Brief report

Person perception and autonomic nervous system response: The costs and benefits of possessing a high social status

J. Cloutier [a,*], G.J. Norman [a], T. Li [a], G.G. Berntson [b]

[a] Department of Psychology, University of Chicago, Chicago, IL, United States
[b] Department of Psychology, The Ohio State University, Chicago, IL, United States

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ABSTRACT

This research was designed to investigate the relationship between sympathetic and parasympathetic autonomic nervous system (ANS) responses to the perception of social targets varying in social status. Participants varying in subjective financial status were presented with faces assigned with either a low, average, or high financial status. Electrocardiographic and impedance cardiography signals were recorded and measures of sympathetic (pre-ejection period; PEP) and parasympathetic (high frequency heart rate variability; HF HRV) cardiac control were derived. These measures associated with the presentation of each face condition were examined in relation to the subjective status of the perceivers. Participants with high subjective financial status showed reduced sympathetic activity when viewing low- and medium-status targets as compared to high-status targets, and lower parasympathetic response when viewing high- and medium-status targets relative to low-status targets.

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1. Introduction

Social hierarchies have far-reaching implications in the lives of social species (Cheney and Seyfarth, 2007; Magee and Galinsky, 2008; Sapolsky, 2004, 2005; Sidanius and Pratto, 1999; Zitek and Tiedens, 2012). Many facets of social interactions are guided by the relative status of hierarchy members (Deaner et al., 2005; Fiske, 2010; Chan and Goldthorpe, 2007; Shepherd et al., 2006). Possessing a high status often confers advantages (i.e. privileged access to resources and potential mates) but it can also come with costs (i.e. repeated challenges from other dominant members of the hierarchy) (Cheney and Seyfarth, 2007; Fiske, 2010).

Recent studies utilizing measures of cardiovascular reactivity found that an individuals' perceived status influences autonomic nervous system (ANS) responses during social interactions (Scheepers, 2009; Scheepers et al., 2012). Furthermore, social status is associated with a broad range of health-related outcomes, including coronary heart disease and hypertension (Adler et al., 2000; Matthews and Gallo, 2011; McEwen and Lasley, 2002; Sapolsky, 2004, 2005; Singh-Manoux et al., 2003, 2005). One potential mediator of the relationship between social status and cardiovascular health is differential activation of sympathetic and parasympathetic responses. Indeed, while sympathetic and parasympathetic responses show stable reciprocal patterns of activation during orthostasis, social psychological stressors (e.g., evaluative stress) can result in bivariate modes of activation (Berntson et al., 1994) which may have direct influences on health outcomes (Berntson et al., 2008). Furthermore, bivariate modes of ANS activity may explain why previous studies have failed to find a relationship between social status and heart rate (Gruennewald et al., 2005). Changes in heart rate are a function of both sympathetic and parasympathetic activity and the co-activation of both branches can lead to no change in heart rate (Berntson et al., 1994). Therefore, the ability to simultaneously measure the activity of both branches of the ANS is important when attempting to elucidate the influence of psychological states on autonomic responses.

Reductions in parasympathetic cardiac control have been linked to elevated arousal, attentional demands, cognitive load, and threat perception (Elliot et al., 2011; Fairclough et al., 2005; Frazier et al., 2004; Houtveen et al., 2002; Butler et al., 2006). Moreover, modulation of parasympathetic cardiac control in response to a psychological challenge is thought to reflect a passive coping strategy (Blascovich and Mendes, 2010). The ability to rapidly modulate parasympathetic responses provides flexibility in response to environmental demands (Porges, 2007; Thayer and Lane, 2000; Thayer and Sternberg, 2006). In contrast, increases in sympathetic responses are believed to indicate the mobilization of physiological resources in the face of a challenge (Berntson et al., 1997; Brener, 1987; Cacioppo et al., 1994; Gendolla and Silvestrini, 2011; Kelsey, 2012; Porges, 2007; Pribram and McGuinness, 1975; Richter et al., 2008; Sherwood et al., 1990). In contrast to the passive coping strategy mentioned above, increases in sympathetic cardiac activity are

* Corresponding author.
 E-mail address: jcloutier@uchicago.edu (J. Cloutier).

thought to reflect an active coping strategy where action is required (Blascovich and Mendes, 2010). Collectively, these findings suggest that the simultaneous measurement of parasympathetic and sympathetic activity has the potential to provide a more comprehensive understanding of the relationship between social status and physiological responses.

The current study examined the relationship between the subjective social status of individuals and their autonomic responses during the perception of conspecifics varying on the same status dimension (i.e., financial status). In contrast to previous studies involving more active social tasks (i.e., Mendes et al., 2007; Scheepers, 2009), the procedure employed involves a passive impression formation task. One prediction, in accord with other benefits incurred by higher social status (Magee and Galinsky, 2008; Matthews and Gallo, 2011), is that perceivers with high status would exhibit minimal ANS reactivity when presented with conspecifics of lower or equivalent levels of social status as their own. On the other hand, perceivers may also view higher or equal-status counterparts as potential threats; thereby showing exaggerated ANS response (Cheney and Seyfarth, 2007; Fiske, 2010).

2. Methods

2.1. Participants

Forty six male undergraduate students from the University of Chicago were included (mean age 20.4 years, SD 3.07). Due to issues in autonomic recordings (e.g., electrode detachment), six individuals were excluded from the study.

2.2. Procedure

Participants answered a series of questionnaires evaluating their social status in relation to other participants in the study. In addition to objective financial status information (i.e., income), a subjective measure of financial status was collected. This measure was a modification of a validated scale extensively used to evaluate subjective SES (Adler et al., 2000; Singh-Manoux et al., 2003, 2005). Participants were presented with a ladder scale with the following instructions: "Think of this ladder as representing where people stand in terms of wealth and financial status amongst the university undergraduate population of the Chicago area. People define wealth and financial status in different ways; please define it in whatever way is most meaningful to you. At the top of the ladder are the people who have the highest standing amongst the undergraduate population. At the bottom of the ladder are the people who have the lowest standing amongst the undergraduate population. Where would you place yourself on this ladder? Please place a large "X" on the rung where you think you stand at this time in your life, relative to other undergraduates of the Chicago area". A photograph of the participant was then taken. Participants were then informed of their financial status relative to the other participants in the study, as indicated by a red marker on a bell-shaped curve representing an average social status. Importantly, participants were told that the distribution of the financial status of participants was not necessarily representative of the distribution of student population. This allowed for the presentation of social targets with higher, equal, or lower financial status than the perceivers during the later experimental session. Accordingly, participants learned to associate a middle shade of gray with their own status level. Subsequently, the target's social status level was also indicated by a shade of gray, with high vs. low status being paired with either a lighter or a darker shade of gray. The status levels paired with the backgrounds were counterbalanced across subjects.

2.2.1. Training

Participants completed a computer-based training task to consolidate their learning of the association between the shade of gray and the levels of social status. During encoding, participants were presented with only the backgrounds of the different shades, without any faces, with a text box indicating the social status level with which it was paired. Fifty trials were presented for each of the three conditions. The status level paired with the backgrounds was counterbalanced across participants (i.e., darker shades indicating either higher or lower status). Following the encoding phase, participants took part in a testing phase during which they were required to accurately identify at least 30 sequential presentations of the backgrounds with the correct status level.

2.2.2. Psychophysiological experimental session

After successful completion of the training task, baseline measures of sympathetic and parasympathetic responses were obtained by having participants passively view a fixation cross on the screen for 5 min. Participants were then asked to form impressions of photographs of individuals believed to be participants of the study. Instructions for the impression formation task were deliberately unconstrained and therefore did not require a specific online response. Participants were simply asked to form an impression of the presented individuals based on their "gut reactions" and were reminded that they would ostensibly later interact with some of the targets. The stimuli presented were from a pool of 30 faces of white males (approximately 19–25 years of age), displayed neutral facial expression, were wearing gray shirts and were photographed on a white background. The faces associated with each social status levels were counterbalanced across participants. These photographs were superimposed on the gray backgrounds indicative of financial status. Blocks of trials of each condition were composed of 10 photographs of different individuals paired with the same financial status (low, medium or high), each presented for 4 s, interspersed with fixation crosses, each presented for 0.5 s. Blocks of trials were separated by 30 s of rest (fixation cross) and presented 4 times in a random order, for a total of 12 blocks of trials.

2.3. Analysis

Cardiovascular measures of sympathetic and parasympathetic cardiac control, respectively, were derived from pre-ejection period (PEP) and high (respiratory) frequency (0.12–0.40 Hz) heart rate variability (HF HRV). HF HRV is a rhythmic fluctuation of heart rate in the respiratory frequency band (respiratory sinus arrhythmia), and has been shown to be a relatively pure index of parasympathetic control (Berntson et al., 1997). A measure of respiration was derived from the cardiothoracic impedance signal (as described below). The electrocardiogram (ECG) was obtained using the standard lead II configuration. HF HRV was derived by spectral analysis of the interbeat interval series from the ECG, following previously specified procedures (Berntson et al., 1997). Briefly, the interbeat interval series was sampled at 1000 Hz (with interpolation) to yield an equal interval time series. This time series was then detrended (second-order polynomial), end tapered, and submitted to a Fast Fourier Transform. HF HRV spectral power was then integrated over the respiratory frequency band (0.12–0.40 Hz). HF HRV is represented as the natural log of the heart period variance in the respiratory band (in ms^2). The respiration rates, in all cases, were within this 0.12–0.40 frequency band.

PEP, derived from impedance cardiography, is the period between the electrical invasion of the ventricular myocardium (Q wave of the ECG) and the opening of the aortic valve (B point; Lozano et al., 2007). The B point was automatically derived by the analysis software by means of a validated algorithm that used the time interval of the Q point to the maximum point of the dZ/dt wave to estimate the location of the B point (Lozano et al., 2007). PEP depends on the time development of intraventricular pressure. Hence, it is widely used as an index of myocardial contractility. Because variations in contractility are modulated by sympathetic beta adrenergic influences, PEP is commonly used as a noninvasive measure of sympathetic cardiac control (Berntson et al., 1997). The impedance cardiogram was obtained using the standard tetrapolar electrode system and procedures described elsewhere (Sherwood et al., 1990). The ECG and basal thoracic impedance (Z0) were measured using a Bionex system (Mindware, Gahanna, OH). Commercial software (Mindware, Gahanna, OH) was used to analyze the electrocardiogram and cardiothoracic impedance signals. All data were visually inspected and artifacts were removed in accordance with previously described methods (Berntson et al., 1998; Lozano et al., 2007). All PEP values were multiplied by −1 so that positive values represent increases in sympathetic tone. Prior to the presentation of stimuli a 5 min baseline recording was taken for ANS measures. For each subject, ECG and impedance data were ensemble averaged across 45 s stimuli presentation blocks.

3. Results

There was no relationship between baseline cardiac measures and socio-economic status ($p = 0.30$). Although ANS values were comparable when viewing targets across low, equal, and high status conditions ($p = 0.61$), results indicated that ANS responses to these targets (specifically, ANS reactivity scores: Post-baseline stimuli presentation) were found to be significantly related to the participants' subjective status. Indeed, hierarchical regression analysis revealed that subjective status was a significant negative predictor of changes in parasympathetic cardiac control (stimulus − baseline) when viewing equal ($b = −0.08$, $t_{32} = −3.08$, $p = 0.01$) and high ($b = −0.09$, $t_{33} = −3.13$, $p = 0.01$) but not low ($p > 0.05$) financial status targets controlling for age and income (see Fig. 1). These results may be indicative of an increased "parasympathetic stress response" when high subjective financial status individuals are presented with targets potentially challenging their social standing. Furthermore, subjective financial status was found to be a significant negative predictor of sympathetic cardiac control (PEP) in both low ($b = 0.98$, $t_{29} = 2.78$, $p = 0.01$)
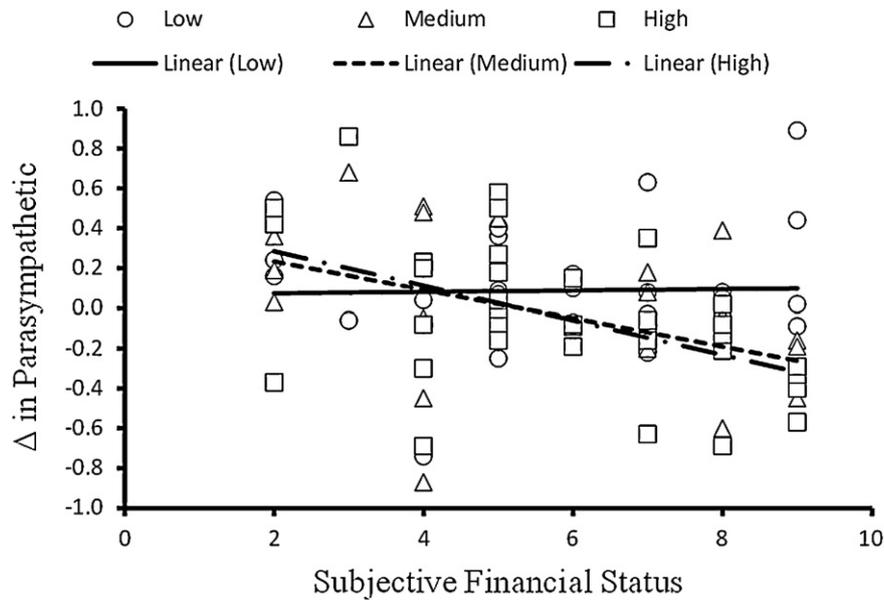
Fig. 1. Participants with high subjective status showed a decrease in parasympathetic cardiac control (indicated by change in HF HRV) when viewing high- and medium-status targets, but not when viewing low-status targets, as compared to participants with low subjective status. Such decrease in parasympathetic cardiac control is believed to occur in response to greater effort, threat or stress from the perceivers.

and equal ($b = 1.02$, $t_{29} = 2.34$, $p = 0.03$) social target viewing conditions such that lower sympathetic reactivity was associated with higher levels of subjective financial status; no significant relationship was detected between sympathetic cardiac control and subjective financial status for the high social target viewing ($p = 0.69$) (see Fig. 2). No significant relationships were detected between heart rate, subjective status or financial status ($p = 0.38$). In contrast to the previous results, these results may indicate a benefit of having a high social status as indicated by a reduction in sympathetic cardiac response when presented with individuals of lower social status. Excluding age and objective socio-economic status does not appreciably alter the aforementioned results.

4. Discussion

The current study is the first demonstration of a relationship between a perceiver's subjective social status, controlling for income, and ANS response during person perception. These findings are illustrations of both the potential benefits and costs of possessing a high social status (Cheney and Seyfarth, 2007; Fiske, 2010; Sapolsky, 2004, 2005). Specifically, a rise in the perceivers' subjective financial status was found to be related to decreases in parasympathetic responses (HF HRV) when viewing targets of equal or higher social status. Thus, individuals with higher status may respond by mobilizing more physiological resources when presented with conspecifics of equal or higher social status.
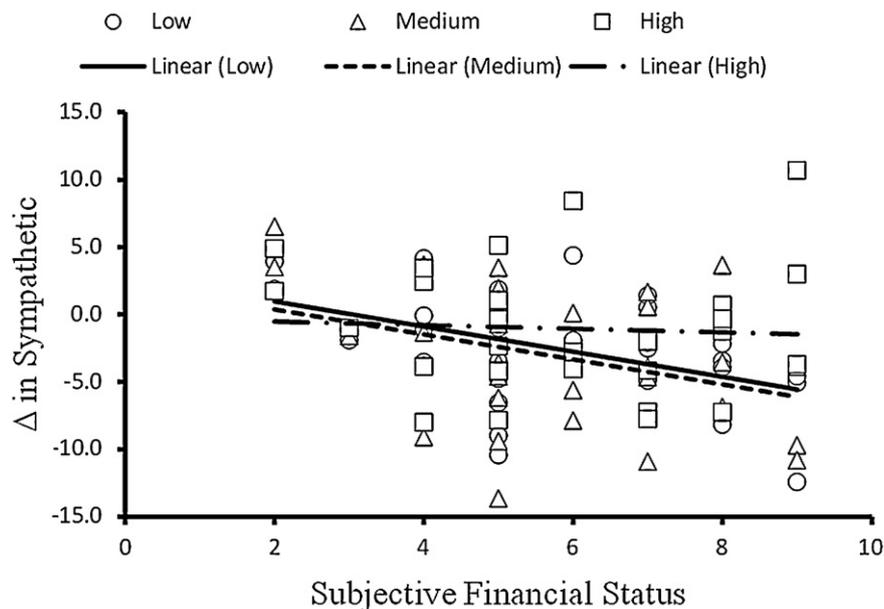

Fig. 2. Participants with high subjective status showed a decrease in sympathetic cardiac response (indicated by change in PEP) when viewing low- and medium-status targets, but not when viewing high-status targets, as compared to participants with low subjective status. Notice that line for sympathetic reactivity is inverted. Such decrease in sympathetic cardiac response is believed to be indicative of a reduction of resources mobilization.

Perceivers with higher subjective social status may view higher or equal-status counterparts as potential threats; thereby showing a decrease in parasympathetic control (Cheney and Seyfarth, 2007; Fiske, 2010). Indeed, previous research found that increases in task demands, arousal, or threat lead to decreases in parasympathetic control (Elliot et al., 2011; Fairclough et al., 2005; Frazier et al., 2004; Houtveen et al., 2002). This response may also illustrate the cost of monitoring potential challenges to one's hierarchical position. As such, in the current context, high status perceivers may have been more sensitive to the social cues communicated by the targets; leading to alterations in parasympathetic cardiac control.

On the other hand, potential benefits of possessing a higher social status were identified when measuring sympathetic responses (PEP). Indeed, higher subjective status was found to be related to decreases in sympathetic responses when presented with conspecifics of equal or lower social status. Such disengagement may be indicative of the self-confidence held by high status individuals when faced with lower status conspecifics (Kraus et al., 2011). This diminished propensity to expend energetically expensive physiological resources may be a consequence of the relative certainty ascribed by high status individual to relations with lower status individuals (Kelsey, 2012; Porges, 2007; Pribram and McGuinness, 1975).

In addition to characterizing ANS involvement during person perception, the present findings may help illuminate some of the mechanisms underlying the relationship between social status and physiological responses. As previously mentioned, an individual's subjective social status is linked to a range of health-related outcomes, even when accounting for "objective" measures of social status (Adler et al., 2000; McEwen and Lasley, 2002; Sapolsky, 2004, 2005; Singh-Manoux et al., 2003, 2005). Indeed, prior studies found that individuals who report having a relatively low social status are more susceptible to suffer from a number of health issues. Stress-related physiological responses associated with social interactions with members at different levels of a social hierarchy may be important mediators of this relationship between social status and health (Cohen et al., 2008; Miller and Cohen, 2005; McEwen and Gianaros, 2010; Marmot, 2004; Sapolsky, 2004, 2005; Segerstrom and Miller, 2004). For instance, numerous studies have found a strong relationship between hypothalamic-pituitary-adrenal axis (HPA) function and low social status (McEwen and Gianaros, 2010; Sapolsky, 2004; Creel, 2001; Ely and Henry, 1978; Manogue et al., 1975). The relationship between autonomic responses and social status, however, has received less attention. Nonetheless, both measures are reliable non-invasive indicators of stress responses (Thayer and Lane, 2000; Thayer and Sternberg, 2006; Berntson et al., 2008) and are capable of significantly higher temporal resolution as compared to salivary or serum measures of stress hormones. Therefore, the measurement of autonomic nervous system activity in relation to social status and person perception may provide insight into the pathways linking social status and health outcomes (Matthews and Gallo, 2011).

Addressing the limitations of the current study, important variables to consider in future research include the social class (Fiske and Markus, 2012) and the gender (Evans et al., 2001) of the perceivers. Furthermore, if perceivers with very high subjective status rarely encounter individuals with even higher social status than them, such targets may be particularly salient, which may in turn increase attentional demands. Additionally, ANS responses of perceivers in the current study were measured during a passive experimental paradigm. Future research will be needed to explore the relationship between social status and autonomic responses following active social stressors (Gruenewald et al., 2006; Martens et al., 2008). Finally, it is possible that different dimensions of social status (e.g., intellectual or moral status), instead of the subjective financial status of the perceivers, would have elicited different patterns of responses (see Cloutier et al., 2012).

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