newReplication/Extension Papers 2020 - 2021

Title

Experiential Stress and Physiological Stress: Implication of Coherence. A Replication and Extension Study

Permalink

https://escholarship.org/uc/item/28k7p8jc

Authors

Naeem, Zanib
Sharma, Ananya
Guo, Joyce
et al.

Publication Date

2021-06-01

Supplemental Material

https://escholarship.org/uc/item/28k7p8jc#supplemental

Experiential Stress and Physiological Stress: Implication of Coherence. A Replication and Extension Study

Ananya Sharma

Joyce Guo

Danielle Klein

Grace Yang

Billy Tan

Mentor: Zanib Naeem

Cognitive Science and Psychology ULaB

University of California, Berkeley

Abstract

The *physiological response* to stress and an individual's *subjective perception* of stress are two systems vital to enabling adaptive responses to dangerous stimuli and maintaining individual well-being. When the body's biological stress response and psychological interpretations of stress become misaligned, referred to as a *low stress-heart rate coherence*, detriments to health can occur (Sommerfeldt et al., 2019). Objective measures of physical stress, such as interleukin-6 and C-reactive protein, pro-inflammatory biomarkers of stress, and heart rate were analyzed in association with self-reported stress, measures of well-being, anxiety, and depression in a pool of Midlife participants from the United States. The present study utilized this data to replicate analyses performed by the original paper, "Individual Differences in the Association Between Subjective Stress and Heart Rate Are Related to Psychological and Physical Well-Being". Preliminary findings from this effort indicate inconsistencies between standard statistical values due to missing data, however still illustrate a significant association between stress-heart rate coherence and wellbeing. We additionally attempted to explore the data further by running all statistical analyses for just white participants, hypothesizing that greater stress-heart rate coherence might be limited to this overrepresented demographic. We could not confirm nor deny the prediction, as we did not have access to full data to run analyses with minority data. In any case, all analyses yielded positive associations between individual well-being and stress heart-rate coherence, although further studies with more representative samples are imperative in understanding the generalizability and mechanisms for coherence.

Keywords: stress, physiological stress, subjective stress, psychological well being, physical wellbeing

Introduction

Implications of stress have been linked to a variety of study results (Haft et al., 2019; Akoury et al., 2019; Frankenhaeuser et al., 1967; Weinberger & Schwartz, 1979; Brown et al., 2012), some exploring links between culture and stress (Haft et al., 2019), the role of trait anxiety (Weinberger & Schwartz, 1979), how lifestyle impacts elderly stress (Bhandari et al., 2020), a resulting myriad of possible relationships to investigate blooming with every new study. Stress, commonly thought of as a sense of *tension* produced by a challenging stimulus, has been linked to productivity in its healthiest manifestation, however has also been abundantly linked to maladaptive functioning when experienced chronically, or when dealt with using ineffective coping skills (Sommerfeldt et al., 2019).

Physiological stress is the body's biological response to stress, denoting activation of the sympathetic nervous system--colloquially referred to as the "fight or flight" response. As commonly experienced, the stress response can be reliably linked to a variety of physiological indicators, such as increased heart rate, sweating, and pupil dilation. However, the bodily form of stress can exist unrealized: the feeling of subjective stress is the conscious realization of the body's state of the stress response. This experience is later verbalized in the form of self-report.

Many studies have been conducted to understand the impact and role of stress in variable conditions. An interesting study by Haft et al. considered the link between cultural influences and stress on immigrant youth ranging from the prenatal period to adolescence (Haft et al., 2019). The study's results demonstrated a significant difference in managing stress at different periods of development. Specifically, the prenatal period is especially sensitive to stressors, which may lead to cross-generational cultural stress. On the other hand, youth raised in a bicultural environment may promote more positive stress responses due to more coping strategies and social support from both cultures. A separate study conducted by Ede et al. looked at connections between aspects of mindfulness, such as awareness and nonjudgement of experiences, and perceived stress and heart rate (Ede et al., 2020). Results demonstrated that awareness of state of mind and acceptance of current feelings will result in improved well-being. Though these are just two studies, what is the possible relation between them? Do bicultural environments end up promoting mindfulness due to coexistence of cultures?

Yet another study done by Weinberger & Schwartz suggest a difference in stress response between truly low trait anxiety participants, moderately high trait anxiety participants, and *repressors*: that is, participants who practice denial coping. Repressors experience more stress than low trait anxiety participants, whereas moderately high trait anxiety participants display an intermediate stress response. With this additional study, we begin to understand the complexity of studying stress, and the difficulty in synthesizing results. However, it is starkly clear that the study of stress is paramount in how we approach rearing children, dealing with life stressors, and navigating humanity.

The present study we are replicating quantitatively and qualitatively measured how the relationship between physiological and subjective stress affects an individual's overall wellbeing. By analyzing physiological indicators of stress, such as interleukin-6 and C-reactive protein levels, with various self-reported scales of stress, researchers found that greater association between heart rate and self-reported stress (stress-heart rate coherence) "significantly related to higher psychological well-being, fewer depressive symptoms, lower trait anxiety, less use of denial coping, and lower levels of proinflammatory biomarkers" (Sommerfeldt et al., 2019).

Clearly, we can appreciate the importance of altering an individual's response to their own stress response; it is without doubt that Sommerfeldt et al.'s study introduces a fascinating new look into how stress can be cognitively managed.

Our present replication of this study focused on reproducing all major statistical analyses conducted in R. This will lead to a deeper understanding of how results were obtained; we additionally conducted an exploratory analysis with the white subset of demographic data in order to investigate if stress-heart rate coherence differed within different groups of people. We hypothesized that the white demographic would display greater stress-heart rate coherence than pooled demographic results. However, due to lack of complete data, our replication and extension were performed with fewer participants than the original study, limiting the novel conclusions we could draw.

Methods and Materials

Participants:

The Midlife in the United States - 2 (MIDUS - 2) data was collected from 2004-2009. MIDUS is a longitudinal study of health and well-being which is conducted nationally. As a part of this study, participants completed surveys (N = 4,963) and a subset of this sample participated in a biomarker project involving a stress-induction session (N = 1,255). The sample size for this study including participants with sufficient data points was N = 1,065. Participants who did not have five complete and valid data points for self-reported stress were excluded from the final sample. Participants completed the biomarker study between 0-62 months following the survey study. The researchers investigated if this lag had any significant moderating effect on results or findings and found none.

Demographics:

Age of participants ranged from 35 to 86 (Mean = 56, SD = 11) in the stress-induction study. Moreover, 57.2% were female (N = 610). Overall, the sample was predominantly white (77.5%) and a significant proportion in the original study was African American (18.1%). However, in our replication the proportion of African American reduced significantly (2.2 %) due to missing data. This data was missing as it was part of the Milwaukee subsample which is no longer accessible. There were N = 118 twin pairs and N = 11 non-twin siblings in the sample. Siblings are a major source of non-independence in the data. Thus, models were adjusted for family membership.

Procedure:

Participants completed a standardized experimental stress-induction paradigm in the lab (Love, Seeman, Weinstein, & Ryff, 2010; Crowley et al. 2011; Shcheslavskaya et al. 2010; detailed

documentation of the study protocol is publicly available at http://www.midus.wisc.edu/midus2/project4/). The stress-induction paradigm included a resting baseline (11 minutes), two psychological stressor tasks (6 minutes each; counterbalanced across subjects), a seated resting period after each task called the recovery period (6 minutes each) and in response to orthostatic challenge: standing from a seated position and staying in that position

(6 minutes). The orthostatic portion of the task was not included in the analyses because changes in heart rate during the task were confounded with physical movement.Thus, the paradigm included 5 phases: baseline, stressor task 1, recovery 1, stressor task 2, recovery 2.

Participants' heart rate was recorded using an electrocardiograph (ECG). The electrodes were positioned on the left and right shoulders as well as the left lower quadrant. Heart rate was measured throughout every phase of the task. Heart rate related analyses is as follows: Average of valid inter-beat (RR) intervals was converted from RR interval units (milliseconds) to beats per minute. Average of 5-minute epoch was analyzed for each phase of the task and scored for quality. Only epochs that contained full 5 minutes of good signal quality without any invalid intervals of data were included in the analysis.

Participants verbally reported their level of stress approximately 20-30 seconds before the end of each task when the experimenter prompted them. Participants reported their stress level on a scale of 1-10 with 1 representing no stress and 10 representing extremely stressed. Thus, a total of six self-reports of stress were collected: baseline, each stressor task, each recovery period and after orthostatic challenge. The first five self-reports were used. Orthostatic time-point induction paradigm was excluded.

Other measures

Psychological stressors:

Participants completed a Stroop color-word task and the MATH task (Morgan and Turner Hewitt Task). The Stroop task consists of color name words with the font color of the word either congruent or incongruent with the word. The word appears on the screen and participants pressed a key on the keypad corresponding to the name of the color determined by the word and not that of the font color. This task was only limited to four colors in the original study. The rate of stimuli was adjusted according to the participant response to standardize for degree of stressfulness. Based on the standardization set, participants displayed an overall accuracy of 67%.

The MATH task is a mental arithmetic task. It is used as a psychological stressor in studies concerning cardiovascular reactivity. Participants in the study solved problems of mental addition and subtraction. These problems were limited to two numbers. The task had five levels of difficulty with level one being 1-digit + 1-digit problem and level five consisting 3-digit + 3-digit problem. The task began at Level 3 and difficulty of the task was adjusted according to the accuracy of response on Level 3.

Psychological well-being:

Participants completed a 42-item version of Carol Ryff's Psychological Well Being (PWB) scale during the MIDUS survey. The scale consists of six subscales which then consist of seven items each. The subscales and their Cronbach’s alpha are as follows: .40 autonomy, .54 environmental mastery, .54 personal growth, .63 positive relations with others, .29 purpose in life, and .66 self acceptance. Participants gave their responses on a Likert type scale about how true each statement was for themselves. Higher scores indicated greater psychological well-being. The PWB scores were divided by 10 to better represent estimates and standard errors.

Participants also completed the Center for Epidemiological Studies Depression Inventory (CES-D), Spielberger Trait Anxiety Inventory (STAI) as a part of stress-induction study and subset of scales from the COPE Inventory during the MIDUS 2 survey.

The CES-D consists of 20 items assessing for depressive symptoms over the past week. It is rated on a 4-point scale starting from 0 indicating *rarely or none of the time* and the highest number being 3 indicating *most or almost all of the time*. Total scores on the CES-D range from 0 to 60 with higher scores indicating increased depressive symptoms. The Cronbach's alpha for CES-D in this study was .89. The scores were divided by 10 to better represent estimates and standard errors.

The STAI consists of 20 items which assess trait anxiety. Participants rate items on a 4-point Likert-type scale with 1 = almost never and 4 = almost always. Cronbach's alpha for the STAI in this study was .91. The scores were divided by 10 to better represent estimates and standard errors.

In the COPE inventory, only one subscale was relevant for the purposes of this study: the denial subscale. This subscale measures the participant's tendency to deny the existence of a stressor as a coping mechanism. Cronbach's alpha for the denial subscale in this study was .76.

Physical well-being:

Fasting blood draws were conducted as a component of the stress-induction study. Two inflammatory biomarkers were examined: IL6 and CRP. IL-6 was assayed using Quantikine high-sensitivity enzyme-linked immunosorbent assay kit HS600B. CRP was assayed using a BN II nephelometer and a particle enhanced immunonephelometric assay. IL-6 and CRP values were log-transformed for statistical analysis as they were positively skewed with bases 2 and 10 respectively.

Statistical analysis:

To replicate this research, we used the MIDUS 2 dataset psychological (ICPSR 4652) and physiological (ICPSR 29282) from the open-source website ICPSR (https://www.icpsr.umich.edu/). This dataset was loaded into R version 4.0.3 for further analysis.

Using the Prep_Coherence_MIDUSII_20180727 R file provided by the researchers, the MIDUS 2 data was loaded into R and cleaned according to the code provided. However, due to inconsistencies in column names within the data set and the code, some of the original code had to be altered for analysis. For example, in the data cleaning code the column containing Stroop/MATH tasks was named B4VTASK1str in the original data cleaning code. However, this name did not align with the dataset provided. After combing through the codebook provided by the researchers which specifies different column names and the factors within the column, the updated column name was identified: B4VCS1. Accordingly, the code was altered to clean the data.

Moreover, Milwaukee subsample data was loaded in the original file and merged with the psychological measures data. Since the Milwaukee subsample data is no longer available for download on the website, we have chosen to exclude the data from the code.

In the process of data cleaning, we re-coded some entries as guided by the R file and obtained individual participant's stress and heart rate coherence plots along with the correlation coefficient. In the plots obtained, there was a strong within participants stress and heart rate coherence as is shown by the original study.

Slopes were extracted by calculating cluster mean center stress for Linear Mixed effects modelling and ANOVA was run to provide estimates of F, error df and p as guided by the original research paper.

After data cleaning, the original datasets were converted into .csv files from .rda versions and saved in the data folder. These .csv files were loaded into the Markdown_Analyze_Coherence_MIDUSII markdown file for statistical analysis. Due to inconsistencies in column names, the code had to be altered again to match the updated column names.

After getting the summary statistics and prepping the variables in long format, some of the initial graphs were obtained. Then we proceeded to statistical analysis for different variables. Using the Holm-Bonferroni method, Multiple Comparisons Correction was carried out.

Our team chose to carry out the Linear Mixed Effects Modelling part of the analysis which was done using the lme4 package in R. This approach examined if the individual differences variable moderated the statistical effect of subjective stress on heart rate. For the LMEM, subjective stress was centered around the participant's own mean and well-being indicator and age were mean centered. Then the heart rate was regressed on the interaction between stress and well being indicator, and the interaction between self reported stress and age after adjusting for age, and account for nonindependence because of participants and families. The model includes six fixed effects: self-reported stress (Level 1), the well-being indicator of interest (Level 2), interaction of self-reported stress and well-being indicator, age (Level 2), interaction of self-reported stress and age, and the intercept. The model contains by-participant random intercept, by-participant random slope for stress, and by-family random intercept. The two by-participant random effects were correlated. This model was represented in R as follows:

> lmer(heartRate ~ stressClusterMeanCentered* wellbeingCentered + StressClusterMeanCentered* ageCentered (1 + stressClusterMeanCentered | subject) + (1 | family) , data = dfLong).

Extension:

An extension of this replication study was carried out by extracting white population's data from the dataset used for replication. The white population's data was extracted using the filter() function from the dplyr package in R. The goal of the extension was to determine if results differed based on race by comparing the results of the replication dataset and the extension dataset. The motivation for this extension was that we were getting different values in our replication in certain statistical analyses due to lack of minority data, especially the Milwaukee sub-sample. The new dataset was subjected to the same statistical analyses and the same formula for Linear Mixed Effects Model.

Results:

Replication figures

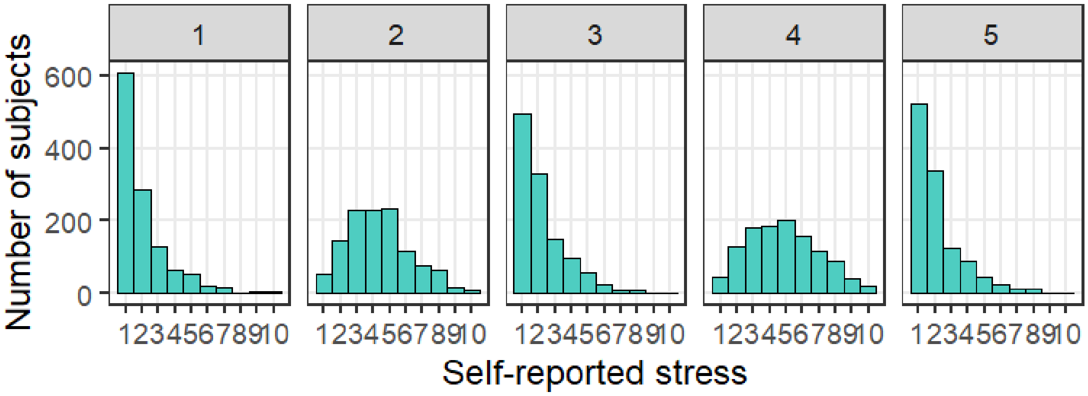

Fig 1. Illustrates the distributions of self-reported stress for the phases of the stress-induction procedure used in the study. The numbers at the top of the graphs correspond to their phase. Phase 1 was the baseline rest for 11 minutes, phase 2 was stressor task 1 a Stroop/MATH task for 6 minutes, phase 3 was recovery 1 for 6 minutes, phase 4 was stressor task 2 a Stroop/MATH task for 6 minutes, and phase 5 was recovery 2 for 6 minutes. The self-reported stress data is from a verbal report with 1 signifying no stress at all to 10 meaning one is experiencing extremely high levels of stress. These values were reported once per participant around the end of each of the five phases. Stroop is the Stroop color-word task and MATH stands for Morgan and Turner Hewitt task.

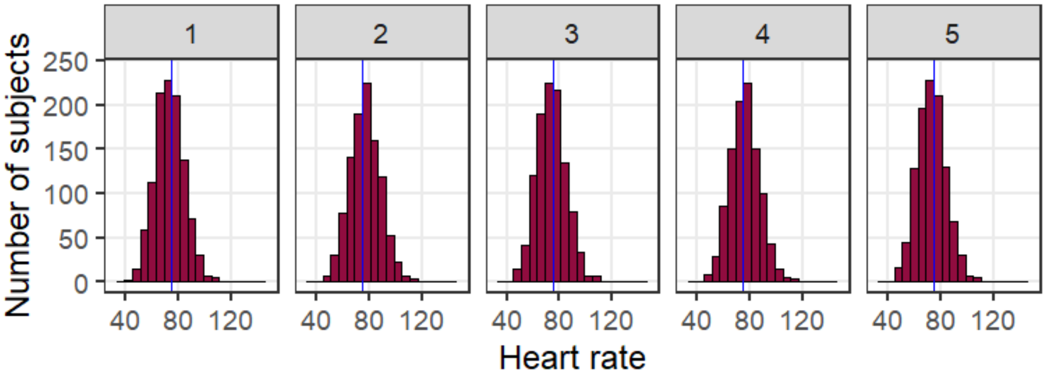

Fig 2. Figure 2 shows the distributions of heart rate for the phases of the stress-induction procedure used in the study. The numbers at the top of each graph correspond to the phases of the blank as described under figure 3. The blue line in each histogram is at a heart rate of 75 for easy comparison between tasks. Heart rate was calculated using the average per 5 min for each phase, and each participant was reported once per phase.

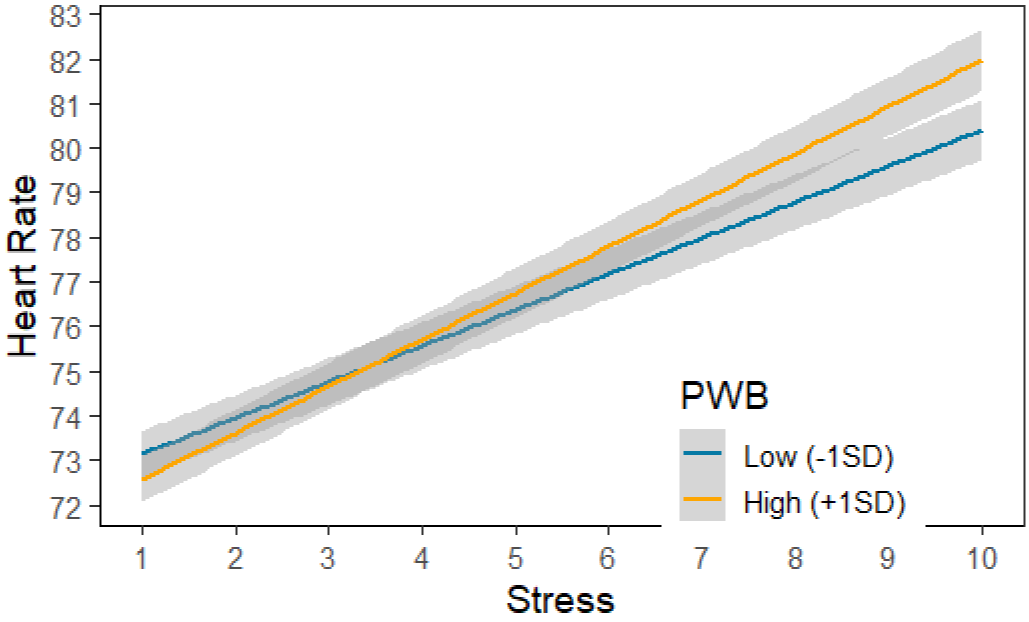

Fig 3. The positive relationship between stress and heart rate of the Psychological Well Being Scale is shown above for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

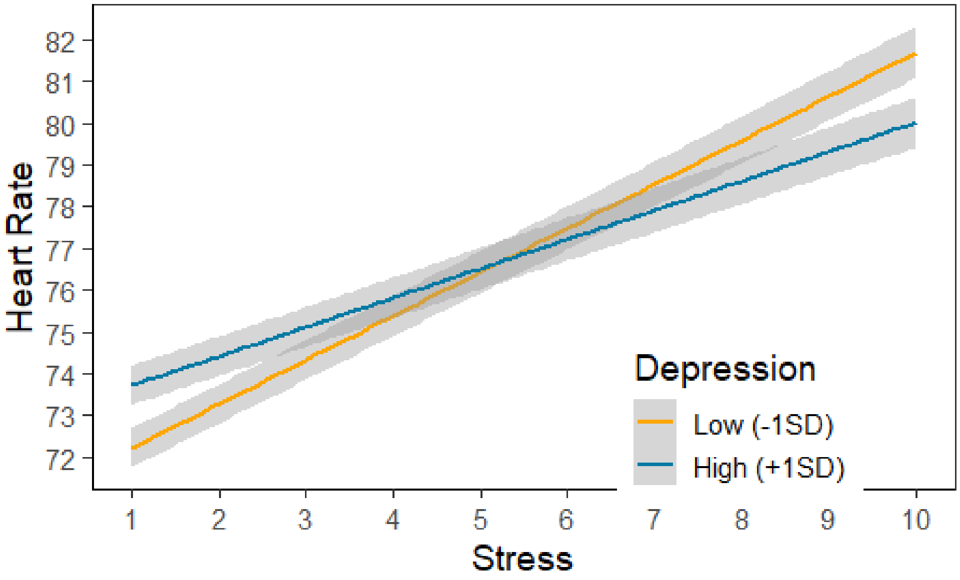

Fig 4. The positive relationship between stress and heart rate of the Center for Epidemiological Studies Depression Inventory (CES-D) is shown above for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

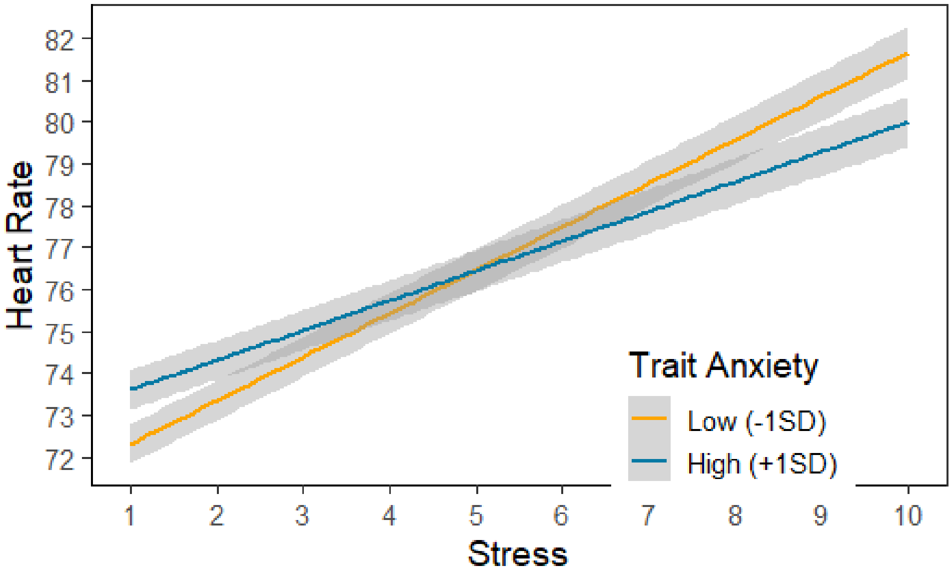

Fig 5. The positive relationship between stress and heart rate of the Spielberger Trait Anxiety Inventory (STAI) is shown above for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

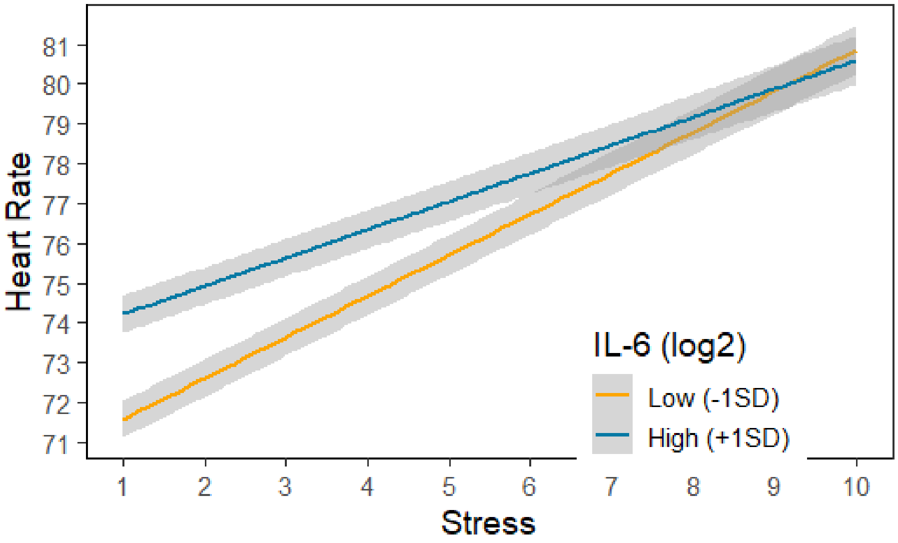

Fig 6. The positive relationship between stress and heart rate of interleukin-6 (IL-6) levels is shown above for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

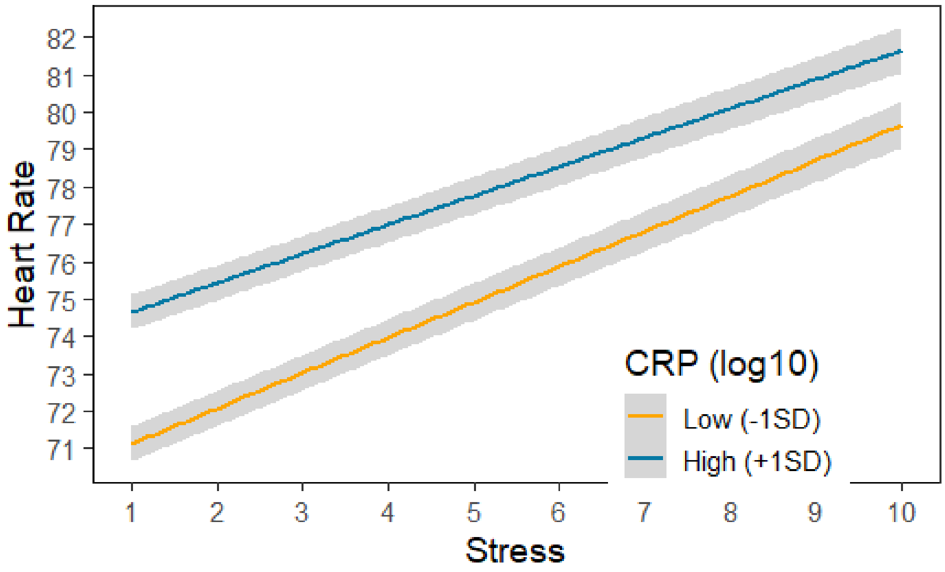

Fig 7. The positive relationship between stress and heart rate of the C-reactive protein is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

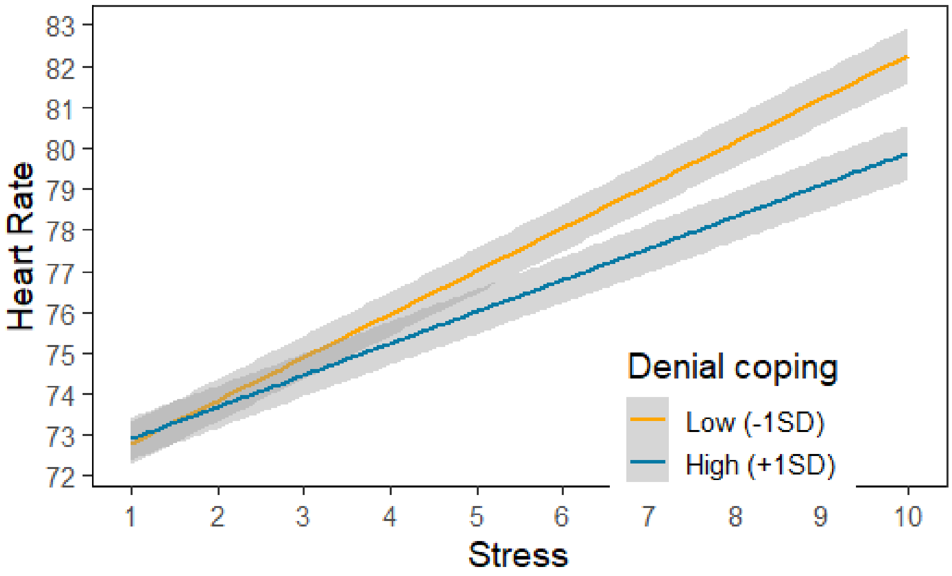

Fig 8. The positive relationship between stress and heart rate of denial coping is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

Fig 9. Graph depicting association between self-reported stress and heart rate. Each line represents a participant and colour denotes the strength of association in the mixed data set.

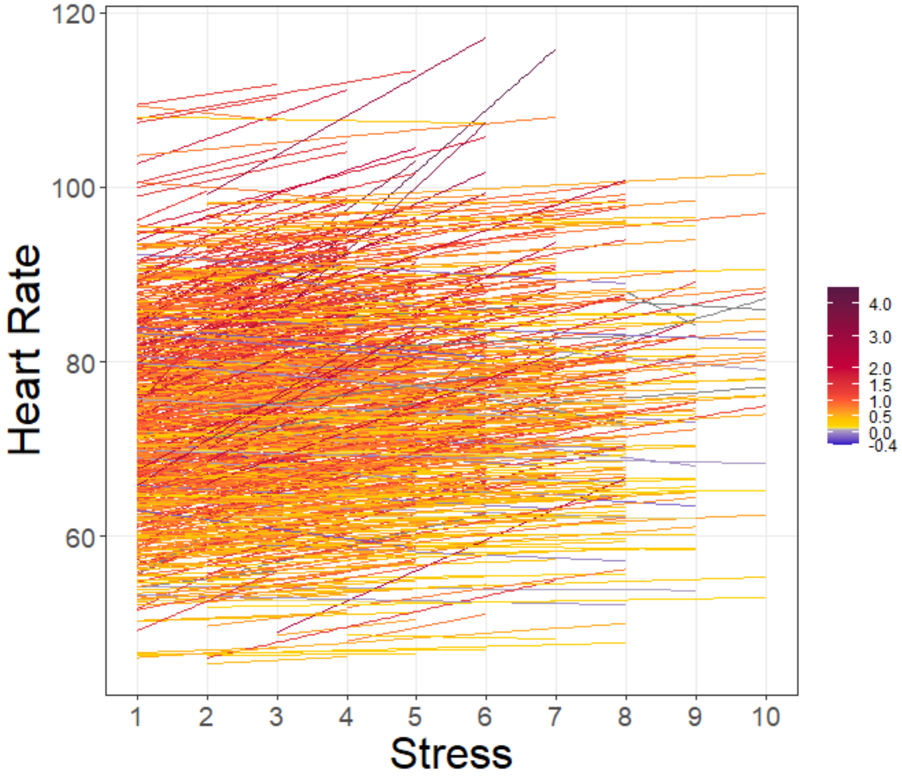

Fig. 10. Replicated figure of association between stress and heart rate; each line represents a participant and colour denoting the strength of association in the mixed data set.

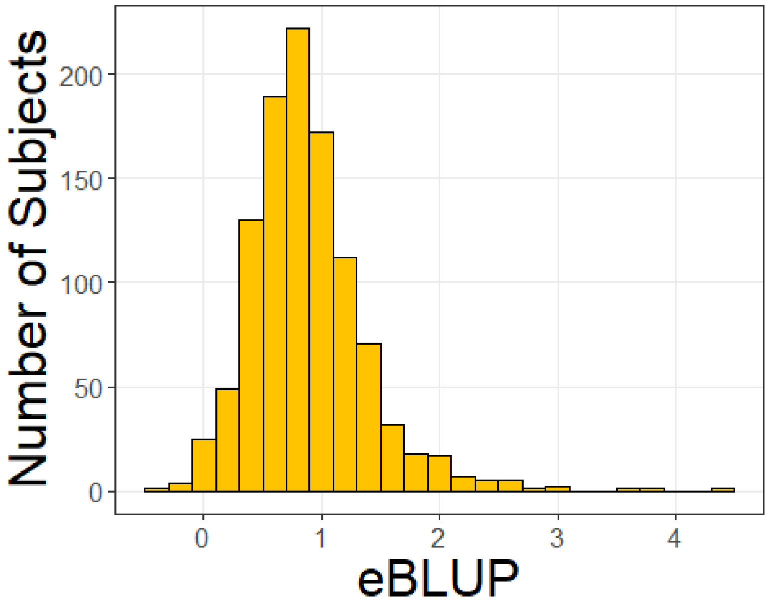

Fig 11. The histogram distribution of empirical best linear unbiased predictors (EBLUPs) for within-participants associations between stress and heart rate. EBLUP relates the significance of the strength of association between two variables, namely stress and heart rate in subjects. An EBLUP value close to 1 or higher indicates a strong and positive correlation. We see most of the available data clustered around 1.

Results:

Extension figures

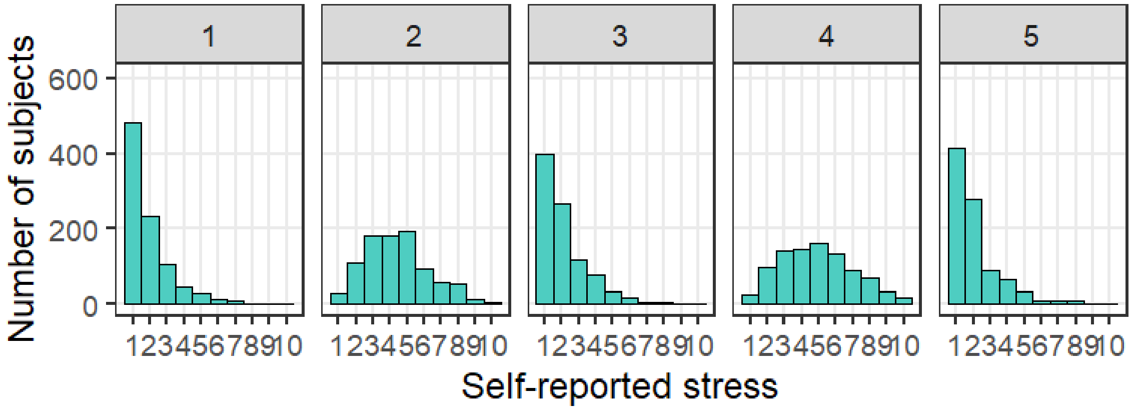

Fig 11. Extension figure showing the distributions of self-reported stress for the phases of the stress-induction procedure used in the study. The numbers at the top of the graphs correspond to their phase. Phase 1 was the baseline rest for 11 minutes, phase 2 was stressor task 1 a Stroop/MATH task for 6 minutes, phase 3 was recovery 1 for 6 minutes, phase 4 was stressor task 2 a Stroop/MATH task for 6 minutes, and phase 5 was recovery 2 for 6 minutes. The self-reported stress data is from a verbal report with 1 signifying no stress at all to 10 meaning one is experiencing extremely high levels of stress. These values were reported once per participant around the end of each of the five phases. Stroop is the Stroop color-word task and MATH stands for Morgan and Turner Hewitt task.

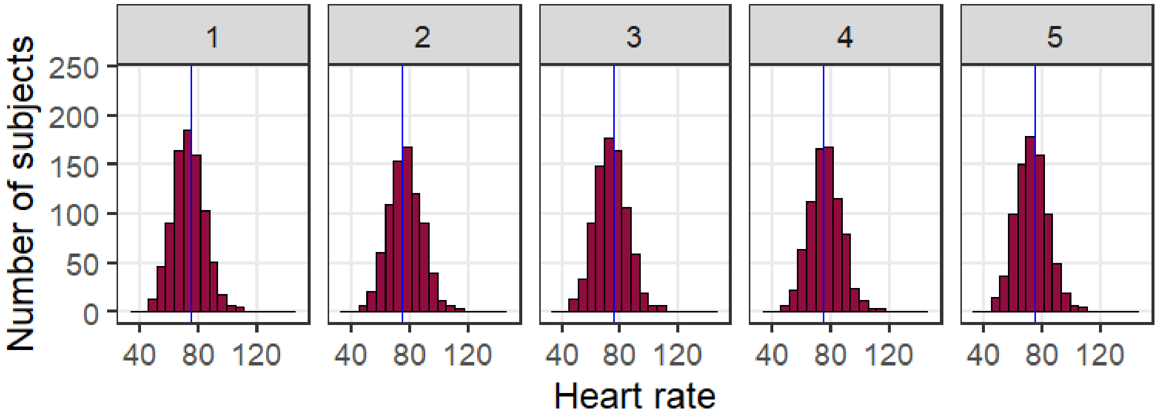

Fig 12. Extension figure showing the distributions of heart rate for the phases of the stress-induction procedure used in the study. The numbers at the top of each graph correspond to the phases of the blank as described under figure 3. The blue line in each histogram is at a heart rate of 75 for easy comparison between tasks. Heart rate was calculated using the average per 5 min for each phase, and each participant was reported once per phase.

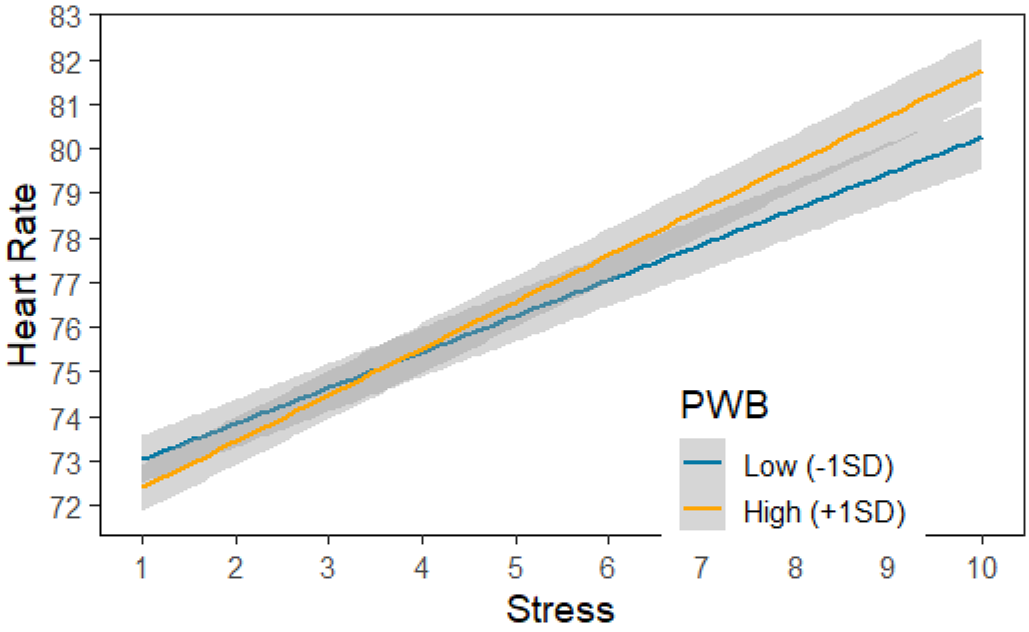

Fig 13. Extension graph depicting the positive relationship between stress and heart rate of the Psychological Well Being Scale is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

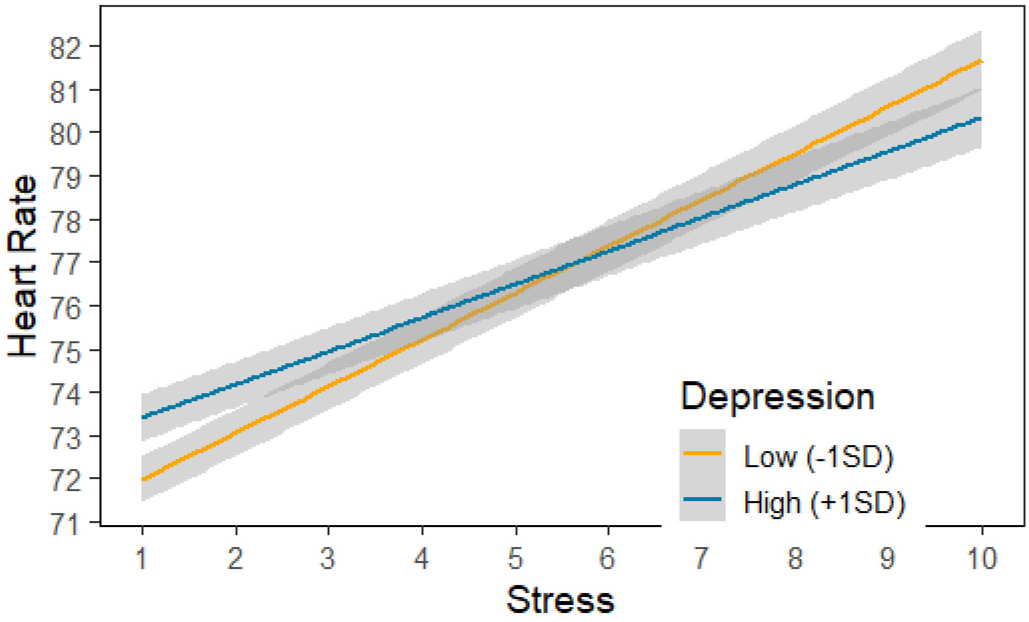

Fig 14. Extension graph depicting the positive relationship between stress and heart rate of the Center for Epidemiological Studies Depression Inventory (CES-D) is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean.The 95% confidence intervals are shown by the gray shading.

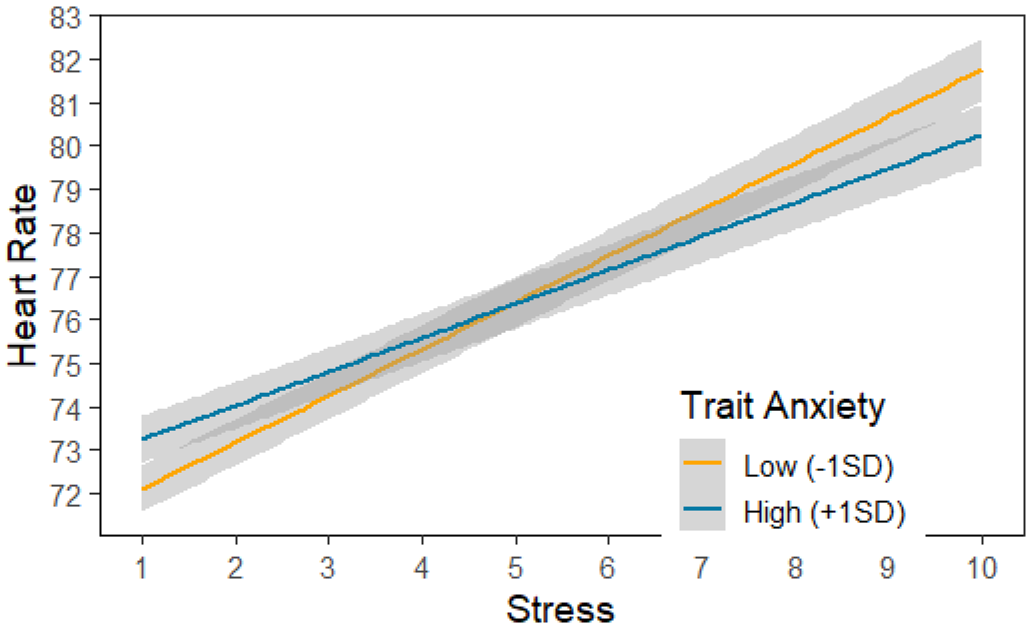

Fig 15. Extension graph depicting the positive relationship between stress and heart rate of the Spielberger Trait Anxiety Inventory (STAI) is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

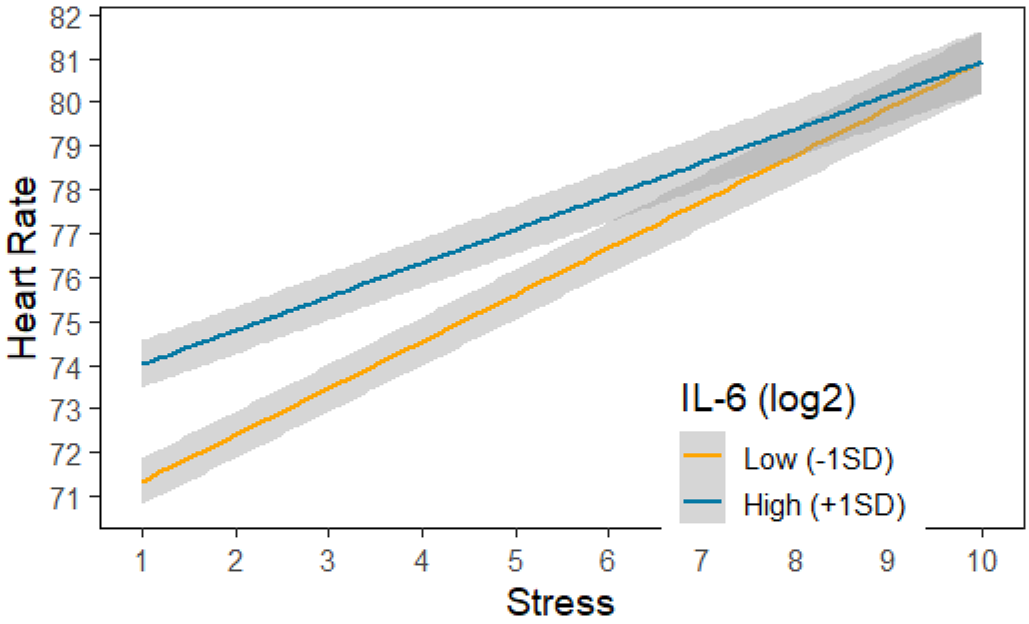

Fig 16. Extension graph depicting the positive relationship between stress and heart rate of interleukin-6 (IL-6) levels is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

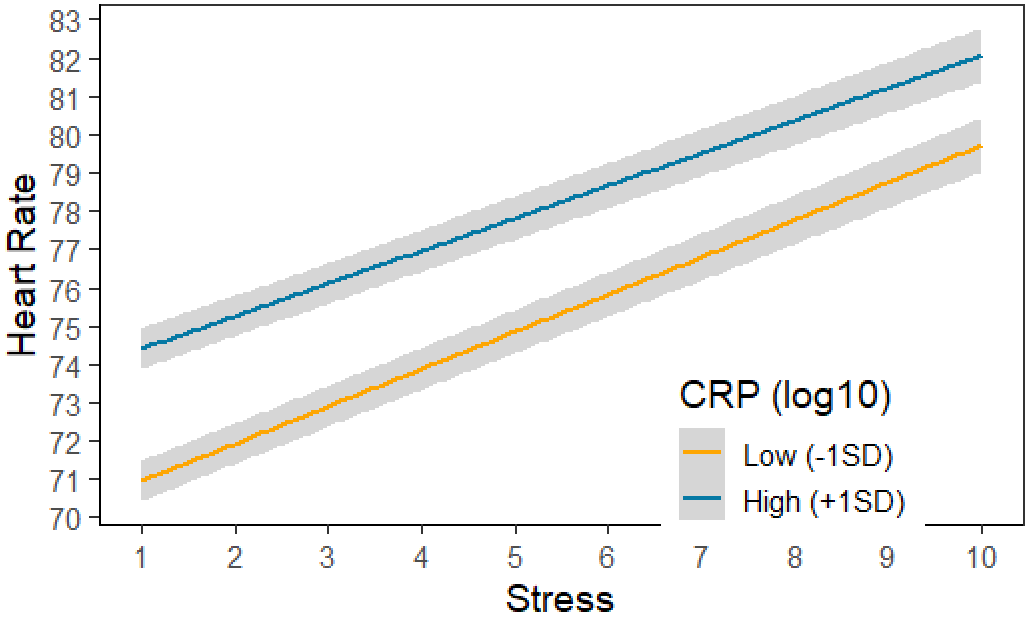

Fig 17. Extension graph depicting the positive relationship between stress and heart rate of the C-reactive protein is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

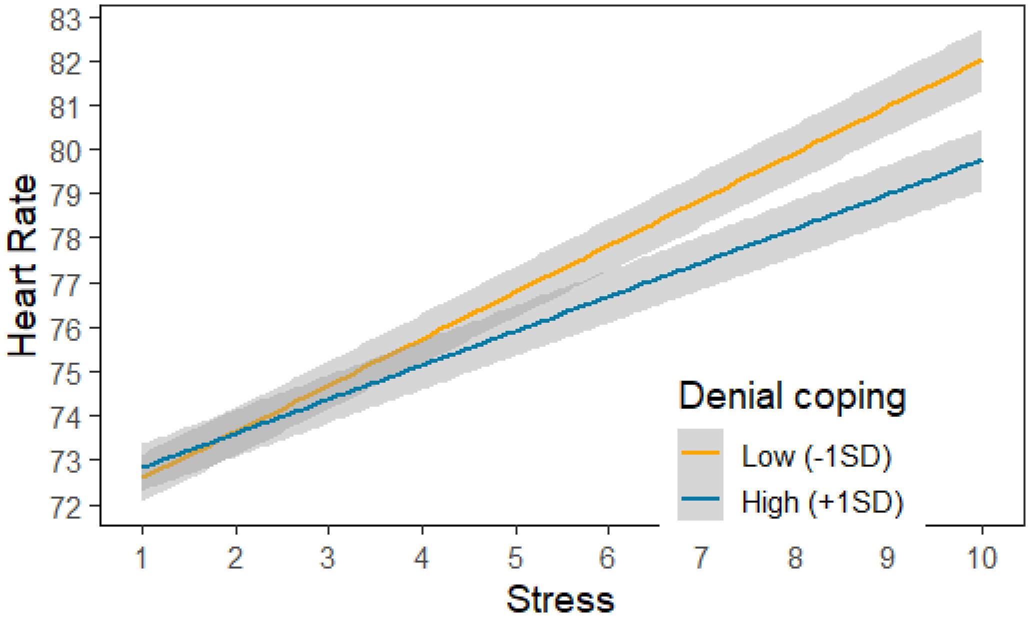

Fig 18. Extension graph depicting the positive relationship between stress and heart rate of denial coping is shown for high levels which is 1 SD above the mean and low levels which is 1 SD below the mean. The 95% confidence intervals are shown by the gray shading.

Fig 19. Extension graph depicting association between self-reported stress and heart rate. Each line represents a participant and colour denotes the strength of association in the mixed data set.

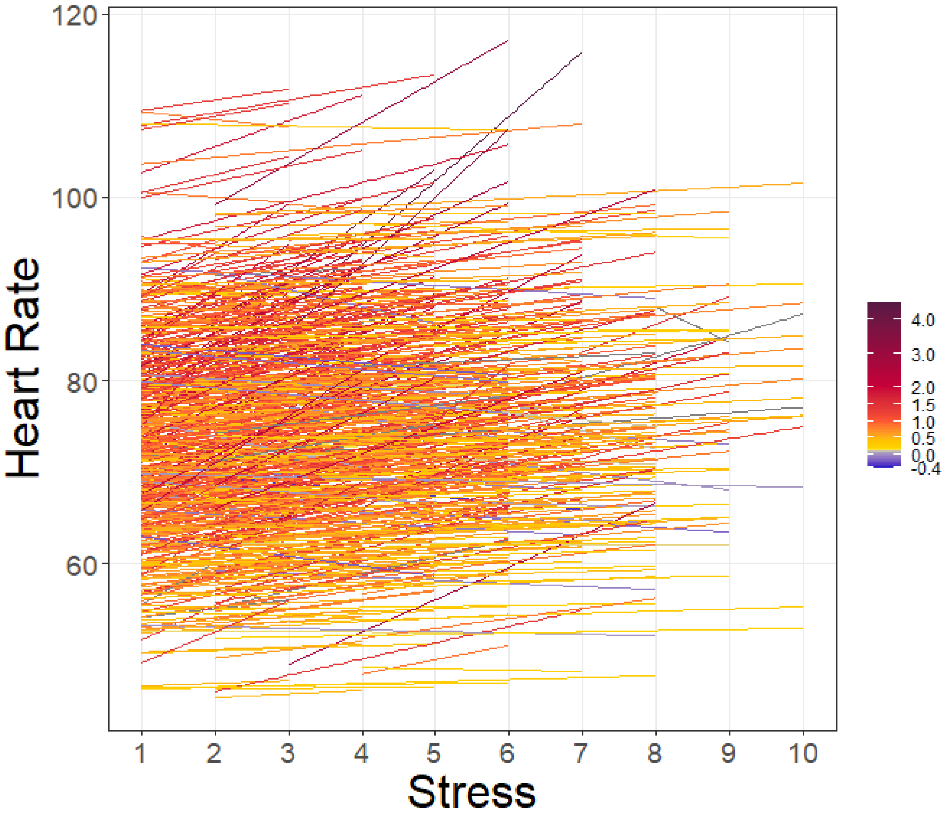

Fig 20. Extension figure of association between self-reported stress and heart rate with each line representing a participant and colour denoting the strength of association in the mixed data set.

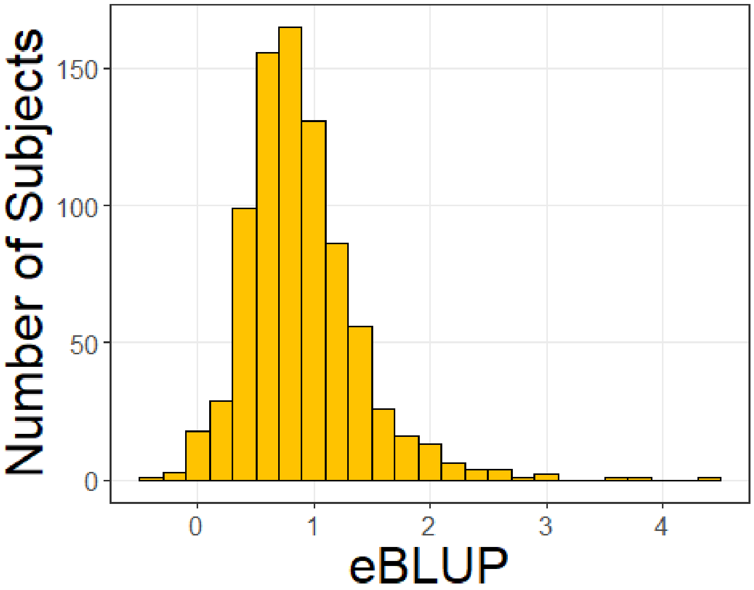

Fig 21. The extension histogram distribution of empirical best linear unbiased predictors (EBLUPs) for within-participants associations between stress and heart rate. EBLUP relates the significance of the strength of association between two variables, namely stress and heart rate in subjects. An EBLUP value close to 1 or higher indicates a strong and positive correlation. Again, we see most of our data clustered around 1.

The main figures we will be discussing are figures 10, 11, 20, and 21. Figure 10 is a replicated figure of the association between self-reported stress and heart rate, with each line representing a participant and color denoting the strength of association in the mixed data set. Figure 11 represents the eBLUP (empirical best linear unbiased prediction) for within participants association. A value closer to 1 shows that there is a strong correlation, and most of our data is closer to 1, meaning that even with missing data, our replicated results support the original study's main conclusion. This graph is for within participants association between stress and heart rate.

Figure 20 is our extension graph, representing the association between self-reported stress and heart rate in majority white data. Each line represents a participant. As in figure 10, the color denotes the strength of the association. Figure 21 is another extension figure representing strength of the association between stress and heart rate of white participants.

Participants with higher stress-heart rate coherence displayed higher psychological well-being within our replication and extension. Our replications differed from that of the researcher's results in terms of p-values, which was initially what prompted extension; this approach clarified that only missing data was creating differences, and our concluding capacity was limited by the small minority data that we had for comparison against white participants..

Between figures 10 and 20, a conclusion can be drawn that the coherence between stress and heart rate in white populations appear to be positively correlated; that is, increased stress leads to increased heart rate across all participants. Figures 11 and 21 analyze the variability between participants in regards to their stress-heart rate coherence data. eBLUP related the strength of association between a participant’s stress and heart rate. Higher eBLUP value indicates positive and strong relationship for stress and heart rate, and an eBLUP closer to 0 indicates a weaker correlation for stress and heart rate. In both figures, the conclusion is that participant stress and heart rate are positively correlated to a significant degree, with little participants displaying an eBLUP value of 0. Both figures display a similar trend, that is, a majority of participants were analyzed to have an eBLUP value close to 1.

Discussion

Our replicated and extended results with just white participants demonstrated that higher stress-heart rate coherence was associated with higher psychological well-being. Different participants showed differing levels of stress-heart rate coherence, but the general trend displayed by eBLUP analysis showed that most participants' stress and heart rate had values close to 1, indicating that stress-heart rate coherence was correlated and significant in participants' well-being.

In this replication, we were unable to fully replicate the analysis due to two factors. First, we did not have access to all the data that was used in the original study. The Milwaukee sub-sample, which consisted predominantly of African Americans, was used in the original study but was no longer an open sourced data set at the time of this replication. As a result, all replication was limited by the missing data set, and replicated figures and resulting conclusions were not congruent with the paper in question. Second, there were differences in the column names used in the dataset and code names used to access those columns during data cleaning and analysis. Thus, considerable alterations had to be made to the code during the replication, especially during data cleaning. Specifically, column names from the dataset were aligned with code names manually. Thus, there might be room for error if the column that the researchers initially intended to use was not used in the replication.

Since we observed differences in values obtained from ANOVA analyses between the original study and replication, we created an extension with the hypothesis that the results would differ for white population only dataset and the original dataset, that is a mix of white population and other race groups. We originally intended to do a comparative analysis of white population and other race data but since we lacked data from other race groups (<50) we had to design our extension differently. We did not see any significant differences between our replication and extension, that is, the analyses run on white population's data matched the analyses run on mixed data considerably. This could be due to the lack of minority data within our mixed dataset, that is, there is a possibility that the minority population sample size in our data set was insufficient to show significant trends in our results. Thus, an important future research avenue for this study would be to explore if there would be different trends for minority populations and in what ways they would differ.

Conclusion

With Sommerfeldt et al.'s study comes significant implications for understanding stress, as touched upon by our preliminary analyses. We understand that stress-heart rate coherence is associated with and likely leads to greater psychological well being, not only within mixed missing data, but within the available data of the white demographic, as our results show. Our hypothesis of white data showing a greater stress-heart rate coherence could not be tested. Our results further poise questions of the mechanisms that allow for a greater stress-heart rate coherence, and bring to light issues in accessing open data. Applications of this research could fit in well with understanding the developmental trajectories of stress-heart rate variability cross culturally, and within differing socioeconomic standings.

References

Sommerfeldt, S. L., Schaefer, S. M., Brauer, M., Ryff, C. D., & Davidson, R. J. (2019). Individual differences in the association between subjective stress and heart rate are related to psychological and physical well-being. Psychological science, 30(7), 1016-1029.

Ede, D. E., Walter, F. A., & Hughes, J. W. (2020). Exploring how trait mindfulness relates to perceived stress and cardiovascular reactivity. *International journal of behavioral medicine*, 1-11.

Weinberger, D. A., Schwartz, G. E., & Davidson, R. J. (1979). Low-anxious, high-anxious, and repressive coping styles: psychometric patterns and behavioral and physiological responses to stress. *Journal of abnormal psychology*, *88*(4), 369.

Frankenhaeuser, M., Fröberg, J., Hagdahl, R., Rissler, A., Björkvall, C., & Wolff, B. (1967). Physiological, behavioral, and subjective indices of habituation to psychological stress. *Physiology & Behavior*, *2*(2), 229-237.

Akoury, L. M., Warren, C. S., & Culbert, K. M. (2019). Disordered eating in Asian American women: Sociocultural and culture-specific predictors. *Frontiers in psychology*, *10*, 1950.

Haft, S. L., Zhou, Q., Stephens, M., & Alkon, A. (2021). Culture and stress biology in immigrant youth from the prenatal period to adolescence: A systematic review. *Developmental Psychobiology*, *63*(3), 391-408.

Brown, R. L., & Turner, R. J. (2012). Physical limitation and anger: Stress exposure and assessing the role of psychosocial resources. *Society and Mental Health*, *2*(2), 69-84.