </ul>
Human	Social categories	Status/Power	<ul style="list-style-type: none"> <li>Stronger for high group-identifiers</li> <li>Cues about changing gender and ethnic status relations within society are threatening for white men (cardiovascular threat response)</li> </ul>	<ul style="list-style-type: none"> <li>Scheepers (2009; 2017)</li> <li>Dover et al. (2016)</li> <li>Scheepers et al. (2009)</li> </ul>

more subjective legitimacy claims. The effects were basically the same throughout: It is threatening to be low in rank when the hierarchy is secure, and threatening to be high in rank when the hierarchy is insecure. We also found direct evidence for the implication of social identification in these effects (Scheepers & Ellemers, 2005).

The findings regarding status and identity are important because of their key role in explaining current societal unrest due to the rapid social and demographic changes that characterise modern societies, and to which many members of (formerly) high-status groups tend to respond quite defensively. These responses may take the form of voting for populist parties or negative attitudes towards migration and changing gender roles and identities. Research has indicated that self-interest plays a less important role in these responses than more cultural and identity-based factors (Hainmueller & Hopkins, 2014; Jones, Cox, & Lienesch, 2017). Moreover, cues about societal change find their way very quickly through social media, influencing the attitudes and responses of people who do not appear to be personally affected in a direct way, and who learn about these changes alone and anonymously. All in all, our work clearly shows that status and identity are key to understanding stress in current rapidly changing societies.

The results we found for challenge and threat as a function of status stability are generally in line with social identity theory (SIT; Tajfel & Turner, 1979) but also enrich work in the social identity tradition in three important ways. First, the application of the biopsychosocial model offers a new motivational perspective to study social identity theory's hypotheses about how people respond to status differences. Although motivation has always been at the heart of social identity theory, the more specific elaboration of this motivational component has mainly focused on outcome variables like increased self-esteem and reduced uncertainty (Abrams & Hogg, 1988). The current approach is complementary to this by focusing not so much on ultimate goals but more on the specific motivational processes that guide the behaviours that may lead to the fulfilment of these goals. In this sense, the current approach fits with the more recently developed self-regulation approach to social identity and inter-group relations (Jonas, Sassenberg, & Scheepers, 2010).

A second way in which the biopsychosocial model of challenge and threat (BPS-CT) approach enriches SIT is by moving beyond the concept of (social identity) threat, and also addressing its motivational counterpart, challenge. Threat has become a core motivational construct in contemporary elaborations of SIT (Branscombe et al., 1999), although threat is seldom directly assessed in empirical work. Threat among members of disadvantaged groups has been hypothesised to result in a diversity of behavioural tendencies, ranging from collective action to giving up on status-relevant tasks. Our current work suggests that not all of these responses are necessarily motivated

by threat. Instead, sometimes people show a more positive challenge response to low status, for example when they appraise the status differential as illegitimate, which may in turn facilitate performance (Scheepers, 2017). Thus, the application of the challenge concept to social identity phenomena may help to explain better why members of disadvantaged groups do not always respond passively or in dysfunctional ways to their position, but sometimes rise up and fight negative stereotypical expectations (Derks et al., 2011; Kray, Thompson, & Galinsky, 2001). Thus, the threat/challenge distinction allows us to show that it is not always threatening to be a member of a low status group and that this can in fact be a positive challenge when status improvement is a viable option.

Finally, the physiological measures that are central in the BPS-CT have several additional methodological advantages. For example, these measures can be obtained in an unobtrusive way, while the processes they tap into are hard to control. As such, they are ideal to capture a concept like threat that is difficult to measure using self-reports because people may not be aware of a threat or, when they are, may respond defensively. Moreover, cardiovascular measures of challenge and threat can be measured in an online and continuous way, making it possible to examine how motivational processes change in real time as a result of changing circumstances. The finding that cues of status instability can turn the threat of low status into challenge provides one example of this (Scheepers, 2009).

Despite these advantages, we are not proposing that one should focus solely on physiological measures when studying social behaviour. Rather, we emphasise that it is the *combination* of physiological and other types of methodologies, like self-reports or behavioural observations, that provides the most complete picture about a certain social phenomenon or process. Take, as an example, the combination of relatively high blood pressure and low sexism that we observed in males when they had just debated a measure intended to increase female labour force participation, and thus potentially changing gender roles, with women. Although threat has often been proposed as a main determinant of inter-group bias, in this case we saw divergent and unrelated responses. These seemingly inconsistent responses are theoretically interesting because they point to the ways in which people strategically adapt their overt responses to an in-group or out-group audience, but also show how people feel while doing this. If we had relied on self-report measures alone, and had inferred threat from reported sexism, we would have (erroneously) concluded that the males in the inter-group condition were not at all threatened. On the other hand, had we only assessed physiological measures, we would have missed the strategic communication of attitudes as a function of the social context. Thus, the combination of different types of measure provides the most complete picture of the motivational and attitudinal responses to changing inter-group relations.

### *Practical implications*

The current research shows that social change has important motivational consequences, that physiological responses help us to understand these consequences, and why interventions targeting them do not always work. That is, the research reviewed here offers added insight into the involuntary stress evoked when current differences in social status are called into question. This also elucidates why such responses cannot be dismissed as simply reflecting strategic messages reflecting reluctance to change. Instead, we see the very real and physical stress people involuntarily suffer when their positions in society become less secure.

For example, our findings reveal the potential impact of the arguments made by contemporary protest groups when they claim that the current societal disparities between, for example, ethnic and gender groups are the result of an unfair system. The threat aroused by such claims helps us to understand why those in power feel vulnerable, even if their current situation seems quite strong. This also explains the pushback against feminist groups within organisations where it is claimed that the overrepresentation of white males in power positions reflects biased selection procedures. Likewise, ethnic minority groups may receive little understanding for their claim that their disadvantaged position in society at least partly reflects past oppression or even slavery. In view of our results, it is not surprising that members of dominant groups (males, ethnic-majority group members) respond defensively to claims that their favourable position was established in an illegitimate way.

The current results also have implications for the relation between social rank and stress-related health-outcomes (Adler et al., 1994; Sapolsky, 2005). As noted above, the threat cardiovascular pattern is a maladaptive profile that is, in the long run, related to negative health outcomes. The current research underlines that it would be too simplistic to assume that those low in status are more or less chronically threatened, while those high in status live a relatively stress-free life. Whether status leads to positive or negative stress is, amongst other things, dependent on the security of the status hierarchy. This also has practical consequences for management practices like the implementation of flexible work contracts and the possibility of demotion to keep workers “on their toes”. Although this may have some short-term benefits in terms of productivity gains (Pettit & Lount, 2010; Pettit et al., 2010), in the longer term employees may pay the price for such practices with their health.

An important unanswered question is how we can use our insights to moderate the threat faced by members of dominant groups when they learn about shifting status relations in society. Although this is not something we have yet addressed empirically, possible answers may be found in the

combination of two identity-based interventions for inter-group threat for which we found evidence in our previous work: the formation of a dual identity, and group-affirmation (Derks et al., 2011; Scheepers, Saguy, Dovidio, & Gaertner, 2014).

A “dual identity” representation concerns the simultaneous identification with one’s own sub-group and an overarching common identity that binds in-group and out-group together (e.g., two ethnic groups, united in one country). In a previous study (Scheepers et al., 2014) ethnic majority-group members were primed with either a one-group identity representation (“we all belong to one group”) or a dual identity representation before an interaction with an ethnic minority-group member. Cardiovascular responses indicated threat in the one-group condition and challenge in the dual identity condition. The fruitfulness of a dual identity representation is likely due to the fact that it secures the distinctiveness of the in-group identity while at the same time strengthening ties with the out-group.

In another line of research, we found evidence for group-affirmation as an antidote to the stereotype threat effect, that is the effect of negative stereotypes about performance on stress that in turn undermines performance. In our study, women performed a parallel parking simulation test, a task for which there is a negative stereotype about women. Before engaging in the task, women in the group-affirmation condition received information about their gender group’s strong performance on an alternative task. During the parking simulation test, women in the group-affirmation condition showed a cardiovascular response pattern indicative of challenge whereas women in the no group-affirmation condition showed a pattern indicative of threat (Derks et al., 2011).

These studies could inform interventions that would reduce status threat in unstable high status group, because they suggest that securing a sense of sub-group distinctiveness is an important factor in reducing inter-group threat. More specifically, this suggests when an out-group “comes closer” to the in-group on a certain performance dimension as a result of social change, this does not have to threaten the status or even existence of the in-group. This way of reducing inter-group threat might be particularly effective in combination with stressing ties with the out-group, which may even lead to challenge, because members of the high status group could even feel proud about the improved lot of new in-group members. Evaluating the effectiveness such interventions is an important topic for future research.

### *Limitations and further research*

To illustrate the generalisability of the stability stress effect, we organised our review around a distinction between different levels of social

hierarchies: the interpersonal level, the inter-group level, and the societal level. In practice, however, many contexts where social hierarchies play a role involve a combination of cues about interpersonal, inter-group, and societal ranks. For example, gender stereotypes may influence the dominance behaviour of a male manager in interaction with a female subordinate. In fact, some of the studies we reviewed here involved a combination of cues about rank across different levels. For example, in the interpersonal power-stability study the power roles were labelled with the social categories “chief designer” and “assistant”; social categories that have power and status connotations. Similarly, the study about traditional versus changing gender roles took place in an interpersonal (i.e., debating) context, even though the focus of the discussion was on societal gender roles. Despite these points of overlap, there are several features of these studies that justify their placement in the interpersonal and societal level sections, respectively. First, it could be argued that in the power-stability study the structural aspects of the power role, that is the ability of the high power person to instruct and to evaluate the lower power person, were made particularly salient during the task, and arguably more so than the value implications of the role labels. Secondly, in the interpersonal power study the interpersonal roles conveyed the aspects of the situation that could (or could not) change, while the value connotations of the chief-designer and assistant labels were not related to the stability manipulation. Likewise, in the gender-role study, potential change referred to societal gender roles and not so much to the debating context itself. Thus, we acknowledge these possibilities for overlap between the different levels at which status or power differentials could be defined, and we note that in practice hierarchal situations often contain information about ranks across these different levels at the same time. Nevertheless, we propose that the distinction between different levels (interpersonal, inter-group societal) that we make in reviewing this research is important for analytical reasons and for examining and illustrating the generalisability of the stability-stress effect.

As mentioned above, another aim of this review was to demonstrate the generalisability of the stability-stress effect from power to status hierarchies. In none of the studies we described, however, was there a direct comparison between physiological responses to possible changes in power versus status. It may be that the intensity of stability stress differs between power and status hierarchies. On the one hand, one can argue that access to resources is so vital for survival that people are particularly sensitive to a potential loss of power. On the other hand, one can also argue that because power often concerns the control over real, tangible resources, it is easier to cope with potential power-loss than with potential status-loss. When anticipating a loss of control over resources, one could either increase effort or – when this seems pointless – disengage from the situation. Status is a more

psychological and more symbolic concept and is dependent on the respect one receives from others. Hence, a potential loss of status may involve more uncertainty, and may be more difficult to cope with, leading to greater threat than a potential loss of power. It is important to note, however, that this reasoning is purely hypothetical. Thus, an important task for future research would be to compare the influence of power versus status loss on the intensity of threat, and its implications for coping abilities.

A related issue that deserves attention in future research is how the intensity of threats to material resources compares to the intensity of threats to identity. Sociological analyses (Hainmueller & Hopkins, 2014; Jones et al., 2017) suggest that the threat arising from current social changes is to a substantial extent rooted in identity. Although material and identity factors contributing to rank will often be correlated and likely reinforce each other, there is – to our knowledge – no research that has examined how they specifically contribute to the threat of social change. Is the threat of losing material resources a more basic and generic form of threat, in that it is also present in other animals? Or in contemporary human societies, is identity a more prominent factor in the threat posed by social change? Or are material and identity-based threats equally strong, and so intertwined that they cannot be meaningfully separated?

Although these are still open questions, hypotheses about them can be informed by research on the specific physiological responses to social versus non-social stressors (e.g., electric shock). Of particular interest here is Dickerson and Kemeny's neuroendocrine model of social-evaluative threat (Dickerson & Kemeny, 2004; Kemeny, 2003). On the basis of both theory and a meta-analysis, Dickerson and Kemeny concluded that social-evaluative stressors are especially likely to lead to strong HPA-axis activation, and thus in turn to cortisol release and cardiovascular responses indicative of threat. Although anticipated change in access to material resources versus change in identity are both social forms of threat, they may nevertheless have different physiological underpinnings that relate to the physical-social dimension in Dickerson and Kemeny's model. If this were the case, this would have important implications both for the health implications of inter-group threat and for interventions intended to reduce damaging responses to such threat.

A boundary condition for the challenge and threat effects described in this review is that they only occur during motivated performance situations. Because of their social and self-evaluative nature, motivated performance situations are precisely the type of situations that potentially trigger the greatest physiological stress responses (Dickerson & Kemeny, 2004). It should be noted, however, that "threatening" information about the economy, migration, an affirmative action plan, etc., can of course also be received and processed during more passive situations, like watching a television news bulletin. Other psychophysiological methodologies than the ones described in the BPS-CT, such as electro-dermal activity (EDA), or

facial-electromyography (EMG), are better suited to capture threat in such more passive situations (Blascovich, Mendes, Vanman, & Dickerson, 2011). However, when such threatening information forms the basis for a (heated) debate with friends or colleagues, the BPS-CT is again applicable in determining whether this forms a threat or a challenge. In fact, many of the decisions we make, like forming or defending a position or deciding who to vote for, and many of the tasks we perform at work, like presenting or negotiating, qualify as motivated performance situations. This suggests that the research reviewed here on how cues about status (security) shape challenge and threat responses is applicable to a wide variety of theoretically interesting, and practically relevant, contexts.

Future research could also further inform the interplay between physiological and other (e.g., emotional) responses to stability threat. Measuring emotions and their respective action tendencies can add valuable insights to the interpretation of physiological responses, for example by clarifying the meaning and content of threats and challenges as indexed by cardiovascular arousal. Consider, for example, anger, which is a negative but approach-oriented emotion. Anger in inter-group contexts is related to challenge CV-reactivity, which fits the approach character of the challenge response (Mendes, Major, McCoy, & Blascovich, 2008). It seems likely that anger is also a relevant emotion in some of the effects shown here, as in the study where gender-inequality was salient, or in the study where low group-status was claimed to be illegitimate. In other instances, like the unstable interpersonal power condition, emotions like “hope” or “eagerness” may be more relevant. Thus, including measures of discrete emotions and their corresponding action tendencies may be of interest in future research as this is likely to provide additional information about the content and meaning of physiological responses of challenge and threat (see, for an illustration regarding shame: Dickerson, Gruenewald, & Kemeny, 2004).

The relationships described above are still hypothetical, and might be tested in future research addressing the relation between physiological threat and challenge states and their affective, attitudinal, and behavioural consequences. Moreover, future research could also aim to integrate different types of physiological responses, like cardiovascular challenge and threat response profiles and the neuro-endocrine responses (cortisol, DHEAS) that are hypothesised to underlie these response profiles (Jamieson et al., 2018).

In conclusion, although reflecting on the status quo is threatening for those low in rank under conditions of stability in the status hierarchy, anticipating a possible *change* in the status quo is threatening for those high in rank. These threat responses, which are indexed by specific changes in cardiovascular reactivity, are generic responses that occur relatively independently of whether differences in rank are based on power or status, or on interpersonal or inter-group comparisons. Learning about the sources

and consequences of inter-group threat may inform interventions intended to reduce dysfunctional responses to such threats in a modern world characterised by increasing change, threat and defence.

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