ARTICLE TITLE: Role of the Valuation of Nervousness in Cortisol Responses to Psychosocial Stress Task and Task Performance in European American and East Asian Students

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Abstract

How people perceive and value negative affective states is associated with physiological responses to stressful events and moderates the association between negative feelings and physiological and behavioral outcomes. However, previous studies on valuation of negative affective states have been conducted mostly in Western cultures. Different cultural backgrounds shape how people view negative emotions as well as how people attend to internal emotional states, which may change the effects of valuing negative emotions. The present study thus examined whether valuation of nervousness was associated with the magnitude and duration of cortisol responses to a standardized laboratory stressor and task performance in East Asian and European American students. Two hundred undergraduate students were recruited through a large pool of students taking psychology courses. They engaged in demanding speech and arithmetic tasks as part of the Trier Social Stress Test (TSST). European American participants who had a higher valuation of nervousness showed lower cortisol reactivity. Valuing nervousness was associated with better speech performance in students from both cultural backgrounds, and the strength of this association was moderated by cortisol level. Our findings call attention to the importance of considering whether negative emotions are viewed as beneficial or an impediment, as well as the cultural context when responding to demanding and threatening situations.

Keywords: Stress, Nervousness, Culture, Trier Social Stress Test, Cortisol, Performance

1. Introduction

A growing body of research has demonstrated that how people perceive and construe their affective states matters, including how they value negative emotions. Valuing negative affective states as a potential resource is a component of coping strategies that have been associated with the magnitude of physiological responses to stressful events (Jamieson et al., 2012) and to better performance on tasks (Beltzer et al., 2014). Additional lines of research have shown that cultural contexts shape how negative emotions are construed and valued (An et al., 2017; Koopmann-Holm & Tsai, 2014; Miyamoto et al., 2014) and how people attend to internal emotional states (Dere et al., 2012; Ryder et al., 2008). Extending these findings and perspectives, the current study focused on how the consideration of negative emotions to have value and utility may be associated with salivary cortisol responses in students from different cultural backgrounds when performing challenging tasks.

1.1. Valuation of Negative Emotion and Physiological Responses to Psychosocial Stress

Research on the links between emotions and health has typically focused on how stress, including environmental or psychosocial demands, can disrupt healthy functioning if intense and prolonged (Lovallo, 2015). Activation of hypothalamic-pituitary-adrenal (HPA) axis and disturbances of the normal daily cortisol biorhythm are considered to be one pathway connecting negative emotions to adverse outcomes and health impairment (Kirschbaum et al., 1993). Experiences of stress and the negative emotions associated with stressful events can also lead to recurrent activation or potentially a dysregulation of the HPA biorhythms (Kirschbaum et al., 1993), which can hasten the onset and progression of disease with detrimental effects on the outcomes (Cohen et al., 1997; Kiecolt-Glaser et al., 2002).

How people construe and value negative emotions, beyond the subjective experience of that emotion, has also been suggested to play a role in the association between negative emotions and physical health. Having a more positive view of negative emotions moderated the association between negative emotions and poor physical health (Luong et al., 2016), suggesting that valuing negative emotions could have potential benefits. Further, laboratory studies have shown that perceiving negative states or emotions as helpful can lead to a more adaptive cardiovascular and adrenal hormonal responses to a stressor (Beltzer et al., 2014; Crum et al., 2017; Jamieson et al., 2012, 2013). Collectively, these studies convey that perceiving negative experiences and emotions as helpful may moderate physiological reactions.

In addition to affecting the initial physiological reactions, a slow recovery after a stressful experience, has been linked to development of disease (Brosschot et al., 2005; Pieper & Brosschot, 2005). However, there has been less research on how the valuation of negative emotions may influence homeostatic recovery and the time to return to a normal, resting state. More specifically, the Cognitive Activation Theory of Stress (CATS, Ursin & Eriksen, 2004, 2010) hypothesized that the magnitude and duration of physiological activation were proportional to the individual's subjective experience and interpretation of the stimulus (i.e., how harmful/threatening versus potentially useful). The duration of the reaction is important because the initial alarm reaction is typically not the mediator of ill health, but if sustained, then the more protracted metabolic changes can progress to a maladaptive dysregulation, which has been described by some as an allostatic change (McEwen, 2000). Thus, our study focused not only on the increase in cortisol secretion immediately after a demanding task, but also the rapidity with which cortisol levels had returned back to the baseline range.

1.2. Valuation of Negative Emotion and Behavioral Outcomes

There has also been relatively little research on the potential benefits of a valuation of negative emotions on behavioral outcomes. Some studies considered the beneficial effect of positively viewing negative experiences (e.g., physical arousal, stress) on objective performance (Jamieson et al., 2010, 2012) and behavioral display measures (Beltzer et al., 2014). Suggestive of a similar pattern, defensive pessimists, who are more likely to perceive some benefits of their pessimistic thinking, were also found to benefit from engaging in negative thoughts before completing a task (Norem & Illingworth, 1993; Seery et al., 2008). Collectively, these findings indicated that perceiving some benefit of negative or aroused states could lead to better task performance. One key hypothesis of our study was that valuing nervousness as being useful and positive would be associated with better task performance.

It was also possible that there would be an association between valuing negative emotion, performance of a stressful task and hormonal activation in response to the demands of the task. That is, the positive role of valuing negative emotions on performance might be more evident among respondents whose cortisol levels were heightened in anticipation of or during early task performance. One study examined how cortisol levels interact with the appraisal of anxiety to predict performance of a negotiation task (Akinola et al., 2016). Among participants with higher post-negotiation cortisol levels, those who were told to think of anxiety as helpful for negotiation demonstrated superior performances than those given no instructions. This relationship was not found for participants with relatively lower cortisol increases post-negotiation. The difference was interpreted as indicating that appraising anxiety as beneficial and useful was more effective among individuals who evinced larger cortisol responses to a stressful experience. Thus, we predicted that the association between performance and valuing negative emotion would depend on the extent of the neuroendocrine activation.

1.3. Valuation of Negative Emotion and Cultural Contexts

Most of the research on this topic has been generated on participants from American or European backgrounds and has not considered the possibility of an influence of cultural context (Beltzer et al., 2014; Crum et al., 2017; Jamieson et al., 2012, 2013), except for a recent study that compared the association between the valuation of negative emotion and cardiovascular responses in European American and East Asian students (Yoo et al., 2021). Thus, whether the valuation of negative emotions is also associated with cortisol responses and behavioral performance across cultures has not been examined before.

Cross-cultural research has highlighted that sociocultural factors (i.e., independence vs. interdependence, analytical vs. dialectical/holistic thinking styles) contribute to how emotions are valued (for a review, see Miyamoto et al., 2017; Bastian et al., 2012; Ma et al., 2017; Miyamoto & Ma, 2011; Sims et al., 2015; Uchida & Kitayama, 2009) and how people attend to internal emotional states (Mesquita et al., 2016; Ryder et al., 2008). Negative aspects of negative emotions are highlighted when seen as threatening to one's autonomy in Western cultural contexts (Bastian et al., 2012; McGuirk et al., 2018), but both negative and positive aspects of negative emotions are more likely to be underscored in the East Asian cultural context (An et al., 2017; Miyamoto et al., 2014; Uchida & Kitayama, 2009).

At the same time, some evidence suggests that East Asians may attend less to internal emotional experiences or states than do Westerners (Dere et al., 2012; Ryder et al., 2008). For example, compared to Canadians of European family backgrounds, Chinese Canadians tended to report placing less emphasis on thinking about internal emotional experiences as opposed to attending to external information (Dere et al., 2012). If East Asians are less likely to attend to internal emotions, there is a possibility that perceiving beneficial or harmful aspects of internal emotions may have less impact on East Asians. Given these possibilities, we tested if the valuation of negative emotions would be linked to cortisol responses and task performance to the same or different degree in students from European American and East Asian cultural backgrounds.

1.4. The Current Study.

Our study investigated (1) how valuing negative emotions is related to adrenocortical responses to a standardized laboratory stress task and (2) the link between valuation of negative emotions and task performance in students from two cultural backgrounds. The analysis focused primarily on nervousness, a specific and relevant negative emotion when experiencing a demanding and evaluative task (Yoo et al., 2021). Similar to nervousness, anxiety has also commonly been used as the term for the negative emotional state evoked by environmental demands that elicit physiological responses. However, the use of the term anxiety might connote more negative associations among Americans, especially for students (Bateson et al., 2011). Therefore, the term nervousness was employed to probe this emotional state without implicit negative connotations that could vary by cultural background. To test our predictions, students' performance was evaluated with a standardized and widely used cognitive and emotional challenge (i.e., Trier Social Stress Test; Kirschbaum et al., 1993) and serial saliva samples were collected to minimize the intrusiveness of the physiological assessment. We hypothesized that their valuation of negative emotions would moderate their physiological response. The second aim focused on task performance, which was examined separately for the speech and math components of the TSST. We hypothesized that a higher valuation of negative emotions would be associated with better task performance, and the association would be more evident among those showing larger cortisol responses. For both hypotheses, we explored if the effects would be moderated by the students' cultural backgrounds.

2. Materials and Methods

2.1. Participants

A convenience sample was recruited through an undergraduate student subject pool taking psychology courses at a large midwestern university in the U.S., as approved by the Institutional Review Board. They were prescreened by ethnicity, citizenship, and health status using a self-administered survey completed at the beginning of the semester. East Asian students self-identified as having ancestral family backgrounds from China, South Korea, or Japan. European American students self-identified as citizens of the United States with white European family backgrounds. Based on the post-session demographic survey, the majority of the sample reported the same ethnicity they identified during prescreening. One student identified as biracial and was thus excluded from the final sample and cortisol assay. We also assessed health-related criteria: (a) diagnosed depression or anxiety disorder, (b) any form of mental illness, (c) currently taking prescription medication for blood pressure or heart disease, or (d) using any form of nicotine regularly; all of the respondents passed the criteria. In addition, participants were asked about their regular intake of alcohol; none reported consuming more than two alcoholic drinks per day. The final sample consisted of 200 participants: 101 European Americans and 99 of East Asian descent. The majority of European American students indicated they lived in the United States all their life ($N = 98$), while the remaining three students reported having resided in the United States for more than 16 years. These students also mentioned that both parents ($N = 89$) or one of their parents were born in the United States ($N=6$). When asked where they were from, all reported being from a city within the United States. The East Asians included both international students (i.e., non-US citizen of East Asian ancestry or origin; N = 83) and East Asian Americans (i.e., US citizens of East Asian ancestry or origin; N = 16). When asked where they were from, 16 reported being from a city within the United States, while others reported being from an East Asian country[1] The gender distribution of the European American (M_{Age} = 18.5, Female = 62.4%) and East Asian descent samples (M_{Age} = 19.1 Female = 57.6%) was similar ($\chi2$ = -0.20, p = 0.49). The age range was also similar (t(198) = 1.90, p = .053), although students of East Asian descent tended to be slightly older than the European Americans.

2.2 Measures

2.2.1. State Anxiety

State anxiety was measured with the 6-item short form of the State-Trait Anxiety Inventory (Marteau & Bekker, 1992), which had been abbreviated from the Spielberger State-Trait Anxiety Inventory (Spielberger et al., 1983). Participants were asked how they felt at the particular moment (e.g., “I am tense,” “I am relaxed.”) on a 4-point rating scale (1 = not at all; 4 = very much). The scale was completed at baseline (20 minutes before task), right before the start of the task, right after completion of the task, and 15 minutes before the end of the recovery period. Cronbach’s alpha values were over 0.75 and omega values (ω) were over 0.83 for all time points and both groups.

2.2.2. Task Experience and Performance

After the task was over, participants completed questions on their experience with the task. Participants were asked the extent to which they perceived the task as important to them,

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[1] East Asian internationals were mostly from China (92.8%), with 5 from Hong Kong, South Korea, Taiwan, or Japan. 95.18% of East Asian internationals had lived in the United States for five years or less, while 4 reported living in the US for more than five years but not all their life. Among East Asian Americans, 14 were second generation (i.e., born in the US) from immigrant backgrounds, with one adoptee and one first generation immigrant from South Korea.

how motivated they were, how much they cared about the task, and how difficult the task was. These questions were answered for both the speech and math tasks and rated on a 7-point scale. The first three items (i.e., concern, motivation, and importance) assessed task relevance and the last item gauged task difficulty.[2] Task relevance scores were calculated by averaging the 3 ratings for each task. Cronbach's alphas were 0.84 ($\omega = 0.84$) and 0.81 ($\omega = 0.82$) for speech and math task relevance, respectively.

Measures of task performance were computed differently for the speech and math tasks. Coding for speech task performance was based primarily on the coding scheme used by Yeager, Lee, and Jamieson (2016; see Beltzer, Nock, Peters, & Jamieson, 2014, for details). Two raters blind to anxiety level and study hypotheses watched video recordings of the participants' speech performance. Performance was rated on non-verbal cues (i.e., closed versus openness, fidgeting (reverse-coded), hand gesture, eye contact with camera), overall confidence, and overall quality of speech. Coding was completed on a scale from 1-to-5. Lower scores indicated more avoidant signaling, low confidence, or low performance quality. Interrater reliability was 0.75. Speech task performance was rated by first averaging each item across the two coders, standardizing each item, then averaging across all items. Chronbach's alpha was 0.76 ($\omega = 0.90$) for the final composite score. (Beltzer et al., 2014; Yeager et al., 2016). Math performance was based on the lowest correct answer attained. The final value had a possible range from 1 to 67 with higher numbers indicating better math performance (e.g., "2" = two correct subtractions from starting number), and then standardized.

2.2.4. Valuation of Nervousness

[2]Although the original aim was to construct a single factor that captured task relevance, the items collectively had low reliability ($\alpha < 0.70$), and further analyses revealed task difficulty to be an independent factor.

To determine how much each participant valued the feeling of nervousness, a composite index was generated from two measures: 1) Emotion Valuation Scale and 2) Nervousness Mindset (see Yoo et al., 2021, for details). The Emotion Valuation Scale is a modified version of the Negative and Positive Affect Valuation Measure (Luong, Wrzus, Wagner, & Riediger, 2016). Following Yoo et al. (2021), we focused on two items from the scale that probed the extent to which nervousness was viewed as 'helpful' or 'disruptive' when completing a demanding task. Each was rated on a 7-point scale (1= not at all; 7 = very much). The Nervousness Mindset scale was a modified version of the Stress Mindset (Crum et al., 2013), which switched the wording of the items from stress to nervousness experienced in a situation where there was a demanding task. The questionnaire included 7 statements (e.g., "The effects of feeling nervous for this task are positive and should be utilized."), rated on a 5-point scale (1 = strongly disagree; 5 = strongly agree). The final score was computed by summing the standardized scores of each item. Cronbach's alpha was 0.80 (European Americans = 0.82, East Asian descents = 0.76) and omega was 0.85 (European Americans = 0.87, East Asian descents = 0.83).

2.2.5. Salivary Cortisol

To examine neuroendocrine activation, cortisol levels were assessed four times: immediately before task instruction, and +10, +25, and +40 minutes after task completion (i.e., Baseline, Post-Task, Recovery 1, and Recovery 2). Samples were assayed in duplicate determinations by enzyme-linked immunosorbent assay (ELISA) at the Salimetrics SalivaLab (Carlsbad, CA). The salivettes were thawed to room temperature and centrifuged for 15 minutes at approximately 3000 rpm to extract saliva from the swab. Sample test volume was 25 µl. This assay has a lower limit of detection of 0.007 µg/dL, with values typically in the range of 0.012-3.0 µg/dL. The mean intra-assay coefficient of variation was 4.6%, and the average inter-assay coefficient of variation was 6.0%. The 25th 50th, and 75th percentile values of the intra-assay coefficients of variation were 0.98,7, 2.24, and 4.15, respectively. We also report the median and average interquartile range by cultural background and timepoint in the Supplemental Materials (Table D).

2.2.6. Test Protocol

Participants were asked to refrain from eating or drinking other than water for at least 2 hours before the start of the session, and to refrain from strenuous activities the day before the session. The 90-minute session was scheduled during the afternoon (between 13:00 – 19:00) to control for diurnal variation in hormone levels. Upon arrival, participants provided informed consent. The session consisted of Baseline, Task, and Recovery periods. The Baseline consisted of a 20-minute rest period in a quiet room to minimize the influence of prior events and travel to the research area. Participants then provided the first saliva sample (i.e., Baseline). They then received instructions on the task and were taken to a different room to complete the Trier Social Stress Task (TSST; Kirschbaum et al., 1993). After the stressor task, participants were guided back to the first room for the Recovery period, where they collected 3 more saliva samples over the next 40 minutes (i.e., +10, +25, +40 minutes since the completion of the TSST). 10 minutes post-task was selected as this is the average peak time point of cortisol response (Dickerson & Kemeny, 2004). Participants also completed several questionnaires during the Baseline period and last 15 minutes of the Recovery period on a personal computer. The session was concluded with a debriefing about the study (Figure 1).[3]

2.2.7. Trier Social Stress Task

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[3]The participants also completed a brief perception task (2 minutes) right before the stressor task, which is not included in the current analysis.

The Trier Social Stress Task included a short speech and mental math, each for 5 minutes, in front of a panel of judges and filmed. During the speech task, participants took on the role of a job applicant and had to convince the judges that they were the best candidate for the vacant position.[4] Participants were given 30 seconds to prepare for the speech task, then prompted to start speaking as the experimenter started the timer for 5 minutes. If participants did not continue to talk for a certain period of time, the experimenter prompted them to continue with their speech (i.e., "You still have time remaining."). After the speech, participants were asked to sequentially subtract 13 from 1022 out loud. If they made a mistake, they were prompted to restart from the beginning, as well as asked to speed up if they were taking too much time from one number to the next.

2.3. Statistical Analysis

Analyses were conducted in R version 4.2.1 (R Core Team, 2019). Linear mixed models were performed using the *lmer* function from "lme4" (Bates et al., 2015) and "lmerTest" (Kuznetsova et al., 2017) packages. Multiple regression models were performed using the lm function from "stats" (R Core Team, 2019) and "lmSupport" packages (Curtin, 2018). Data for the study are available at https://osf.io/ycez3/?view_only=469f6fcd5ea04c7aaeaa0784cfdfdd9c. We first checked for missing values, outliers, and normality of continuous data. A few participants had missing data on self-reported anxiety at baseline (N = 1), task experience (N = 2), or math task performance (N = 1). These participants were not included in descriptive and manipulation check analyses. Participants who did not give consent to use their recorded speech

[4]Experimenter and judges included both Asians and European Americans, and were both male and female. Experimenters and judges were randomly assigned to participants. When experimenter and judges' gender and ethnicity were regressed on cortisol response (using percentage change values), we found no gender nor ethnicity effect on cortisol reactivity and recovery (ps > 0.1).

task for performance coding (N = 25) were excluded when analyzing our second set of hypotheses involving task performance. Because the distribution of the salivary cortisol values was skewed, values were log-transformed and a small number of higher outlier values were set at the 3 SD point from the mean (7 out of 800 saliva samples) following the statistical recommendations of Winsor and Tukey (Tukey, 1962). This approach preserves the relative rank of the values but retains the participant in the analysis and thus does not exclude high responders from statistical modeling and conclusions (Reifman & Keyton, 2010).

Demographic and psychological variables were examined initially with independent t tests. To evaluate the effectiveness of the task manipulation, we conducted linear mixed effects models (LMEMs) to verify that paradigm elicited the intended psychological reaction (i.e., a change in STAI values) and physiological reaction (i.e., change in salivary cortisol). These analyses controlled for age, gender, and the respective anxiety and cortisol levels at baseline. We also added self-identified ethnicity (i.e., European American vs. East Asian) as a moderator in the model to test whether the effectiveness of the paradigm varies by cultural background. Cultural differences in cortisol reactivity and recovery were also tested using the percentage change values as outcomes in multiple regression models.

To test our first set of hypotheses, multiple regression analysis was used to determine whether cortisol reactivity and recovery varied by the valuation of nervousness. Cortisol reactivity and recovery were operationalized as percentage change in cortisol concentration between two time points (c.f., Fiocco et al., 2007). Cortisol reactivity measure was computed as the percentage difference between baseline and peak (i.e., 10 minutes post-task; (10 minutes post-task - baseline)/baseline×100). Cortisol recovery was computed for both initial recovery (i.e., 25 minutes post-task) and final recovery (i.e., 40 minutes post- task). Initial recovery was the percentage difference between values at peak and 25 minutes post-stressor: ((25 minutes post-task - 10 minutes post-task)/ 10 minutes post-task ×100), while final recovery was the percentage difference between values at peak and 40 minutes post-task: ((40 minutes post-task – 10 minutes post-task)/ 10 minutes post-task ×100).

$$(Cortisol\ Percentage\ Change) = \beta_0 + \beta_1(Valuation\ of\ Nervousness) + \beta_2(Age) + \beta_3(Gender) + \beta_4(Baseline\ Cortisol) + e \quad (1)$$

The same multiple regression analysis was conducted to examine whether there was an interaction between valuation of nervousness and self-identified ethnicity (i.e., European American vs. East Asian) on cortisol responsiveness. Post hoc multiple regression analyses by self-identified ethnicity were further conducted to examine the moderating effect of valuation of nervousness on cortisol response by cultural background. For the first set of hypotheses, we applied the Bonferroni adjustment by dividing .05 by 3 = .017 (model for each computed cortisol value – cortisol reactivity, cortisol recovery 1, and cortisol recovery 2) to adjust for possible type 1 error inflation.

$$(Cortisol\ Percentage\ Change) = \beta_0 + \beta_1(Valuation\ of\ Nervousness) + \beta_2(Cultural\ Background) + \beta_3(Valuation\ of\ Nervousness \times Cultural\ Background) + \beta_4(Age) + \beta_5(Gender) + \beta_6(Baseline\ Cortisol) + e \quad (2)$$

For our second set of hypotheses, multiple regression analyses were conducted to analyze the moderating effect of cortisol responses on the association between valuation of nervousness and task performance. We regressed task performance (i.e., speech, math) on post-task cortisol, valuation of nervousness, their interaction terms, and control variables (baseline cortisol, age, and gender).

$$
\begin{aligned}
(Task\ Performance) &= \beta_0 + \beta_1(Post - Task\ Cortisol) + \beta_2(Valuation\ of\ Nervousness) \\
&+ \beta_3(Post - Task\ Cortisol \times Valuation\ of\ Nervousness) + \beta_4(Age) \\
&+ \beta_5(Gender) + \beta_6(Baseline\ Cortisol) + e \qquad (3)
\end{aligned}
$$

Lastly, the same regression model tested the interaction of post-task cortisol and self-identified ethnicity on the relationship between valuation of nervousness and task performance.

$$
\begin{aligned}
(Task\ Performance) &= \beta_0 + \beta_1(Post - Task\ Cortisol) + \beta_2(Valuation\ of\ Nervousness) \\
&+ \beta_3(Cultural\ Background) \\
&+ \beta_4(Post - Task\ Cortisol \times Valuation\ of\ Nervousness) \\
&+ \beta_5(Post - Task\ Cortisol \times Cultural\ Background) \\
&+ \beta_6(Valuation\ of\ Nervousness \times Cultural\ Background) \\
&+ \beta_7(Post \\
&- Task\ Cortisol \times Valuation\ of\ Nervousness \times Cultural\ Background) \\
&+ \beta_8(Age) + \beta_9(Gender) + \beta_{10}(Baseline\ Cortisol) + e \qquad (4)
\end{aligned}
$$

We considered p-values less than .05 to be statistically significant for all test except when testing the first set of hypotheses. If statistically significant, effect sizes of interactions of interest (ΔR^2) were reported based on Type 2 Sum of Squares which relies on sequential likelihood ratio tests of models stripped of the interaction vs models that include it. All of the main analyses controlled for age, gender, as well as baseline cortisol values.

3. Results

Table 1 presents summary statistics of demographic, self-report, task performance, and baseline values of both anxiety and cortisol by cultural background.

3.1. Preliminary Analyses

3.1.1. Self-Report and Behavioral Measures

Perception of the task experience (i.e., difficulty and relevance) and performance on the speech and math task were analyzed with respect to cultural background (Table 1). European American participants reported more difficulty with the speech task when compared to East Asian participants, $t(198)=-3.55$, $p < .001$, but did not differ in other aspects of task experience ($|t| < 1.26$, $p > .21$). Considering that there were also likely differences in speech difficulty, we conducted additional analyses controlling for speech difficulty. Those results are summarized in Supplemental Materials (Supplemental Table A). Neither speech or math performance differed between European American participants and those of East Asian cultural backgrounds (Speech Task: $t(173)=1.57$, $p = .12$; Math Task: $t(196)=-0.07$, $p = .94$; Table 1). A difference was found in speech performance; specifically, European Americans ($M = 0.22$, $SD = 1.08$) were rated higher than East Asian students ($M = -0.25$, $SD = 0.84$) in openness (versus closed) posture, $t(173) = 3.22$, $p = .002$.

The two groups of participants also did not differ in their valuation of nervousness ($t(198) = -1.02$, $p = .31$; Table 1). When this attribute was examined further by delineating the three component factors that comprise the valuation of nervousness score (i.e., Positive Nervousness Mindset, Negative Nervousness Mindset, Utility of Nervousness; see Yoo et al., 2021, for details), we found differences in the Utility of Nervousness factor ($t(198) = -2.64$, $p = .009$), but not for Nervousness Mindset factors (positive nervousness mindset: $t(198) = -0.86$, $p = 0.393$, negative nervousness mindset: $t(198) = -0.65$, $p = .51$).

3.1.2. Manipulation Check

The TSST protocol was effective in inducing psychological reactions as evinced by increased anxiety levels. Compared to baseline, self-reported anxiety was higher right after being given instructions, $b = 0.43$, $SE = 0.03$, 95% CI [0.37, 0.49], $t(36.56) = 14.11$, $p < .001$, right after completing the task, $b = 0.67$, $SE = 0.04$, 95% CI [0.59, 0.75], $t(13.19) = 16.45$, $p < .001$, and then returned to baseline levels by the end of the session, $b = 0.12$, $SE = 0.04$, 95% CI [0.05, 0.20], $t(0.92) = 3.22$, $p = .21$. These indicated a transient increase in self-reported anxiety followed by adaptation during the recovery period.[5] East Asian students reported higher levels of anxiety at baseline when compared to European Americans ($t(198) = -3.53$, $p < .001$; Table 1). However, their changes in self-reported anxiety in response to the TSST and during the recovery period were not different ($|t| < 0.30$, $p > .59$; Figure 2).

We next examined whether the TSST protocol was effective in activating neuroendocrine responses. Linear mixed effects models indicated there were changes in salivary cortisol response over time (Table 1). Compared to baseline, cortisol levels were increased post-task (i.e., +10 mins after completion of stressor task; $b = 0.35$, $SE = 0.03$, 95% CI [0.29, 0.40], $t(10.97) = 12.49$, $p < .001$), and still remained higher than baseline during the Recovery 1 period (i.e., +25 mins after completion of stressor task; $b = 0.19$, $SE = 0.03$, 95% CI [0.13, 0.24], $t(10.58) = 6.64$, $p < .001$). However, by the end of the final Recovery period, cortisol levels had returned to baseline levels (i.e., +40 mins after completion of stressor task; $b = 0.03$, $SE = 0.03$, 95% CI [-0.02, 0.08], $t(10.85) = 1.09$ $p = .30$. In addition, in keeping with the results on self-reported anxiety, baseline cortisol level also differed by cultural background. East Asian students had higher cortisol levels when compared to European American students, $t(198) =-2.02$, $p = .045$).

[5] Significance of the anxiety findings remained when the model was tested without covariates.

To take the baseline differences into account, the subsequent analyses controlled for baseline cortisol.

Cortisol levels at each time point post-task (compared to baseline) were examined with respect to the influence of cultural background as a manipulation check. East Asian students did not differ from European American participants at Post-Task (b = 0.04, SE = 0.05, 95% CI [-0.05, 0.14], t(131.01) = 0.87, p = .39), nor was there an influence of cultural background at the first recovery time point (Recovery 1; b = -0.05, SE = 0.06, 95% CI [-0.16, 0.07], t(79.15) = -0.77, p = .44). However, cortisol levels did differ across the two student groups at the Recovery 2 time point when compared to baseline, b = -0.13, SE = 0.05, 95% CI [-0.24, -0.03], t(67.44) = -2.45, p = .007. That is, at the end of the session, European American students still had cortisol levels higher than at baseline (b = 0.09, SE = 0.03, t(22.76) = 2.76, p = .011), whereas the East Asian students had returned to baseline levels (b = -0.04, SE = 0.04, t(1.19) = -1.07, p = .46). The same patterns were also found when cultural background was regressed on percentage change in cortisol levels (Reactivity: b = -2.26, SE = 5.62, t(196) = -0.40, p = .69; Recovery 1: b = -3.59, SE = 1.23, t(196) = -2.93, p = .004; Recovery 2: b = -6.86, SE = 1.55, t(196) = -4.42, p < .001).

3.2. Main Analyses

3.2.1. Cortisol

To test the first set of hypotheses, cortisol responses to the task were examined with respect to a moderating influence of valuation of nervousness. Regression analysis did not indicate the influence of the valuation of nervousness on neither cortisol reactivity nor recovery (|t| < 3.40, p > 0.591). We then tested whether cortisol responses to a demanding task varied with respect to both the valuation of nervousness and cultural background. A significant interaction was found for cortisol reactivity (overall R^2= .373), b = 12.77, SE = 4.64, t(193) = 2.75, 95% CI [3.62, 21.92], p = .007, ΔR^2= .026 (Table 2; Figure 3). Specifically, European American students who had reported a lower valuation of nervousness (i.e., -1 SD) experienced a larger increase in cortisol levels from baseline to post-task when compared to those who expressed a higher valuation of nervousness (i.e., +1 SD), b = -7.87, SE = 3.10, t (193) = -2.54, p = .012. In contrast, there was not a significant moderating effect of the valuation of nervousness among East Asians, b = 4.90, SE = 3.45, t (193) = 1.42, p = .16[6].

3.2.2. Task Performance

The final analyses tested the second set of hypotheses regarding the association between valuation of nervousness and task performance. The findings were partially congruent with the hypothesis that a higher valuation of nervousness would contribute to better task performance. Specifically, the more participants reported that they perceived nervousness to be useful, less disruptive, and to facilitate productivity, their speech performance was rated higher by the independent raters (b = 0.02, F(1, 170) = 5.26, p = .023, ΔR^2= .029). Math performance, on the other hand, was not significantly influenced by how individuals valued nervousness, b = -0.01, F(1, 168) = 1.22, p = .27.

We had also predicted cortisol levels would moderate the association between how nervousness is valued and task performance. This hypothesis was partially confirmed. The association between valuation of nervousness and speech task performance was moderated by

[6] Considering the cultural differences in self-reported anxiety levels at baseline, another model was conducted with baseline anxiety included as an additional covariate. The significance remained the same. See Supplemental Material (Table B) for details. We also used LMEM to test the same hypothesis and found that the significance remained the same. See Supplemental Material (Table C) for details.

post-task cortisol levels after controlling for baseline cortisol, b = 0.12, SE = 0.05, 95% CI [0.02, 0.22], $F(1, 167) = 5.63$, $p = .019$, $\Delta R^2 = .031$. Specifically, the strength of the association between a valuation of nervousness and speech task performance was stronger among those with larger increases in cortisol (i.e., + 1 SD; b = 0.22, SE = 0.07, $F(1, 167) = 10.95$, $p = .001$), while not significant among those with relatively small increases in cortisol post-task (i.e., - 1 SD; b = -0.01, SE = 0.07, $F(1, 167) = 0.03$, $p = .86$). The significance of this link remained when the models were run without control variables (i.e., age, gender, and ethnicity). There was not a moderating effect of cortisol on the association between valuation of nervousness and math performance. Finally, we did not find a significant three way interaction that would indicate students from different cultural backgrounds varied in how cortisol responses impacted the association between valuation of nervousness and task performance (b = -0.09, SE = 0.10, $F(1, 164) = 0.75$, $p = .39$).

4. Discussion

The current study focused on two goals; (1) whether the link between salivary cortisol responses to a standardized cognitive and emotional challenge differed by how the feeling of nervousness is valued, and (2) examining the relationship between how individuals valued nervousness and how well they actually performed on stressful tasks and whether such relationship varied by individuals' cortisol response to the tasks. We also explored whether these effects varied by cultural background.

The present results partially supported our predictions about cortisol responses to demanding tasks and revealed a moderating effect of valuation of nervousness among students of European American family backgrounds. European American students reporting lower valuation of nervousness showed more cortisol reactivity to the task. This pattern was not evident among

East Asian participants. Considered together, the findings suggested that the role of valuing negative emotions when performing a demanding or stressful event may be different depending on cultural backgrounds, with a stronger association between valuation and cortisol reactivity evident among European American students.

Our predictions about task performance were supported during the performance of the speech task. Not only was perceiving nervousness as being useful and not disruptive associated with more confidence and a higher quality of speech, it was also manifested in better non-verbal body language. The extent of this association differed with respect to cortisol responses. In particular, the positive benefits of valuing nervousness on performance were greater among those who showed larger cortisol responses to the task. This connection with cortisol responses was not moderated by cultural background, suggesting that the valuation of nervousness as an aid in performing a demanding task may generalize across cultures.

This study revealed cultural variation in the persistence of the cortisol response after certain types of stressful events. Specifically, European Americans continued to maintain higher-than-baseline cortisol levels during the initial part of the recovery period, whereas East Asian students had already returned to baseline level. Such variation in the pace of recovery is not likely attributable to differences in the clearance of cortisol from circulation, but rather more likely related to a lingering central activation of the neuroendocrine axis. A recent meta-analysis on cross-cultural heterogeneity in cortisol responses to TSST also concluded that cultural values and beliefs were significant contributors to the variation across national and ethnic groups (Miller & Kirschbaum, 2019). Although potential differences in the procedures across researchers and sites may contribute to some variation in results, the conclusions from country-level analyses are in keeping with other findings of sociocultural influences on physiology and health.

Our findings also confirmed that the TSST protocol, including both the speech and difficult arithmetic tasks, reliably induced anxiety in our student participants. There were some cultural differences with East Asian students reporting higher levels at baseline before the task than European Americans. The difference in self-reported anxiety prior to performance could be explained by cultural differences in attention to contextual cues, as East Asians have been found to be more attentive to contextual information than European Americans (Masuda & Nisbett, 2001). That is, during the baseline period, which took place in another room, the East Asian participants may have been more attentive to the experimental setting and had higher levels of anticipatory anxiety than did the European American participants, even though they had been instructed to relax during this 20-minute period provided for all participants. This interpretation would be in keeping with the significant difference in baseline cortisol level between the two groups. Yet, it is of interest that this cultural difference was obscured post-task, with both groups reporting similar levels of anxiety after the demanding tasks.

With regard specifically to the students' valuation of nervousness, our findings did differ from the findings of prior studies (An et al., 2017; Miyamoto et al., 2014; Sim et al., 2015; Uchida & Kitayama, 2009; Yoo et al., 2021). Even when compared to Yoo and colleagues' (2021) studies with the same scales, we did not find significant differences in how nervousness was valued (except for the Utility of Nervousness factor) between European Americans and East Asians. A possible contributing factor could be a procedural difference in the timing of the assessment during the protocol. During the present study, participants completed the nervousness questionnaire at the end of the session, whereas participants in the Yoo et al. study completed the instrument on a different day. The potential influence of this aspect of protocol, including whether the questionnaire is completed in the same room as the demanding task or at a different location will need to be resolved in further research.

Overall, whereas the valuation of nervousness was linked to both cortisol responses and speech task performance among European American students, valuing nervousness was associated with only speech task performance among East Asian students. These findings indicate the possibility that individual valuation of nervousness may have more consistent effects in Western cultural contexts than in East Asian cultural contexts, which would be in keeping with prior studies showing greater attention paid to internal emotional states by Westerners than East Asians (Dere et al., 2012; Ryder et al., 2008). At the same time, this seeming discordance between the endogenous physiological state as reflected by cortisol level and the external psychological state conveyed by behavior among East Asian students may also be indicative of another cultural contribution. Other researchers have highlighted that there may be cultural differences in the importance of internal versus external aspects of the self (Curhan et al., 2014; Kim et al., 2010; Leung & Cohen, 2011). In East Asian cultural contexts, where people are defined more in terms of their relationships and interdependence, external features of the self-observable to others are more paramount than internal attributes, compared Western cultural contexts, where people are defined more in terms of their unique internal attributes. While speculative, it may be that for East Asian students, the valuation of negative emotions exerted a stronger influence on external behavioral outcomes and appearance rather than their internal physiological state. These findings point out that cultural contexts need to be examined in relation to the cultural meanings underlying the specific outcome in question, rather than simply reduced to the valuation of emotion. One broader implication of such findings is that controlling for race/ethnicity/culture as a confounding factor may not be sufficient because cultural contexts can often drive and moderate the links between psychological and physiological factors (Consedine et al., 2005; Kitayama et al., 2015). However, we also acknowledge that the lack of significant association between valuation of nervousness and cortisol responses among East Asian students appears to differ from a previous study that focused on measures of autonomic arousal to the TSST (Yoo et al., 2021). Potential differences between autonomic arousal and cortisol responses (e.g., external visibility) should be investigated in the future.

Related to the findings on performance, there was a divergence in results for the speech and math tasks. This difference may be related in part to how speech and math performance was coded. For the speech task, we used multiple indices, taking into account different aspects of speech performance (e.g., non-verbal cues, overall speech quality) over the 5 minutes, while a single index was used to quantify math performance (i.e., lowest number reached). The single index of math performance might not have captured subtler differences in performance in relation to valuation of nervousness (Mattarella-Micke et al., 2011). Alternatively, performance on the math task may reflect more objective skills in mental arithmetic, which might be less sensitive to an influence of the valuation of nervousness.

Interestingly, European American students rated the difficulty of the speech task to be higher than did the students from East Asian backgrounds. Considering that the majority of East Asian international students spoke English as a second language, the observed pattern would appear to be counterintuitive. Perhaps re-enacting an interview for a potential job in English is closer to actual experiences for European American students, thus resulting in the speech task being perceived as more difficult. In fact, the magnitude of the difference in cortisol levels between European American and East Asian students at the end of the session decreased when the rating of speech difficulty was controlled for in the model, although the statistical significance of the culture difference still remained. However, the findings do indicate that the perceived difficulty of the speech task was related to how long the higher cortisol levels persisted during the recovery period. Further research is needed to determine whether the use of culture-specific topics or situations might provide a more sensitive way to probe cultural variation in physiology and performance.

Several limitations of this research should be acknowledged. Other cultural and non-cultural factors are also likely to be contributors to activation of the HPA axis and how long cortisol levels are maintained during a recovery period. For example, prior research has highlighted the complex psychological and neural processes that can contribute to individual variation in how long people sustain a negative and positive state after the experience has occurred (Schuyler et al., 2014; Tugade & Fredrickson, 2004). Future research should focus not only on cultural differences in the reactions to negative events, but also on the degree to which people reflect back on those experiences. Also, it is important to acknowledge that this assessment focused on a student sample, and thus the conclusions may not necessarily generalize to older adults.

In addition, it is important to acknowledge that East Asian students were residing in the US while attending university at the time of participation. We thus cannot completely rule out being "othered" or being a minority in a more dominant cultural setting, was a confounding factor in the link between valuation of nervousness and cortisol responses to a demanding task. East Asians, despite being the "model minority," are still considered to be outsiders in the US and may experience discriminatory behavior from the majority group (Li & Nicholson, 2021; Yao, 2018). For a minority member, expecting to be the target of prejudice has been shown to induce negative affect and self-regulation when interacting with a majority member (Shelton et al, 2005). There are also potentially other ways through which minority status might influence responses. It would be important for the future research to replicate the findings by examining East Asians who are residing in their native country and East Asian cultural context.

In addition, many historical and more recent studies have revealed how immigrants' physiology can be altered in their host countries (Marmot & Syme, 1976; Schwingel et al., 2007). A systematic review on acculturation and stress biomarkers (Scholaske et al., 2021) has shown that with acculturation and longer residence in the US and other Western countries, East Asians tend to have higher inflammatory physiology and poorer health. General information on participants' length of stay in the United States, a frequently used index of acculturation and the extent to which immigrants attune their psychological tendencies to the host culture (de Leersnyder et al., 2011), was collected. International students (n=83) reported being in the US for less than 5 years, while East-Asian American students (n=16) had lived all their lives or at least more than 16 years in the United States. This uneven distribution in the length of stay precluded a test of acculturation as a factor in the current study. Future research on acculturation as a potential factor will require a larger and more balanced sample to see whether the observed differences in our study were reflective of acculturation.

Notwithstanding the limitations, this study conveys the relevance and importance of considering the valuation of emotion and the cultural context when investigating associations between emotions, physiology, and performance. The results also highlight how a particular psychological attribute, valuing nervousness, can be beneficial for performance. In this study, its favorable effects were most evident among the students with higher cortisol levels. Our study also found that at least among European Americans, valuing nervousness was linked to reduced neuroendocrine reaction to the TSST. The activation of cortisol release appears to provide a sensitive bioindicator of the valuation of nervousness in the context of demanding or challenging events. More generally, our focus on the value for nervousness is in keeping with the emerging view that there can be some benefit of perceiving a utility of negative emotions, especially within certain cultures and contexts.

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