# Interpersonal Stress and Coping in First-Year Undergraduate Students: Insights from Behavioral, Self-Report, and Neural Data

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PSY 3981 Honors Seminar Fall 2020

**Abstract**

The transition to college exacerbates stress, and coping strategies like cognitive reappraisal can moderate how interpersonal stress affects psychological well-being, with individual differences in reappraisal being measurable at the neural level using the late positive potential (LPP) component. The present study sought to understand A) where and when there is a significant modulation in the LPP with implementation of cognitive reappraisal and B) the relationship between self-reported coping with interpersonal stress and modulation of the LPP using cognitive reappraisal, and C) the relationships of self-reported coping and LPP modulation with interpersonal stress and depression and anxiety symptoms. First-year Vanderbilt students were recruited within their first 6 months of college to complete self-reported stress and coping questionnaires and complete tasks using electroencephalogram. For the early time window over centroparietal region, cognitive reappraisal significantly reduced the amplitude of the LPP, but effects of reappraisal were not significant in later time windows or over frontal region. There was not a significant relationship between self-reported and neurophysiological indicators of coping, although there was a relationship between self-reported coping and depression, as well as LPP and depression.

## Introduction

Approximately 52% of college students report experiencing high feelings of stress in a typical college semester (Number, 2018). The transition to college involves changes in social circles, newfound independence, and an adjustment to new academic standards (Hudd et al., 2000). Prior research on college adjustment has relied upon self-reported measures of stress. However, in contrast to objective assessments of exposure to stressful life events, the subjective perception of stress is often confounded with internalizing symptoms (Harkness & Monroe, 2016). Exposure to both chronic and episodic stressful life events, especially interpersonal events, has been established as a robust predictor of depression and anxiety (Vrshek-Schallhorn et al., 2015). During this transition to college, positive peer relationships can be a major buffer to other domains of stress, while negative peer relationships can result in feelings of isolation and lowered self-confidence. Other interpersonal behaviors such as social withdrawal can increase symptoms of psychopathology (Katz et al., 2011).

### *Interpersonal Stress*

Interpersonal stress is particularly salient to first year college students in part because of rapidly changing interpersonal relationships which occur in the transition to college (Lopez & Gormley, 2002). Not only is interpersonal stress predictive of depression, but depression is also characterized by increases in "dependent" stressful events, or events that are brought about in some way by the person themselves (Davila et al., 1995). People with depressive symptoms may conduct behaviors that increase stressors, and there can be a bidirectional relationship (Hammen, 1985). Interpersonal behaviors in people with depressive symptoms may also contribute to interpersonal stress generation. For instance, relationship style, such as anxious attachment and need for reassurance, also influence the prevalence of interpersonal stress in one's life (Eberhart & Hammen, 2009). Managing emotions related to interpersonal stress may be helpful to not only psychological

well-being, but also in decreasing the development of depressive symptoms and future dependent stressful events. Although the presence of interpersonal stress has been shown to result in negative emotionality, individual differences in reactions to stress are key in moderating how interpersonal stress will affect psychological wellbeing overall (Cokley et. al, 2013, Compas et al., 2017). Reactions to interpersonal stress may hence be a critical component in understanding risk for depressive and anxiety symptoms in first year students.

*Coping and Emotion Regulation*

Coping and emotion regulation are both self-regulatory tools that can be used to deal with difficult situations. Although these have been used interchangeably in the literature, they make unique contributions to our understanding of emotional responses. Emotion regulation refers to conscious and unconscious efforts to control the experience, intensity, and expression of emotion regardless of the precipitant resulting in an emotion. While emotion regulation involved conscious and unconscious efforts to control the experience, intensity, and expression of emotion regardless of the precipitant resulting in an emotion, coping is a broader construct in scope, including attempts to regulate cognitions, behaviors, and physiology in addition to emotion, but narrower in the precipitant, specifically involving responses to stressors. In this way, coping and emotion regulation are overlapping concepts (Compas et al., 2017). The terms are related to one another, but are distinguished by the range in type of reaction and by whether they occur in response to a stressor or not. Adaptive coping strategies can reduce the impact of interpersonal stress on psychopathology and are an excellent target for intervention.

Coping exists on a spectrum of automatic responses, which are involuntary and reactive, and controlled processes, which focus on intentional and voluntary responses (Compas et al., 2017). For this study, the focus will be controlled processes because they are more easily manipulated in

intervention research. Models of coping and stress are widely debated in research, and often coping and its subtypes have inconsistent naming, so for the sake of simplicity, the present study will focus primarily on cognitive reappraisal as defined by Compas (2000).

Compas identified several empirically-derived categories through factor analysis in adolescents 17-19 years old coping with social stress. The two main categories of coping strategies include engagement coping and disengagement coping. Disengagement coping encompasses avoidance and denial, and is an example of which could be active ignorance towards your worsened mood (Compas et al., 2000). Engagement coping involves the direction of attention towards the situation.

The present study focuses on a strategy within engagement coping called cognitive reappraisal, or reframing the stressor mentally, that is part of secondary control coping (Compas et al., 2000). Primary control coping involves changing the stressor or emotions directly using skills like emotional expression, problem-solving, and emotion regulation. For example, if you begin feeling depressed and try going out with friends or working towards a better job, you would be using primary coping techniques. Primary control coping strategies include emotional regulation, emotional expression, and problem solving. Secondary control coping focuses more on adaptation to the stressor, including skills like distraction, acceptance, cognitive reappraisal, and positive thinking. For example, if in your depressed state you began focusing more on other parts of life than the depression, or tried to reframe your interpretation of stressors in your life, you would be using secondary coping skills. Secondary control coping strategies include cognitive restructure, positive thinking, acceptance, and distraction (Compas et al., 2017).

*Correlates of Coping Subtypes*

Certain coping strategies are associated with higher psychological wellbeing than other strategies, although this can change depending on context. Cognitive reappraisal, problem-solving, and acceptance have been correlated with high psychological wellbeing while avoidance, suppression, and rumination are associated with lower rates of wellbeing (Schäfer et al., 2017). College students report using negative coping strategies in response to stress, with students implementing self-punishment and avoidance in response to daily stressors. The same study found that for specific stressors, college-aged men used both adaptive and maladaptive emotion-focused coping skills, whereas women just used maladaptive emotion-focused coping. Problem-focused coping was used less than emotion-focused coping (Brougham, 2009). Given heightened stress during the transition to college, coping tendencies can either exacerbate or buffer the effects of stress on internalizing symptoms.

*Choice of Coping in the Proposed Study*

Coping strategies, however, are not universally positive in their effects across contexts and domains of stress. A meta-analysis by Clark (2005) on coping and interpersonal stress for instance found that active coping was more effective when implemented in situations with controllable rather than uncontrollable stressors (Clarke, 2005). Along that same vein, problem-focused coping was associated with lower psychological adjustment when dealing with cancer-related stress in youth (Alridge & Roesch, 2007). Additionally, one study using an emotion-focused coping strategy assessment targeting five domains of life stress, including financial, academic, family, daily, and social, found that coping strategy use also differed across domains (Brougham et al., 2009). Because coping strategy use and outcomes have been largely associated with specific life contexts/stressors in the literature, for the purpose of this study, we focused on factors and strategies related to interpersonal stress. A large distinguishing factor in the usefulness of primary and secondary control

coping is whether or not the situation is controllable. In the case of chronic illness for instance, secondary control coping is more widely associated with healthy adjustment than primary control coping, and disengagement coping is associated with poorer adjustment (Compas et al., 2012).

Secondary control coping is of particular interest for our study in college student populations for a few reasons. Adjustment to the college setting and feelings of alienation are often long-term sources of stress, and although controllable on some levels, are often persistent and emerging through the first year of college. Past research found that interpersonal stress is also at least partially dependent on individual's behaviors, so primary control coping may also be relevant to understanding adaptive coping. Secondary control coping skills have also been linked to higher levels of psychological well-being across most domains of stress, including interpersonal stress. Additionally, secondary control coping is well-validated in the literature and conceptually better understood than other forms of coping in the research, so it is the main focus of this study.

Cognitive reappraisal is a strategy within secondary control coping which entails reframing a stressor in a more positive way to reduce emotion arousal. Like secondary control coping, it is also associated with positive well-being emotionally as well as socially (Gross & John, 2003). Cognitive reappraisal is relatively simple to teach through intervention and implement in laboratory experiments. It can induce immediate change in both self-reported and neurophysiological measures of emotion. Both of these factors make cognitive reappraisal an ideal coping/emotion regulation strategy in research involving multiple measures to capture emotional response.

*Event-Related Potentials Measures of Coping/Emotion Regulation*

Electroencephalogram, or EEG, uses electrodes placed on the scalp to detect electrical activity in the brain. EEG detects neural activity at a fraction of the cost of fMRI, making it ideal for research with larger sample sizes. EEG also has high temporal sensitivity and can closely capture

how emotional regulation processes emerge across time. EEG is often used during sleep studies and in the identification of seizures, but it has a wide potential for application in the field of affective neuroscience and clinical psychology. Of particular interest are event-related potentials, or ERPs, which refer to segments of neural data from the EEG which measure the of neural response to specific cognitive or emotional stimuli. The late positive potential (LPP) is a specific ERP that is thought to reflect increased motivation and prolonged attention to salient stimuli, starting around 300ms after stimulus presentation (Kujawa & Burkhouse, 2017). It tends to be more sensitive to arousal level than valence type, enhanced for both positively and negatively arousing stimuli compared with neutral, with negatively arousing stimuli evoking a slightly larger amplitude (Brown et al., 2012). Both intrinsic motivational significance and the evaluative context are key moderators in the LPP to images (Schupp et al., 2003).

The implementation of emotion regulation and coping strategies has been shown to reduce the LPP over centroparietal sites and enhance a later LPP over frontal sites (Moser et al., 2014). Successful modulation of the LPP with these strategies is associated with reduced anxious-depressed symptoms and increased use of emotion regulation later in life, providing evidence that this can be a useful target of intervention beyond the length of the study (Dennis & Hajcak, 2009; Babkirk et al., 2015; Moser et al., 2014). A study on adolescent girls indicated that life stress was associated with decreases in depressive symptoms when the LPP is increased for positive images, although unpleasant images did not result in a significant relationship, indicating some form of relationship between depressive symptoms and the LPP (Levinson, Speed, & Hajcak, 2018). In situations of high stress following a natural disaster, children's psychiatric symptoms were positively associated with higher stress when the LPP was heightened in response to unpleasant images, revealing vulnerabilities to the development of psychopathological symptoms (Kujawa et al., 2015). In other

studies with participants having clinical levels of depression and anxiety, the LPP has been found to be abnormal and blunted (Foti et al., 2010; Kujawa et al., 2015). Further research is necessary to understand the exact meaning of the LPP in different developmental categories in response to different stressors and stimuli**.**

### *Coping, Emotion Regulation, and the LPP*

Emotion regulation studies on the LPP tend to fall into either mindfulness or reappraisal, both of which are essential to more fully understanding the LPP. Mindfulness studies have been a particularly important source of information regarding the LPPs response to emotion regulation strategies. One such study found that trait mindfulness was associated with both lowered LPPs to positively and negatively arousing stimuli (Brown et al., 2012). Other studies have focused more on reappraisal of images presented on a computer screen. Foti and Hajcak (2008) found that descriptions of images could influence participant's emotional perception of them as indicated in an altered LPP. Similarly, a later study by Macnamara, Ochsner, & Hajcak (2011) found that "reappraisal frames", or descriptions of images before their presentation, had an effect on the LPP. Unpleasant, emotionally arousing pictures with a neutral reappraisal frame were associated with a smaller LPP than when paired with negative reappraisal frames, telling us that even the suggestion of an interpretation of a stimulus can impact neural responses in the brain.

#### *Emotion Regulation Task*

The current emotion regulation task is based largely on Moser and colleagues' (2014) study on trait worry and reappraisal. Participants were instructed to look at a series of images that were either neutral/low-arousal or negative/high-arousal with instruction to either decrease their emotional response to the image or react normally, then complete questionnaires to assess their emotional reaction and effort spent regulating their emotions for the images. Additionally, the study used a

questionnaire to assess participant's levels of trait worry and trait reappraisal. The study found that trait reappraisal decreased the parietal LPP, while trait worry increased the parietal LPP (Moser et al., 2014). This study is particularly important because it combines habitual emotion regulation patterns with LPP alterations.

More recent work has linked laboratory measures of coping in children in response to family-related stress with habitual coping, and psychological well-being. The study used a similar reappraisal task to others, but instead used only negative images and had instructions to either cognitively reappraise the image, distract from it, or just look at it (Moser, 2014). After each trial, a question displayed asking how the negative image made the participant feel. More recent work found emotion ratings during both reappraisal and distraction conditions were associated with anxiety and depressive symptoms and distraction trial emotion ratings were linked with self-reported secondary control coping use (Bettis et al., 2018).

The present study aimed to understand associations between neurophysiological measures of emotion regulation, interpersonal stress, and self-reported coping to interpersonal stress. Few studies have compared these three facets of stress and coping experience in particular to interpersonal stress in young adults. Additionally, I examined the effect of self-reported coping and neurophysiological measure of reappraisal on the relationship between interpersonal stressors and symptoms of depression and anxiety. Three specific research questions were explored in the course of this study:

1. Is there a significant change in the LPP when participants use cognitive reappraisal versus just look at negative images?
2. What is the relationship between self-reported use of adaptive secondary control coping and the LPP in response to emotional reappraisal?

3. What relationship do self-reported coping and/or LPP while employing cognitive reappraisal have with interpersonal stress and symptoms of depression?

We predicted that there will be a significant alteration in the LPP between cognitive reappraisal and the negative look condition. We also predicted an association between self-reported coping and LPP residuals in response to cognitive reappraisal. Finally, we hypothesized there is a relationship between both self-reported coping and LPP residuals with interpersonal stress and depressive symptoms.

## Method

### *Participants*

Sixty-five 18-19 year old first-year undergraduate students were recruited within their first 6 months of attending college at Vanderbilt University. All participants spoke English and attended Vanderbilt University as their first college, attending full-time. Recruitment of participants occurred within 6 months of beginning college through SONA, posters on campus, emailing student organizations, and speaking at large introductory psychology courses. Due to the COVID-19 pandemic, participants recruited after Spring 2020 did not participate in the EEG assessment. 46 participants were recruited to complete the EEG, but 2 participants did not complete the task, 3 had too many interpolated channels, 1 did not have good ocular data, and 1 had extremely poor data quality. The final EEG analysis included 40 participant's data.

### *Procedure*

Study protocols and revision to accommodate a virtual zoom format during the coronavirus pandemic were approved by Vanderbilt University's institutional review board. Informed consent was obtained by research assistants before the first session, and information

about confidentiality and mandatory reporting was repeated at the start of the first session. All participants were asked for permission to record the session. Before the coronavirus pandemic during Fall 2019/Spring 2020, participants first completed the Life Stress Interview. Next, the participant was set up with the electroencephalogram while they filled out surveys. After the EEG was set-up, participants completed several computer tasks including the Emotion Regulation Task. After the computer tasks, participants had a chance to finish surveys if they had not already. After the coronavirus pandemic began in Spring 2020, sessions occurred entirely over zoom. Informed consent was obtained either in advance of or during the zoom session. Research assistants conducted a qualitative interview and the Life Stress Interview, and following participants completed surveys. This adjustment excluded use of the electroencephalogram, so later participants did not complete the Emotion Regulation Task.

*Materials and Measures*

**Emotion Regulation Task**

Participants participated in a computer task involving negative social/interpersonal images, such as of people fighting or scenes of bullying, and neutral images of scenes and objects. Images were selected from the International Affective Picture System (IAPS) and Open Affective Standardized Image Set (OASIS) picture set. Before beginning, participants learned about emotional reappraisal, or thinking positively about negative stimuli/experiences, and were led through several example images before starting the task. During the task, participants were instructed to either emotionally reappraise (“reappraise”) or react normally to (“look”) either negative or neutral images. Commands “reappraise negative”, “look negative”, or “look neutral” were presented before the onset of a corresponding neutral or negative image for 1000ms (See

Figure 1). Data was recorded 200ms seconds before stimulus presentation to establish a baseline for understanding the LPP.

**Electroencephalogram Data Acquisition and Analysis**

EEG data was recorded using a 32-channel actiCHamp system from BrainProducts. Cz was used as the online reference during data acquisition, and date were re-referenced to the average mastoid recording (TP9 and TP10) offline. Ocular electrodes were placed 1cm above, below, and outside to the right eye, and 1cm outside of the left eye. Processing of data was completed using BrainVision Analyzer (BVA) and data were band pass filtered from .01 to 30 Hz and segmented from 200ms before and 6000ms after image presentation. Data was processed with semi-automated artifact rejection and eye blink correction, and additionally manually looked over by research assistants to remove other noise and artifacts. Faulty recordings of individual electrodes were interpolated using surrounding electrodes, but in cases where there were many faulty electrodes, data were excluded. 200ms before stimulus onset was used as the baseline for understanding relative positivity during recorded time windows 400ms-1000ms, 1000ms-3500ms, and 3500ms-6000ms over centroparietal (CPz, P1, Pz, P2, POz) and frontal regions (F1, Fz, F2, FC1, FCz, FC2).

**Chronic and Episodic Stress**

The UCLA Life Stress Interview (LSI; Hammen et al., 1985) is an established interview to objectively and thoroughly measure chronic and episodic experiences of stress. Both acute and chronic stress were evaluated given that both are associated with depressive symptoms (Vrshek-Schallhorn et al., 2015). The interview examines stress over domains of peer relationships, romantic relationships, academics, family, transition to college, and the pandemic over the previous 6 months. The interviews typically lasted between 45 minutes and 90 minutes. Within

each major domain, the lead researcher rated the level of chronic stress from 1, the least stressful, and 5, the most stressful, in half point increments. Since life stress is biased by stress experience in self report measures, interview measures of stress are better at assessing objectives life stress than self-report (Harkness & Monroe, 2016).

**Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007)**

The IDAS is a 64 item Likert type scale which assess symptoms of depression and anxiety. Participants ranked how much they has experienced items from a 1, Not at All, to 5, Extremely, over the last two weeks. The IDAS includes a scale for dysphoria and a scale for general depression, additionally including suicidality, lassitude, insomnia, appetite loss, appetite gain, ill temper, well-being, panic, social anxiety, and traumatic intrusions. The present studying utilized the dysphoria and social anxiety scale, consistent with our previous work. The means and internal consistencies of symptoms in previous research on college students and young adults demonstrated good reliability in prior work ($M$=20.43, $SD$=7.68, α= = .89 for dysphoria; $M$ = 9.60, $SD$ = 4.14, α = .82 for social anxiety; Watson et al., 2007).

**Responses to Stress – Peer/College Stress (RSQ; Compas, 2000)**

The RSQ is a 57 item self-report assessment of coping styles in which participants rate stress regarding different experiences from 1 (*not at all*) to 4 *(very)* over the last 6 months. This particularly focuses on secondary control coping in the college context in regards to interpersonal peer stress.

## Analysis Plan

To assess for effects of reappraisal on the LPP, we conducted a 3 (Time: 400-1000, 1000-3500, 3500-6000) X 3 (condition: reappraise, look, neutral) repeated measures ANOVA over

centroparietal and frontal sites. Where sphericity was violated, a Greenhouse--Geiser Correction was applied. Where the LPP was significantly modulated by reappraisal compared with look negative, unstandardized residual scores were calculated to isolate the effect of condition. Bivariate correlations with self-reported reappraisal and depressive symptoms were then examined.

## Results

### Neurophysiological Measures of Reappraisal

Means for the LPP in each time window and pooling are presented in Table 1.

**Centroparietal LPP**. In the 3 (Time: 400-1000, 1000-3500, 3500-6000) X 3 (condition: reappraise, look, neutral) repeated measures ANOVA over centroparietal sites, there was a main effect of condition, $F(2, 31) = 10.03$, $p < .001$, $\eta_p^2 = .23$, such that simple within-subject contrasts showed that the LPP in the reappraise condition was significantly enhanced compared to the neutral condition, $F(1,31)=10.42$, $p=.003$, $\eta_p^2 =.24$, and the negative condition was significantly enhanced compared the neutral condition, $F(1,31)=14.48$, $p=.001$, $\eta_p^2 =.31$. There was also a significant interaction effect between time and condition $F(2.66, 31) = 5.78$, $p <.01$, $\eta_p^2 = .15$. There was no significant main effect of time ($p = .23$). To interpret the time X condition interaction, we conducted repeated-measure ANOVAs to assess the effect of condition separately within each time window. The condition effect was significant in the first time window (400ms-1000ms), $F(1.53, 31) = 33.35$, $p <.001$, $\eta_p^2 = .50$. The contrast analysis within 400ms-1000ms was significant between both the reappraisal and neutral conditions, $F(1, 31) = 31.31$, $p <.001$, $\eta_p^2 = .49$, and the negative and neutral conditions, $F(1, 31) = 44.98$, $p <.001$, $\eta_p^2$

= .58. Importantly, there was also significant reduction in the LPP during reappraisal compared with looking at negative stimuli for the early time window, $F(1, 31) = 4.76$, $p<.05$, $\eta_p^2 = .13$. The effect of condition with enhanced LPPs to both emotional conditions compared with neutral was also significant in the middle time window (1000-3500 ms), $F(2, 31) = 8.07$, $p = .001$, $\eta_p^2 = .20$, such that LPPs during reappraisal, $F(1, 31) = 11.30$, $p < .01$, $\eta_p^2 = .26$, and looking at negative stimuli, $F(1, 31) = 10.26$, $p < .01$, $\eta_p^2 = .24$, were enhanced compared to neutral, but reappraisal did not significantly differ from looking at negative stimuli, $p=.71$. Finally, the effect of condition was not in the late time window (3500-6000ms), $p = .21$.

**Frontocentral LPP**. In the 3 (Time: 400-1000, 1000-3500, 3500-6000) X 3 (condition: reappraise, look, neutral) repeated measures ANOVA over frontal sites, there was significant main effect of time $F(1.26, 31) = 47.49$, $p<.001$, $\eta_p^2 = .59$, such that LPP amplitudes increased significantly from the early (400-1000ms) to middle (1000-3500ms), $F(1, 31) = 36.14$, $p<.001$, $\eta_p^2 = .52$, and late (3500-6000ms) time windows, $F(1, 31) = 93.11$, $p<.001$, $\eta_p^2 = .74$, but the middle and late windows did not significantly differ $p=.13$. Also, there was a significant time X condition interaction, $F(2.53, 31) = 4.10$, $p<.01$, $\eta_p^2 = .11$, and a non-significant, trending effect of condition, $F(2, 31) = 2.76$, $p=.07$, $\eta_p^2 = .08$. To further interpret the interaction and assess the effect of condition, we conducted repeated-measures ANOVAs within each time window. In the early time window over frontal sites, there was a significant effect of condition $F(2, 31) = 7.35$, $p =.001$, $\eta_p^2 = .182$, such that simple contrasts showed that the LPP to reappraisal $F(1, 31) = 5.71$, $p<.05$, $\eta_p^2 = .15$, and to negative $F(1,31) = 11.86$, $p<.01$, $\eta_p^2 = .26$, were significantly enhanced

compared to the neutral condition. Contrast analysis, however, indicated that reappraisal did not significantly differ from looking at negative images, $p = .15$. There was additionally a main effect of condition in the middle time window, $F(2, 31) = 4.47$, $p < .05$, $\eta_p^2 = .12$, such that in the contrasts analysis, reappraisal $F(1, 31) = 7.74$, $p < .01$, $\eta_p^2 = .19$ and look at negative $F(1, 31) = 4.50$, $p < .05$, $\eta_p^2 = .12$ were enhanced compared to the neutral condition. The LPP contrast between reappraisal and negative was not significant in the middle time window, $p = .43$. Finally, in the late time window, there was not a significant effect of condition, $p = .49$.

**Associations Between Stress and Depression**

The general depression subscale was associated with chronic stress, $r = .53$, $p < .001$, and interpersonal stress, $r = .51$, $p < .001$, such that higher levels of depressive symptoms are associated with higher levels of chronic and interpersonal stress. Secondary coping was also significantly associated with both chronic, $r = -.38$, $p < .05$, and interpersonal, $r = -.39$, $p < .05$, stress, such that higher self-reported secondary control coping was associated with lower levels of chronic and interpersonal stress.

**Associations between Reappraisal Effects on LPPs and Self-reported Reappraisal and Depression**

Considering the LPP during reappraisal only significantly differed from looking at negative emotional images in the early (400-1000ms) time window over centroparietal sites, we calculated unstandardized residual scores predicting reappraisal from look negative in this time window and pooling. To assess the associations between neural reappraisal ability indexed by the LPP with self-reported reappraisal and depressive symptoms, we conducted bivariate correlations.

The centroparietal reappraisal residual score at 400-1000ms was not significantly associated with self-reported secondary coping $r$ = -.07 , $p$= .78, but depressive symptoms were significantly associated with LPP residuals, $r$ = .37, $p$<.05, such that larger responses during reappraisal across centroparietal sites (i.e., less of a reduction in neural responses during attempts to regulate emotions) were associated with higher levels of depressive symptoms. The depressive symptom subscale was also significantly associated with secondary coping $r$ = -.49, $p$=.005, such that higher levels of depressive symptoms were associated with lower levels of secondary control coping. Gender was significantly associated with centroparietal residuals at 400-1000ms, such that female-identifying persons had larger residuals during reappraisal across centroparietal sites.

## Discussion

The first goal of this study was to understand how cognitive reappraisal impacts the amplitude of the late positive potential compared to just looking at negative stimuli. We found that for the early time window in the centroparietal region, cognitive reappraisal significantly reduced the amplitude of the LPP, but not in other time windows or in the frontal region. This finding aligned with our hypothesis. The other goal of the study was to understand the relationship between self-reported secondary control coping and reduction of the LPP in response to cognitive reappraisal. Contradictory to our hypothesis, there was no significant relationship between self-reported and neurological indicators of coping.

The first goal of this study was to understand whether or not there is significant modulation in the LPP between when participants use cognitive reappraisal versus just look at negative images. In both the early and middle time window for the centroparietal and the frontocentral sites, there was a significant difference between the neutral and negative look

condition and the neutral and reappraisal condition. This indicates that images with a more negative valence and higher arousal elicited a larger LPP from participants for most of the time windows. Importantly, in the early (400-1000ms) time window in the centroparietal pooling we did find that reappraisal significantly differ from the negative look condition, meaning that cognitive reappraisal significantly reduced emotional reactivity indexed by the LPP. This differed from prior research, which found reappraisal resulted in an enhanced frontal LPP from 700-1000ms followed by decreased centroparietal LPP in a relatively late 1000-6000ms window (Moser et al., 2014). Whereas Moser found that the frontocentral LPP was associated with positive reappraisal, the present study found no such association (Moser et al., 2014).

Although other studies examining adults and LPP alterations during reappraisal did demonstrate centroparietal LPP reductions in early time windows (Hajcak & Nieuwenhuis, 2006; Foti & Hajcak, 2008), there are a few possible explanations for the discrepancies between the current findings and those of other studies (Moser et al. 2014). Potential explanations could be related to differences in time windows scored for ERPs, measurements of self-reported emotion regulation and coping, stimuli differences between studies, and differences in task instructions which may "frame" the image to come (Moser et al, 2014, Macnamara, Ochsner, & Hajcak (2011), Foti and Hajcak (2008).

Other explanations may involve the brevity of the task or the extent to which interpesonal stress is dependent. Given that successful modulation in the LPP has been associated with increased use of emotion regulation later in life (Dennis & Hajcak, 2009; Babkirk et al., 2015; Moser et al., 2014), it is possible that the brevity of the intervention, the cognitive reappraisal task instructions, both in terms of teaching and the immediate measuring of the LPP may also play a role in the lack of a relationship between self-reported coping and the LPP. Top-down and

bottom-up neural processes may also cause differences due to the complexity of teasing apart such mechanisms. Another possible explanation may be that the early LPP may also capture automatic processes in the brain, whereas self-reported secondary control coping is a controlled process and may occur later, so when others studies found a late time association with self-reported measures, this can account for that as an explanation (Moser, 2014; Compas, 2008). Finally, secondary control coping may not be the most effective form of coping for interpersonal stress; some literature suggests it is better with uncontrollable stressors (Clarke, 2005). Our focus was on images featuring interpersonal threat, which is a less independent type of stress and may be less effective since secondary control coping works best with more independent stressors (Davila et al., 1995) Hence, secondary control coping may have been less effective at modulating the LPP during the emotion regulation task.

Consistent with prior literature, there was a negative relationship between depressive symptoms and self-reported coping (Schäfer et al., 2017). Additionally, in the early centroparietal time window, participants with larger LPP reductions during reappraisal had less depressive symptoms. This finding indicates higher levels of depressive symptoms are associated with less modulation of the LPP during reappraisal, which is consistent with the broader literature showing depression is associated with impairments in emotion regulation and reduction the LPP (Joormann & Gotlib, 2010; Kovacs et al., 2009; Foti et al., 2010; Kujawa et al., 2015), and that reappraisal-induced reduction in LPP is associated with lower symptoms of anxiety and depression (Dennis & Hajcak, 2009; Babkirk et al., 2015; Moser et al., 2014). Also consistent with prior literature, higher levels of chronic and interpersonal stress were both associated with higher levels of depressive symptoms and lower levels of secondary control coping. Although not related to one another, the LPP reappraisal residuals and self-reported coping had significant

negative correlations with depressive symptoms. This suggests that neural reappraisal and self-reported reappraisal may capture unique, but equally important aspects of emotion regulation, such as automatic versus controlled processes.

Limitations primarily surround the COVID-19 pandemic which disrupted collection of EEG data, thereby reducing the number and diversity of participants who completed the Emotion Regulation Task and decreasing the power of the results. Additionally, because participants reappraised images themselves, it is also difficult to standardize the reappraisal and ensure it was happening. Finally, the stimuli used in the task was not particularly racially diverse due to limited number of interpersonal images with valence ratings in the OASIS and the IAPS images.

Interestingly, gender was associated with the LPP such that women tended to have larger LPP residuals during reappraisal. This has implications about how emotion regulation strategies may differ by gender. This may be accounted for by differences in self-reported preferences for coping styles by gender, where for specific stressors, college-aged men used both adaptive and maladaptive emotion-focused coping skills, whereas women just used maladaptive emotion-focused coping (Brougham, 2009). Still, his difference does not account for a correlation between gender and depressive symptoms or gender and self-reported secondary coping, it more likely is due to some facet of how the LPP is impacted by reappraisal in the brain.

Gender differences in modulation of the LPP are also worth exploring in the future. Other future studies could include emotion ratings and other measures to specifically understand the differences between self-reported measures of coping and neural activity in response to coping. A longitudinal study looking at the impact of brief intervention and a longer intervention may also help better understand this relationship, which has implications for how to teach coping skills to individuals moving through phases of high interpersonal stress.

This study builds on the literature by exploring the domain of interpersonal stress in particular and comparing self-reported coping to the reappraisal-induced modulation of the LPP. Our findings support prior literature regarding the relationship of coping to depression and stress, and depression to the LPP. Findings related to the LPP were in some ways inconsistent with the literature, which may be a result of a focus on interpersonal stimuli, time frames analyzed, specificity of coping, instructions, or something else entirely. Still, this study built upon previous work by identifying early neural markers of individual differences in emotion regulation and finding associations to depression, finding that self-report and neural measures of coping/emotion were independently associated with depression, using a new type of stimuli in the emotion regulation task, and learning from a multi-method approach to understanding interpersonal stress and coping. Perhaps most important, in understanding that there is a disconnect between self-reported and neural indicators of coping, it is possible to develop future studies which better understand how different study methods may target different underlying mechanisms of coping in response to stress.

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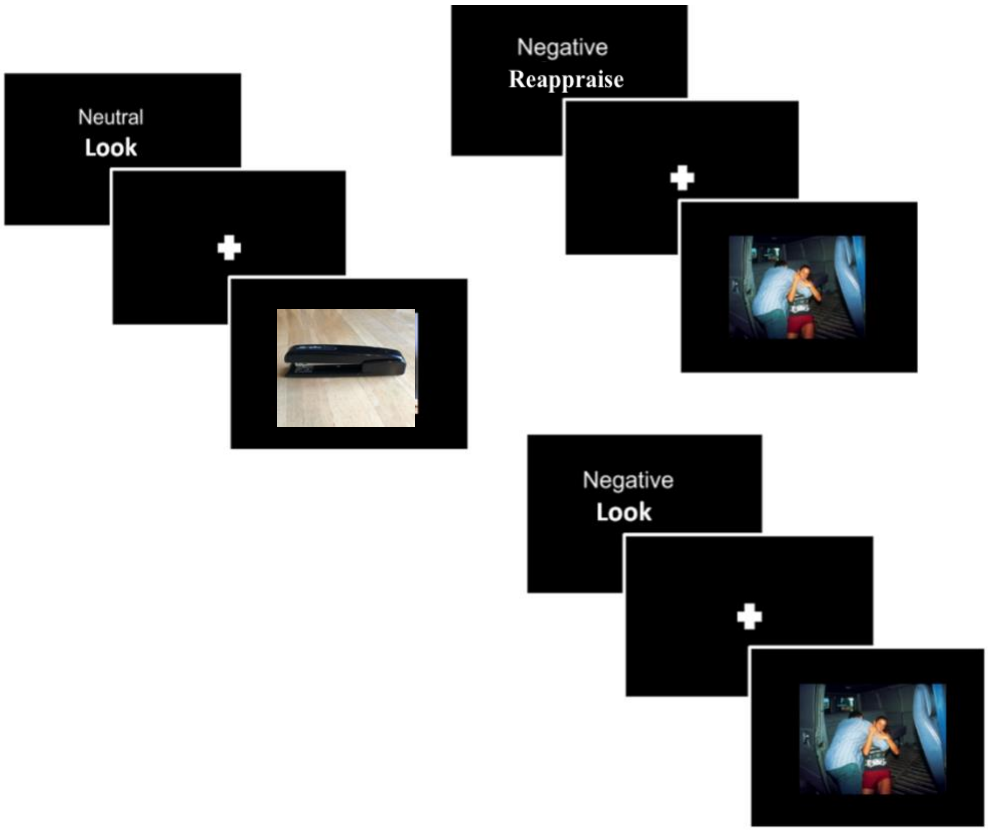


Figure 1. Emotion Regulation Task. LOOK NEGATIVE is the passive viewing condition, whereas DECREASE NEGATIVE is the cognitive reappraisal condition.

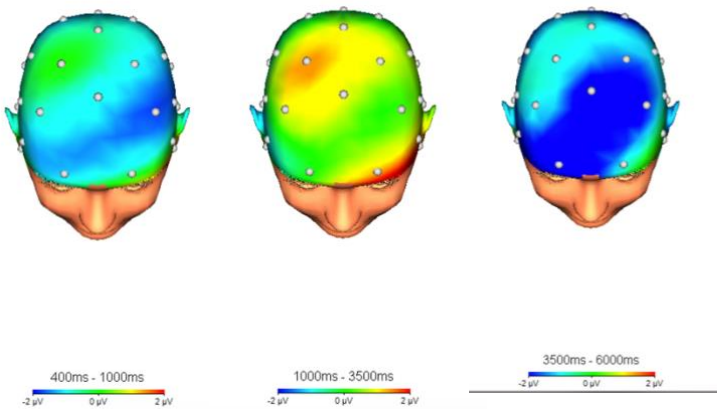


Figure 2. Frontal Scalp Distributions

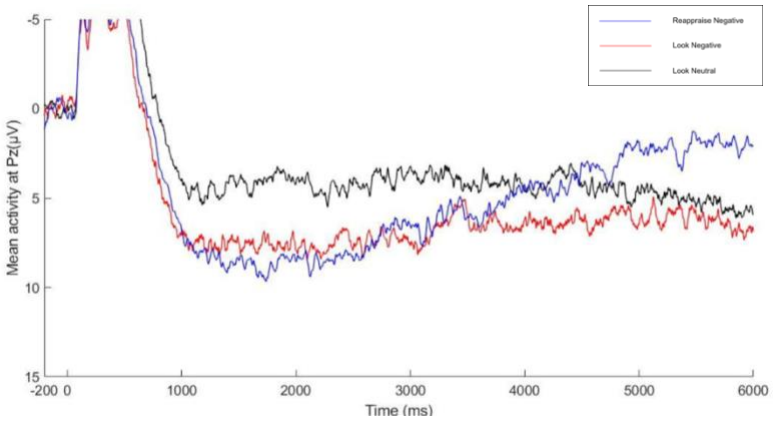


Figure 3. Frontal Event Related Potential at Pz

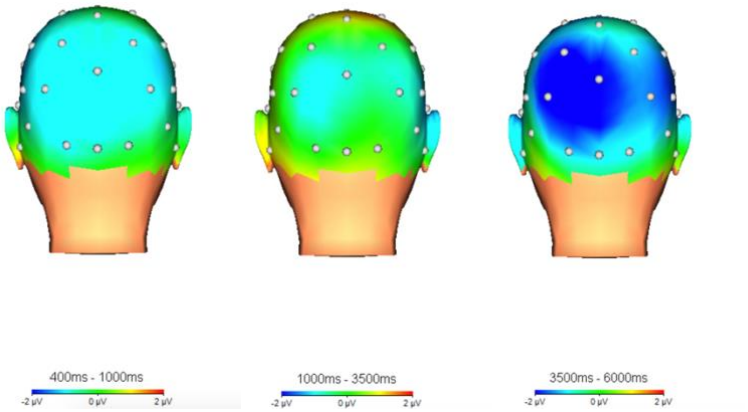


Figure 4. Centroparietal Scalp Distributions

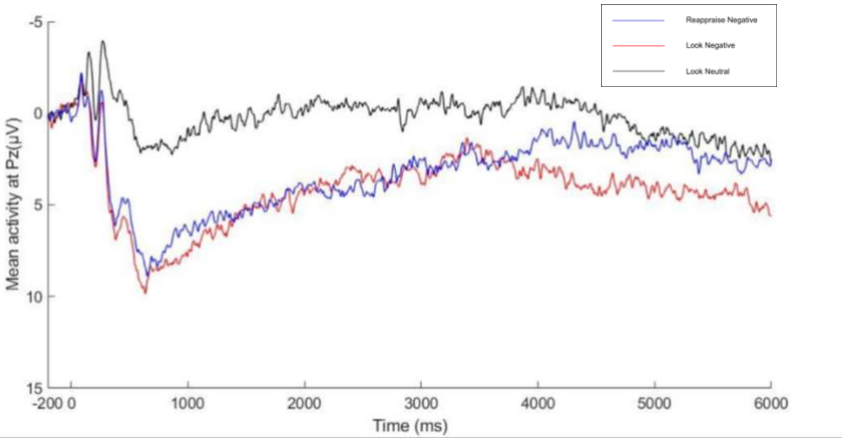


Figure 5. Centroparietal Event Related Potential at Pz

Table 1. Mean LPP activity for the three time windows within each emotional condition and electrode pooling.

| **Electrode Pooling** | **400-1000ms** | **1000-3500ms** | **3500-6000ms** |
|---|---|---|---|
| Centroparietal | | | |
| *Look* | 7.27 | 4.95 | 5.00 |
| *Reappraise* | 6.18 | 4.62 | 3.20 |
| *Neutral* | 1.50 | 1.32 | 2.71 |
| Frontal | | | |
| *Look* | 0.20 | 7.30 | 6.78 |
| *Reappraise* | -0.96 | 8.11 | 5.05 |
| *Neutral* | -3.34 | 5.10 | 5.91 |

Table 2
*Correlation Matrix with Self-Reported Reappraisal and Depression*

| | age | gender | centroparietal residuals 400_1000ms | general depression scale | secondary coping | chronic stress | interpersonal stress |
|---|---|---|---|---|---|---|---|
| age | 1.00 | | | | | | |
| gender | -.28 | 1.00 | | | | | |
| centroparietal residual 400_1000ms | .25 | -.36* | 1.00 | | | | |
| general depression scale | .01 | -.08 | .37* | 1.00 | | | |
| secondary coping | -.02 | -.27 | -.07 | -.49** | 1.00 | | |
| chronic stress | .28 | -.24 | .32 | .53*** | -.38* | 1.00 | |
| interpersonal stress | .20 | -.25 | .30 | .51*** | -.39* | .86*** | 1.00 |

*correlation is significant at the .05 level (two-tailed)
**correlation is significant at the .01 level (two-tailed)
***correlation is significant at the .001 level (two-tailed)