Social Support as a Shaper of our Physiological Responses to Stressors: Implications for the Relationship between Socioeconomic Status and Health

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Abstract

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Theoretical and empirical work suggests that social support is an important predictor of both psychological and physiological responses to stressors. A separate line of research shows that early life socioeconomic status programs physiological responses to stressors later in life. Bridging these two lines of research, I designed a series of studies to examine the ways in which the reception of social support can moderate physiological reactivity and emotional responses as a function of early life experience. In Study 1, I examined these questions in the context of an interpersonal interaction, while Study 2 utilized a social evaluative task. In Study 3, I used the same social evaluative task as in Study 2 and let social support vary freely by using two participants, and randomly assigning one to be the actor, and the other to be the evaluator. I found that early life socioeconomic status in interaction with the presence or absence of social support strongly predicted inflammatory responses (Study 1 and 2) and changes in oxytocin following an interpersonal interaction (Study 1). Finally, in Study 3, I found that perceptions of the evaluator’s subjective social status and the speaker’s subjective social status interacted to predict inflammatory responses. Together these studies show that the significance of social support as a predictor of changes in oxytocin and inflammation varies as a function of the nature of the stressor. In addition, these findings show that with regards to social evaluative threat, the actor’s perception of their evaluator’s social class matters more than their objective social class or that of their evaluator.
Acknowledgments and Dedication

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I would like to dedicate this work to my Mother and Father, Shama and Madhu John. You began shaping this work in my very early days by encouraging my desire to read and by fostering my tendency to question everything relentlessly. You provided, and continue to provide an example of courage in the face of adversity and of exceeding expectations, and most importantly, I believe, an example of extending generosity and compassion to everyone, but in particular to those less fortunate.
Social Support as a Shaper of our Physiological Responses to Stressors: Implications for the Relationship between Socioeconomic Status and Health

Socioeconomic status (SES) is a consistently powerful predictor of health and disease in human populations. The relationship between SES and health, in which individuals at the upper ends of the SES distribution fare better than those below them, has been documented for a striking variety of mental and physical health outcomes including cardiovascular disease (Clark, Desmuelles, Luo, Duncan & Wielgosz, 2009) and depression (Wang, Schmitz & Dewa, 2010). This gradient holds across the life span (Chen, Matthews & Boyce, 2002).

One of the prominent mechanistic hypotheses about how SES exerts its effects on health is by affecting inflammation. While inflammation is a critical component of the immune system’s defense against infection and injury, chronic activation of inflammatory pathways can eventually lead to deleterious health outcomes. Over-activation of these pathways is one specific mechanism by which SES is believed to shape health. Inflammatory cytokines, the product of these pathways, increase in response to acute psychosocial stress (Slavich, Way, Eisenberger, & Taylor, 2010) and are elevated under conditions of chronic stress, such as low SES (John-Henderson, Jacobs, Mendoza-Denton & Francis, 2012). Increases in the inflammatory cytokine Interleukin-6 are associated with acute stressful experiences (John-Henderson, Rheinschmidt, Mendoza-Denton, Francis, 2014), and excessive inflammation, indexed by elevated levels of inflammatory cytokines (e.g. IL-6), is implicated in numerous illnesses including but not limited to, cardiovascular disease, depression, and diabetes (Cesari, Penninx & Newman, 2003; Liu, Ho, & Mak, 2011; Wellen & Hotamisligil, 2005).

The conventional explanations for this relationship (e.g. that the poor have less access to health care and are more likely to engage in behaviors with adverse health implications) fail to fully account for the huge discrepancy in health outcomes (Sapolsky, 2005). Recent research highlights the role of psychosocial stressors associated with poverty. Not only do low SES individuals have a disproportionate share of psychosocial stressors compared to their high SES counterparts, but they are also more likely to feel that they have little to no control over the stressor. Both of these factors further increase the frequency and degree to which they activate the stress response, and may consequently increase their vulnerability to stress-sensitive disease (Sapolsky, 2005).

In particular, early life experiences appear to have powerful and lasting effects on health outcomes later in life (Carroll, Cohen & Marsland, 2011, Chen et al., 2012; Cohen, Janicki-Deverts, Chen, & Matthews, 2010). For example, individuals whose parents owned their homes early in life exhibited genetic profiles indicative of a better regulation of inflammatory responses later in life. This finding was not mediated by current economic circumstances, life stress, or health practices, and could not be undone by changes in SES later in life (Miller & Chen, 2007). These findings suggest that early life SES, independent of current SES and irrespective of social mobility, is a powerful shaper of inflammatory profiles later in life by affecting the expression of genes important to the regulation of inflammation.

While these relationships may paint a bleak picture for individuals born in to low early life socioeconomic environments, recent research provides evidence that some low
SES individuals thrive and demonstrate resilience with regards to health despite confronting the difficulties associated with low SES backgrounds (Chen et al., 2012; John-Henderson et al., 2012). In addition, individual characteristics or situational processes buffer some individuals from the adverse health outcome associated with low SES. Lower levels of implicit social class bias among low SES individuals predicts decreased levels of inflammatory markers (John-Henderson et al., 2012), and individuals from low early life SES backgrounds, who report experiencing high levels of maternal warmth, showed reduced activity of a transcription factor that promotes inflammation in adulthood (Chen, Miller, Kobor & Cole, 2011). Given that inflammation is increasingly implicated in numerous diseases and conditions, these findings suggest that positive early life experiences and positive psychological traits can buffer low SES individuals from vulnerability to adverse health outcomes.

Seeking Social Connection in Response to Stress

The discussion of physiological responses to stressors has been largely focused on the fight-or-flight response. We can choose to confront a stressor head on, or attempt to flee or escape. The fight-or-flight response depends on two coordinating systems, the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenocortical (HPA) axis. Together, these systems allow us to combat or escape from a threat, however, over-activation of these systems can lead to a host of negative health outcomes including hypertension, strokes, severe anxiety, central obesity, and depression (Taylor, 2006).

While this is part of the story, there is a third potential response to a stressor or threat; that is social affiliation, or coming together with another individual or individuals to better cope with the threat. Research from animal and human models indicates that there is in fact a neurocircuitry that prompts affiliative behavior in response to stress. When an individual feels alone or without adequate social connection or support, a biological signaling system is activated that indicates the need for affiliation, and this need is then met through behaviors that increase affiliation. This system is believed to regulate social-approach behavior, in the same way that occurs for other basic needs such as hunger and thirst (Taylor, 2006).

The opportunity to affiliate and the experience of feeling supported may be particularly important for low SES individuals. A growing body of literature supports the idea that low SES individuals are more vigilant to threat in their environments (Kraus, Piff, Mendoza-Denton, Rheinschmidt, & Keltner, 2012). This vigilance is associated with heightened physiological reactivity and also an increased tendency to interpret ambiguous situations as being threatening (Chen & Matthews, 2001). At the same time, as outlined in Kraus et al., 2012, lower SES individuals are more disposed toward prosociality than their high SES counterparts, and are more likely to respond to threatening environments with prosocial or other-oriented behavior. Thus, social connections and social support might be particularly important for these individuals to thrive in and adapt to otherwise threatening and stressful situations.

The Effects of Social Support on Emotional Responses

One potential pathway through which the reception of social support could affect health outcomes is by shaping emotional responses to a stressor. More specifically, when facing a stressor, receiving social support could offer protective effects by increasing the experience of positive emotion while decreasing negative emotions during a stressful situation. Conversely, the lack of a supportive other during a stressful interaction or
situation could heighten negative emotions and reduce positive emotions. Importantly, with regards to the SES-health gradient, emotional responses could differ as a function of both SES and availability of social support in a given situation, and this difference could have important implications in mediating the relationship between SES and health.

**Oxytocin as a Moderator of Physiological Responses**

The hormone oxytocin is believed to be the biological communicator of a deficiency in social affiliation or support. Its release is believed to promote social contact for one’s own protection from the threat. In other words, oxytocin levels rise as a reflection of social distress resulting from lack of social connection or affiliation. For example, one study found that women who reported dissatisfaction with their social relationships exhibited elevated levels of oxytocin (Taylor, 2006).

In animal models, exogenous administration of oxytocin has been related to increases in physical proximity and preference for individuals in whose presence the oxytocin was administered (Panksepp, 1998; Taylor, 2002). In humans, intranasal administration of oxytocin increases trust (Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005), eye gaze (Guastella, Mitchell, & Dadds, 2008) and the ability to infer the emotional states of others (Domes, Heinrichs, Michel, Berger, & Herpertz, 2007).

In conjunction with increased positive social contact, oxytocin appears to moderate physiological stress responses. For example, women who report having more physical contact with their partners, and men who receive exogenous oxytocin exhibit reduced byproducts of the physiological stress response coordinated by the SNS and HPA axis (Taylor et al., 2006). Additionally, exogenously administered oxytocin has been shown to induce strong physiological anxiolytic effects, by decreasing levels of cortisol (Heinrichs, Baumgartner, Kirschbaum, & Ehlert, 2003). Importantly, it also promotes the shift of energy toward health promoting internal activities such as wound-healing and may have a protective role in the cardiovascular system, possibly through its anti-inflammatory actions (Knox & Uvnas-Moberg, 1998). In addition, oxytocin may feedback on the nervous system (Taylor, 2002) and may increase an individual’s ability to feel relaxed and safe by downregulating the reactivity of the autonomic nervous system. (Uvnas-Moberg, 1998). All of these properties of oxytocin make it an excellent biomarker for exploring how emotional states and feelings affect physiological processes, and how consequently, positive social interactions could bestow health benefits.

While it appears that oxytocin is capable of attenuating biological responses, these studies rely on exogenous administration of oxytocin, and the majority of studies focus on its effects on cortisol levels. They do not explore the manner in which endogenous levels of oxytocin vary as a function of SES and other psychological traits, nor do they examine changes in endogenous levels of oxytocin in direct response to experiences, or the implications of these changes for the inflammatory response, and consequent health outcomes.

**The Current Research**

Given the research documenting the resilience of some low SES individuals with regards to health outcomes, and given the documented effect of exogenous administration of oxytocin on byproducts of the HPA axis, I designed a series of studies to explore the simultaneous changes in endogenous levels of oxytocin and markers of inflammation in response to stressors as a function of SES. To my knowledge, no research has explored these trajectories simultaneously or how they are affected by social support. I hypothesize
that increases in levels of oxytocin associated with receiving social support, could be
associated with a dampened inflammatory responses to stressors, particularly for
individuals from low SES backgrounds.

To examine changes in levels of inflammation, I focus on changes in the
inflammatory cytokine Interleukin-6 (IL-6). Prior research has shown that brief
naturalistic stressors shift the profile of cytokine production in such a way that increases
levels of the class of cytokines to which IL-6 belongs (Segerstrom & Miller, 2004). As
such, I expected to see rises in IL-6 in response to a social evaluative task. Pro-
inflammatory cytokines such as IL-6 are critical for orchestrating the inflammatory
response to fight against injury or infection. However, if the inflammatory response
becomes persistent or exaggerated it can lead to a host of diseases and conditions.

In this research I measure levels of IL-6 in oral mucosal transudate (OMT).
Inflammation levels in OMT are not a reflection of systemic levels of inflammation and
the majority of research linking inflammation to health outcomes utilizes assessment of
inflammation levels in blood. Recent research exploring the relationship between
inflammation levels in blood and OMT have found inconsistencies between the two
measurements (Fernandez-Botran, Miller, Burns & Newton, 2011). Inflammatory
markers in OMT, however, are affected by social evaluative stress (Dickerson et al.,
2009; John-Henderson et al., 2014). As such, while not a surrogate for systemic levels of
inflammation, levels of inflammation in OMT are nevertheless important.

I simultaneously examine changes in oxytocin as a potential mechanism by which
social support affects physiological change, because of the known links it has to social
connection and support previously outlined. It is important to note that I measure salivary
oxytocin levels, a peripheral measure of oxytocin, and that there is an ongoing debate
about if or how peripheral measures relate to central measures of oxytocin, and
consequently whether peripheral measures hold biological validity. However, there is
some evidence showing correlations between central and peripheral release of oxytocin
(Wotjak, Ganster, Kohl, Holsboer, Landgraf, & Engelmann, 1998), and there are
numerous studies documenting significant relationships between peripheral levels of
oxytocin and pathological conditions, social experiences, and oxytocin receptor
genotypes (Crockford, Deschner, Ziegler, & Wittig, 2014). As such, I predict that
endogenous levels of salivary oxytocin will be sensitive to presence or absence of social
support when facing stressful social interactions.

Study 1

In this study I examined differences in changes in levels of inflammation and
changes in levels of oxytocin in response to a stressful social interaction. Specifically,
participants recounted a negative experience from their past. Through the use of
confederates, half of the participants received social support from their purported partner,
while the other half interacted with a partner that appeared disinterested and did not
provide social support. I examined whether receiving social support differentially
affected physiological responses as a function of socioeconomic status and hypothesized
that individuals from low early life SES backgrounds would be most physiologically
reactive to the presence or lack of social support. I predicted that this sensitivity would be
reflected by heightened inflammatory responses (gauged by post-interaction levels of IL-
6) in the absence of social support, and heightened increases in oxytocin in response to
the reception of social support.
Method

Participants
Seventy-two undergraduate students (22 male) at UC Berkeley participated for partial course credit. Participants were 19.34 years old on average (Range=18-23; SD=1.25). Forty-five participants identified as Asian American, fifteen as Caucasian, five as Latino, four as African American, two as Middle Eastern, and one as other.

Procedure
Participants were randomly assigned to one of two experimental conditions: confederate-supportive or confederate-unsupportive. The participant recounted a negative experience from their past to trained confederates. Three confederates attended training sessions conducted by two experimenters to learn standardized supportive and unsupportive behaviors. Confederates were given a list of behaviors. They were asked to exhibit the following behaviors. In the unsupportive condition the confederates were told to avert their gaze from participant every few seconds, fidget and shift their weight to appear uncomfortable, lean backwards, refrain from nodding and asking questions. In addition the confederates were asked to make a distressed face (tightening of the lips, eyebrows lowered and pulled forward), modeled after Eisenberg et al., 1989. In the supportive condition, participants were asked to maintain eye contact with participant as long as possible, lean forward, make at least two validating comments (e.g. I'm sorry, I understand), ask one question about the event and nod their head. In addition confederates were asked to make noises and expressions that signaled compassion (furrowing in the center of the brow, lower face relaxed, frowning or open) modeled after Eisenberg et al., 1989. At the end of the training session, each confederate was asked to model the list of behaviors and the experimenters observed and gave suggestions as needed. Experimenters watched the confederates during the first week of sessions and gave feedback to further standardize the expressions used during the manipulation.

Participants provided baseline samples of oral mucosal transudate (OMT) and saliva. Next, they were introduced to the confederate through participation in a fast-friends task (Aron, Melinat, Aron, Vaollone, & Bator, 1997), in which the participant and confederate went through a series of notecards with questions to facilitate rapport building. The participant and confederate were seated in chairs facing one another throughout the interaction. The experimenter left the room at the beginning of the fast-friends task and monitored the interaction while waiting in the control room next door. To standardize the experience of the participant across conditions, the confederate responded to questions with previously scripted answers.

After three minutes of social interaction, the participant completed the first set of surveys to assess initial impressions of the confederate, and the confederate was sent to another room where they were purportedly filling out the same survey. Participants reported how much they liked their partner on a scale from 1 (strongly dislike) to 7 (strongly like) (M=4.9, SD=1.05), and how similar they were to their partner on a scale from 1-6 with higher numbers reflecting greater similarity (M=3.66, SD=1.13). As part of the survey, participants were given a description of the second social interaction and were asked to briefly describe the negative experience they planned to share with their partner. After completion of the surveys, the confederate returned to the interaction room for the second social interaction.

The experimenter reminded them of the instructions they read in the survey, and
told the participant that they would share their experience first and then would be asked to listen to their partner’s experience. Although the confederate never shared their experience, these instructions were given to decrease suspicion. The speaker was instructed to speak for the full three minutes, and if they stopped before this time, the confederate reminded them of the instructions. After giving instruction, the experimenter left the room and waited in the control room next door where they were able to observe the interaction. By random assignment, participants interacted with either a supportive or unsupportive confederate. The experimenter returned to the interaction room after three minutes and asked the participants to fill out surveys to assess changes in perception of their partner following the task. These questions were embedded in a series of numerous scales to assess other variables of interest.

Twenty-five minutes after the beginning of the second social interaction, the experimenter returned to the room and asked the participant to temporarily stop filling out the survey, and obtained a second salivary sample and OMT sample. At the end of the session, all participants were debriefed.

**Measures**

**Socioeconomic Measures**

**Early life SES.** Participants reported whether their parents owned or rented their home when they were in kindergarten (Saxton, John-Henderson, Reid, & Francis, 2011). In addition, participants were asked to describe their family’s social class position when they were a child, on a scale ranging from 1 (lower class) to 5 (upper class) ($M=2.73$, $SD=1.06$; John-Henderson et al., 2014). These measures were significantly correlated ($r=.45$, $p<.001$).

**Current SES.** Participants reported their parental income on a scale from 1 (US$20,000 and below) to 6 (US$110,000 and above) over the past year ($M=4.27$, $SD=1.90$; Mendoza-Denton, Downey, Purdie, Davis, & Pietrzak, 2002). The MacArthur scale of subjective social status was used to capture subjective SES. A social ladder was presented and participants placed an “X” on the rung on which they felt they stood relative to the rest of the population in the United States ($M=5.74$, $SD=1.82$; Adler, Epel, Castellazo & Ickovics, 2000). In addition, subjective social class was indexed on a scale from 1 (poor) to 7 (upper class) ($M=3.14$, $SD=1.03$; John-Henderson et al., 2014).

**Coded Stress**

Three observers were shown videos of the participant during the interaction and asked to code for overall stress by reporting how stressed the participant appeared (0=not stressed at all, 1=slightly stressed, 2=somewhat stressed, and 3=very stressed). Observers were trained by watching four videos together in the presence of the two experimenters and discussed what behaviors constituted stress. All observers coded the first twenty files and showed high reliability (ICC=.78). Therefore after coding the first twenty files only one observer coded the videos for each of the remaining participants.

**Health Measures**

**Inflammation measures.** Levels of IL-6 were assessed in OMT. Prior research characterizes increases in IL-6 specifically in response to stressors as indicative of an inflammatory response (Dickerson et al., 2009; Slavich, et al., 2010). In line with the pre to post-stressor design used in these studies, changes in levels of IL-6 in response to the stressful experience of recounting a negative experience were determined.
Participants provided a baseline sample for IL-6 measurement ($M = .96$ picograms/milliliter, $SD = 0.83$). An Orasure collective device (Epitope, Beaverton, OR.) was placed between the lower cheek and gum for two minutes. Twenty five minutes following the social interaction, participants provided a second sample of OMT for measurement of post-stressor IL-6 levels ($M = 1.59$ pg/mL, $SD = 1.33$). The samples were frozen and stored at -80°C. IL-6 concentrations were determined by an enzyme linked immunosorbent assay (ELISA) using commercially available kits (R&D systems, Minneapolis, MN). As in previous research (Saxton et al., 2011; Kielcot-Glaser et al., 2003), raw IL-6 baseline (skewness = 2.51 SE =0.30) and activation (skewness = 1.24 SE = 0.30) values were normalized by log-transformation.

**Salivary oxytocin levels.** Oxytocin (OT) is a neuropeptide that is produced primarily in the hypothalamus. OT is implicated in social behaviors, including social bonds and the management of stressful experiences. OT is reactive to stressors, and exogenous administration of oxytocin modifies immune function. Reproducible changes in salivary oxytocin are documented as a function of experience, supporting the use of saliva as a noninvasive method of monitoring changes in this hormone (Carter et al., 2007). A passive drool sample of saliva was obtained at the beginning of the session to assess baseline levels of oxytocin ($M=2.39$, $SD= 0.89$) and twenty five minutes after the social interaction to assess changes in oxytocin ($M=2.17$, $SD=0.70$) in a previously frozen 2 mL cryovial. Immediately following collection, the cryovial was returned to the freezer where it remained until analysis.

**Body mass index (BMI).** Participants reported their height and weight, from which we calculated their BMI ($M = 22.24$, $SD = 3.71$), using the formula: $[(\text{weight in pounds} \times 703) / (\text{height in inches})^2]$. I used BMI as a covariate for the analyses specifically related to inflammation, given its relationship with baseline levels of IL-6 in previous research (Khaodhiar, Ling, Blackburn & Bistrian, 2004).

**Beck depression inventory (BDI).**
A 21 question multiple choice self-report inventory used to assess depressive symptoms was included in the survey ($M=7.6$, $SD=3.2$; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961).

**Emotion**

**Subjective emotion.** Participants indicated to what extent they felt each of the following both before and after the interaction: annoyed/irritated, sad, anxious, ashamed, surprise/shock, relaxed/comfortable, failed, excited/enthusiastic, self-conscious, afraid/scared, happy, angry, bored, and embarrassed.

**Severity of Experience**
I coded severity of the experience shared by the participant on the following scale: 1=somewhat distressing, 2=distressing, 3= very distressing. I coded this variable in order to test whether severity of experience was associated with SES ($M=1.19$, $SD=0.62$).

**Results and Discussion**
Bivariate relationships between study variables are shown in Table 1.

**Social Support, Early Life SES and Inflammation**
To test for main effects of early life SES and social support condition on log-transformed IL-6 levels, current parental income and baseline IL-6 levels were entered into step 1 of a multiple regression analyses as control variables, and early life SES and
social support condition were entered into step 2. Social support condition was a significant independent predictor of post-stressor IL-6 levels ($\beta = -.18$, $t(61)= -2.05$, $p=.04$.) This relationship was in the predicted direction, with the unsupportive condition predicting greater post-stressor IL-6 levels. Early subjective SES was not a significant independent predictor of post-stressor IL-6 levels ($\beta = -.15$, $t(61)= -1.37$, $p=.18$). The model was significant $F(2,61)=40.10$, $p<.001$ and explained 56% of the variance in post-stressor IL-6 levels.

To test for interactive effects, in step 3, I entered the interaction term of social support condition and early SES. Importantly, the main effect of social support condition on post-stressor IL-6 levels was qualified by this significant interaction (See Figure 1: $\beta = .23$, $t(61)=2.01$, $p=.05$). The overall model was significant $F(5,61)=20.94$, $p<.001$ and explained 62% of the variance in post-stressor IL-6 levels. Simple slope analyses revealed a negative relationship between early life SES and inflammation only in the unsupportive condition (unsupportive: $\beta = -.48$, $t(57)= -4.84$, $p<.001$, supportive: $\beta = -.13$, $t(57)=1.13$, $p=n.s.$).

**Subjective SES and Inflammation**

The MacArthur measure of subjective social status was a significant predictor of post-interaction IL-6 ($\beta = -.31$, $t(57)= -2.56$, $p<.05$). The interaction between this measure and social support condition was non significant.

**Social Support, Parental Income and Inflammation**

To test for main effects of parental income and social support condition on post-interaction IL-6 levels, early SES and baseline IL-6 levels were entered into step 1 of a multiple regression analyses as control variables, and current parental income and social support condition in step 2. Social support condition was a significant independent predictors of post-interaction IL-6 levels ($\beta = -.17$, $t(59)= -2.06$, $p=.04$) while parental income was not ($\beta = -.06$, $t(59)= -0.53$, $p=.60$). The overall model was significant $F(4,61)=23.88$, $p<.001$, and explained 63% of the variance in post-interaction IL-6 levels.

To examine interactive effects of parental income and condition on post-interaction levels, in step 3 I added the interaction term to the model. The interaction was not significant ($\beta = .18$, $t(59)= -1.54$, $p=.13$). This model remained significant $F(5,61)=20.04$, $p<.001$ and explained 64% of the variance in post-interaction IL-6 levels.

**Social support, SES and Oxytocin**

To test for main effects of early life SES and social support condition on post-interaction oxytocin levels, baseline oxytocin levels were entered into step 1 of a multiple regression analyses as control variables, and early life SES and social support condition were entered into step 2. Social support condition was a significant independent predictor of post-interaction oxytocin ($\beta = .31$, $t(59)=2.88$, $p=.01$). Neither current parental income nor early subjective SES were predictors of post-interaction oxytocin ($\beta = .31$, $t(59)=2.88$, $p=.01$). This model was significant $F(4,61)=8.05$, $p<.001$.

In step 3, the interaction term of social support condition and early subjective SES was entered. The main effect of social support condition on post-interaction oxytocin levels was qualified by a significant interaction between social support condition and early life subjective SES (see Figure 2, $\beta = -.30$, $t(57)= -2.11$, $p=.04$).

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1 These findings remained the same using a simultaneous regression model.
Simple slope analyses revealed an inverse relationship between early life SES and oxytocin only in the supportive condition (supportive: $\beta = .76$, $t(61)= 3.63$, $p< .01$; unsupportive: $\beta = .13$, $t(61)= 0.61$, $p = .54$). The overall model was significant $F(4,61)= 8.04$, $p<.001$ and explained 38% of the variance in post-interaction oxytocin levels.

Oxytocin and IL-6

Our two physiological dependent measures IL-6 and Oxytocin were not significantly related to one another ($r=.17$, $p=.26$).

Emotion

Before examining whether self-report emotions following the social interaction differed across conditions, we conducted an exploratory factor analysis (EFA). First, I conducted a principal components analysis with varimax rotation including all of the self-report emotions. Three factors were extracted. The total variance accounted for by these three factors was 69.77%. Communality values were well defined by this factor solution, with all variables exceeding .45. Loadings of variables on factors are reported in Table 2. Loadings under .40 were left blank. The first factor appears to measure ‘negative withdrawal emotions’ and the second factor appears to measures positive emotions and the third appears to measures ‘negative approach emotions’.

Next, I examined whether there were significant interactive effects between early SES and condition in predicting negative withdrawal emotional responses (factor 1). There was no significant interaction between early SES and condition in predicting negative withdrawal emotions ($\beta = -.23$, $t(58)=-1.40$, $p=.16$). Next, I tested for main effects of early SES and social support condition on negative withdrawal emotions. The main effect of early SES was non significant. ($\beta = .08, t(58)=.64, n.s.$). However, there was a significant main effect of condition on negative withdrawal emotions, with greater report of negative withdrawal emotions in the no support condition (no support: $M=3.36$, $SD=2.05$, support $M=2.24$, $SD=1.21$, $t(62)=2.69$, $p=.009$).

I then tested for interactive effects between early SES and condition on positive emotion responses (factor 2). There was no significant interaction between early SES and condition in predicting positive emotion responses to the interaction, ($\beta = .01, t(58)=.024$, $p=.98$). There was no significant main effect of early SES on positive emotion responses ($\beta = .05, t(58)=.36$, $p=.72$), however there was a significant main effect of condition on positive emotion responses, with the support condition predicting greater positive emotion responses (support: $M=3.90$, $SD=1.88$, no support: $M=2.90$, $SD=1.75$, $t(62)=2.19$, $p=.03$).

Next, I tested for interactive effects between early SES and condition in predicting negative approach emotions (factor 3). The interaction was not significant ($\beta = -.04$, $t(58)=-.29$, $p=.77$). There was no significant main effect of early SES on negative approach emotions ($\beta = -.03$, $t(58)=-.22$, $p=.83$), however there was a significant main effect of condition on negative approach emotions with greater report of negative approach emotions in the no support condition (support: $M=1.64$, $SD= 0.66$, no support: $M=3.40$, $SD=1.76$, $t(62)=5.35$, $p<.001$.)

Finally, I tested for significant relationships between the 3 emotion factors and post-interaction levels of IL-6, controlling for baseline levels of IL-6. There was no significant relationship between post-interaction IL-6 and negative withdrawal emotions

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2 These findings remained the same using a simultaneous regression model.
(factor 1) or negative approach emotions (factor 2) ($r'_{s \leq 0.13}$, n.s.). However, there was a significant relationship between positive emotions and post-interaction levels of IL-6 ($r = -0.27, p = .03$), indicating an association between greater report of positive emotions following the interaction and lower levels of post-interaction IL-6.

**Coded Stress**

The interaction between early SES and social support condition on coded overall stress of the participant was non significant ($\beta = -0.06, t(53) = -0.36, p = .72$.) The main effect of early SES on overall coded stress was not significant ($\beta = -0.06, t(55) = -0.43, p = .67$). However, there was a significant main effect of condition on overall coded stress with greater stress coded in the no support condition (support: $M = 0.81$, $SD = 0.73$, no support: $M = 1.57$, $SD = 0.77$, $t(57) = 3.94, p < .001$).

**Discussion**

In Study 1, I found that early life SES, in interaction with social support condition, independent of current SES, predicts both inflammatory responses to a stressful interpersonal interaction and changes in levels of salivary oxytocin. As mentioned in the results, post-task levels of oxytocin and IL-6 were not significantly correlated. As such, I examined oxytocin and IL-6 as parallel outcome variables.

Interestingly, in line with prior research (John-Henderson et al., 2014), here it was participant’s early life SES (not current SES) that interacted with the presence or absence of social support in the face of a stressor to predict physiological responses. This finding contributes to the growing literature that highlights the importance of early life experiences in shaping health outcomes across the life course.

While a measure of trait use of reappraisal and suppression in regulation of emotion was collected, there were not measures to capture the individual experience during the interaction, including the emotions they experienced. In addition, no significant relationships between post-task levels of oxytocin and IL-6 and the coding of emotional and behavioral responses emerged.

**Study 2**

Prior research has shown that contexts in which the self can be judged negatively by others (i.e. social-evaluative threat or SET), elicit increases in inflammatory cytokine activity (Dickerson, Gable, Irwin, Aziz & Kemeny, 2009). In this study, participants completed the Trier Social Stress Test (TSST), a combination of procedures that reliably induces stress in human participants (Dickerson & Kemeny, 2004) while being evaluated by two research assistants. This task consists of an anticipatory five minute period during which the participant prepares a speech, a five minute speech delivery period, and a three minute arithmetic task.

The purpose of this study is two-fold. The focus remains on variations in physiological responses to stressors as a function of SES and social support. First, I extend the findings from Study 1 by changing context to an experience of explicit social evaluation. In Study 1, participants believed that their partner would also be sharing an experience, and while social interactions always involve a certain degree of evaluation, they were not explicitly told that their partner would be evaluating them. Secondly, I hope to elucidate the mechanism through which receiving social support moderates the stress response for low SES individuals. While the initial findings from Study 1 demonstrate that for low SES individuals, receiving social support during a stressful social interaction strongly attenuates post-stressor levels of inflammation, I am unable to
say what emotions were experienced during the interaction in response to our manipulation of social support.

**Method**

Upon arriving, participants provided a baseline sample of OMT and saliva and were subsequently randomly assigned to one of three conditions, the no audience TSST or control condition, the negative audience TSST, or the friendly TSST. After completion of the TSST, participants provided a post-stressor sample of OMT and saliva. Finally, each participant completed a battery of surveys to collect demographic information, and assessments of emotions they experienced during the task, assessment of strategies they used to manage stress during the task, and measures of their perception of the evaluator.

**Participants**

One hundred and sixteen undergraduate (46 male; age=18-31, \( M=19.34 \), \( SD=1.35 \)) students participated for partial course credit. Forty-three participants identified as Asian-American, thirty nine as Caucasian, nineteen as Latino, eight as middle eastern, five as other, and one as Native American.

**Procedure**

After providing informed consent, participants provided baseline samples of OMT and saliva and completed baseline measures of self-esteem and emotion before completing the TSST in front of trained research assistants who acted as evaluators. The research assistants ranged in age from 19-26. The evaluators were asked to report the current annual income of their parents of their parents on a scale from 1 (US$20,000 and below) to 6 (US$110,000 and above), \( (M=4.5, SD=1.5) \).

The evaluators attended a training session with two experimenters. In the unsupportive condition evaluators were told to keep their expression neutral, sigh once to signal exasperation, lean backwards and cross arm, look at the other evaluator disapprovingly, look around as if bored or distracted, write notes when participant made a mistake, pinch eyebrows together to look skeptical at least two times, and not to smile or nod their head at any point. In the supportive condition, evaluators were told to smile, nod their head repeatedly, make one validating noise (e.g. *Uh huh* or *ooh*), lean forward, write notes when participant makes a good point, look at other evaluator approvingly, and make compassionate facial expressions during the arithmetic task, modeled after Eisenberg et al., 1989 (see Study 1 for more details), and not to cross their arms at any point. During the training session, the experimenters asked the evaluators to perform the behaviors required in each condition and gave feedback. The experimenters watched the evaluators during the first few experimental sessions and gave further feedback to ensure that the behaviors were standardized. During the sessions the evaluators had the behaviors listed on a sheet as a reminder during the task on the clipboard that they were purportedly taking notes on.

Each participant had five minutes to prepare a speech focusing on the qualities they have that would make them a desirable candidate for a job. After the preparation period, the participant delivered their speech for 5 minutes in one of the three conditions described below.

**Control Condition of TSST**

In the control (no audience) condition, the participant spoke while standing and facing a video camera. The experimenter sat off to the side, out of direct view of the participant. The only interaction the experimenter had with the participant during the
speech was to remind them that they needed to keep speaking for the entire five minutes if they stopped prematurely.

**Negative condition of TSST**

The participant spoke while standing and facing two trained research assistants acting as evaluators who remained seated during the entire task. The experimenter left the room once the speech began and waited in the control room next door where they observed the speech through video recording. The only interaction the experimenter had with the participant during the task was to remind them over the intercom to continue to speak for the full five minutes if needed. The evaluators exhibited the behaviors previously described for this condition.

**Friendly Condition of TSST**

The setup in this condition was the same as in the negative condition previously described. The evaluators exhibited the behaviors described for the friendly condition.

**Arithmetic Portion of Trier Social Stress Test**

After five minutes of speaking, the experimenter stopped the speaker and gave them the following instructions:

*Please count backwards out loud by 7’s from 2,935 for three minutes. Please continue for the full three minutes regardless of whether you feel you made a mistake or not.*

The evaluators remained seated facing the speaker during this task while observing their performance. During this portion of the task, the experimenter stood to the side of the speaker and urged them to go faster at the following times during the three minutes. After thirty seconds, the experimenter said “You need to try and go faster”. One minute after this prompt, the experimenter said “Please go faster”. Finally, after another minute, the experimenter said “It is important that you go faster”. This script was followed regardless of the speed or accuracy of the speaker. If the speaker stopped prematurely the experimenter reminded them that they needed to continue for the full three minutes.

Following completion of the TSST, participants provided a post-stressor OMT and saliva sample and completed surveys to assess which emotions they experienced during the task and to assess their perceptions of the evaluators.

**Manipulation check**

To ensure that the manipulation of social support was successful in both audience conditions, participants were asked about their perceptions of the evaluators. Participants in the friendly condition reported that their evaluators were significantly more supportive ($M$=3.97, $SD$=1.52) than the participants in the negative condition ($M$=1.91, $SD$=0.73, $t(51)=-6.00$, $p<.01$).

**Measures**

**Socioeconomic Measures**

**Early life SES.** Participants reported whether their parents owned or rented their home when they were in kindergarten (Saxton et al., 2011). In addition, participants were asked to describe their family’s social class position when they were a child, on a scale ranging from 1 (lower class) to 5 (upper class) ($M$=3.07, $SD$=1.03; John-Henderson et al., 2014). These measures were significantly correlated ($r=.35$, $p<.001$).

**Current SES.** Participants reported their parental income on a scale from 1 (US$20,000 and below) to 6 (US$110,000 and above) over the past year ($M$=4.60,
SD=1.80; Mendoza-Denton et al., 2002). The MacArthur scale of subjective social status was used to capture subjective SES (M=5.63, SD=1.70; Adler et al., 2000). In addition, subjective social class was indexed on a scale from 1 (poor) to 7 (upper class) (M=3.11, SD=1.00; John-Henderson et al., 2014).

**Health Measures**

**Inflammation measures.** IL-6 levels in OMT were measured. In line with the pre to post-stressor design used in these studies changes in levels of IL-6 in response to the stressful experience of social evaluation were determined.

Participants provided a baseline sample for IL-6 measurement (M = .98 picograms/milliliter, SD = .53). An Orasure collective device (Epitope, Beaverton, OR.) was placed between the lower cheek and gum for two minutes. Twenty five minutes following the social interaction, participants provided a second sample of OMT for measurement of post-stressor IL-6 levels (M = 1.81 pg/mL, SD = 0.99). The samples were frozen and stored at -80°C. IL-6 concentrations were determined by an enzyme linked immunosorbent assay (ELISA) using commercially available kits (R&D systems, Minneapolis, MN). As in previous research (Saxton et al., 2011; Kielcet-Glaser et al., 2003), raw IL-6 baseline (skewness = 2.51 SE = .30) and activation (skewness = 1.24 SE = .30) values were normalized by log-transformation.

**Salivary oxytocin levels.** A passive drool sample of saliva was obtained at the beginning of the session to assess baseline levels of oxytocin (M=2.73, SD=1.11) and twenty five minutes after the social interaction to assess changes in oxytocin (M=2.42, SD=1.03) in a previously frozen 2 mL cryovial. Immediately following collection, the cryovial was returned to the freezer where it remained until analysis.

**Body mass index (BMI).** Participants reported their height and weight, from which I calculated their BMI (M = 24.34, SD = 3.21), using the formula: [(weight in pounds * 703) / (height in inches)^2].

**Beck depression inventory (BDI).**

A 21 question multiple choice self-report inventory used to assess depressive symptoms was included in the survey. (M=8.2, SD=3.2; Beck et al., 1961).

**Emotion**

**Subjective emotion.** Participants indicated to what extent they felt each of the following both before and after the interaction: annoyed/irritated, sad, anxious, ashamed, surprise/shock, relaxed/comfortable, failed, excited/enthusiastic, self-conscious, afraid/scared, happy, angry, bored, and embarrassed.

**Coded Stress**

Four independent trained research assistants coded how stressed or anxious the participant appeared using the following scale: 0=not stressed at all, 1=slightly stressed, 2=somewhat stressed, 3=very stressed. The inter-rater reliability was high (ICC=.75).

**Results and Discussion**

**Manipulation Check**

To determine whether our manipulation of support was successful I tested whether reported stress differed significantly across conditions. Participants in the no support condition reported significantly greater stress than participants in the support condition (no support: M=3.61, SD= 0.78, support: M= 3.10, SD=1.04, t(52)=1.97, p=.05).

**Social Support, SES, and Inflammation**
I conducted a regression with the control and social support conditions (dummy coded), our standardized version of early subjective SES, and two interactions (early ses x dummy coded social support condition and early SES x dummy coded control condition) predicting post-task levels of IL-6, controlling for baseline levels of IL-6. In this model our interaction terms compare the social support condition to the no support condition, and the control condition to the no support condition. I found a significant interaction for the social support and early SES interaction term ($B=.36$, $t(98)=2.49$, $p=.01$, but not for the interaction term for early SES and the control condition ($B=.07$, $t(98)=0.44$, n.s.).

There was no significant interaction in the same regression when using current SES as a predictor, therefore I do not refer to current SES again in these analyses.

Since I had a priori contrast in mind, I broke the sample into two comparisons to examine interactions further.

**Contrasts Between No Support and Other Conditions.**

**No Audience vs. no support condition.** First, I compared the no audience (control) condition to the no social support condition. To test for main effects of early life SES and social support condition on log-transformed IL-6 levels, current parental income and log-transformed IL-6 levels were entered into step 1 of a multiple regression analyses as control variables, and early life SES and social support condition (control and non supportive condition) in step 2. Both main effects were significant (social support condition: $\beta=-.32$, $t(72)=-3.02$, $p<.01$, early life SES: $\beta=-.45$, $t(72)=-3.80$, $p<.001$). To test for interactive effects between early life SES and social support condition the interaction term was added to the model. The interaction term was non-significant ($\beta=.07$, $t(72)=.36$, $p=n.s.$).  

**No Support vs. Support condition.** To test for main effects of early life SES and social support condition on log-transformed IL-6 levels, current parental income and baseline IL-6 levels were entered into step 1 of a multiple regression analyses as control variables, and early life SES and social support condition (supportive and non supportive condition) were entered into step 2. Social support condition was a significant independent predictor of post-stressor IL-6 levels ($\beta=-1.0$, $t(71)=-5.19$, $p<.001$). This relationship was in the predicted direction, with the no support condition predicting greater post-stressor IL-6 levels. Early subjective SES was a significant independent predictor of post-stressor IL-6 levels ($\beta=-.47$, $t(71)=-2.65$, $p=.01$).

As in Study 1, the main effect of social support condition on post-stressor IL-6 levels was qualified by a significant interaction between social support condition and early SES ($\beta=.23$, $t(77)=2.04$, $p=.05$; see figure 3). The overall model was significant $F(5,71)=3.42$, $p=.01$, and explained 45% of the variance in post-stressor IL-6 levels.

**Simple slopes analyses.** Overall, across all three condition, simple slope analyses revealed a significant negative relationship between early life SES and inflammation in the no support condition (support: $b=-.18$, $t(67)=-2.60$, $p=.01$, and the control condition ($b=-.58$, $t(67)=-6.50$, $p<.001$), but not in the supportive condition ($b=.05$, $t(67)=0.59$, $p=n.s.$). In addition I also found a significant difference among low early life SES individuals between the support and no support condition ($b=.76$, $t(61)=3.63$, $p<.001$).

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3 These findings remained the same using a simultaneous regression model.
However, there were no differences among high SES individuals between the social support and other two conditions ($b's < .05$, $t(67) < .60$, n.s.). Figure 4 shows post-task levels of IL-6 as a function of early life SES and all three social support conditions.

**Post-Task Levels of Oxytocin**

There were no significant interactions between early life SES and condition in predicting post-stressor levels of oxytocin. Correlations between early life SES and post-task levels of oxytocin across conditions are presented in Table 3.

**Self-reported Post-task Emotion**

Before examining whether self-report emotions following the TSST differed across conditions, I conducted an exploratory factor analysis (EFA). First, I conducted a principal components analysis with varimax rotation including all of the self-report emotions. Three factors were extracted. The total variance accounted for by these three factors was 79%. Communality values were well defined by this factor solutions, with all variables exceeding .45. Loadings of variables on factors are reported in Table 4. The first factor appears to measure ‘negative withdrawal emotions’ and the second factor appears to measures ‘negative approach emotions’ and the third factor reflects positive emotions.

After conducting the EFA, I tested the interaction between social support conditions and early SES on negative withdrawal emotions and found that the interactions were not significant (support condition: $\beta = .04$, $t(80) = .19$, $p = .85$, control condition: $\beta = .06$, $t(80) = 0.29$, $p = .77$). I then tested for a main effect of early SES on negative withdrawal emotions and found that it was also not significant ($\beta = -.003$, $t(89) = -0.03$, $p = .98$). Using a one way analysis of variance I tested for main effect of condition on negative withdrawal emotions and found that there were significant differences between groups $F(2,90) = 6.15$, $p < .01$. Testing for contrast effects revealed that self-report of negative withdrawal emotions was significantly higher in the no support condition compared to the support condition (no support: $M=4.63$, $SD=2.60$, support: $M=3.05$, $SD=1.58$, $t(88)=2.78$, $p = .01$. However, there was no significant difference between the no support condition and the control condition ($t(88)=0.05$, $p = .96$).

Next, I tested the interaction between social support conditions and early SES on negative approach emotions. As with negative withdrawal emotions, there were no significant interactions (support condition: $\beta = -.06$, $t(84) = -0.29$, $p = .77$, control condition: $\beta = -.09$, $t(84) = -0.42$, $p = .67$). The main effect of early SES on negative approach emotions was not significant ($\beta = .08$, $t(89) = 0.76$, $p = .45$). Finally, I tested for a main effect of condition and found there was a significant difference across conditions $F(2,90) = 3.25$, $p = .04$, however none of the a priori contrasts were significant (no support/support: $t(88)=1.77$, $p = .08$; no support/control: $t(88)=0.44$, $p = .66$).

As with negative withdrawal and negative approach emotions, the interactions between early SES and social support condition on self-report of positive emotions were not significant (support: $\beta = -.02$, $t(84) = -0.11$, $p = .91$, control: $\beta = .06$, $t(84)=0.28$, $p = .78$). The main effect of early SES on positive emotions was not significant ($\beta = .04$, $t(89)=.35$, $p = .73$). The main effect of condition on positive emotions was not significant $F(2,90)=.04$, $p = .96$.

Finally, I tested for significant relationships between the three emotion factors and post-task levels of IL-6, controlling for baseline levels of IL-6. I found that there were no significant correlations.
Coded Stress

I conducted a regression with the standardized early SES term, dummy coded support condition, dummy coded control condition, and the interactions between early SES and the two dummy coded conditions. There were no significant interactions between early SES and conditions, β’s < -.01, n.s. Therefore I examined if there were any main effects of early SES or condition. In a regression predicting coded stress early SES was not a significant predictor, β = -.01, n.s. Furthermore, there was no significant main effect of condition on coded stress.

Discussion

In this study, the inflammation findings paralleled the findings from Study 1. In the new context of a social evaluative threat, individuals from low early life SES backgrounds once again exhibited the greatest levels of post-task IL-6 when they were in the no social support condition. This significant negative relationship between early life SES and post-task levels of IL-6 existed in both the control and no support condition, but disappeared in the support condition.

While the interactive effects of early life SES and social support condition in predicting post-task levels of oxytocin did not emerge as they did in Study 1, there was a significant relationship between early life SES and post-task levels of oxytocin in the social support condition, such that low early life SES was associated with higher levels of post-task oxytocin. This finding has important implications with regards to the potential buffering effects of social support, as it indicates that social support in the face of a stressor is a particularly powerful elicitor of increases in oxytocin for individuals from low early life SES backgrounds. Given what is known about oxytocin and its potential to buffer adverse physiological responses, this is important as it points to social support as a promising intervention strategy for diminishing the association between low early life SES and heightened adverse physiological reactivity to stressors.

Study 3

This study utilized a modification of the standard TSST design used in the previous study. One participant was randomly selected to act as the evaluator, and the other performed the TSST. Each participant was given instructions, and the evaluators were told that they could ask the other participant questions during the task if they felt it was appropriate.

SES varied freely and I focused on the following questions: 1) How accurate are the participants’ assessments of their evaluator’s SES? 2) Will social support offered by the evaluator vary as a function of SES? 3) To what degree do these factors influence changes in inflammation and changes in oxytocin? I predicted that the speaker’s perception of their evaluator’s current SES would be accurate, and would be the strongest predictor of their inflammatory response to the TSST. This prediction was informed by prior research showing that individuals are able to quickly and accurately assess others’ SES (Kraus & Keltner, 2009), and because an individual’s current appearance and behavior is more likely to reflect their current SES compared to their early life SES. Furthermore, I predicted that low current SES evaluators would offer more social support during the task. This prediction was based on research indicating that lower SES is associated with more prosocial behavior (Piff, Kraus, Cote, Cheng & Keltner, 2010).

Method

Participants
One hundred and ninety (66 male, age=18-34, $M=19.82$, $SD=1.52$) participants were recruited from the Research Participant Pool at U.C. Berkeley. Eighty one participants identified as Asian American, seventy as Caucasian, twenty as Latino, nine as middle eastern, six as African American, and four as other.

**Procedure**

Upon arriving at the lab, both participants were seated next to each other while they provided informed consent. Participants drew a number to determine whether they would be the speaker or the evaluator, however they were not immediately told what the number meant. Each participant then filled out an initial brief survey, in which they were asked questions to gauge their perception of the other participant’s socioeconomic status.

The participant who was selected as the speaker then provided a sample of OMT for assessment of baseline levels of IL-6 and a salivary sample for assessment of baseline oxytocin levels. After this collection, the experimenter provided details of the task in front of both participants. Specifically, they said that the speaker would take five minutes to prepare a five minute speech about the qualities and traits that would make them a desirable candidate for a research assistant position. The experimenter asked the evaluator to continue to fill out demographic surveys. The experimenter left the room during these five minutes and waited in the control room next door where they were able to observe the participants.

After the five minutes of preparation, the experimenter informed the evaluator that following the completion of the task, they would be asked to provide an evaluation of the participant’s performance and asked the speaker to begin their speech. The evaluator was given a clipboard with paper and a pen for note taking during the speech. The experimenter remained in the room seated off to the side and not in direct view of the speaker or evaluator. After five minutes of speaking, the experimenter stopped the speaker and gave them the following instructions:

"Please count backwards out loud by 7’s from 2,935 for three minutes. Please continue for the full three minutes regardless of whether you feel you made a mistake or not”

The experimenter reminded the evaluator that they should continue to observe the speaker’s performance during the task to include in their evaluation of their overall performance on the task. In addition, they told them to allow the speaker to continue regardless of whether they felt they had made a mistake. During this portion of the task, the experimenter stood to the side of the speaker with a stopwatch and urged them to go faster at the following times during the three minutes. After thirty seconds, the experimenter said, “You need to try and go faster.” One minute after this prompt, the experimenter said, “Please go faster.” Finally, after another minute, the experimenter said, “It is important that you go faster.” This script was followed regardless of the speed or accuracy of the speaker. If the speaker stopped prematurely the experimenter reminded them that they needed to continue for the full three minutes.

Following completion of the modified TSST, a second sample of OMT was collected to assess changes in IL-6 levels, and a second salivary sample to assess changes in oxytocin. The speaker answered a short series of questions about their perception of the evaluator following the task. At the same time, the evaluator provided an evaluation of the speaker’s performance on the TSST along with a series questions
about their perceptions about the speaker following the task.

**Measures**

**Socioeconomic Measures**

**Early life SES.** Participants reported whether their parents owned or rented their home when they were in kindergarten (Saxton et al., 2011). In addition, participants were asked to describe their family’s social class position when they were a child on a scale ranging from 1(lower class) to 5(upper class) ($M=3.00, SD=1.02$; John-Henderson et al., 2014). These measures were significantly correlated ($r=.45, p<.001$).

**Current SES.** Participants reported their parental income on a scale from 1 (US$20,000 and below) to 6 (US$110,000 and above) over the past year ($M=4.75, SD=1.90$; Mendoza-Denton et al., 2002). In addition subjective social class was indexed on a scale from 1 (poor) to 7 (upper class) ($M=3.11, SD=.99$; John-Henderson et al., 2014). The MacArthur scale of subjective social status was used to capture subjective SES ($M=5.86, SD=1.70$; Adler et al., 2000).

**Perceived SES of evaluator.** Participants reported their subjective perception of their evaluator’s SES on a scale from 1 (poor) to 4 (upper class) ($M=2.55, SD=.58$; John-Henderson et al., 2014).

**Health Measures**

**Inflammation measures.** As in Study 1 and Study 2, I 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 ($M=1.30$ picograms/milliliter, $SD=.65$). Twenty five 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, $SD=1.44$). Storage and analyses of samples followed same procedures as the first two studies. As in previous research (Saxton et al., 2011; Kielcot-Glaser et al., 2003), raw IL-6 baseline (skewness = 2.51 SE =0.30) and activation (skewness = 1.24 SE =.30) values were normalized by log-transformation.

**Salivary oxytocin levels.** A passive drool sample of saliva was obtained from the speaker at the beginning of the session to assess baseline levels of oxytocin ($M=2.31, SD=.95$) and twenty five minutes following the beginning of the TSST to assess changes in oxytocin ($M=2.40, SD=.95$). Storage and analyses of samples followed same procedures as the first two studies.

**Body mass index (BMI).** Participants reported their height and weight, from which I calculated their BMI ($M=21.13, SD = 3.71$), using the formula: $[(\text{weight in pounds} * 703) / (\text{height in inches})^2]$.

**Beck depression inventory (BDI).** A 21 question multiple choice self-report inventory used to assess depressive symptoms was included in the survey ($M=7.8, SD=3.05$; Beck et al., 1961).

**Emotion**

**Subjective emotion.** Participants indicated to what extent they felt each of the following both before and after the interaction: annoyed/irritated, sad, anxious, ashamed, surprise/shock, relaxed/comfortable, failed, excited/enthusiastic, self-conscious, afraid/scared, happy, angry, bored, and embarrassed.

**Coded Support**

Three independent trained research assistants coded how supportive the evaluator
appeared using the following scale: 0=not supportive at all, 1=slightly supportive, 2=somewhat supportive, 3=very supportive (M=1.32, SD=.86). Prior to coding, the research assistants met with experimenters and viewed four videos while the experimenters pointed out examples of supportive and non supportive behaviors. The inter-rater reliability was high (ICC=.74).

**Results**

**Accuracy of Perceptions of Social Class**

I predicted, based on prior research (Kraus & Keltner, 2009), that participants would be accurate in their perceptions of the other participant’s social class. I found that individuals who placed themselves low on the spectrum of social class perceived their evaluator to be higher than the actual subjective social class of their evaluator, and the converse was true of individuals high on the spectrum of social class, as they tended to perceive their evaluators to be of lower social class than the actual subjective social class of their evaluator (r=.21, p=.058). **Social Support Offered by Evaluator and Social Class**

I predicted that low social class participants would offer more social support during the task, and that the speaker would perceive this difference and report it. However, the findings revealed no significant differences in amount of social support perceived and the social class of the evaluator.

**Subjective Social Class, Perceptions of Evaluator’s Social Class and Post-task IL-6**

To test for main effects, of subjective social class (where would you place yourself on the following spectrum for social class: lower class- upper class) and perceived social class of the evaluator (using same scale) on post-task IL-6 of the speaker, I ran a regression model with these variables controlling for baseline IL-6. I observed a main effect of subjective social class, $\beta = -.27, t(89)= -3.70, p=.001$. Perceived social class of the evaluator was not a significant main effect $\beta = .08, t(89)= 1.09, p=n.s.$ To test for interactive effects, I added the interaction term of the two variables in step 3. The interaction between the two variables was significant $\beta = .15, t (89)=2.14, p = .04$ (See Figure 5).

Simple slopes analyses revealed a significant positive relationship between perceived social class of evaluator and inflammation only for individuals who placed themselves high on the spectrum of social class ($b=.15, t(89)= 2.32, p=.02$). Further simple slopes analyses revealed a significant negative relationship between actor subjective social class and inflammation only when the evaluator was perceived to be of low social class ($b=-.26, t(89)=-5.75, p<.001$).

**Subjective Social Class of Speaker, Subjective Social Class of Evaluator and Post-task IL-6**

To test for main effects of subjective social class of speaker and subjective social class of evaluator in predicting post-task levels of IL-6 I ran a parallel regression analysis. Into the model, I entered baseline IL-6, and subjective social class of speaker and subjective social class of evaluator. There was a significant main effect of speaker subjective social class ($\beta =-.25, t(87)=-3.28, p=.001$).

To test for interactive effects, I entered their interaction term into step 3, however the interaction term was not significant in predicting post-task levels of IL-6 ($\beta =.01$.

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5 These findings remained the same using a simultaneous regression model.
This finding indicates, that while the subjective social class of the speaker is important in predicting their inflammatory response, the actual self reported subjective social class of the evaluator is not significant. Instead, as indicated in the previous model, the speaker’s perception of the social status of the evaluator is significant.

**Subjective Social Class of Speaker, Perceptions of Evaluator’s Social Class and Post-task Oxytocin**

To test for main effects of subjective social class and the speaker’s perception of their evaluator’s social class on post-task levels of oxytocin, I ran a regression model with baseline levels of oxytocin in step 1, and each of these variables in step 2. The main effects of these variables on post-task oxytocin were not significant (actor’s subjective social class: $\beta = -.07, t(85) = -0.66, p = .51$; perceived social class of evaluator: $\beta = .06, t(85) = 0.60, p = .55$).

In step 3, I entered the interaction term of these two variables and found that the interaction was not significant ($B = -.10, t(85) = -.88, p = .38$).

**Subjective Social Class of Speaker, Subjective Social Class of Evaluator and Post-task Oxytocin**

Using a similar model to the one described above, I tested for main effects of subjective social class of speaker and actual subjective social class of their evaluator on post-task levels of Oxytocin. As in the model above, these main effects were not significant (Subjective social class of speaker: $\beta = -.10, t(84) = -1.02, p = .31$; subjective social class of evaluator: $\beta = .02, t(84) = 1.17, p = .86$).

To test for interactive effects of these variables on post-task Oxytocin, in step 3 of this model I entered the interaction term. Once again, this interaction was not significant ($B = -.003, t(84) = -.03, p = .98$).

**Emotion**

I conducted an exploratory factor analysis with varimax rotation on post-task self reported emotions of the speaker. Two factors were extracted. The total variance accounted for by these two factors was 69%. Communality values were well defined by this factor solutions, with all variables exceeding .45. Loadings of variables on factors are reported in Table 5. The first factor measures negative emotions and the second factor measures positive emotions.

After conducting the EFA I tested for significant relationships between the two emotion factors and post-task levels of IL-6, controlling for baseline levels of IL-6. I found that negative emotions (factor 1) were positively related to post-task levels of IL-6 ($r = .21, p = .04$), and positive emotions (factor 2) were negatively related to post-task levels of IL-6 ($r = .20, p = .05$).

**Coded Support**

To explore whether there was main effects of any measure of social class and coded support offered by the evaluator I ran regression models with each of the social class variables as predictors of coded stress. There were no significant main effects for any of the social class variables in predicting coded support.

**Discussion**

The hypotheses for Study 3 were informed by the findings in the first study and by prior literature showing emotional and behavioral differences as a function of SES. I expected to find differences in the degree of social support offered by the evaluator as a
function of their SES, with low SES individuals offering more social support compared to their high SES counterparts. However, as reported I did not observe differences in social support offered as a function of social class. This finding was not in line with the literature that suggests that low social class individuals display more empathy and are more compassionate towards others (Piff et al., 2012). It is possible that this discrepancy occurred in part because of the power dynamic that was created by taking two peers and assigning one to a position of relative power (the evaluator).

The findings in this study were different in that early life SES did not predict the inflammatory responses of the speaker. Instead I found significant interactions between the speaker’s subjective social status and the perceived social class of their evaluator. These findings point to the importance in perceptions of the evaluator’s social class and subjective social class, rather than objective measures of early life SES or objective measures of current SES. Lastly, an interesting finding that emerged was the tendency for low SES individuals to overestimate their evaluator’s SES, while high SES individuals underestimated their evaluator’s SES. The direction of these inaccuracies, may in part explain the relationship between subjective social class and post-task levels of inflammation. An important extension of this study will be to determine the role of challenge and threat interpretations in shaping these patterns of inflammatory responses.

**General Discussion**

**Changes in Inflammation and Oxytocin as a Function of SES**

The findings in the first two studies suggest that in the face of a stressor, the lack or presence of social support is a particularly strong predictor of physiological responses for individuals from low early life SES backgrounds. Specific to changes in levels of inflammation, this was the case in both an interpersonal interaction (Study 1) and in a prototypical social evaluative setting (Study 2). Significant differences between post-stressor levels of IL-6 as a function of early life SES background emerged only in the unsupportive condition, with individuals from low early life SES backgrounds exhibiting the highest levels of IL-6 when they did not receive social support.

With regards to post-stressor levels of oxytocin in the context of an interpersonal interaction (Study 1), significant differences as a function of early life SES emerged only in the supportive condition, with individuals from low early life SES backgrounds exhibiting the highest levels of oxytocin in the supportive condition. However, when the nature of the stressor changed in Study 2 to a social evaluative threat, no significant interactions between early life SES and social support condition emerged. However, there was a significant correlation between early life SES and post-task levels of oxytocin, such that low early life SES predicted greater levels of oxytocin following the task. Oxytocin is sometimes viewed as a biological promoter of social contact in contexts in which it may be lacking (Taylor, 2006). As such, I expected to find increases in oxytocin in response to the lack of social support. However, oxytocin can also increase in response to positive experiences, so perhaps in this context, the reception of social support elicited increases in oxytocin.

Taken together, the physiological data from Study 1 suggests that individuals from low early life SES backgrounds are the most physiologically reactive to the presence or absence of social support during an interpersonal interaction. These individuals exhibit a greater degree of change in levels of oxytocin when they receive social support, and exhibit the greatest increases in levels of IL-6 in the absence of social support.
The Importance of Perceptions in a Social Evaluative Context

In Study 3, I shifted the focus to how physiological responses in a social evaluative context might be moderated by perceptions of the social class of the evaluator. The findings indicate that the actor’s subjective social class and the perceived social class of the evaluator were more important than objective social class or the actual social class of the evaluator in predicting changes in inflammation. Overall, individuals who identified as being of low social class, exhibited greater post-task levels of IL-6. There was no significant difference for these individuals as a function of perceived social class of their evaluator. However, for self identified high social class individuals, there was a significant difference in post-task levels of IL-6 as a function of perceived social class of their evaluator. Interestingly, when these individuals perceived their evaluator to be of a higher social class than themselves, they exhibited greater levels of post-task IL-6. This last finding is particularly intriguing given what we know about social hierarchies from both the animal and human literature. Given our natural tendency to establish hierarchies and given what is known about the benefits associated with higher status within a hierarchy (e.g. Akinola & Mendes, 2013; Sapolsky, 2005), this finding could be interpreted as a result of concern that one’s status or rank is threatened by the relative higher status of another. These findings offer further support for the burgeoning literature that speaks to the importance of subjective measures of social class and socioeconomic status when considering implications for health.

In Study 3, I predicted that there would be differences in the perception of how supportive or threatening the evaluators were as a function of objective SES. Specifically, based on prior research showing that low SES individuals engage in more prosocial behaviors (Piff, et al., 2010), we hypothesized that these individuals would be perceived as more supportive evaluators. However, no significant relationships between objective or subjective measures of SES and the speaker’s perception of how supportive their evaluator was emerged. This study differed from Study 2 with regards to the evaluator. Specifically, while in Study 2 the evaluator was in a position of relative power, in Study 3, the evaluator was a peer. As a result, it is perhaps not surprising that the perception of their evaluator’s social class so strongly predicted their inflammatory response to the stressor. Interestingly, in Study 3, the speaker’s early life SES did not predict their inflammatory response to the stressor. It is possible, that this could be a result of a lack of variance in the degree of social support offered by the evaluator. In other words, evaluators were unlikely to mirror the degree of social support offered in the unsupportive or supportive conditions used in Studies 1 and 2. By manipulating social support, I was able to see how the total lack of social support throughout a social evaluative task differentially predicted outcomes.

The literature on the effects of early life SES on later health suggests there is a programming effect that takes root in the early years of life, shaping physiological responses to stressors later in life. It is possible that this automatic response only emerges under particularly stressful contexts, which would explain why I only found significant interactions between early life and social support in the studies in which I was able to control the amount of support offered by using confederates.

General Conclusion and Future Research

The findings across the three studies highlight the importance of context in
predicting physiological responses. Studies 1 and 2 were consistent with a large body of work highlighting the power of early life SES in shaping physiological responses later in life. However, Study 3 suggested that in the context of a social evaluative stressor, when evaluated by a peer, perceptions of social class matter more. With regards to emotion the findings from the first two studies showed that positive and negative emotional responses were associated with the presence or absence of social support. Post-task self-reported motions (positive and negative) were also associated with post-task levels of IL-6 (Study 1 and 3). These emotion findings could have important implications as they could inform social support interventions and interventions designed to buffer physiological reactivity to stressors by managing emotional responses.

Oxytocin was only predicted by an interaction between early life SES and social support condition in the context of an interpersonal reaction. This difference across studies suggests that for individuals from low early life SES backgrounds, there is something particularly powerful about the reception of social support during a stressful interpersonal reaction, that is associated with an increase in levels of endogenous oxytocin. Future work should explore whether these interactions exist across other contexts, and further examine the specific forms of social support that are most beneficial in different contexts.

Future research should expand upon this work in the following ways. First, in order to more fully understand the relationship between these biomarkers, multiple samples should be collected to obtain a more comprehensive understanding of the nature of these physiological trajectories. Second, given that social support plays a critical role in buffering potentially adverse physiological responses to stressors, intervention focused research should consider ways in which social support can be inserted into stressful situations to decrease vulnerability for low SES individuals. Finally, given the findings from the final study, an important extension of this work will be to examine the role of challenge and threat interpretations both before and after the task. Given that there is an established cardiovascular pattern of response for challenge and threat, an interesting extension of this work would be a simultaneous examination of cardiovascular and inflammatory responses to social evaluative stressors.

This work makes an important contribution to our understanding of the role of social support in the SES-health gradient. The findings from the first two studies highlight the vulnerability of individuals from low SES backgrounds to heightened inflammatory responses to stressful situations when they do not have access to social support. On a more optimistic note, the findings also suggest that when social support is available, the inflammatory response of these individuals is reduced substantially. In addition, the reception of social support was associated with a rise in oxytocin, which could in part explain the reduction in levels of IL-6. Further, the rise in oxytocin in response to the reception of social support for individuals from low early life SES backgrounds suggests a possible pathway through which the association between low SES and adverse health could be reduced.
Figure 1. Post-interaction IL-6 levels as a function of early SES composite and social support condition, controlling for baseline IL-6 and current parental income. (Study 1).
Figure 2. Post-interaction levels of salivary oxytocin as a function of early SES and social support condition, controlling for baseline IL-6 and current parental income. (Study 1).
Figure 3. Post-stressor levels of IL-6 as a function of early life SES and social support condition. (Study 2).
Figure 4. Post-task levels of IL-6 as a function of early life SES and social support condition (Study 2).
Figure 5. Post-task levels of IL-6 as a function of the current subjective social class of the actor perceived social status of the partner (Study 3).
Table 1  
*Bivariate correlations among main variables of interest in Study 1*

<table>
<thead>
<tr>
<th></th>
<th>Baseline IL-6</th>
<th>Post-Stressor IL-6</th>
<th>Early SES</th>
<th>Current SES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline IL-6</td>
<td>---</td>
<td>0.67**</td>
<td>-0.96</td>
<td>0.36</td>
</tr>
<tr>
<td>Post-Stressor IL6</td>
<td>---</td>
<td>-0.29*</td>
<td>-0.18</td>
<td></td>
</tr>
<tr>
<td>Early SES</td>
<td>---</td>
<td></td>
<td>-0.31**</td>
<td></td>
</tr>
<tr>
<td>Current SES</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *p < 0.05, ** p < 0.01
Table 2
*Summary of Exploratory Factor Analysis for self-report emotions following interaction (Study 1)*

<table>
<thead>
<tr>
<th>Item</th>
<th>Factor Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative Withdrawal (factor 1)</td>
</tr>
<tr>
<td>Failed</td>
<td>.81</td>
</tr>
<tr>
<td>Afraid</td>
<td>.78</td>
</tr>
<tr>
<td>Embarrassed</td>
<td>.74</td>
</tr>
<tr>
<td>Self-conscious</td>
<td>.87</td>
</tr>
<tr>
<td>Anxious</td>
<td>.68</td>
</tr>
<tr>
<td>Ashamed</td>
<td>.67</td>
</tr>
<tr>
<td>Sad</td>
<td>.65</td>
</tr>
<tr>
<td>Bored</td>
<td>-.14</td>
</tr>
<tr>
<td>Angry</td>
<td>.45</td>
</tr>
<tr>
<td>Annoyed</td>
<td>.43</td>
</tr>
<tr>
<td>Happy</td>
<td>.03</td>
</tr>
<tr>
<td>Relaxed</td>
<td>-.01</td>
</tr>
<tr>
<td>Excited</td>
<td>.05</td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>5.6</td>
</tr>
<tr>
<td>% of variance</td>
<td>40</td>
</tr>
</tbody>
</table>

Note: Factor loadings over .40 appear in bold.
Table 3
Correlations between early life SES and post-stressor levels of oxytocin (controlling for baseline levels of oxytocin) across conditions. (Study 2)

No support condition:
<table>
<thead>
<tr>
<th>Early SES</th>
<th>post-stressor levels of oxytocin</th>
</tr>
</thead>
<tbody>
<tr>
<td>correlation:</td>
<td>-.25</td>
</tr>
<tr>
<td>Significance:</td>
<td>.17</td>
</tr>
<tr>
<td>df:</td>
<td>30</td>
</tr>
</tbody>
</table>

Control Condition:
<table>
<thead>
<tr>
<th>Early SES</th>
<th>Post-stressor levels of oxytocin</th>
</tr>
</thead>
<tbody>
<tr>
<td>correlation:</td>
<td>-.21</td>
</tr>
<tr>
<td>Significance:</td>
<td>.21</td>
</tr>
<tr>
<td>df:</td>
<td>37</td>
</tr>
</tbody>
</table>

Support Condition
<table>
<thead>
<tr>
<th>Early SES</th>
<th>Post-stressor levels of oxytocin</th>
</tr>
</thead>
<tbody>
<tr>
<td>correlation:</td>
<td>-.45</td>
</tr>
<tr>
<td>Significance:</td>
<td>.09</td>
</tr>
<tr>
<td>df:</td>
<td>29</td>
</tr>
</tbody>
</table>
Table 4
Summary of Exploratory Factor Analysis for self-report emotions following TSST (Study 2).

<table>
<thead>
<tr>
<th>Item</th>
<th>Negative Withdrawal (Factor 1)</th>
<th>Negative Approach (Factor 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annoyed/Irritated</td>
<td>.42</td>
<td>.58</td>
</tr>
<tr>
<td>Anxious</td>
<td>.56</td>
<td>.40</td>
</tr>
<tr>
<td>Ashamed</td>
<td>.84</td>
<td>.25</td>
</tr>
<tr>
<td>Surprised/shocked</td>
<td>.67</td>
<td>.37</td>
</tr>
<tr>
<td>Failed</td>
<td>.85</td>
<td>-.05</td>
</tr>
<tr>
<td>Self-conscious</td>
<td>.80</td>
<td>-.08</td>
</tr>
<tr>
<td>Afraid/scared</td>
<td>.69</td>
<td>.34</td>
</tr>
</tbody>
</table>
Table 5
*Summary of Exploratory Factor Analysis for self-report emotions following TSST (Study 3).*

<table>
<thead>
<tr>
<th>Item</th>
<th>Negative emotions (Factor 1)</th>
<th>Positive emotions (Factor 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failed</td>
<td>.85</td>
<td>-.06</td>
</tr>
<tr>
<td>Afraid</td>
<td>.79</td>
<td>-.02</td>
</tr>
<tr>
<td>Embarrassed</td>
<td>.83</td>
<td>-.23</td>
</tr>
<tr>
<td>Self-conscious</td>
<td>.76</td>
<td>-.24</td>
</tr>
<tr>
<td>Anxious</td>
<td>.77</td>
<td>-.38</td>
</tr>
<tr>
<td>Ashamed</td>
<td>.87</td>
<td>-.15</td>
</tr>
<tr>
<td>Angry</td>
<td>.45</td>
<td>-.87</td>
</tr>
<tr>
<td>Annoyed</td>
<td>.61</td>
<td>-.40</td>
</tr>
<tr>
<td>Happy</td>
<td>-.10</td>
<td>.90</td>
</tr>
<tr>
<td>Relaxed</td>
<td>-.15</td>
<td>.88</td>
</tr>
<tr>
<td>Eigenvalues</td>
<td>6.04</td>
<td>1.50</td>
</tr>
<tr>
<td>% of variance</td>
<td>55</td>
<td>13.66</td>
</tr>
</tbody>
</table>

Note: Factor loadings above .40 appear in bold
References


Liu, Y., Ho, R. C., & Mak, A. (2011) Interleukin (IL)-6, tumor necrosis factor alpha (TNF-alpha) and soluble interleukin-2 receptors (sIL-2R) are elevated in patients with major depressive disorder: A meta-analysis and meta-regression. Journal of Affective Disorders, 139, 230-239. doi: 10.1016/j.jad.2011.08.003


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