

RESEARCH ARTICLE

Early-life Socio-economic Status and Adult Health: The Role of Positive Affect

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Abstract

The aim of this paper is to develop a further understanding of the relationship between early-life socio-economic status (SES) and adult health disparities. This was accomplished through evaluation of state indicators of positive and negative affect as mechanisms through which early-life SES was associated with susceptibility to a rhinovirus (i.e. the common cold). Analyses were conducted among 286 adults in a viral challenge study in which participants were exposed to a rhinovirus via nasal drops and cold symptoms were evaluated over a period of 5 days. Participant age, body mass index, sex, education, ethnicity, pre-challenge virus-specific antibody titres and subjective adult SES, along with virus type and season of participation, were included as covariates. Early-life SES was associated with cold incidence through state positive affect, but not state negative affect. In addition, contrast analysis indicated that the indirect effect through state positive affect was stronger than the indirect effect through state negative affect. Findings provide further support for early-life SES being an important variable associated with adult health, and that state self-reported positive affect may be an underlying mechanism associated with susceptibility to rhinoviruses. Copyright © 2016 John Wiley & Sons, Ltd.

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Keywords

health disparities; socio-economic status; positive affect; negative affect; the common cold

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Low early-life socio-economic status (SES) is reliably associated with poor adult health independent of current SES (Braveman et al., 2005; Cohen, Janicki-Deverts, Chen, & Matthews, 2010; Miller et al., 2009). Indeed, those from low early-life SES backgrounds are more likely to experience repeat hospitalizations each year (National Center for Health Statistics, 2015) and are expected to live shorter lives than their high SES counterparts (Braveman, Cubbin, Egarter, Williams, & Pamuk, 2010). As a result, identifying mechanisms underlying the association between early-life SES and later health is important.

Those from low SES backgrounds are more likely to report low positive affect (PA; i.e. energy and engagement within one's environment) and high negative affect (NA; i.e. general distress) in comparison with those from high SES backgrounds (for reviews, see Chen, 2004; Gallo & Matthews, 2003; Taylor, Way, & Seeman, 2011). Importantly, low early-life SES is associated with increased risk of reporting low PA and high NA using trait (Schöllgen, Huxhold, &

Schmiedek, 2012) and state measures of self-reported affect (Chiang et al., 2015). Moreover, those from low early-life SES backgrounds demonstrate stronger physiological reactions to acute stressors in comparison with those from high early-life SES backgrounds (Evans & Kim, 2007). Environmental factors, such as exposure to chronic stressors and lack of access to resources, are hypothesized variables that explain why those from low early-life SES backgrounds are more susceptible to low PA and high NA, as well as physiological reactions to stressors, than their high SES counterparts (e.g. Chandola & Marmot, 2011). Those who experienced poverty and chronic stress in childhood exhibit neurological patterns (i.e. decreased ventrolateral and dorsolateral prefrontal cortex activity) associated with poor regulation of negative emotions (e.g. Kim et al., 2013), which may predispose these individuals towards a lifetime of adverse health outcomes (e.g. Herbert & Cohen, 1993; Fagundes & Way, 2014). In the present study, we adopted a well-established virus challenge experimental paradigm to test potential mechanisms

(i.e. state PA and NA) by which low early-life SES may make one more susceptible to the common cold in adulthood.

In the field of psychoneuroimmunology, the virus challenge paradigm involves exposing individuals to a virus and examining how psychological factors are associated with susceptibility to the virus, after accounting for previous exposure to the virus (Luecken & Gallo, 2008). When one is exposed to a virus, his or her immune system creates virus-specific antibodies. Virus-specific antibodies reduce an individual's susceptibility to the virus in the future (Sompayrac, 2012). Accordingly, it is important to control for virus-specific antibody titres when investigating whether psychological factors are important for predicting susceptibility to viruses above and beyond the influence of the immune system (e.g. Morag, Morag, Reichenberg, Lerer, & Yirmiya, 1999).

Those with high trait NA are more susceptible to cold viruses in comparison with those with low NA (Cohen, Tyrrell, & Smith, 1993). Alternatively, high trait PA is associated with decreased susceptibility to the common cold (Cohen, Doyle, Turner, Alper, & Skoner, 2003; Cohen & Pressman, 2006; Pressman & Cohen, 2005). Recent work has suggested that PA may be a stronger predictor of health outcomes than NA (e.g. Cohen et al., 2003; Moskowitz, 2003) and that state PA is important for predicting real-time biological processes including adaptive immune and neuroendocrine responses that may be independent of NA (i.e. immunoglobulin A antibody response to infection; Dockray & Steptoe, 2010; Steptoe, Wardle, & Marmot, 2005); however, state NA is also associated with immune and neuroendocrine responses including lower counts of natural killer cells and T cells in the hours after experiencing a stressor (Brosschot, Smelt, de Smet, & Heijnen, 1991; Cacioppo et al., 2000; Wright, Strike, Brydon, & Steptoe, 2005). Indeed, there is evidence that affective states can enhance inflammatory immune responses (e.g. Fagundes, Glaser, Hwang, Malarkey, & Kiecolt-Glaser, 2013) in a maladaptive manner that can place individuals at greater risk for illness (Uchino, Smith, Holt-Lunstad, Campo, & Reblin, 2007). Specifically, high state NA is associated with high inflammation (Fagundes et al., 2013), whereas high state PA is associated with low inflammation (Stellar et al., 2015). Importantly, those with low SES demonstrate exaggerated immune responses to acute stressors (Derry et al., 2013; Pace et al., 2010) in comparison with those from high SES backgrounds. Therefore, it is important to evaluate state PA and NA as mechanisms underlying the relationship between early-life SES and susceptibility to the common cold. Available evidence indicates that higher PA is associated with lower objective susceptibility to viruses and fewer unfounded health-related complaints whereas higher NA is associated with more unfounded health-related complaints (e.g. Cohen et al., 2003;

Watson & Pennebaker, 1989). Accordingly, given that state PA is independently associated with immune responses to infection (e.g. Dockray & Steptoe, 2010; Steptoe et al., 2005) and objective illness, whereas state NA is not, state PA may be a stronger mechanism underlying that association between early-life SES and cold incidence than state NA in viral challenge studies.

The present study sought to elucidate the mechanisms underlying the association between early-life SES and adult health through evaluating associations between early-life SES, self-reported PA and NA during a 1-day period, and susceptibility to a cold virus. In prior work using the virus challenge paradigm, higher early-life SES and trait PA were associated with decreased cold incidence (Cohen, Doyle, Turner, Alper, & Skoner, 2004; Cohen et al., 2003), and higher trait NA was associated with increased susceptibility to cold viruses (Cohen et al., 1993). This study sought to extend this work by evaluating state PA and NA as underlying mechanisms through which early-life SES may be associated with susceptibility to the common cold. Such an investigation is important given that the common cold is one of the most frequently encountered (Heikkinen & Järvinen, 2003) and costly health concerns (Goetzl et al., 2004). In line with the available literature, we hypothesized that early-life SES would be associated with cold incidence through state PA and NA, and that state PA would be a stronger mechanism than state NA given that objective criteria were utilized to determine cold incidence.

Methods

Participants and procedure

Between the years of 1997 and 2001 in the United States, potential participants who responded to advertisements were screened for participation in the present study approximately 3 weeks prior to the virus challenge described later. Those who had a history of psychiatric illness, cardiovascular disease, asthma, or nasal or oncological surgery were excluded from the study. Also excluded were individuals who had an abnormal urinalysis, abnormal complete blood count or blood enzymes, or were pregnant, lactating, seropositive for the human immunodeficiency virus or taking regular medication. The sample included 334 healthy individuals (52.4% female, $n = 175$) aged 18 to 54 years [standard deviation (SD) = 10.4]; however, 48 participants were removed from study analyses owing to an inability to complete the measure of early-life SES described later, yielding a final sample of 286. Individuals participated in 10 groups and were isolated in separate rooms on a single floor of a hotel over a period of 5 days to minimize the influence of external factors. After being isolated, participants were given nasal drops containing 100 to 300 TCID₅₀ of one of two rhinoviruses (RV39, $n = 228$; or RV23, $n = 106$) in order to support generalizability of findings.

Symptoms of illness (e.g. congestion, runny nose, chills, sore throat and mucus weight) were evaluated over a period of 5 days. All investigators were blind to participant characteristics including self-report and biological measures outlined later. Following completion of the study, participants were paid \$800. The study was approved by the institutional review boards at Carnegie Mellon University and the University of Pittsburgh.

Measures

Demographics/control variables

During screening, participant height and weight were measured in order to calculate a body mass index $\{BMI = \text{weight [kg]} / [\text{height (m)}]^2\}$ for each individual. Participants also provided self-reports of age, sex, ethnicity, and level of education (i.e. high school graduate or lower, some college, associate's degree and college graduate and above). Season of participation was included as a control variable given that individuals are more susceptible to cold viruses in the winter months (e.g. Cohen et al., 2004).

Subjective adult SES was measured via the MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo, & Ickovics, 2000), USA Ladder version. On the measure, respondents were presented with an illustration of a nine-step ladder and were instructed to interpret steps at the top of the ladder as representing individuals with the most money, education and respected jobs. Similarly, respondents were instructed to interpret steps at the bottom of the ladder as reflecting those who have the least amount of money, education and respected jobs. Individuals were asked to place an 'X' on the appropriate step of the ladder that represents their social standing at the current time relative to others in the United States. Acceptable psychometric characteristics have been identified using the Scale of Subjective Social Status (e.g. Operario, Adler, & Williams, 2004). Participants receive a value between 1 (lowest status) and 9 (highest status) based on the rung of the ladder on which they place an 'X'.

To evaluate prior exposure to the challenge virus, study staff collected blood samples 1 to 2 days prior to the virus challenge. Serum samples were stored at -20°C until heated to 56°C for use. Viral-specific immunoglobulin A and immunoglobulin G antibody levels were evaluated using enzyme-linked immunosorbent assays. Data represent the reciprocals of the final dilution of serum.

Early-life SES

To measure early-life SES, participants were asked to recall whether or not their parents owned a home during each of the first 12 years of life by selecting 'yes', 'no' or 'don't know'. The number of years participants responded 'yes' were summed to form an overall score. Those who could not recall whether or

not their parents owned a home at any point during their childhood ($n=48$) were removed from present study analyses. This approach to evaluating early childhood SES was utilized given that home ownership is associated with greater income and assets than renting (e.g. Ortiz & Zimmerman, 2013). Home owners possess the vast majority of the nation's wealth in comparison with those who rent or do not own homes (Di, 2005; Wolff, 2014). Oliver and Shapiro (2006) suggest that home ownership is central to understanding socio-economic disparities in the United States. Indeed, children of homeowners demonstrate better cognition, fewer behavioural issues, less teenage pregnancy and a greater likelihood of receiving a high school diploma than children of non-homeowners (Dietz & Haurin, 2003; Green & White, 1997; Haurin, Parcel, & Haurin, 2003).

The majority of participants were able to recall home ownership during their early life. No differences were identified among those who were able to recall if their parents owned a home during each of the first 12 years of life in comparison with those who were not. The first 12 years of life was chosen given evidence that pre-adolescent life experiences may be the most formative in regard to the development of emotion regulation skills (Chen & Miller, 2014). Recall of parental home ownership was significantly correlated with maternal ($r=0.24$), paternal ($r=0.25$) and subject ($r=0.33$) educational attainment in a prior study (Cohen et al., 2004). Moreover, neighbourhood poverty and home ownership were negatively associated ($r=-0.45$; Harkness & Newman, 2003) in a study of the effects of homeownership on children, and subjective measures of SES are associated with homeownership among adults (Franzini & Fernandez-Esquer, 2006). A subjective measure of early-life SES was not included in the original study.

State positive and negative affect

During the first day post-challenge, participants were asked to indicate the degree to which various adjectives described their mood during that day on a scale from 1 (haven't felt this way at all since getting up) to 5 (felt that way a lot since getting up). Nine adjectives for PA (i.e. lively, full-of-pep, energetic, happy, pleased, cheerful, at ease, calm and relaxed) and nine adjectives for NA (i.e. sad, depressed, unhappy, on edge, nervous, tense, hostile, resentful and angry) were summed to form an overall indicator of each affect dimension. Cronbach's alpha coefficients indicated good (NA $\alpha=0.88$) to excellent (PA $\alpha=0.93$) internal consistency for state affect measurement. The day after inoculation was chosen for measurement of state PA and NA given that the initial stress of being quarantined and exposed to a virus may have subsided. Moreover, individuals were unlikely to experience effects associated with exposure to a rhinovirus during this time. Indeed, less than 10% of participants report

having a cough, needing extra bed rest, sneezing, watering eyes, sore throat, nasal stuffiness, sinus pain, headache, chills or malaise on the first day after inoculation with a rhinovirus (Tyrrell, Cohen, & Schlarb, 1993). Therefore, the first day post-challenge was chosen to represent the optimal time, based on present study procedures, in which to evaluate the role of state affect.

Trait positive and negative affect

A modified version of the Trait Adjective Questionnaire (Usala & Hertzog, 1989) was utilized to generate indicators of trait PA and NA to be utilized in the ancillary analyses described later. Participants were asked to respond by indicating the degree to which each adjective describes how they typically or generally are on a scale ranging from 0 (not at all accurate) to 4 (extremely accurate). Six adjectives were utilized as indicators of NA (e.g. tense, nervous and sad), and nine adjectives comprised the PA scale (e.g. relaxed, cheerful and pleased). Reliability coefficients were acceptable in the present study for both PA ($\alpha = 0.79$) and NA ($\alpha = 0.76$).

Cold incidence

Participants were considered to have a clinical cold if they were infected and met objective illness criteria. Evidence for infection included recovery of the challenge virus on any of the 5 days post-challenge or a >400% increase in virus-specific antibody titres (Cohen, Doyle, Skoner, Rabin, & Gwaltney, 1997). Objective illness criteria included having a total adjusted mucus weight of at least 10 g or at least 35 min of total adjusted mucociliary clearance time (Cohen et al., 1997; Cohen et al., 2004). Mucus weights were assessed through collecting used tissues in a sealed plastic bag, weighing the bag and subtracting the weight of the tissues and the bag each day. Mucociliary clearance time was measured via the time required for dye administered in the anterior nose of each participant to reach the nasopharynx each day. Baseline adjusted scores were calculated by subtracting baseline scores from the sum of the totals for the 5 days post-challenge for both mucus weight and mucociliary clearance time.

Statistical analyses

Primary study analyses were conducted using SPSS software (version 21; IBM Corp, 2012). Factor analyses of affect measures were performed using EQS structural equation modelling software (version 6.1; Bentler, 2005). The PROCESS macro (Hayes, 2013) for SPSS was utilized to evaluate two mediation models. In the first model, state PA and NA were evaluated as simultaneous mediators of the association between early-life SES and cold incidence. For the second model, trait PA and NA were evaluated as simultaneous mediators of the association between early-life SES and cold incidence. In both models, the same covariates were utilized (i.e. participant ethnicity, sex, level of

education, age, BMI, current SES and virus-specific pre-challenge antibody titres); however, in the model with state PA and NA as simultaneous mediators, trait PA and NA were not included as covariates. Similarly, in the model with trait PA and NA as simultaneous mediators, state PA and NA were not included as covariates. Indirect effects were tested using 5000 bootstrap resamples with bias-corrected 95% confidence intervals. Importantly, given our dichotomous outcome, the PROCESS macro identifies binary dependent variables and utilizes logistic regression analyses when appropriate. Furthermore, the PROCESS macro allows for comparison of the strength of indirect effects when simultaneous mediators are included in the model tested (Preacher & Hayes, 2008).

Results

Descriptive statistics for all study variables are presented in Table I, and zero-order correlations are presented in Table II. Factor analyses were performed to rule out a unidimensional structure of the state affect data. A single factor produced a poor solution to the data [$\chi^2(135, N = 286) = 1903.29, p = 0.14$; comparative fit index (CFI) = 0.54; root mean square error of approximation (RMSEA) = 0.20]. Consistent with the available literature (e.g. Crawford & Henry, 2010), a two-factor solution, in which state PA and NA were allowed to correlate and error between items from within the same factor was allowed to intercorrelate, produced a better fit to the data [$\chi^2(62, N = 286) = 75.23, p = 0.12$; CFI = 1.00; RMSEA = 0.03]. Similarly, a two-factor solution [$\chi^2(38, N = 286) = 76.31, p < 0.001$; CFI = 0.98; RMSEA = 0.06] was a better fit than a one-factor solution [$\chi^2(90, N = 286) = 2016.30, p = 0.32$; CFI = 0.57; RMSEA = 0.17] for trait affect, suggesting that a unidimensional fit to the data was not observed for both state and trait affect.

As can be seen in Figure 1, participants with higher childhood SES reported higher state PA during the first day post-challenge. Early-life SES was not significantly associated with state NA. Furthermore, higher early-life SES and state PA were associated with decreased cold incidence. Of note, none of the control variables were associated with state PA, while participant ethnicity was significantly associated with state NA ($\beta = 0.15, p = 0.03$) such that White participants reported lower state NA than non-White participants. Control variables associated with cold incidence included type of virus ($\beta = -0.58, p < 0.001$), participant ethnicity ($\beta = 0.35, p = 0.04$), season of participation ($\beta = 0.39, p = 0.007$) and pre-challenge antibody titres ($\beta = -0.49, p = 0.003$). The 95% bias-corrected confidence interval for the indirect effect of state PA on the association between early-life SES and cold incidence did not include zero [-0.19, -0.01]. Accordingly, results indicated that state PA partially mediated the association between early-life SES and cold incidence. Alternatively, the 95% bias-corrected

Table 1. Study sample characteristics

Variable	Number (%) or mean (SD)
Ethnicity	
Caucasian	226 (67.7)
African-American	99 (29.6)
Asian	4 (1.2)
Native American	3 (0.9)
Hispanic	2 (0.6)
Sex	
Male	159 (47.6)
Female	175 (52.4)
Education	
High school graduate or lower	99 (29.6)
Some college	107 (32.0)
College graduate or above	59 (17.7)
Challenge virus given	
Rhinovirus-23	106 (31.7)
Rhinovirus-39	228 (68.3)
Season of participation	
Winter	65 (19.5)
Spring	176 (52.7)
Summer	28 (8.4)
Fall	65 (19.5)
Cold incidence	
Met objective criteria for a cold	86 (25.7)
Did not meet objective criteria for a cold	248 (74.3)
Age	28.85 (10.39)
Body mass index	26.32 (5.84)
Number of years parents owned a home between the ages of 1 and 12 years (i.e. early-life socio-economic status)	7.33 (5.11)
Pre-challenge virus-specific antibody titres	6.18 (6.29)
State positive affect	19.90 (8.20)
State negative affect	1.36 (3.19)
Adult socio-economic status	4.25 (1.76)
Trait positive affect	23.40 (5.24)
Trait negative affect	6.00 (4.24)

SD: standard deviation.

confidence interval for the indirect effect of NA included zero $[-0.01, 0.11]$. Therefore, state NA did not mediate the association between early-life SES and cold incidence. When contrasting the indirect effects of state PA and NA, results indicated a significant difference as the 95% bias-corrected confidence interval did not include zero $[-0.23, -0.01]$. Thus, in addition to a difference in significance, results indicated that the indirect effect of state PA on the association between early-life SES and cold incidence was stronger than the indirect effect of state NA. Findings remained when including state PA and NA on the day of inoculation as covariates in ancillary analyses; however, state PA was no longer significantly associated with cold incidence ($B = -0.28, p = 0.13$) when trait PA and NA were entered as additional covariates, resulting in a non-significant indirect effect.

We also examined trait PA and NA in a model identical to the model depicted in Figure 1. In this model (Figure 2), early-life SES was not significantly associated with trait PA or NA. Moreover, trait NA and PA were not significantly associated with cold incidence. The indirect effects of trait PA (95% confidence interval = $-0.05, 0.02$) and NA (95% confidence interval = $-0.02, 0.09$) were also non-significant.

Discussion

The present study utilized the virus challenge experimental paradigm to evaluate indicators of state PA and NA as underlying mechanisms of the association between early-life SES and adult health. Self-reported state PA, but not state NA, during the first day in quarantine partially explained the relationship between early-life SES and cold incidence. Findings were independent of participant ethnicity, sex, level of education, age, BMI, pre-challenge virus-specific antibody titres and current SES, as well as type of virus exposed to and season of participation. Furthermore, results indicated that state PA was a stronger mechanism linking early-life SES and cold incidence than state NA when contrasting the indirect effects (Preacher & Hayes, 2008). As previously mentioned, PA has been identified as more powerful predictor of health outcomes when compared with NA (e.g. Moskowitz, 2003). Accordingly, present findings provide further evidence for the importance of state PA as a predictor of health outcomes. Furthermore, findings are consistent with prior work demonstrating that NA is associated with unfounded health complaints as opposed to objective indicators of illness (Watson & Pennebaker, 1989). Indeed, state NA was not significantly associated with cold incidence in the present study.

An important consideration is that deception was not utilized in the present study. Participants were well aware that they were to be exposed to a rhinovirus and quarantined as part of their participation in the study. As a result, findings may reflect that low early-life SES individuals are less able to adaptively regulate PA during a stressful event than those from high SES backgrounds. Indeed, we know that those with low early-life SES are more likely to demonstrate poor emotion regulation in comparison with those from high SES backgrounds (e.g. Chen & Miller, 2014). Moreover, those from low SES backgrounds are more likely to demonstrate maladaptive immune responses to stressors than high early-life SES individuals (e.g. enhanced inflammation; Derry et al., 2013; Pace et al., 2010). Thus, although findings are consistent with the theory that low early-life SES is associated with poor health outcomes due to emotion regulation difficulties (Chen & Miller, 2014), it is unclear if present study findings generalize outside of a potentially stressful virus challenge paradigm; however, given that individuals with low early-life SES are more likely to

Table II. Zero-order correlations

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Early-life SES	—													
2. State PA	0.16*	—												
3. State NA	-0.06	-0.26*	—											
4. Cold incidence	-0.14*	-0.14*	-0.01	—										
5. Ethnicity	0.36*	-0.08	0.10	0.07	—									
6. Sex	0.04	-0.04	-0.06	-0.10	0.08	—								
7. Education	0.27*	0.04	0.03	0.03	0.15*	-0.02	—							
8. Challenge virus	-0.13*	0.09	-0.05	-0.15*	-0.08	-0.06	0.01	—						
9. Season of participation	0.04	0.05	-0.05	0.09	-0.05	-0.08	-0.01	0.15*	—					
10. Participant age	-0.07	0.13*	0.03	0.05	-0.07	-0.05	0.01	0.11	-0.06	—				
11. Body mass index	-0.09	0.07	0.04	0.05	-0.14*	-0.01	-0.03	0.05	-0.01	0.32*	—			
12. Subjective adult SES	0.22*	0.06	-0.09	0.01	0.15*	0.03	0.22*	-0.04	0.09	-0.01	-0.07	—		
13. Pre-challenge AB titres	-0.08	0.05	0.04	-0.14*	-0.08	0.06	-0.07	-0.02	0.02	0.21*	0.10	-0.02	—	
14. Trait PA	0.05	0.47*	-0.13*	-0.09	0.01	0.01	0.03	0.02	0.07	0.02	0.04	0.12*	0.01	—
15. Trait NA	0.02	-0.26*	0.36*	0.04	0.04	0.02	-0.09	-0.06	-0.16*	0.01	-0.09	-0.16*	0.03	-0.37*

Note. Cold incidence coded as 0 = did not meet objective criteria for a cold and 1 = met objective criteria for a cold; ethnicity coded as 0 = non-White and 1 = White; sex coded as 0 = male and 1 = female; education coded as 1 = high school graduate or lower, 2 = some college and 3 = college graduate or above; challenge virus coded as 0 = RV39 and 1 = RV23; season of trial coded as = 0 non-winter (i.e. spring, summer and fall) and 1 = winter.

AB: antibody; SES: socio-economic status; PA: positive affect.

* $p < 0.05$.

experience high stress and low PA on a daily basis (e.g. Gallo & Matthews, 2003; Gross, Richards, & John, 2006), and are more susceptible to viruses (e.g. Cohen et al., 2004) and age-related health problems (e.g. Chen & Miller, 2014) than those from high SES backgrounds, results provide a useful example of how early-life SES and emotion regulation may be associated with health outcomes.

There are a number of interventions or strategies that are associated with increases in state PA that may be useful for reducing health risk among those from low SES backgrounds. For example, repeatedly expressing gratitude and visualizing the best possible self is associated with sustained increases in state PA (Sheldon & Lyubomirsky, 2006). Self-focused writing interventions have also been found to increase state PA (Frein & Ponsler, 2014), although it is unclear if self-focused writing is associated with persistent increases in state PA. Moreover, increased mindfulness, via

mindfulness-based stress reduction interventions, leads to increased state PA (Snippe, Nyklíček, Schroevers, & Bos, 2015), which may explain why mindfulness-based stress reduction interventions improve both mental (Khoury, Sharma, Rush, & Fournier, 2015) and physical health (Grossman, Niemann, Schmidt, & Walach, 2004). Such interventions may be particularly promising for reducing susceptibility to the common cold given that high state PA is associated with improved antiviral immunity (Carrico et al., 2005). However, the majority of studies targeting interventions to increase state PA have not targeted low early-life SES samples. As a result, further research is clearly needed to determine if interventions associated with increased state PA reduce health risk among those from low SES backgrounds.

Given the role of immune functioning in determining susceptibility to viruses, present study findings may have implications beyond susceptibility to the

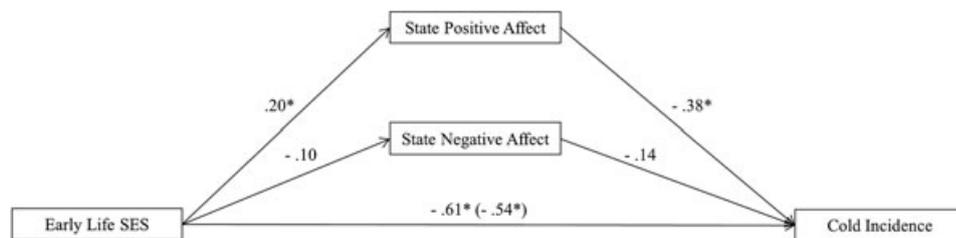


Figure 1. A mediation model of associations between early-life socio-economic status (SES), state positive and negative affect, and cold incidence. Values represent standardized regression coefficients for predictors of positive and negative affect and logistic regression coefficients for predictors of cold incidence. The logistic regression coefficient between early-life SES and cold incidence, controlling for state positive and negative affect, is in parenthesis. * $p < 0.05$

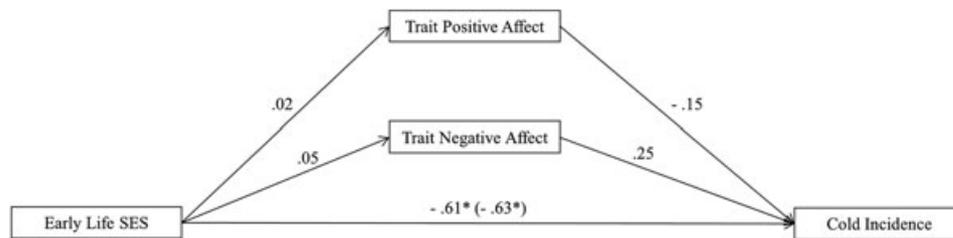


Figure 2. A mediation model of associations between childhood socio-economic status (SES), trait positive and negative affect, and cold incidence. Values represent standardized regression coefficients for predictors of positive and negative affect and logistic regression coefficients for predictors of cold incidence. The logistic regression coefficient between early-life SES and cold incidence, controlling for trait positive and negative affect, is in parenthesis. * $p < 0.05$

common cold (e.g. Doyle et al., 2010). Immune functioning is hypothesized as a mechanism linking early-life environments and risk of developing cardiovascular disease, type 2 diabetes and cancer in adulthood (e.g. Fagundes & Way, 2014). Those who experience low PA and high NA exhibit dysregulated immune functioning (e.g. Herbert & Cohen, 1993; Kiecolt-Glaser, McGuire, Robles, & Glaser, 2002; Stellar et al., 2015; Steptoe, Wardle, & Marmot, 2005). Accordingly, future work evaluating PA and NA as mechanisms linking early-life stress and other health concerns is needed.

Limitations

The present study is limited by use of recalled childhood experiences (e.g. Amato, 1991). Participants in the present study were asked to recall parental home ownership during early childhood, and it would be difficult to evaluate the accuracy of participants' responses; however, the vast majority of participants demonstrated little difficulty in responding. Small to moderately sized positive associations between parental home ownership and other indicators of SES have been identified (e.g. Cohen et al., 2004; Franzini & Fernandez-Esquer, 2006; Harkness & Newman, 2003), indicating that a better understanding of the association between early-life SES and susceptibility to cold viruses is needed. As data were collected between 1997 and 2001, it would be interesting to investigate if findings may have differed if data had been collected more recently. In addition, maintaining a high degree of PA may have been difficult for participants in the present study given that, during quarantine, they had limited ability to explore their environment and engage in physical and social activity, two key aspects of activating and maintaining PA (e.g. Garcia, Archer, Moradi, & Andersson-Arntén, 2012). Thus, there may be important strategies used by individuals who were able to maintain or produce a high level of PA, which were not evaluated in the present study. Future work should take these factors into account as well. The present study is also limited by non-significant findings when trait PA and NA were entered as covariates in ancillary analyses. Such findings may relate to shared

variance given that state PA and trait PA are highly correlated. Additionally, we may not have had enough statistical power to demonstrate that state PA is an independent indicator of affect associated with cold incidence given that state and trait measures of affect have different predictive utility in prior work (e.g. Merz & Roesch, 2011). Thus, further investigation of the potentially unique role of state PA in determining health outcomes is warranted. Lastly, small to moderate associations between primary study variables were identified, indicating that there may be important factors that were not measured in the present study. Accordingly, investigation of other potential mechanisms underlying susceptibility to cold viruses is needed.

Conclusions

In summary, PA in the first day after a virus challenge partially explained the relationship between early-life SES and susceptibility to cold viruses in adulthood. These findings support state PA as an important variable that may shape biological responses that have a clear impact on health outcomes. As a result, designing and implementing interventions that improve PA may assist individuals who have vulnerabilities to health problems, such as those with low early-life SES. Present findings could be utilized in policy decisions by demonstrating that those with low early-life SES are more likely to contract diseases such as the common cold that impact their ability to perform everyday activities (e.g. employment and schooling) than those from high SES backgrounds. Moreover, findings provide further support for a lifespan or developmental approach to research in psychoneuroimmunology.

Conflict of interest

The authors have declared that they have no conflict of interest.

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