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Short communication

The role of interpersonal processes in shaping inflammatory responses to social-evaluative threat

Neha A. John-Henderson[a,*], Jennifer E. Stellar[b], Rodolfo Mendoza-Denton[c], Darlene D. Francis[d]

[a] Department of Psychology, University of Pittsburgh, United States
[b] Department of Psychology, University of Toronto, Canada
[c] Department of Psychology, University of California, Berkeley, United States
[d] School of Public Health, University of California, Berkeley, United States

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ABSTRACT

In response to social-evaluative threat induced in the laboratory, lower (compared to higher) subjective social class of a participant predicts greater increases in the inflammatory cytokine interleukin-6 (IL-6). In spite of the interpersonal nature of social-evaluation, little work has explored whether characteristics of the evaluator shape physiological responses in this context. In the current study, in a sample of 190 college students (male = 66), we explored whether one's subjective social class interacts with the perceived social class of an evaluator to predict changes in Oral Mucosal Transudate (OMT) IL-6 in response to the Trier Social Stress Test (TSST). Participants were randomly assigned to be the speaker or the evaluator. Extending past work, we found that while speakers low in subjective social class consistently respond with strong increases in IL-6 regardless of their perception of their evaluator's social class, speakers high in subjective social class responded with greater increases in IL-6 when their evaluator was perceived as high social class compared to when they were perceived as low social class. This finding highlights the importance of perceptions of the evaluator in informing inflammatory responses to a social-evaluative task.

An individual's perceived social standing, or subjective social class, predicts health outcomes (Adler, Epel, Castellazo, & Ickovicks, 2000), psychological well-being (Singh-Manoux, Marmot, & Adler, 2005), physiological responses (Akinola & Mendes, 2013) and markers of inflammation (Saxton, John-Henderson, Reid, & Francis, 2011), independent of objective measures of socioeconomic status (e.g. wealth, occupation). The above examples represent a growing body of research highlighting the role of perceived status in shaping health-related outcomes. They are also in line with evidence suggesting that our sense of self is, in part, informed by where we see ourselves in relation to others (Suls, Martin, & Wheeler, 2002).

Past experimental work demonstrates that low subjective social class individuals exhibit exaggerated increases in plasma interleukin-6 (IL-6), a marker of immune system inflammation (compared to high subjective social class individuals) in response to social evaluation in a laboratory setting (Derry et al., 2013). While inflammation is a critical component of our body's natural defense against infection and injury, chronically elevated levels of inflammation markers are associated with risk for numerous diseases including cardiovascular disease, type 2 diabetes, and some forms of cancer (Ershler & Keller, 2000; Maggio, Guralnik, Longo, & Ferrucci, 2006).

Despite the inherent interpersonal nature of social-evaluative stressors, however, little work has tested how the characteristics of the evaluator, either objective or perceived, influence an individual's stress reactivity or interact with a person's own perceived social class to influence stress reactivity. A growing body of research indicates that perceptions of one's social class within society as a whole, along with relative status in a given context, shape patterns of action and thought (Fiske & Markus, 2012). Given that perceptions of the social standing of the 'other' in a social interaction likely informs relative status, it is plausible that these perceptions influence perceptions of threat and, consequently, shape the dynamics of the interaction. In the present study we use the Trier Social Stress Test (TSST), a classic social-evaluative stressor (Kirschbaum, Pirke,

* Corresponding author at: 4405 Sennott Square, 210 S. Bouquet Street, Pittsburgh, PA 15260, United States.
E-mail address: neha.jh@pitt.edu (N.A. John-Henderson).

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& Hellhammer, 1993) to test if the subjective social class of the speaker interacts with perceptions of the evaluator's social class to predict changes in levels of IL-6.

In the current study we measure levels of IL-6 in Oral Mucosal Transudate (OMT), a filtrate of blood plasma. We note that levels of IL-6 in plasma and those in OMT are only modestly correlated (Fernandez-Botran, Miller, Burns, & Newton, 2011). However, numerous studies have examined these markers in OMT and found localized increases in these inflammatory markers in the mouth following acute social stress (Chiang, Eisenberger, Seeman, & Taylor, 2012; John-Henderson, Rheinschmidt, & Mendoza-Denton, 2015; John-Henderson, Rheinschmidt, Mendoza-Denton, & Francis, 2013; John-Henderson, Stellar, Mendoza-Denton, & Francis, in press; Slavich, Way, Eisenberger, & Taylor, 2010; Weik, Herforth, Kolb-Bachofen, & Deinzer, 2008). The patterns observed resemble the well-documented impact of psychological stress on cellular inflammatory signaling and expression of systemic markers of inflammation (Bierhaus et al., 2003; Pace et al., 2006). Further, given that the mouth plays an important role in immune surveillance and responses, differences in local inflammatory responses to acute social stress could be important, independent of systemic responses (O'Connor, Irwin, & Wellisch, 2009).

1. Participants

One hundred and ninety (66 male, age = 18–34, $M = 19.82$, SD = 1.52, eighty Asian, sixty-nine Caucasian, twenty Latino, nine Middle Eastern, eight African American, and four other) participants were recruited from a public university. They arrived in groups of two, though we ensured none of the participants had met before the experiment.

2. Procedure

Upon arrival, each participant answered questions to gauge his/her perception of the other participant's social class. After completing these measures, participants were randomly assigned to act as either the speaker or evaluator in a modified version of the TSST. There were 95 participant dyads, 55 of which consisted of partners of the same sex.

The participant who was selected as the speaker provided a sample of Oral Mucosal Transudate (OMT) for assessment of baseline levels of IL-6. The experimenter gave the speaker 5 min to prepare a five-minute speech about the qualities that would make them a desirable candidate for a research assistant position. The evaluator was asked to take notes regarding the speaker's performance during the task.

The evaluator watched the speaker give their speech, while the experimenter was seated off to the side out of direct view. The speaker counted backwards out loud by 7's from 2935 for 3 min. During these 3 min, the experimenter prompted them on three occasions to go faster. Thirty minutes after beginning the task, a second sample of OMT was collected. The speaker answered a short series of questions about his/her perception of the evaluator following the task. At the same time, the evaluator completed an evaluation of the speaker's performance on the TSST along with a series of questions about his/her perceptions about the speaker following the task.

3. Measures

3.1. Subjective social class

All participants reported their subjective social class on a scale from 1 (lower class) to 5 (upper class) (speaker: $M = 3.14$, SD = 0.98, evaluator: $M = 3.00$, SD = 1.00; Horberg, Oveis, Keltner, & Cohen, 2009; Stellar, Manzo, Kraus, & Keltner, 2011). Speakers also reported their perception of the evaluator's social class on the same scale ($M = 2.55$, SD = 0.58).

3.2. Inflammation measures

We assessed IL-6 levels in OMT, examining changes in levels of IL-6 in response to the stressful experience of social evaluation. The speaker provided a baseline sample for IL-6 measurement ($M = 1.30$ pg/mL, SD = 0.95). An Orasure collective device (Epitope, Beaverton, OR) was placed between the lower cheek and gum for 2 min. Thirty minutes following the social interaction participants provided a second sample of OMT for measurement of post-stressor IL-6 levels ($M = 2.03$ pg/mL, SD = 1.44). Samples were stored in a −80° freezer until time of analysis. IL-6 concentrations were determined by an enzyme linked immunosorbent assay (ELISA) using commercially available kits (R&D systems, Minneapolis, MN). IL-6 values at baseline and post-task were normalized by log-transformation to correct for skewness.

3.3. Body mass index (BMI)

Participants reported their height and weight, from which BMI was calculated ($M = 21.13$, SD = 3.71).

3.4. Self-reported sleep

Participants reported the average number of hours they slept each night in the week preceding data collection.

3.5. Ethnicity

We created a dummy variable for ethnicity (1 = Caucasian, 0 = Other).

3.6. Gender mismatch

To consider whether being evaluated by an individual of the same sex or of the opposite sex affected post-stressor IL-6, we created a dummy variable, with 0 reflecting participant dyads where the speaker and evaluator were of the same sex, and 1 reflecting participant dyads where the speaker and evaluator were mismatched on gender.

4. Results

A one-way ANOVA revealed that there were no significant differences between speakers and evaluators in sex, ethnicity, or subjective social class, indicating that random assignment was successful, $F(1,185) = 0.65$, $p = 0.42$, $F(1,188) = .15$, $p = 0.70$, and $F(1,187) = 0.14$, $p = 0.71$, respectively.

Lower subjective social class was associated with higher baseline levels of IL-6 ($r = -0.46$, $p < 0.001$). We did not observe baseline differences in IL-6 as a function of race or gender. We found that participants' perceptions of evaluator social class and the evaluators' actual social class were not significantly correlated, $r = -0.09$, $p = 0.41$, indicating a significant discrepancy between the self-reported subjective social class of the evaluator and the speakers' perceptions.

In the following results we test whether perceptions of the evaluator's social class (independent of the self-reported subjective social class of the evaluator) interact with the speaker's subjective social class to predict pro-inflammatory cytokine reactivity during a social-evaluative stressor. Given our primary interest in IL-6

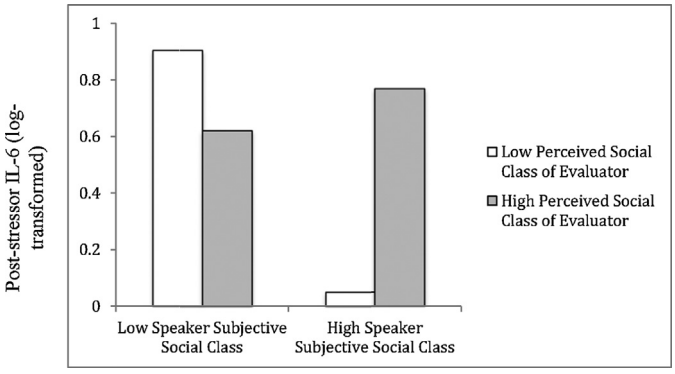

Fig. 1. Speakers' log-transformed post-task levels of IL-6 as a function of subjective social class and perceptions of the evaluator's social class. The means displayed below are adjusted according to listed covariates.

responses to the TSST, post-stressor IL-6 is our dependent variable, while controlling for baseline levels of IL-6.

In a regression model we entered ethnicity, gender, gender mismatch, self-reported sleep, baseline IL-6, BMI and self-reported subjective social class of the evaluator as covariates in step 1, and speaker subjective social class and *perceived* social class of the evaluator and their cross product in step 2. We observed a main effect of baseline IL-6 ($\beta = 0.63$, $t(68) = 7.53$, $p < 0.001$) and speaker subjective social class ($\beta = -0.30$, $t(68) = -3.36$, $p = 0.001$). However, the main effect of speaker subjective social class on post-task IL-6 was qualified by a significant interaction with perceived social class of the evaluator ($\beta = 0.19$, $t(68) = 2.33$, $p = 0.02$; see Fig. 1).

We also conducted simple slopes analyses with our main measures: participant's subjective social class and partner's perceived social class as well as all our aforementioned covariates. We mean centered subjective social class and perceived evaluator social class and found that perceptions of the evaluator's social class did not influence post-task IL-6 levels for participants with low subjective social class (one standard deviation below the mean) because the confidence interval includes zero, $B = -0.09$, $t = 0.97$, CI 95%: −0.29, 10 (Preacher, Curran, & Bauer, 2006). However, the evaluator's perceived social class did positively predict post task IL-6 levels for participants with high subjective social class (one standard deviation above the mean), $B = 0.24$, $t = 2.16$, CI 95%: 0.02, 46. These results suggest that the perceived social class of the evaluator matters for participants with higher subjective social class, but not for those who reported lower subjective social class. In addition, it also suggests that high subjective social class participants had stronger IL-6 responses to partners perceived to also be high in social class compared to low in social class.

5. Discussion

Our current findings demonstrating that lower subjective social class predicts a more pronounced inflammatory response to a social-evaluative stressor are in line with past work (Derry et al., 2013). Extending this research, we found a significant interaction between the speaker's subjective social class and the perceived social class of their evaluator, such that perceptions of the evaluator only shaped inflammatory responses for those high in subjective social class, but not for those low in subjective social class. Further, the findings indicate that individuals who perceive themselves to be of high social class are more significantly affected physiologically by the perception that their evaluator is of equivalently high social class.

Perceptions of the social class of the 'other' may be a particularly important characteristic in social interactions in which an individual is being evaluated. This could be in part because these perceptions inform relative status more strongly than the actual subjective social class of the other. The interactive pattern observed in this research makes sense in the context of recent research indicating that relative social status may be a more powerful informant of physiological outcomes than objective status (Akinola & Mendes, 2013; Archie, Altmann, & Alberts, 2012; Laurence et al., 2011).

We measured changes in levels of IL-6 in OMT; in the future observed patterns in IL-6 levels should also be assessed using plasma to allow for a more direct examination of health processes. However, as noted previously, local inflammatory processes within the mouth may have implications independent of systemic responses (O'Connor, Irwin & Wellisch, 2009). We were unable to account for the role of lifestyle factors, such as diet or exercise, known to affect inflammatory outcomes (O'Connor, Bower, et al., 2009). We did however have a measure of average hours of sleep per night in the week preceding data collection and this was not a significant predictor of baseline or post-task IL-6. Inclusion of this variable as a covariate did not affect the reported results. Relatedly, our measure of BMI reflected self-reported height and weight. Ideally, these measures should be measured directly to avoid over- or underestimation. Further, our sample consisted of young, healthy college students, which limits the generalizability of these findings. As such, future investigations should test these relationships in samples that are more representative of the larger population.

While prior work examining physiological responses to social evaluation has not focused on the role of perceptions of the other, our findings suggest that these perceptions, in combination with an individuals' subjective social class, are important in determining physiological responses to social-evaluation. As such, it will be important for future investigations to explore the role of these factors when considering outcomes associated with social-evaluation.

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