Hierarchy and Health: Physiological Effects of Interpersonal Experiences Associated With Socioeconomic Position

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Objective: The inverse association between socioeconomic position (SEP) and cardiovascular disease may involve social psychophysiological processes. To test effects of aspects of SEP on physiological reactivity, we experimentally manipulated 3 features of social context related to social hierarchy—social rank or status relative to an interaction partner, the partner's degree of dominant behavior, and the presence of social—evaluative threat. Method: The study design was a 2 × 2 × 2 (Participant Relative Status [high vs. low] × Partner Dominance [high vs. low] × Evaluative Threat [high vs. low]) factorial, and 180 undergraduates participated. Cardiovascular and salivary cortisol responses were measured while participants engaged in a controlled interaction task with a prerecorded confederate partner. Results: Lower participant relative status resulted in greater increases in systolic (SBP) and diastolic blood pressure (DBP). Interacting with a more dominant partner resulted in greater increases in SBP and heart rate (HR), and larger changes in cardiac sympathetic and parasympathetic activation. Higher levels of social—evaluative threat evoked larger increases in HR and SBP. In some cases, these effects were stronger in men than in women, and aspects of the low status social context had synergistic effects on some physiological outcomes. Conclusion: Interpersonal interactions and experiences may contribute to the association between SEP and cardiovascular health through the mechanism of physiological activation. Recurring patterns of everyday social experiences and their physiological effects may be a pathway linking the broader social context to cardiovascular disease.

Keywords: socioeconomic status, socioeconomic position, dominance, evaluative threat, cardiovascular reactivity, salivary cortisol

Major health disparities in the United States persist despite enormous health care expenditures. Socioeconomic position (SEP) or socioeconomic status (SES) is perhaps the most significant disparity, where rates of morbidity and mortality from many causes—including cardiovascular disease (CVD)—are higher at lower levels of social status (Adler, 2009; Ruiz, Prather, & Steffens, 2012; Steptoe & Kivimäki, 2013). Objective indicators of SEP (i.e., education, income, and occupation) predict these health outcomes, as do perceptions of social rank in relation to others (i.e., subjective social status) when controlling objective SEP (Adler et al., 2008). Hence, the association between SEP and CVD involves both objective and subjective aspects of one's relative rank or standing in the social hierarchy (Galobardes, Shaw, Lawlor, Lynch, & Davey Smith, 2006).

Although this general association may involve a variety of mechanisms (e.g., health behavior, access to care, exposure to environmental toxins), physiological stress responses play a prominent role in conceptual models linking SEP to health (Matthews, Gallo, & Taylor, 2010). Specifically, low SEP is thought to contribute to morbidity and mortality in part because it entails more frequent, pronounced, and prolonged psychophysiological stress responses (e.g., increases in blood pressure, heart rate [HR], and neuroendocrine responses associated with psychological stress), which in turn contribute to the development of CVD (Steptoe & Kivimäki, 2013). Although observational studies have supported this conceptualization (e.g., Almeida, Neupert, Banks, & Serido, 2005; Cundiff, Uchino, Smith, & Birmingham, 2015), experimental data are lacking, likely because SEP is not amenable to manipulation.

Although individual’s objective SEP cannot be readily manipulated, psychosocial phenomena associated with SEP can be. For example, perceptions of SEP relative to others can be manipulated within a laboratory context. This experimental approach permits stronger causal inferences about effects of SEP on physiological response. Such studies can also isolate specific elements of SEP as influences on physiological responses. The present study took this type of laboratory-based, social psychophysiological approach (Smith & Christensen, 1992), by manipulating three psychosocial experiences associated with SEP.

Specific elements of SEP that could influence physiological responses include perceptions of oneself as lower in the social hierarchy than others during social interaction (Cundiff, Smith, Uchino, & Berg, 2013), greater sensitivity to social threat
(Chen, Langer, Raphaelson, & Matthews, 2004), and greater exposure to dominant and controlling behavior from others (Gallo, Smith, & Cox, 2006). That is, when interacting with others, low SEP is associated with greater perceptions of being in a “one down” position, greater perceptions of social evaluation, and greater experience of interaction partners as dominant and controlling, rather than deferential. Each of these interpersonal experiences has been associated with increased psychophysiological stress responses (Adler, 2009; Chen et al., 2004; Dickerson & Kemeny, 2004; Mendelson, Thurston, & Kubzansky, 2008). Hence, perceptions of lower relative status, exposure to social—evaluative threat, and exposure to dominant social stimuli may each plausibly contribute to the general association between low SEP and CVD.

Disentangling Relative Status, Dominance, and Threat

Perceptions of relative status and exposure to interpersonal dominance and evaluative threat often co-occur, but they are distinct experiences associated with low SEP. These aspects of low SEP could differentially influence physiological response, could combine to have synergistic effects, or could have overlapping effects. In an example of a synergistic effect of evaluative threat and relative status, evaluation by higher status observers evokes greater physiological response than evaluations by low status observers (Wright, Killebrew, & Pimpalpuro, 2002). Similarly, lower perceived relative status in an evaluative situation can lead to lower perceptions of relative competence and a greater perceived likelihood of failure, which in turn evokes greater physiological response (Mendes, Blascovich, Major, & Seery, 2001). Thus, evaluative threat may have greater effects when combined with low relative status (Lam & Dickerson, 2013).

As noted above, low objective SEP is associated with greater exposure to dominant behavior from interaction partners in everyday life (Gallo et al., 2006), and interactions with dominant (vs. deferential) partners evoke greater physiological stress responses (Newton, 2009; Smith, Cundiff, & Uchino, 2012). Dominant behavior expressed by others often signals their competence and a greater perceived likelihood of failure, which in turn evokes greater physiological response (Mendes, Blascovich, Major, & Seery, 2001). Thus, exposure to dominant behavior and perceptions of relative status may have overlapping effects on physiological response (Mendelson et al., 2008). However, interacting with someone perceived to be from a higher economic, educational, or occupational background could heighten physiological stress responses regardless of that individuals’ actual social behavior (i.e., dominance vs. deference), and the dominant behavior of an interaction partner could heighten physiological response regardless of that partner’s relative status. Thus, a partner’s dominant behavior and relative status could also have independent effects on physiological response during social interaction.

Notably, race and sex can also be important correlates of SEP because these social categories are socially stratified. For example, an individual’s race may change the frequency of exposure to social stressors and/or individuals’ psychophysiological responses to such stressors (e.g., Blascovich, Spencer, Quinn, & Steele, 2001; Pascoe & Smart-Richman, 2009). This is consistent with the idea that everyday social experiences of individuals may account for a significant portion of the variance typically attributed to broad social determinants of health such as race. Similarly, prior evidence has suggested that there may be sex differences in physiological responses to experiences associated with SEP, because men typically display greater psychophysiological sensitivity to social hierarchy cues (Newton, 2009). Although both men and women show SEP inequalities in psychosocial risk factors and health outcomes, in some instances the association of SEP with health is stronger among men (Anderson & Armstead, 1995; Davey Smith et al., 1998; Elov, 2009; Torssander & Erikson, 2010), consistent with the view that men may be more responsive to aspects of social hierarchy than women (Newton, 2009).

The Present Study

To examine the possible independent, overlapping, and synergistic effects of aspects of SEP, the current study used a social interaction task involving a prerecorded partner to manipulate perceived relative status (i.e., perceptions of SEP relative to the interaction partner), dominant (vs. deferential) behavior of the partner, and social—evaluative threat, and measured cardiovascular and neuroendocrine stress responses. Cardiovascular reactivity (CVR) refers to increases in HR and blood pressure in response to stressors. The magnitude of CVR has been linked to future CVD (Chida & Steptoe, 2010). Underlying autonomic determinants of CVR are also informative. Cardiac pre-ejection period (PEP) provides a well-validated index of sympathetic activation in response to stress, whereas respiratory sinus arrhythmia as measured by high-frequency heart rate variability (hfHRV) provides an index of parasympathetic activation (Thayer, Hansen, & Johnsen, 2008). Increased sympathetic activation and parasympathetic withdrawal are both implicated in the effects of stress on CVD (Steptoe & Kivimäki, 2013; Thayer et al., 2008). Salivary cortisol reactivity was also examined as another indicator of cardiovascular risk, because it has also been linked to cardiovascular health (Hamer, Endrighi, Venraru, Lahiri, & Steptoe, 2012), evaluative threat, and other psychological processes related to social status, such as self-conscious emotions (Lam & Dickerson, 2013).

Given the prior research presented above, it was predicted that low participant relative status, dominant behavior by interaction partners, and high social—evaluative threat would evoke heightened CVR. It was also expected that social—evaluative threat would evoke heightened cortisol responses. The effects of partner dominance and relative status on cortisol response are not well-established in prior research, precluding specific predictions for their effects on this outcome. Finally, we also hypothesized that men would be more responsive to manipulations of the three aspects of SEP than women.

Method

Participants

Participants were undergraduate men (n = 86) and women (n = 91) enrolled in the University of Utah’s Department of Psychology research participation pool (Mdn_age = 21 years, range: 17–60 years). Most were full-time students (81.4%), employed (60.3%),

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made less than $15,000 annually (66.0%), and identified as White (73.6%) (10.7% Hispanic, 7.9% Asian American). Average parental income was between $75,000 and $125,000, average paternal education was a bachelor’s degree, and average maternal education was an associate’s degree.

**Design and Procedures**

The study was a $2 \times 2 \times 2 \times 2$ (Participant Relative Status [high vs. low] × Partner Dominance [high vs. low] × Evaluative Threat [high vs. low] × Sex [male vs. female]) factorial design. Figure 1 provides a timeline of study procedures. The study was described as examining the physiological effects of social interaction. Due to the diurnal rhythm of cortisol, participants began the protocol no earlier than 11:30 a.m. and completed the protocol no later than 6:30 p.m. When participants arrived, they were seated alone in the experimental chamber and informed that they would engage in a discussion of current events with another student from the research participation pool, while physiological responses were assessed. They were further told that their interaction partner had already arrived and was in another room nearby. They were also told that, during the experiment, their conversation with that partner would occur through a microphone and speaker to avoid effects of extraneous factors present in face-to-face interaction (e.g., appearance). Participants were further informed that, to facilitate a more natural interaction, they would receive some “basic information” about each other before interaction.

**Background assessment and baseline.** After informed consent, participants completed two paper questionnaires: (a) ratings of objective and subjective social status and (b) ratings of his or her stance on the three potential topics for discussion (described in subsection Interaction task). Next, electrodes and a blood pressure cuff were attached, followed by a 10-min minimally engaging baseline task (Jennings, Kamarck, Stewart, Eddy, & Johnson, 1992), in this case rating pairs of outdoor photographs while sitting quietly (e.g., Smith, Ruiz, & Uchino, 2000). After baseline, participants provided the first cortisol sample and completed state affect measures.

**Participant relative status manipulation.** After baseline, participant relative status was manipulated by a supposed exchange of information between the participant and the interaction partner. Participants were presented with a demographic sheet of objective and subjective ratings of social status (identical in format to the one they completed earlier) and led to believe that these ratings had been provided by their partner. The information provided indicated that the partner was either three tiers above or three tiers below (or the maximum possible) the participant’s self-reported social standing on all indices of social status (participants’ objective and subjective social status, and objective status of their parents).

**Social—evaluative threat manipulation.** Low threat instructions specifically stated that neither participants’ nor partners’ responses during the interaction task would be evaluated, and asked only that participants speak clearly. High threat instructions stated that participants and their partners would be evaluated for competence, intelligence, skill, and accuracy of information. Further, during the high threat condition, an experimenter sat and faced the participant, and supposedly made periodic ratings of both the participant and the partner.

**Partner dominance manipulation.** The prerecorded interaction partner was gender-matched with the participant, and the same male and female were recorded for all conditions. High dominant partners spoke in an assertive manner (i.e., confident, definitive), and low dominant partners spoke deferentially (i.e., hesitant speech, lack of certainty, questioning tone). To accommodate various topics and stances (i.e., for or against), multiple versions of the male and female partner recordings were available.

**Interaction task.** Participants “interacted” with the confederate recording in a series of three, 90-s exchanges on a currently debated topic. Participants provided ratings of his or her stance on each of three possible topics (same-sex marriage, universal health care, effectiveness of online classes) prior to baseline. The topic about which the participant held the strongest opinion was selected. In the prerecorded remarks, interaction partners supported the opposing viewpoint.

During debriefing at the conclusion of the experiment, participants answered open-ended questions to gauge suspicion regarding the deception. Three participants spontaneously reported disbelief or suspicion (e.g., that the partner was a confederate), and were excluded from analyses.

**Figure 1.** Schematic of the laboratory protocol (manipulated variables are in boldface).
Measures

Socioeconomic position. The construct of socioeconomic position is multifaceted and was measured using multiple instruments.

Objective SEP. The background questionnaire included queries about income and education. Response choices for educational status for participants and their parents ranged from partial high school to graduate degree, and annual household income ranged from $0–$4,999 to greater than $500,000.

Subjective social status. In the background questionnaire, participants also completed the MacArthur Scale of Subjective Social Status (SSS), consisting of two visual analog ladder scales, one rating perceived status within the United States and one within the community (Adler et al., 2008). The United States ladder is anchored to objective indicators of SES, stating that the 10th rung represents people who have the best jobs, best education, and make the most money. The community ladder is defined by the rater and simply asks participants to indicate where they stand in their community, with the 10th rung being those with the highest standing. These 10-rung ladder scales have shown good test–retest reliability, and expected associations with objective indicators of SEP (Operario, Adler, & Williams, 2004), as well as convergent and discriminant validity with measures of income and psychosocial risk factors (Cundiff et al., 2013). Participants’ average subjective social status in the United States was 5.3 out of 10 rungs. Average subjective social status in the community was 5.5 out of 10 rungs. A similar scale was completed after the interaction task, asking participants to rate their own and their partners’ status.

Perceptions of Confederate Partner. After the task, participants were asked to rate the interpersonal style of the interaction partner.

Partner behavior. A 32-item version of the Impact Message Inventory (IMI-C; Schmidt, Wagner, & Kiesler, 1999) was used to assess participants’ perception of their partner’s behavior along the control (dominance vs. submission) and affiliation (warmth vs. hostility) dimensions during the interaction. This scale has construct validity (Nealey-Moore, Smith, Uchino, Hawkins, & Olson-Cerny, 2007), and both dimensions had good internal reliability in the current sample (Cronbach’s α > .72).

Psychological reactions to the task. Participants were also asked to rate their emotional state at two time points.

State affect. Participants completed state affect measures following baseline and the interaction task. These 12-item anxiety and anger scales are sensitive to experimental manipulations (Nealey-Moore et al., 2007), and were reliable in this sample (αs > .75).

Physiological reactions to the task. Participants physiologival reactions to the task were assessed using multiple measures.

Cardiovascular reactivity. Using a Critikon Dinamap oscillometric monitor (Model 100), mean systolic (SBP) and diastolic blood pressure (DBP) readings were calculated for each epoch to increase the reliability of these assessments (Kamarck et al., 1992). Readings were taken every 60 s during the 10-min baseline, and the last five readings were averaged to form baseline values. Readings were taken six times during the discussion task, 30 s after the beginning of each 90-s speaking or listening turn. The participant took three turns speaking and three turns listening—speaking and listening were averaged separately. A MindWare Technologies 2000 D Impedance Cardiograph was used along with spot electrodes placed in the tetra polar configuration (Thayer et al., 2008), and raw electrocardiography (ECG) data were visually inspected for artifacts and abnormal beats (Bernston, Quigley, Jang, & Boysen, 1990). HRV Analysis Software, Version 5.2 (MindWare Technologies, Gahanna, OH) was used to derive hHRV (in ms²/Hz) from the ECG data, and the PEP was calculated as the time interval (in milliseconds) between the Q-point of the ECG data and the B-point of the dZ/dt signal.¹

Salivary cortisol. Given the timing of salivary cortisol responses to psychosocial stressors (Dickerson & Kemeny, 2004), samples were collected following baseline, and 25 and 35 min after beginning the interaction task. Samples were collected with Sarstedt cortisol salivettes, stored using standard procedures, and analyzed at the Technical University of Dresden using immunodassays (IBL-International) with well-documented sensitivity (0.2 nmol/L), reliability (intra- and interassay coefficients of variation < 5%), and validity (Miller, Plessow, Rauh, Gröschl, & Kirschbaum, 2013). Analyses of cortisol responses statistically controlled for time since waking.

Overview of Analyses

The results of 2 × 2 × 2 × 2 (Participant Relative Status [high vs. low] × Partner Dominance [high vs. low] × Evaluative Threat [high vs. low] × Sex [male vs. female]) analyses of variance (ANOVRAs) are presented below. Change scores (i.e., task minus baseline) were analyzed for affective and physiological responses to the task (Llabre, Spitzer, Saab, Ironson, & Schneiderman, 1991). Univariate ANOVRAs were performed on affective change scores, and mixed ANOVRAs were performed on physiological change scores, adding an additional repeated factor to account for speaking and listening portions of the task in the case of CVR and for the two posttask measurements in the case of cortisol. Significant interactions were further analyzed using mean comparisons (Bernhardson, 1975). Effect sizes are reported as eta-squared. Variations in degrees of freedom between analyses reflect missing data due to poor-quality signal or out-of-range values for measures obtained by impedance cardiography.

Results

Randomization was successful with respect to baseline demographics; there were no differences between groups on measures of objective or subjective SEP. We organized results by conceptually related dependent variables. We do not present higher order (i.e., three- and four-way) interactions, because they were rare, accounted for little variance, and did not alter the interpretations of the effects reported below. Bivariate correlations among dependent variables are presented in Table 1.

Manipulation Checks

Participant relative status. A difference score was computed (i.e., self minus partner) for participants’ posttask ratings of them-

¹ An average was calculated from five readings taken at 60-s intervals during the 5-min recovery period. The persistence of these stress responses during recovery is noteworthy, because they predict the development of cardiovascular disease (Chida & Steptoe, 2010).
Table 1

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<tr>
<th>ΔSBP</th>
<th>ΔDBP</th>
<th>ΔHR</th>
<th>ΔPEP</th>
<th>ΔRSA</th>
<th>ΔCortisol</th>
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<tr>
<td>0.66*</td>
<td>0.51**</td>
<td>−0.20*</td>
<td>−0.32**</td>
<td>0.19*</td>
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<tr>
<td>0.26**</td>
<td>0.00</td>
<td>−0.28**</td>
<td>0.11</td>
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<tr>
<td>−0.21*</td>
<td>−0.66**</td>
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<td>−0.07</td>
<td>−0.11</td>
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* p ≤ .01, ** p ≤ .001.

Summary of manipulation checks. The experimental manipulations were generally effective and specific. The participant relative status manipulation had expected effects on participants’ SSS ratings of themselves and their interaction partners, whereas the partner dominance and evaluative threat manipulations did not influence these ratings. The partner dominance manipulation had expected effects on the IMI-C ratings of the partner’s level of dominance and control during the interaction, whereas the participant relative status and evaluative threat manipulations did not. Finally, only the evaluative threat manipulation altered state anger, and to a lesser extent state anxiety, and did so in the expected direction.

Physiological Reactivity During Social Interaction

Blood pressure response. The low participant relative status group displayed larger increases in SBP than the high status group (M = 26.6 mmHg, SE = 1.1 vs. M = 21.8 mmHg, SE = 1.5), F(1, 161) = 12.06, p < .001, η² = .072. Also, the high partner dominance group displayed larger increases than did the low dominance group (M = 26.6 mmHg, SE = 1.1 vs. M = 22.0 mmHg, SE = 1.4), F(1, 161) = 10.22, p < .001, η² = .061. The main effect of evaluative threat approached significance, such that high threat participants tended to display larger increases than the low threat group (M = 25.5 mmHg, SE = 1.5 vs. M = 22.7 mmHg, SE = 1.2, respectively), F(1, 161) = 3.65, p = .058, η² = .023.

Qualifying these main effects on SBP was a Participant Relative Status × Partner Dominance interaction, F(1, 161) = 3.8, p = .05, η² = .024 (see Figure 2). Among lower status participants, those interacting with high dominant partners showed greater increases in SBP than those with low dominant partners. Also, among participants interacting with high dominant partners, those lower in relative status displayed larger increases in SBP than those higher in relative status, both t(161) = 3.8, p < .001. There was no effect of partner dominance for participants who were higher status, and no effect of participant relative status for participants with low dominant partners. Hence, the main effects of participant relative status and partner dominance described above were largely attributable to the particularly large increase in SBP associated with the combination of lower relative status and interacting with a high dominant partner. Lastly, there was also a Participant Relative Status × Sex interaction on SBP, F(1, 161) = 4.0, p = .048, η² = .025 (see Figure 3). Mean comparisons revealed that lower relative status evoked greater SBP increases for men, t(161) = 2.4, p = .008, but not women.

For DBP, only the main effect of participant relative status was significant, such that lower status participants showed significantly larger increases in anger than low threat participants (M = 2.78, SE = 0.43 vs. M = 1.41, SE = 0.41), F(1, 161) = 5.39, p = .022, η² = .033.

Participants interacting with high dominance partners reported larger increases in state anger than those interacting with low dominance partners, F(1, 161) = 20.4, p < .001. However, this effect was not significant when Impact Message Inventory ratings of partner warmth were controlled in analysis of covariance, and partner warmth was inversely associated with state anger change, F(1, 161) = 19.7, p < .001.
larger increases in DBP ($M = 14.4$ mmHg, SE = .62 vs. $M = 11.1$ mmHg, SE = .84), $F(1, 161) = 15.87, p < .001, \eta^2 = .092$.

**HR, PEP, and hfHRV.** For HR, the main effect of participant relative status was not significant, but both partner dominance and evaluative threat significantly affected changes in HR. Participants with high dominant partners had greater increases in HR than did participants with low dominant partners ($M = 18.9$ bpm, SE = 1.2 vs. $M = 9.8$ bpm, SE = 1.7), $F(1, 161) = 25.74, p < .001, \eta^2 = .142$, and those in the high evaluative threat group displayed greater HR responses than those in the low threat group ($M = 15.7$ bpm, SE = 1.7 vs. $M = 12.2$ bpm, SE = 1.2), $F(1, 161) = 5.79, p = .017, \eta^2 = .036$.

For PEP, the main effects of participant relative status and evaluative threat were not significant. However, there was a main effect of partner dominance, such that interacting with a high dominant partner evoked greater increases in PEP (i.e., greater increases in sympathetic activation) than did low dominant partners ($M = -18.0$ ms, SE = 1.2 vs. $M = -15.4$ ms, SE = 1.5), $F(1, 150) = 3.53, p = .035$. These main effects were qualified by a Partner Dominance $\times$ Evaluative Threat interaction, $F(1, 150) = 3.98, p = .048, \eta^2 = .026$ (see Figure 5a). High (vs. low) evaluative threat resulted in decreased hfHRV only when interacting with a high dominant partner, $t(150) = 2.79, p = .003$, and interacting with a high (vs. low) dominant partner resulted in decreased hfHRV only in the high evaluative threat group, $t(150) = 3.53, p < .001$.

**Salivary cortisol.** There were no main effects of the manipulated variables on change in salivary cortisol, but there was a significant Partner Dominance $\times$ Evaluative Threat interaction,

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3 There was a small main effect of participant relative status on diastolic blood pressure (DBP) during recovery, $F(1, 161) = 4.0, p = .047, \eta^2 = .025$; lower status resulted in higher sustained DBP responses ($M = 4.0$ mmHg, SE = 0.57 vs. $M = 2.4$ mmHg, SE = 0.59). For both systolic blood pressure (SBP) and DBP, there was a significant Participant Relative Status $\times$ Sex interaction, $F(1, 161) = 6.80, p = .01, \eta^2 = .042$, and $F(1, 161) = 5.67, p = .035, \eta^2 = .035$, respectively. For SBP, low relative status men displayed higher SBP than high relative status men ($M = 13.2$ mmHg, SE = 0.57 vs. $M = 8.2$ mmHg, SE = 0.59); $t(161) > 2.4, p < .01$, but this effect was not significant for women ($M = 7.3$ mmHg, SE = 0.57 vs. $M = 8.3$ mmHg, SE = 0.59). Similarly for DBP, low relative status men displayed higher DBP than high relative status men ($M = 5.4$ mmHg, SE = 0.57 vs. $M = 1.8$ mmHg, SE = 0.59); $t(161) > 2.4, p < .01$, but this effect was not significant for women ($M = 2.6$ mmHg, SE = 0.57 vs. $M = 3.0$ mmHg, SE = 0.59).
Overall, results supported the viability of multiple interpersonal pathways from low SEP to psychophysiological processes related to disease development. Lower perceived relative status resulted in greater increases in SBP and DBP. Interacting with a more dominant partner, an experience that is more common for individuals lower in SES (Gallo et al., 2006), resulted in greater increases in SBP and HR, as well as larger decreases in PEP and hFHRV. These latter effects suggest that interactions with a more dominant partner evoke both greater sympathetic activation and greater withdrawal of parasympathetic activity. Finally, higher levels of social—evaluative threat evoked larger increases in HR and marginally larger increases in SBP.

These aspects of the social context of low SEP also had synergistic effects on physiological responses in several instances. Specifically, high levels of partner dominance combined with low relative social status produced particularly large increases in SBP, and the combination of high evaluative threat and dominant partner behavior produced particularly large decreases in parasympathetic activity and large increases in salivary cortisol. Hence, both lower relative status and high evaluative threat appeared to increase the stress of interacting with a high dominant partner. Similarly, interacting with a more dominant partner appeared to increase the stress associated with social—evaluative contexts and lower relative social status. Thus, some of the unhealthy physiological effects of low SEP may result from combinations of social experiences that are more common in low status contexts. However, of the three aspects of SEP manipulated, partner dominance appears to be particularly important. The number and magnitude of partner dominance effects—both main effects and interactions with the other two aspects of SEP—suggest that displays of dominance may be the most physiologically relevant indicator of SEP during social interactions.

In some instances, effects of aspects of SEP were stronger among men than women. Specifically, lower relative status evoked larger increases in SBP among men but not women, and only men showed greater decreases in PEP (i.e., greater sympathetic activation) in response to dominant interaction partners. These results support prior research in which men have been more physiologically responsive to social hierarchy cues (Newton, 2009), and are consistent with the fact that associations of SEP with health outcomes are sometimes stronger among men than women (Elo, 2009). Such differences may reflect parallel sex differences in social motives and interpersonal behavior, in which men sometimes display more dominance and related competitive striving (Helgeson, 2015).

**Discussion**

The effects of low SEP on subsequent CVD and other health outcomes may involve the mechanism of more frequent, pronounced, and prolonged physiological stress responses (Matthews et al., 2010; Steptoe & Kivimäki, 2013). To test the effects of aspects of SEP on physiological reactivity, the current study manipulated three features of social context related to social hierarchy—perceived social status relative to an interaction partner, the partner’s degree of dominant behavior, and the presence of social—evaluative threat. The experimental manipulations were generally effective, with expected effects on ratings of subjective social status, perceptions of partner behavior, and changes in negative affect. Further, the interaction task evoked substantial cardiovascular and neuroendocrine responses, as well as increases in negative affect. Hence, this experimental analog provides a reasonable test of the effects of aspects of social status on physiological reactivity during social interaction.

**Limitations**

Given that the sample consisted of mostly White, college-aged adults, the current results should not be generalized to other groups. Experiences related to SEP and social hierarchy may have different effects on historically marginalized, older, or less educated groups. For example, the multiple facets and indicators of SEP likely have different implications across racial and ethnic groups (Braveman et al., 2005), and it is possible that groups marginalized on the basis of race may react quite differently to the experimental manipulations of aspects of social rank used here. For racial and ethnic minorities, lower SEP involves overlapping cultural, institutional, interpersonal, and intrapersonal processes.
that likely have strong effects on their prior exposure and characteristic response to the experience of relative status, dominance displayed by others, and social—evaluative threat (Brondolo, Libratti, Rivera, & Walsemann, 2012).

Also, results of the temporary manipulations of aspects of SEP used here might not generalize to the stable differences in SEP that influence health, such as race, income, and education. It will be important to confirm that these experiences do, in fact, occur more frequently in daily life at lower levels of SEP, and to determine the extent to which such daily experiences and their associations with SEP vary across individual (e.g., age, race) and environmental (e.g., urban vs. rural, extent of neighborhood cohesion and social capital) factors. It is important to note that participants in the present study shared an educational institution with interaction partners and may have assumed other socioeconomic similarities, potentially dampening the manipulation of relative status. Again, the greater social distance and potential for interpersonal strain inherent in relative status differences based on racial discrimination may limit such presumed similarities (Brondolo et al., 2012), quite possibly altering the effects of the experimental manipulations used here.

The effects of social—evaluative threat in the current study were somewhat weaker than those in some prior studies (Lam & Dickerson, 2013), perhaps because the procedure resulted in a weaker manipulation of the construct. For example, evaluators were purportedly rating both members of the dyad. This may have been less stressful than circumstances where individuals are the sole focus of evaluation. Further, the impact of this manipulation may have differed by partner dominance, obscuring the overall effect of social—evaluative threat. Participants and partners took opposing sides in a discussion while being evaluated. Hence, participants with high dominant partners may have felt they were “losing,” inducing a sense of being negatively evaluated by the rater; whereas participants with low dominant partners may have felt they were “winning,” inducing a sense of being positively evaluated. The interactive effects of evaluative threat and partner dominance on hHRV and salivary cortisol are consistent with this view. Also, the manipulation of social—evaluative threat used here emphasized competence and intelligence. Threats regarding social inclusion (e.g., rejection, ostracism, exclusion) are also a likely component of low SEP, and can have similar physiological effects (Smith & Jordan, 2015). However, threats regarding social inclusion may combine differently with other aspects of SEP (e.g., relative status) in influencing physiological responses.

Additionally, as previously stated, the partner dominance manipulation could have been more exact; participants reported perceiving their partners as not only more dominant but also less warm and friendly. This limitation was addressed by repeating all analyses as ANCOVAs, controlling partner warmth and reporting only those effects of partner dominance that were significant after controlling for the unintended manipulation of warmth.

It is important to note that the specific physiological effects of the manipulations varied. Although the effect sizes were moderate in several cases, the somewhat inconsistent pattern across outcomes indicates that replication is clearly warranted. Lastly, the social interactions we studied were well-controlled, and as such were somewhat lacking in ecological validity. For example, the prerecorded partners’ responses were not contingent on the content of participants’ speech, perhaps reducing realism and engagement. The aspects of social status manipulated here may have different effects on physiological response during more naturalistic interactions.

Future Directions

The current study provides evidence that interpersonal interactions and experiences may contribute to the association between SEP and cardiovascular health through the mechanism of physiological reactivity. To the extent that these controlled, laboratory-based interactions resemble interpersonal interactions in daily life, recurring patterns of everyday social experiences (e.g., exposure to social dominance expressed by others, perceptions of low relative status) may be an important pathway linking the broader social context to CVD (Smith et al., 2012). Additionally, these commonly co-occurring aspects of low SEP social contexts appear to combine synergistically to evoke particularly large physiological responses. Hence, it may be important to consider multiple aspects of the social context associated with social hierarchy (e.g., relative rank and exposure to dominance), in order to explicate the effects of SEP on physiological mechanisms and ultimately on disease.

It may also be important to examine multiple aspects of stable SEP as they relate to the momentary experiences of SEP studied here. For example, racial group membership and SEP are often overlapping indicators of SEP, in that non-Whites are also more likely to experience lower SEP. Although we did not examine racial differences in this study, differences in racial and ethnic groups can also be conceptualized as reflecting differences in SEP, and the manipulations here may be similarly relevant to the experiences of ethnic minorities. For example, differences in exposure to social dominance may be similar to experiences of discrimination, threats of negative social evaluation are similar to the experiences of stigma and stereotype threat, and perceptions of lower relative social rank when applied to racial groups can be likened to internalizing negative stereotypes and thus perceiving oneself as comparatively lower in relative rank. Hence, each of the manipulations here is theoretically consistent with social experiences thought to contribute to SEP differences in health specifically based on racial group membership (e.g., Blascovich et al., 2001; Pascoe & Smart-Richman, 2009).

In addition to addressing limitations of the present study described previously, future research could extend the current findings to more ecologically valid social interactions and contexts, which better capture the experience of everyday interactions. For example, experimental analogs of low SEP could incorporate less structured social interactions and/or implicit manipulations of multiple, often intersecting aspects of SEP, such as relative social rank and racial group membership. Ambulatory studies of SEP could also incorporate measures of evaluative threat, exposure to dominant social behavior, and perceptions of relative status during interactions in order to examine the frequency and magnitude of these more proximal interpersonal experiences in daily life, as well as their effects on physiological responses believed to link SEP with the development of disease. Such studies of daily life would allow us to test whether health risk is mitigated in individuals who report lower SEP but do not experience increased exposure to the constructs manipulated here (e.g., infrequent experiences of low perceived SEP and exposure to dominance), and could also help illuminate which social contexts are most likely to be associated
with perceived or actual differences in relative social rank (e.g., work vs. home, strangers vs. acquaintances or close others) and exposure to social dominance.

References


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