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A Pilot Study of Neural Markers of Emotion Reactivity: Developmental Differences and Associated Risk for Psychopathology

Christina M. Hogan
University of Massachusetts Amherst

A PILOT STUDY OF NEURAL MARKERS OF EMOTION REACTIVITY: DEVELOPMENTAL DIFFERENCES AND ASSOCIATED RISK FOR PSYCHOPATHOLOGY

A Thesis Presented

by

CHRISTINA M. HOGAN

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Approved as to style and content by:

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Jennifer M. McDermott, Chair

_____
Lisa Harvey, Member

_____
Adam Grabell, Member

_____
Caren Rotello, Department Head
Psychological and Brain Sciences

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ABSTRACT

A PILOT STUDY OF NEURAL MARKERS OF EMOTION REACTIVITY:

DEVELOPMENTAL DIFFERENCES AND ASSOCIATED RISK FOR

PSYCHOPATHOLOGY

MAY 2021

CHRISTINA HOGAN, B.A., CORNELL UNIVERSITY

M.S., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Jennifer M. McDermott

Emotion reactivity refers to the extent to which one experiences emotion (Nock et al., 2008) and is an important underlying component of the development of effective social and behavioral functioning. Emotion reactivity can be understood as distinct from other emotion-related constructs because it is defined specifically as the speed and intensity of one's initial and automatic emotional activation, as opposed to one's ability to control or change one's emotional response (Cole, Martin, & Dennis, 2004). Both over-reactivity and under-reactivity to emotional stimuli have been related to increased risk for psychopathological disorders such as major depressive disorder, social anxiety disorder, generalized anxiety disorder, and separation anxiety disorder (Bylsma, Morris, & Rottenberg, 2007; Goldin et al., 2009; Carthy, Horesh, Apter, Edge, & Gross 2010).

A small and emerging literature indicates that neural markers signifying emotion reactivity to negative stimuli relate to patterns of risk for psychopathology in young children. However, far less is understood about how neural markers of emotion reactivity to pleasant stimuli, or the variability between neural markers of emotion reactivity to pleasant and unpleasant stimuli, relate to risk for psychopathology in children. It is also unclear whether the

patterns of neural reactivity associated with processing unpleasant and pleasant stimuli are similar or different between young children and young adults. An understanding of similarities or differences of neural patterns of risk and reactivity between these age groups could provide important insights into the developmental differences in symptom patterns. Therefore, this study has two aims: 1) to determine whether neural markers of emotion reactivity to unpleasant and pleasant stimuli correspond to risk for psychopathology and how this relationship differs between young children and young adults and 2) to examine whether the time course of neural markers of emotion reactivity to unpleasant and pleasant stimuli relate to varied patterns of activation and whether they predict unique patterns of psychopathology symptomology.

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CHAPTER 1

A PILOT STUDY OFNEURAL MARKERS OF EMOTION REACTIVITY: DEVELOPMENTAL DIFFERENCES AND ASSOCIATED RISK FOR PSYCHOPATHOLOGY

A) Introduction

Emotion reactivity refers to the speed and intensity of initial and automatic emotional activation and is an important underlying component of the development of effective social and behavioral functioning (Cole, Martin, & Dennis, 2004). Emotion reactivity can be understood as distinct from other emotion-related constructs because it focuses on the extent to which one experiences emotion (Nock et al., 2008) as opposed to one's ability to control or change one's emotional response (i.e. emotion regulation; Cole, Martin, & Dennis, 2004). Differences in emotion reactivity, both over-reactivity and under-reactivity, have been related to increased risk for psychopathological disorders such as major depressive disorder, social anxiety disorder, generalized anxiety disorder, and separation anxiety disorder (Bylsma, Morris, & Rottenberg, 2007; Goldin et al., 2009; Carthy, Horesh, Apter, Edge, & Gross 2010), however, these relations have not been thoroughly explored in young children.

Due to these risks associated with varied emotion reactivity, it is crucial to have accurate measures of this construct in children that can inform our understanding of risk for maladaptive outcomes, however, existing research has fallen short of providing a comprehensive examination of this connection. Whereas existing research has examined emotion reactivity in early childhood populations, fewer studies have examined the concept using neuroscience-based approaches, which are vital for obtaining a more objective view of emotion reactivity. Further, the most

common stimuli used in existing research to present to participants when measuring emotion reactivity are those from the International Affective Picture System. These images are developmentally inappropriate for young children, which leads to limited use or ethical questions when utilized in research with children. Therefore, this study will use a novel, developmentally appropriate, stimuli set (i.e., the Child Affective Picture System; CAPS) to examine neural markers of children's emotion reactivity to pleasant, unpleasant, and neutral images in the form of an event-related potential (ERP) called the late positive potential (LPP). Neural reactivity will be assessed across emotion categories and between children and young adults in order to contrast patterns of nascent and mature emotion reactivity to unpleasant and pleasant stimuli. This study will also investigate the relation between neural reactivity to emotion stimuli and risk for psychological symptoms. By examining patterns between children and young adults, we can determine whether patterns of neural reactivity to emotional stimuli differ between these age groups as well as whether neural reactivity differentially predicts risk for psychopathology symptoms between children and young adults. Detecting age group differences could present the opportunity for future developmental research to identify early risk factors for emotion reactivity problems and inform design of interventions to alleviate risk for psychopathology at younger ages.

1. Emotion Reactivity

Emotion itself has been broadly defined as a fluid and complex progression of feeling, consisting of variations in the intensity, persistence, and modulation of feelings (Cole, Martin, & Dennis, 2004; Thompson, 1994). Although emotion reactivity has been defined as one's immediate and automatic emotional response (Cole, Martin, & Dennis, 2004), the study of emotion reactivity is challenging due to the intricate relations between emotion reactivity and

other important emotion concepts. For instance, the concept of persistence of emotion reactivity, or the length of time the emotion persists before returning to baseline levels of arousal (Nock et al., 2008), can be closely tied to the concept of emotion regulation. In fact, researchers have noted the challenge of distinguishing between reactivity and regulation, as one's initial response to an emotion may be influenced by one's regulatory strategies (Kagan, 1994; Davidson, Jackson, & Kalin, 2000). Further, emotion regulation has been defined using constructs that closely overlap with emotion reactivity, having been described as both automatic and effortful (Davidson, Jackson, & Kalin, 2000; Gross 2002) and theorized to be temporally overlapping with emotion reactivity (Davidson, Jackson, & Kalin, 2000). Though intricately tied, the distinction between these related concepts is that emotion regulation is a skill that can be learned, practiced, and improved throughout development (Cole, Dennis, Smith-Simon, & Cohen, 2009), whereas emotion reactivity is an individual factor that likely predisposes a person to have deficits in emotion regulation (Nock et al., 2008). Despite the challenges posed by these nuanced definitions, understanding emotion reactivity remains an important task because it is an underlying factor in one's ability to modify and control one's emotion response and thus has a clear connection to risk for development of emotional problems or psychopathology.

Perhaps most important in the consideration of early emotion reactivity is its role in elucidating why and how psychopathology develops. Higher levels of emotion reactivity to negative stimuli have been shown to be related to psychopathology in adults, adolescents, and older children including major depressive disorder, social anxiety disorder, generalized anxiety disorder, and separation anxiety disorder (Bylsma et al., 2007; Goldin et al., 2009; Carthy et al., 2010). Given the unique role that reactivity plays in developing psychopathology, gaining a deeper understanding of the development of emotion reactivity could illuminate possible

intervention points early in childhood. Despite this critical connection, little is understood about how emotion reactivity changes from childhood to young adulthood, representing an important void of knowledge that, if filled, could further illuminate how risk for psychopathology presents during different developmental stages. For instance, if patterns of over-reactivity or under-reactivity to emotional stimuli show specific connections to clinical symptomology in early childhood, but not in young adulthood, it will be important for future work to track the change in this pattern over time using longitudinal, within subjects designs.

2. Measuring Emotion Reactivity

Much of the literature on emotion reactivity in children and adults has focused on subjective perceptions of emotion and on autonomic nervous system responses, such as cortisol, sweat, blood circulatory response, and skin conductance. Research on adults has also extensively studied neural underpinnings of emotion reactivity using functional magnetic resonance imaging (fMRI), positron emission tomography (PET), and EEG, which allow for measurements of emotion that reflect affective response directly from the brain. In comparison to other brain-focused measurements of emotional response, such as fMRI and PET, EEG is ideal for studying emotion reactivity due to its superior temporal resolution (Mauss & Robinson, 2009; Dennis & Hajcak, 2009). A further benefit of using EGG is that it is well-suited for young children due to its relatively non-invasive and simple setup that has fewer limitations on movement. EEG is able to measure brain responses through a cap worn on the head by recording electrical activity from the scalp related to cortical activity (Stern, Ray, & Quigley, 2001).

EEG is particularly useful in the measurement of emotional response, which has been demonstrated in the extensive research establishing a clear relation between EEG and both emotion and emotion-related constructs in children and adults (Coan & Allen, 2004; Hajcak,

Weinberg, MacNamara & Foti, 2012; Nelson & McCleery, 2008). In particular, event-related potentials (ERPs), which are evoked neural responses time-locked to specific stimuli or responses (Stern, Ray, & Quigley, 2001), are a common approach when collecting EEG to measure emotion reactivity (Nelson & McCleery, 2008; Hajcak & Dennis, 2009; Hua, Han, & Zhou, 2015). The excellent temporal resolution of ERPs (on the order of milliseconds) is especially important when measuring emotion reactivity due to the various changes in duration, intensity, onset, and offset of emotional response one undergoes while experiencing emotion (Hua, Han, & Zhou, 2015). This resolution will allow for the comparison of reactivity across contexts, such as the differential reactivity to varied emotion categories. Thus, ERPs are ideal for examining rapid neural responses to emotional stimuli in children (Hajcak & Dennis, 2009) and measuring emotion reactivity in the present study.

a. Late positive potential (LPP). Although measurement of its timing varies from study to study, the LPP is generally recognized as the portion of the ERP response that falls within 300 to 1,000 milliseconds following the presentation of emotional stimuli in adults (Hua, Han, & Zhou, 2015; Hajcak & Olvet, 2008). In children, the LPP can start as late as 500 milliseconds following stimulus onset (Dennis & Hajcak, 2009). This component is thought to reflect increased attention to emotional stimuli compared to neutral stimuli (Solomon, DeCicco, & Dennis, 2012; Hajcak & Dennis, 2009) and has been regularly used to examine emotion reactivity. Specifically, research examining the LPP in adults has found that viewing arousing images of pleasant and unpleasant nature both elicit equally enhanced LPP responses compared to viewing neutral images (Hajcak, Moser, & Simons, 2006). Further research shows that the LPP is attenuated when a more neutral stimulus is presented, thus confirming that the LPP is sensitive to emotional arousal (Foti & Hajcak, 2008). The literature therefore suggests that a

lower LPP response corresponds to an overall lower emotional response (Dennis & Hajcak, 2009). Although these studies focused on adults, other research suggests similar patterns in children (aged 5 to 8 years old), indicating that the LPP can be used as a reflection of continued, increased attention to emotional stimuli of both positive and negative valence in children as well as in adults (Hajcak & Dennis, 2009). Finally, the majority of the literature involving the LPP has examined the component as a whole, but some research that has examined the LPP in early, mid, and late windows during emotion processing has shown that the early LPP is largest in adults while the late LPP is largest in preschoolers (Hua, Han, Chen, Yang, Zhour, & Hu, 2014). Similar research has found that children's mid LPP amplitudes were decreased when using an emotion modulation strategy in response to unpleasant images (Dennis & Hajcak, 2009).

Further research suggests that the LPP is also useful in measuring the relation between emotional response and the development of psychopathology and behavioral problems. This neural correlate in adults has been connected to attachment anxiety, generalized anxiety disorder, and phobias, such that those who exhibited higher LPP responses when viewing negative stimuli were at higher risk for psychopathology (Macnamara & Proudfit, 2014; Leutgeb, Schafer, & Schienle, 2009; Weinberg & Hajcak, 2010; Zilber, Goldstein, & Mikulincer, 2007). Enhanced LPP amplitudes to negative stimuli have also been connected to Major Depressive Disorder in adults (Foti et al., 2010) and suicidality in undergraduate students (Kudinova et al, 2016), whereas attenuated LPP amplitudes have been linked with delinquency in juveniles and ADHD in children (Pincham, Bryce, & Fearon, 2014; van Meel et al., 2011).

b. Group differences. Research has long indicated the presence of gender differences within risk for psychopathology symptoms, with a general pattern of females being more likely to be diagnosed with internalizing and mood disorders such as anxiety and depression, and males

more likely to be diagnosed with substance abuse disorders, antisocial behavior disorders, and externalizing disorders (Kramer, Krueger, & Hicks, 2008; Compton, Conway, Stinson, Colliver, & Grant, 2005; Klose & Jacobi, 2004). Further, these differences have been found to exist both in adults' and children's patterns of psychopathology (Leadbeater, Kuperminc, Blatt, & Hertzog, 1999; MacNamara & Proudfit, 2014). Findings exploring neural correlates of emotion suggest that gender also plays a role in accounting for individual differences, with patterns of males exhibiting a general positivity bias to emotional stimuli compared to females (Syrjänen & Wiens, 2013; Stevens & Hamann, 2012). Overall, the existing literature highlights gender as an important individual characteristic that can account for differences in both psychopathology and neural correlates of emotion reactivity, and should be examined when conducting research within these realms.

Less explored, but also important, is the potential difference in psychopathology and neural correlates of emotion reactivity between age groups. Some research has examined emotion reactivity to affective stimuli among older adults as compared to young adults and has found that older adults show decreased neural responses to affective images compared to young adults and that older adults display underarousal on EEG measures of reactivity (Smith, Hillman, & Duley, 2005; Woodruff-Pak & Papka, 1999). Though existing research appears to be limited to comparisons between older and younger adults, it provides a grounding for, and evidence of, the hypothesis that different age groups display different reactivity to affective images. When examining age groups of young children and young adults, children are expected to display higher levels of and more variation in their emotion reactivity compared to young adults due to the difference in developmental stages and abilities related to emotion reactivity and regulation.

Therefore, this study will examine two age groups to explore these developmental differences in emotion reactivity: young childhood and young adulthood.

In sum, the LPP is well established as a clear neural correlate of emotion reactivity in both children and adults with strong connections to risk for impaired behavioral and emotional functioning. Yet this informative marker has received far less research attention in early childhood (Hua, Han, Chen, Yang, Zhour, & Hu, 2014; McLean, Van den Bergh, Baart, Vroomen, van den Heuvel, 2020), with the vast majority of studies examining the LPP in children only including children as young as five years old (Solomon, DeCicco, & Dennis, 2012; Dennis & Hajcak, 2009; Babkirk, Rios, & Dennis, 2015). Further, no existing research has directly compared the LPP in children and adults yet to our knowledge. Because of the differences in developmental abilities related to emotion regulation dependent upon age, and the skill's close ties with reactivity (McRae et al., 2012; Kagan, 1994; Davidson, Jackson, & Kalin, 2000), we would expect to find differences in reactivity between young children and adults, and therefore differences in how their reactivity predicts symptomology. Thus this study will examine whether emotional under-reactivity or over-reactivity as measured by the LPP response to affective stimuli predicts differential risks in children as compared to adults.

3. Need for Developmentally Appropriate Stimuli Set

Another large shortcoming of the current literature is the stimuli used when measuring emotion reactivity in children. Each previously cited study here that has shown affective stimuli to children has used the International Affective Picture System, or IAPS. The IAPS is a set of 700 color photographs that are intended to elicit emotional response in participants who view them, employing emotional categories of unpleasant, neutral, and pleasant images (Lang, Bradley, & Cuthbert, 1997; Hajcak & Dennis, 2008). The IAPS is used ubiquitously in research

to examine emotional response due to its strong standardization and norming processes and reflects a reliable method of eliciting emotional response in participants.

However, because these images were developed to evoke strong emotional response in adults, their developmental appropriateness for children has questionable ethical implications. The content of IAPS images includes graphic depictions of violence, illness, and mutilations, which present controversy when showing them to young children (Mikels et al., 2005). This assertion is supported by research that has demonstrated that children who view disturbing images while watching TV have an associated risk of nightmares, and that this relationship is stronger than the effect of waking-life experiences or reading (Stephan, Schredl, Henley-Einion, Blagrove, 2012). In addition to this risk of disturbing child participants, the IAPS also does not include enough pictures stimulating a fear response, so it cannot reliably induce this emotion in participants (Quiñones-Camacho, Wu, & Davis, 2018). Even a more recently developed picture set with higher quality images, the Nencki Affective Picture System, or NAPS, has limited ability to elicit discrete emotions due to the small number of images in each category (Quiñones-Camacho, Wu, & Davis, 2018). Finally, even when studies select images from IAPS which they deem developmentally appropriate to use with children, the use of this new collection of images is not as reliable as when using the full set, as this new collection did not undergo the same validity testing, and there has been too little research conducted on the use of the IAPS in children to confirm this validity (Hajcak & Dennis, 2008). These shortcomings of the IAPS and other image sets for research in children highlight the specific need for a developmentally appropriate stimuli set and its use in emotion reactivity research across a wider range of ages.

4. The Present Study

This study will examine a neural biomarker of emotional reactivity, the LPP, to compare how children and young adults respond to affective images using a developmentally appropriate stimuli set (the Child Affective Picture System; CAPS). In particular, this study will examine LPP amplitude differences across pleasant, unpleasant, and neutral emotion categories among participants in early childhood. This study will also test the relation between emotion reactivity, as assessed via the LPP, and risk for psychopathology as measured by parent- and self-report clinical questionnaire scores. We will also test whether LPP responses to pleasant, unpleasant, and neutral images manifest in a similar manner between children and young adults, while also testing whether these patterns correspond to risk for psychopathology in a similar or distinct pattern between children and young adults. Specific hypotheses are listed below:

Hypothesis 1a: There will be different amounts of total LPP activation depending on emotion category, such that higher total LPP amplitude will be seen when viewing positive and negative emotion stimuli compared to when viewing neutral stimuli.

Hypothesis 1b: There will be different amounts of LPP activation depending on emotion category when examining subwindows of the LPP, such that a larger LPP amplitude will be found in the late window and a smaller LPP amplitude will be found in the early window.

Hypothesis 2a: The total LPP amplitude to different emotion categories will differentially correspond to risk for certain types of psychopathology, such that risk for externalizing-related symptoms will correspond to LPP amplitude when viewing pleasant images and internalizing symptoms will correspond to LPP amplitude when viewing unpleasant images.

Hypotheses 2b: The time frame of the LPP will also relate to unique patterns of risk for symptomology, such that elevated processing in the late window of the LPP will more strongly predict psychopathology symptoms than processing in the mid and early windows.

Hypothesis 3a: Children and young adults will show different patterns in how their LPP amplitudes vary by emotion category, such that more variation in activation between emotion categories is expected in young adults when examining the total LPP, reflecting clearer distinctions between these categories compared to children. The time frame of the LPP will also predict different amounts of activation, such that there will be elevated processing in the late window of the LPP and decreased processing in the early window of the LPP for children compared to adults.

Hypothesis 3b: Children and young adults will show different patterns in how their LPP amplitudes correspond to risk for psychopathology when examining the total LPP amplitude as well as when exploring the subset of LPP time windows (early, mid, and late). Specifically, it is hypothesized that children will show a stronger connection between LPP amplitude and clinical symptomology than will young adults.

B) Method

1. Participants

Participants were recruited from two age groups: children in early childhood and young adults. Sixty-five children were recruited and participated in the study, however, the final sample of children included 25 young children from the Amherst, Massachusetts area, with ages ranging from 42 months old to 79 months old *(M* = 56.38, *SD* = 8.77*)*. Eight children were excluded due to refusing to wear the EEG cap and only completed behavioral data. Of the remaining 57 children who wore the EEG cap, 13 were excluded for error in data collection leading to a lack

of EEG data (due to both equipment malfunction and collection artifacts) and 15 were excluded for a lack of sufficient usable epochs. Of the remaining 29 children, all had a minimum of 8 epochs in at least one of the three emotion categories, and 25 had a minimum of 8 epochs across all three categories. Young adult participants were undergraduate students from the University of Massachusetts Amherst with ages ranging from 19 to 22 years old (M = 20.30, SD = 1.13). A sample of 28 young adults were recruited[1] and participated in the study, but the final sample of young adults included in analysis was 20 (eight were excluded from analysis due to a lack of sufficient usable ERP trials within each emotion category). Both the young adult and child participants primarily identified as European American (96%) with 13 child participants (52%), and 15 young adult participants (75%) identifying as female.

2. Procedure

Research assistants recruited participants in early childhood by phone calls and emails directed to parents and caregivers. Young adult participants were recruited via the SONA System, through which participants were awarded extra credit in their psychology classes for taking part in the study. Interested children and young adults were then screened for eligibility. An eligible participant must have not been diagnosed with a language disorder, learning disorder, intellectual disability, uncorrected hearing or visual disability, Autism or Asperger's Disorder, psychosis, or Cerebral palsy. Upon arrival for the lab visit, which lasted approximately 90 minutes, young adults gave informed consent, children gave verbal assent, and parents or caregivers of the children gave informed consent on behalf of their children. Participants were then fitted for an electroencephalogram (EEG) cap, secured on their head by two research

[1] Further data collection from male undergraduate participants was initially proposed, but data collection was prevented due to the COVID-19 pandemic.

assistants. During this time young adults completed self-report questionnaires and parents of children completed parent-report questionnaires concerning their children.

Next participants passively viewed on a computer screen a total of 99 pictures throughout a series of three blocks, with 33 pictures per block, all while wearing the EEG cap. Pictures were shown in blocks to allow children to rest or move around in between blocks, and to ensure more children would have a larger number of usable epochs. Images were randomly divided among blocks and pleasant, unpleasant, and neutral images were evenly distributed within blocks. Participants were presented a snowflake image on the screen for 550ms as a reminder to sit still or "freeze," a black screen for 550ms, a fixation mark for 250ms, the emotional stimuli picture for 3 seconds, and then a yellow circle. Upon seeing the circle, the research assistant would ask the participant, "what does this picture make you feel?" If the child did not have a response, he/she would then be prompted with, "does it make you feel grossed out, sad, angry, scared, no feelings at all, or happy?" This question was represented through an image of six cartoon faces displaying six emotion options (neutral, happy, sad, angry, disgusted, scared). Using whichever emotion the participant indicated, the researcher would then ask how much of the emotion they felt (a little, more than a little, medium, more than medium, or a lot). This question was represented through an image of five thermometers displaying increasing fullness, called a 'feelings thermometer" to the children participants. After completing the task for all three blocks, young adults were given SONA credit for their participation, families of children were compensated $20 for their participation, and children were given a small prize.

a. Affective picture-viewing stimuli. The images used to create the CAPS picture set were collected through a thorough rating process to identify images that represented the desired emotional categories. The images were purposely selected from uncommon storybooks in order

to reduce the likelihood that children had seen them before and decrease the chance that the child would react to the familiarity of the image as opposed to the emotion evoked by the image. The selected images were then rated by graduate and undergraduate researcher assistants based on valence and arousal, as well as rated for the developmental appropriateness of the images and to ensure there were not repetitive images within the set. Finally, the remaining images were further rated by 34 undergraduate students at the University of Massachusetts Amherst for valence and arousal. The 99 images that were most commonly rated with the same valence and arousal by the undergraduate students were selected as the final stimuli for the CAPS stimuli set. These 99 images were comprised of 25 pleasant images, 49 unpleasant images, and 25 neutral images, Within the 49 unpleasant images, subcategories consisted of 15 images selected to evoke sadness, 14 to evoke anger, 17 to evoke fear, and 3 to evoke disgust.

b. EEG data recording. Continuous EEG was recorded during the task. Data were collected from Ag-AgCl electrodes fastened to the cap, which was then placed on the scalp. A 64-channel Lycra Electro-Cap was used with sensor placement in accordance with the International 10-20 System. The current study focused on site Pz and data from the left and right mastoids behind both ears (Hajcak, Weinberg, MacNamara & Foti, 2012). Using NeuroScan amplifiers with 16-bit A–D conversion, high and low band pass filters were set at .01 to 100 Hz, respectively. Impedances were kept below 10 kΩ. Electrooculogram (EOG) was used to identify eye movements by placing two electrode channels, one above and one below, the outer canthus of the left eye, so that identified eye blinks could be removed from the data.

3. Measures

a. Demographic questionnaire. Young adults and parents or caregivers of children completed a demographic questionnaire. The form included questions such as the caregiver's

age, education level, and relationship to child, as well as questions about the child's age, schooling, gender, and ethnicity. Young adults answered questions about their age, schooling, gender, and ethnicity.

b. Clinical symptom assessment. Clinical symptom assessments for children and young adults were collected through two self-report measures: The Behavior Assessment System for Children-2 (Parent Rating Scale) and the Behavior Assessment System for Children-3 (adolescent form for 18-25 year olds).

i. Behavior Assessment System for Children 2 – Parent rating scale – preschool form. The BASC-2 PRS preschool form (ages three to six) was used to evaluate behavior and risk for psychopathology in children, as reported by their parents or caregivers (Reynolds, 2010). Parents answered 134 statements regarding their child's behaviors (e.g. "makes friends easily") by selecting *Never* (1), *Sometimes* (2), *Often* (3), or *Almost Always* (4). The BASC-2 has good reliability, exceeding $\alpha = .80$ for all subscales (Reynolds & Kamphaus, 1994). The present study examined the internalizing, adaptive skills, and behavioral symptoms composite scales, as well as the hyperactivity, anxiety, depression, and somatization scales.

ii. Behavior Assessment System for Children 3 - Self-report of personality - college form. The BASC-3 SRP college form was used to measure risk of behavioral and emotional problems as well as clinical psychopathology risk in young adults aged 18 to 25. The questionnaire consists of various statements about a person's thoughts and feelings and is composed of subscales that are answered with "true" or false" or answered with a four-point Likert scale ranging from *Never* (1) to *Almost always* (4). The BASC-3 SRP college form has good reliability, with an alpha of .95 in its composite scale, .86 in its clinical and adaptive scales, and .84 in its content scale (Reynolds, Kamphaus, & Vannest, 2010). In this study the

internalizing composite (α =.97), emotional symptoms composite (α =.97), anxiety (α =.91), depression (α =.88), somatization (α =.79), and hyperactivity problems (α =.82) were also examined (Reynolds & Kamphaus, 2015).

c. Late Positive Potential (LPP). ERPs were created by averaging amplitudes separately for each picture type (pleasant, neutral, sadness, fear, anger, disgust), and total (600-2,000ms), early (600-1,000ms), mid (1,000 -1500ms), and late (1500 - 2,000ms) LPP timing ranges were calculated. EEG epochs that exceed +/- 150 uV were excluded. Epochs were baseline corrected and averaged for each block. Eye blinks were regressed and remaining data was re-referenced to the average mastoids and filtered using a zero phase shift filter.

C) Statistical Approach

Statistical software SPSS (Version 23) was used for all data analyses (IBM Corp, 2016). Descriptive statistics were calculated in order to examine the mean amplitudes and standard deviations of the LPP, as well as to determine if there were any outliers within the young adult or children participants. Means and standard deviations were also calculated for clinical symptomology scores, as measured by the BASC-2 and BASC-3 for the children participants and the young adults respectively, and outliers were examined and considered for exclusion. In accordance with prior literature examining the LPP in children and adults, analyses focused on the parietal region using site Pz (Hajcak, Weinberg, MacNamara & Foti, 2012). Due to the uneven number of males and females within the undergraduate age group, analyses of this age group involving gender are exploratory only.

To address hypothesis 2a, that total LPP amplitude to different emotion categories will differentially correspond to risk for psychopathology, partial correlations were calculated between participants' LPP amplitudes for each picture category and their clinical symptomology

scores, with participant gender as a control variable. Clinical symptomology was represented by the parent-reported and self-reported behavioral scores (for children and young adults respectively) on internalizing symptoms, overall symptoms, and adaptive skills composite scales, as well as the anxiety, depression, somatization, and hyperactivity subscales. Because not all scales between the BASC-2 and BASC-3 directly correspond to each other, comparisons between the difference versions were made with guidance from the BASC-3 manual. Overall symptoms were examined using the behavioral symptoms index composite scale for children and the emotional symptoms index composite scale for young adults. Adaptive skills were examined using the adaptive skills composite scale for children and the personal adjustment composite scale for young adults.

For hypothesis 1b and 3a (that larger LPP amplitude would be found in the late window and smaller LPP amplitude in the early window, and that young adults would show larger differences in LPP amplitude between emotion categories) a series of ANOVAs was conducted. First, a repeated measures ANOVA was conducted with emotion category as the within-subject variable, consisting of three categories of pleasant, neutral, and unpleasant stimuli, and with age and gender as the between-subjects variables. Post-hoc tests were conducted for any significant results ($p < .05$). Second, reactivity to emotion categories was assessed with three separate repeated measures ANOVAs, one each for the early, mid, and late windows of the LPP. For each analysis, emotion category served as the within-subject variable, consisting of three categories of pleasant, neutral, and unpleasant stimuli, and age group and gender served as the between-subjects variables. Because the assumption of sphericity was violated in each of the four ANOVAs according to Mauchley's test of sphericity, the Greenhouse-Geisser correction was used to interpret all ANOVA results (Abdi, 2010).

To assess hypotheses 2a & 3b, (that total LPP amplitude would differentially correspond to psychopathology symptoms and that children would show stronger connections between emotion reactivity measured at the total, early, mid, and late windows of the LPP and psychopathology risk), partial correlations between clinical symptomology scores and LPP amplitude at total, early, mid, and late windows were calculated. These correlations were calculated using gender as a control variable, and were calculated with the age groups combined as well the age groups separated.

D) Results

1. Descriptive Statistics, Outliers, and Epoch Filter

Descriptive statistics for LPP amplitude and clinical symptomology are presented in Table 1. The data were also examined for outliers using visual examination of histograms and boxplots, which revealed eight possible outliers for total LPP amplitude at size Pz (five when viewing pleasant images, one when viewing neutral images, and two when viewing unpleasant images), and three possible outliers for clinical scales (two in the depression scale and one in the emotional symptoms index composite scale). When calculating these participants' standard deviations from the group means for their respective categories, only one was found to be greater than 3.29 standard deviations from the mean (Tabachnick & Fidell, 2013) and was excluded from analyses that used the scale on which they had an outlying score.[1] In all analyses using LPP amplitude, participants with fewer than 8 useable epochs for the emotion categories present in the analyses were excluded from analysis.[2]

2. Hypothesis 1

[1] A smaller standard deviation from the mean ($SD < 2.5$) was also used to calculate outliers, and revealed four outliers. Excluding these outliers did not change the significance of any of the reported findings.
[2] Analyses were also conducted with a more conservative epoch requirement of 10, and significant results from all ANOVAs were comparable when using 10 or 8 epoch requirements.

i. Early LPP. Results of the repeated measures ANOVA indicated a significant difference in the mean amplitude of the early LPP at site Pz depending on emotion category, F (2, 82) = 3.37, p = .047, partial eta^2 = .076. Follow-up pairwise comparisons using the Bonferroni adjustment showed that the early LPP amplitude was larger when viewing pleasant images compared to unpleasant images (mean difference = 3.08μV, p = .043). No statistically significant differences were found in the amplitude of the early LPP when viewing pleasant images compared to neutral images (mean difference = .3.53μV, p = .146), or between early LPP amplitude when viewing unpleasant and neutral images (mean difference = -3.08μV, p = 1.00).

ii. Mid LPP. A significant interaction between emotion category and gender was found when examining the mid LPP at size Pz, F (2, 82) = 4.89, p = .014). Follow-up analyses comparing the emotion categories within each gender showed that among males, mid LPP amplitude was higher when viewing pleasant compared to unpleasant images (mean difference = 7.31μV, p = .010; see Figure 1), but there was not a significant difference in amplitude between neutral images and either pleasant or unpleasant images (p's > .22). In contrast, females showed no significant differences in amplitude between any of the emotion categories (p's > .13). When comparing reactivity to each emotion category between genders, females exhibited a significantly larger mid LPP amplitude when viewing unpleasant images compared to males (mean difference = 7.34μV, p = .022; see Figure 2). Gender differences in mid LPP amplitude were not present when viewing pleasant (mean difference = 3.307μV, p = .321) or neutral images (mean difference = -3.03μV, p = .307).

iii. Late LPP. There was not a main effect of emotion category on late LPP amplitude at site Pz, nor significant interactions between emotion category, gender, or age.

iv. Correlations. Partial correlations between LPP amplitude at size Pz in the early, mid, and late windows and clinical symptomology controlling for gender are presented in Tables 6a, 6b, and 6c. A significant positive correlation was found between early LPP amplitude and somatization symptomology when viewing neutral images, r (41) = .32, p = .039. Additionally, a significant negative correlation was found between mid LPP amplitude to neutral images and hyperactivity symptoms, r (41) = -.37, p = .015. For the late LPP amplitude, a negative correlation emerged between reactivity to neutral images and hyperactivity symptoms, r (41) = -.33, p = .030, whereas a positive correlation emerged with somatization symptoms, r (41) = .34, p = .028.

v. Exploratory Analyses. Exploratory analyses were conducted to examine partial correlations between LPP amplitude at site Pz at early, mid, and late windows at sub-categories of the unpleasant images (anger, sadness, fear, and disgust) controlling for gender. A positive correlation emerged between early LPP amplitude for anger-related images and depression symptomology, r (44) = .29, p = .047. No significant correlations were found between any other window of the LPP and other sub-categories of the unpleasant images.

3. Hypothesis 2

All partial correlations between total LPP amplitude at size Pz when viewing pleasant, unpleasant, and neutral images and clinical symptomology are presented in Table 5. A significant negative partial correlations was found between total LPP amplitude when viewing neutral images and hyperactivity symptomology, r (41) = -.35, p = .024), as well as a significant positive partial correlation between total LPP amplitude when viewing neutral images and somatization symptomology, r (41) = .30, p = .048, when controlling for gender.

Correlations between total LPP amplitude at site Pz and clinical symptomology for young adults and children are presented in Table 7. For young adults, a significant positive correlation was found between total LPP amplitude to neutral images and somatization symptomology, r (17) = .53, p = .019, and a marginal negative correlation emerged between total LPP amplitude to neutral images and hyperactivity symptoms, r (17) = -.44, p = .058. Significant correlations from exploratory analyses of the subcategories within the unpleasant image category were also found for young adults between total LPP amplitude to fear-related images and somatization symptoms, r (17) = .46, p = .050. For children, no significant correlations were found between total LPP amplitude for any emotion category and symptomology, including exploratory analyses of unpleasant subcategories.

Correlations between LPP amplitude at the early, mid, and late timing windows and clinical symptomology for young adults and children are presented in Tables 8a, 8b, and 8c. When examining young adults, correlations between somatization symptoms and amplitude to neutral images were found for the early, r (17) = .55, p = .015, the mid, r (17) = .55, p = .015, and the late, r (17) = .48, p = .038 LPP. Marginal correlations were also found between mid LPP amplitude and hyperactivity symptoms, r (17) = -.44, p = .057, and depression symptoms, r (17) = .45, p = .053. When examining children separately, a significant correlation was found between late LPP amplitude to neutral images and somatization symptoms, r (21) = .42, p = .045.

i. Exploratory analyses. Exploratory analyses examining correlations between early, mid, and late LPP amplitude when viewing unpleasant image sub-categories and symptomology separately by age groups revealed significant correlations for young adults between early LPP amplitude when viewing fear-related images and internalizing, r (17) = .51, p = .027, depression r (17) = .48, p = .039, and somatization, r (17) = .51, p = .022, symptoms. A correlation was also

found for young adults between early LPP amplitude to anger-related images and depression symptoms, r (17) = .46, p = .050. No correlations were found for the child group when examining timing windows within the sub-categories of unpleasant images.

4. Hypothesis 3

The question of whether young adults would show larger differences in total LPP amplitude at site Pz between emotion categories compared to children was tested using a repeated measures ANOVA with emotion category (pleasant, neutral, and unpleasant) as the within-subject variable, and age and gender as the between-subjects variables. There was not a main effect of emotion category, F (2, 82) = 1.90, p = .165, however, a significant interaction between emotion category and gender emerged, F (2, 82) = 4.02, p = .031, partial eta^2 = .089, such that males showed significantly higher total LPP amplitudes when viewing pleasant compared to unpleasant images (mean difference = 6.15μV, p = .009). No further differences for males were found between amplitude when viewing pleasant and neutral images (p = .225) or unpleasant images and neutral images (p = 1.00). For females, no significant amplitude differences were found between between any of the emotion categories (p's > .24). When comparing between males and females for each emotion category, a marginal difference emerged for reactivity to unpleasant images (mean difference = 5.43μV, p =. 066). There were no significant differences between genders for amplitude to pleasant images or neutral images (p's > .31). No differences in age group emerged for any of the analyses. The effect of age group was also explored by the early, mid, and late windows of the LPP with the series of ANOVAs from hypothesis two, which also failed to find main or interactive effects with age group.

E) Discussion

The present study aimed to better understand neural markers of emotion reactivity as measured by the LPP, as well as to explore the relation between this neural marker and risk for psychopathology, examining these processes among children and young adults using a novel stimulus set. In contrast to prior studies using stimuli sets developed for adults, this study used a affective picture set that was designed to be more developmentally appropriate for use with children so that the same images could be shown to both children and young adults. The specific aims of the study were to examine 1) the connection between total LPP amplitude to different emotion categories and symptomology, 2) the differences in LPP amplitude dependent upon timing windows and the relation between the different windows and symptomology, and 3) the differences between children's and young adults' total LPP amplitudes to emotion categories, as well as their differential patterns of connection between symptomology and LPP amplitude at total, early, mid, and late windows. Overall, results showed that 1) LPP amplitude varied by emotion category only during the early window of the LPP, 2) LPP amplitude was related unexpectedly to only hyperactivity and somatization symptoms, and 3) there was no effect of age on LPP amplitude. These results and their implications are in discussed in more detail below.

1. LPP Amplitude and Emotion Category

A primary goal of this study was to assess emotion reactivity to different timing windows of the LPP for different emotion categories. Varying levels of emotion reactivity dependent upon emotion category and LPP window were predicted, such that participants were anticipated to show the most elevated neural processing in the late window of the LPP for pleasant and unpleasant images. Results instead indicated that LPP amplitude varied by emotion category only during the early window of the LPP and total LPP amplitude did not vary by

emotion category. This finding contradicts previous research suggesting that more processing in the total LPP would be apparent in pleasant and unpleasant categories (Solomon, DeCicco, & Dennis, 2012; Hajcak & Dennis, 2009) and in windows corresponding to longer durations (e.g., mid and late windows) given extended processing of emotion information (Hua, Han, Chen, Yang, Zhour, & Hu, 2014; Dennis & Hajcak, 2009). As such, the current findings may be better understood as a reflection of the immediacy of emotional reactivity processing with the early LPP reflecting how quick the stimuli capture participants' attention. Since neural reactivity differed only in the early LPP, perhaps this pattern can inform our understanding of emotion processing in general, such that distinct categories of emotion may be processed on a neural level immediately upon viewing a stimulus and typical reactivity declines upon continued viewing of the stimuli as evidenced by lower levels of LPP in mid and late windows of the LPP.

Though the hypothesized differences by emotion category were not detected when examining total LPP, a non-hypothesized finding relating to emotion category and gender emerged, showing that male and female participants may process emotional stimuli differently. Whereas male participants showed greater total LPP amplitude to pleasant stimuli than to unpleasant stimuli, females showed greater LPP amplitude to unpleasant stimuli compared to males. These findings may relate to a similar pattern in LPP research that has found that males show a positivity bias in their LPP amplitudes when viewing emotional stimuli (Syrjänen & Wiens, 2013). They may also reflect findings in a larger body of research that support gender differences in emotion arousal, with a pattern of males showing higher activation to positive stimuli in the Slow Positive Potential component (Bianchin & Angrilli, 2012), rating positive pictures as more arousing (Bradley, Codisplot, Cuthbert, & Lang, 2001), and showing more left amygdala activation to pleasant stimuli in fMRI research (Stevens & Hamann, 2012).

2. Emotion Reactivity and Risk for Psychopathology

Another goal of this study was to understand the connection between clinical symptomology and neural reactivity to affective content. It was predicted that results would indicate differential patterns of risk for psychopathology dependent upon neural reactivity to the various emotion categories that participants viewed. Specifically, risk for externalizing-related symptoms, such as hyperactivity, was hypothesized to be correlated with greater LPP amplitude when viewing pleasant images, whereas risk for internalizing-related symptoms (such as anxiety, depression, and somatization) was expected to be correlated with LPP amplitude when viewing unpleasant images. Contrary to the initial hypotheses, results indicated no correlation between symptomology and total LPP amplitude when viewing pleasant or unpleasant images. Instead, unexpected correlations were found between hyperactivity symptoms and LPP amplitude when viewing neutral images, such that hyperactivity symptoms were negatively correlated with amplitude when examining the total LPP, mid, and late windows of the LPP.

The negative correlations found between hyperactivity symptoms and LPP amplitude during the mid and late windows, such that those with more hyperactivity symptoms showed less emotion reactivity to neutral stimuli, may simply reflect a correlation commonly found between hyperactivity and brain arousal. Models of hyperactivity describe the behavior as a response to lower brain arousal, which is further evidenced by the pathways of treatment and medication for hyperactivity (i.e. stimulants; Sander, Arns, Olbrich, & Hegerl, 2010; Straub et al., 2018). Therefore, these findings may indicate that participants with hyperactivity symptoms did not immediately attend to the affective stimuli, yet attended more after having the stimulus present for a longer amount of time.

Another unexpected finding was the correlation between somatization symptoms and total LPP amplitude to neutral images. Somatization refers to concern about physical symptoms in relation to psychological distress, and has been considered the physical manifestation of disorders particularly when a person in unable to verbalize their emotional distress (Gupta Karkhanis & Winsler, 2016). Distinct from the other clinical symptoms measured, somatization is a transdiagnostic symptom of many categories of disorders, including depressive disorders and anxiety disorders, as well as somatic symptom disorders (Tacchini & Vismara, 2019). As these symptoms are present in many internalizing disorders, the present study's finding that those with higher somatization tendencies displayed more emotion reactivity to neutral images may reflect the well-established connection between internalizing and heightened reactivity to ambiguous or novel stimuli (Moser, Durbin, Patrick, & Smith, 2015; Gorka, Lieberman, Shankman, & Phan, 2016). Perhaps the neutral images are initially ambiguous to participants who experience this internalizing symptom and are therefore more arousing to them, leading to increased LPP amplitudes when viewing this emotion category.

3. Developmental Differences

A final goal of this study was to explore potential differences in neural responses to affective stimuli between children and young adults, and determine if these patterns are related to clinical symptomology. First, the study predicted a difference between children's and young adult's LPP amplitudes, such that young adults would show larger differences in their LPP amplitude between emotion categories that would reflect more differentiation between the emotional valences. Results indicated no difference in amplitude when viewing different emotion categories between age groups, but instead showed a significant interaction between emotion category and gender. As with the prior gender interaction detected when examining all

participants combined across age groups, this finding may be understood to reflect a similar pattern relating to the aforementioned male positivity bias in neural and affective research.

Second, in examining the different connections between symptomology and reactivity among young adults and children, correlations revealed a pattern of a consistent connection between symptomology and emotion reactivity for the young adult group, but not for the children, contrary to the study's hypothesis. Whereas children's emotion reactivity was only found to be correlated with somatization in the late LPP when viewing neutral images, young adults' emotion reactivity at the total, early, mid, and late windows of the LPP was correlated with somatization when viewing neutral images. These findings with somatization for young adults seem to suggest that young adults who may have a sensitivity to ambiguous stimuli process affective images more than children with the same sensitivity. Perhaps this finding reflects a developmental difference in the presentation of somatization, such that young adults who experience more sensations of physiological arousal are more sensitive to affective stimuli, whereas this connection may not be present with the same strength when younger.

Further, within the early LPP, young adults also showed distinct correlations that were not present in children, between reactivity to fear-related images and internalizing, depression, and somatization symptoms, as well as a correlation between anger-related images and depression. While these findings are consistent with previous research in children demonstrating the same connection between internalizing symptoms and enhanced amplitude when viewing emotional stimuli (Lewis & Stieben, 2004; McLean, Van den Bergh, Baart, Vroomen, van den Heuvel, 2020), they do not explain the apparent lack of connection in the present study's child age group. Despite the image set having been designed to elicit strong responses in children, these findings of a connection between symptomology and reactivity for young adults may

provide evidence of the CAPS image set's utility for a wider age range, suggesting this image set provides salient stimuli for both age groups. The lack of connection for children may also be due to the study's sample of children, which may not have included children with high enough clinical scores to capture this connection between neural reactivity and symptomology. Moreover, the children and young adult clinical reports differed by nature of their reporting, with the young children's reports coming from parent reports, and the young adults' reports coming from self-reports. As some clinical symptoms, especially internalizing symptoms, are often more difficult to observe from an outside perspective, it is possible that the true nature of children's clinical symptomology was not fully captured by the parent report (Makol, De Los Reyes, Ostrander, & Reynolds, 2019). Conversely other evidence suggests that parents may be more likely to over-report negative symptoms about their children (Youngstrom, Lober, & Stouthamer-Loeber, 2000), further leading to a possible discrepancy between the parent-report and the self-report measured used in this study. Further still, perhaps these findings reflect normative developmental differences in emotion reactivity between children and young adults. The lack of findings in the child age group may have been due to the group as a whole experiencing high rates of emotion reactivity, as children are still developing emotion regulation during early childhood and would be expected to display less variation in reactivity compared to young adults.

4. Limitations

It is important to consider the limitations of this study when interpreting the findings. The study's sample was very limited in its racial and gender diversity, with a primarily white and female sample. Though no questions were posed regarding the gender of participants, findings relating to gender were demonstrated in the results. Therefore, it is important to interpret these

findings with caution, as it will be important to replicate any findings relating to gender with a more balanced sample. Further, the homogeneity of race and ethnicity as well as the lack of clinical severity in the sample limits the generalizability of the findings.

It is also important to consider the comparison this study made between the measures for young children and young adults using the BASC-2 and BASC-3. As the questionnaires used are from different editions of the manual, there are differences between the composite scales. Although comparisons were made with the guidance of the BASC-3 manual's suggestions for comparing between the two versions, direct contrasts (i.e., comparing composite scores of externalizing, overall symptoms, and adaptive skills) were difficult.

Lastly, the study was limited in its sample size. The sample included 45 participants, and when looking at groups separately included 25 children and 20 young adults. Loss of participants is an important limitation of the present study that may also provide insight into some of the null findings. During data collection, many children would speak up excitedly or get up upon seeing the child friendly stimuli, and the associated movement related artifact in the EEG signal impacted the usability of the ERP trials during which the child had this reaction. Future studies should consider methodologies that are more amenable to movement, which may allow for greater retention of data from children with strong reactions to the stimuli. The low sample size also limited the statistical power of the study and increased the likelihood of type I error, meaning that the findings of this study may not be reliably significant until replicated with a larger sample size (Button et al., 2013). Similarly, adjustments and corrections were not made to the correlational findings, which may also increase the chance of type I error in those findings.

5. Implications and Future Directions

This research contributes to our understanding of the possible relations between emotion reactivity and risk for psychopathology. Though the hypothesized relations between these measures were not found, the finding between reactivity to neutral images and somatization and hyperactivity symptomology provides insight into emotion reactivity in children and young adults who experience those symptoms. Future research should examine the connection between processing in the late window of the LPP in participants with hyperactivity symptoms, as it may inform research that seeks to understand emotional response in children with ADHD. However, future studies should explore whether the somatization findings are more closely linked to internalizing as proposed, or if somatization scores instead represent solely physical symptoms. This consideration may present a possible new avenue to understand both physiological and neural arousal.

The study's findings also shed light on the connection between young adults' and children's differences in patterns of symptomology and emotion reactivity, with children showing little connection between symptomology and reactivity, and adults showing more consistent connections between neural reactivity and internalizing, hyperactivity, and somatization symptoms. These findings may point to a pattern of psychopathology development, such that symptoms typical in young adults may not emerge in early childhood. This possibility presents the opportunity to further explore the development of symptoms and examine other developmental stages and different age groups in future research to find a clearer points of symptom onset or age specific markers to inform intervention efforts.

Future research may expand upon the current analyses by examining additional neural regions (e.g., frontal) in order to explore possible age-related differences in emotional processing

across different areas of the brain. Specifically, examining LPP amplitude as measured in the frontal sites may provide new insight as previous research in a related but distinct image set that explored frontal LPP activity showed connections between image reactivity and child outcomes (McDermott & Egwatu, 2019). Furthermore, including a more racially and gender diverse sample remains an important task for future research that will allow for either the generalizability of findings or the identification of key differences between more groups. Lastly, the correlations between neural reactivity and symptomology suggest that exploring a population with a larger range of clinical symptoms, including participants with more elevated symptoms, is imperative in order to obtain a more comprehensive understanding of connections between emotion reactivity and psychopathology risk.

Table 1

Descriptive statistics for total, early, mid, and late LPP amplitude at site Pz and clinical symptomology.

	Combined				Children				Young Adults			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
Total LPP amplitude												
Pleasant	3.03	10.53	-21.85	35.54	5.13	11.21	-11.24	35.54	0.53	9.32	-21.85	26.21
Neutral	-0.04	8.63	-24.49	17.05	0.28	10.20	-24.40	17.05	-0.45	6.51	-18.25	11.12
Unpleasant	1.18	8.86	-18.58	25.17	2.36	10.39	-10.11	25.17	-0.22	6.56	-18.58	11.75
Early LPP amplitude												
Pleasant	4.20	8.50	-13.64	35.22	6.38	9.58	-10.15	18.19	1.61	6.30	-13.64	14.15
Neutral	0.80	7.88	-20.88	18.19	1.47	9.45	-20.88	18.19	0.01	5.60	-15.11	11.72
Unpleasant	1.60	7.51	-17.48	18.57	2.45	8.95	-11.37	18.57	0.58	5.34	-14.48	9.18
Mid LPP amplitude												
Pleasant	3.00	11.35	-21.90	36.26	5.28	12.18	-14.84	36.26	0.29	9.88	-21.90	29.55
Neutral	-0.03	8.75	-24.96	20.86	0.54	10.39	-24.96	20.86	-0.72	6.46	-18.20	10.27
Unpleasant	1.25	9.79	-20.02	28.64	2.75	11.61	-14.60	28.64	-0.54	6.92	-20.02	12.80
Late LPP amplitude												
Pleasant	2.11	12.97	-28.38	47.38	3.97	13.93	-20.38	47.38	-0.11	11.67	-28.38	32.76
Neutral	-.073	10.14	-26.66	19.51	-0.93	11.90	-26.66	19.51	-0.48	7.84	-20.81	13.55
Unpleasant	0.79	10.31	-20.41	27.62	1.91	12.18	-13.71	27.62	-0.55	7.60	-20.41	12.74
Clinical Symptomology												
Internalizing	50.12	9.58	32	73	48.61	9.86	32	73	51.85	9.19	39	70
Anxiety	51.24	10.01	34	74	50.68	10.77	34	74	51.95	9.20	39	73
Depression	49.36	9.28	35	81	47.84	7.43	35	63	51.25	11.08	40	81
Somatization	50.22	10.97	35	74	46.32	9.36	35	66	55.10	11.08	43	74
Hyperactivity	49.78	8.91	36	75	48.96	6.93	32	62	50.80	11.01	38	75
Adaptive Skills	50.60	8.72	32	65	51.52	7.33	35	62	49.45	10.27	32	65
Overall Symptomology	49.38	5.89	38	67	48.2	6.52	38	67	50.85	4.76	45	62

Table 2

Intercorrelations table for all participants controlling for gender.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total LPP																			
1. Pleasant	--																		
2. Neutral	.25																		
3. Unpleas.	.69***	.47**																	
Early LPP																			
4. Pleasant	.87***	.11	.61***																
5. Neutral	.24	.93***	.45**	.16															
6. Unpleas.	.60***	.35**	.91***	.59***	.36*														
Mid LPP																			
7. Pleasant	.98***	.25	.68***	.83***	.22	.60***													
8. Neutral	.20	.98***	.40**	.03	.89***	.25	.20												
9. Unpleas.	.63***	.47**	.98***	.54***	.44**	.88***	.63***	.40**											
Late LPP																			
10. Pleasant	.96***	.30	.65***	.71***	.26	.54***	.93***	.26	.60***										
11. Neutral	.29	.97***	.51***	.14	.84***	.40**	.30*	.93***	.51***	.32*									
12. Unpleas.	.72***	.49***	.96***	.62***	.46**	.78***	.70***	.44**	.90***	.70***	.51***								
Symptoms																			
13. Int.	-.01	.14	.07	-.08	.18	-.02	-.01	.18	.09	.03	.06	.09							
14. Anxiety	.09	.13	.08	.06	.08	.11	.12	.08	.07	.06	.20	.06	.19						
15. Dep.	-.01	.20	.15	-.10	.16	.20	.01	.19	.12	.02	.22	.13	.36*	.66***					
16. Somat.	-.12	.33*	-.01	-.08	.32*	.03	-.12	.26	-.03	-.12	.37*	-.03	.34*	.61***	.57***				
17. Hyper.	-.20	-.35*	-.06	-.18	-.28	-.06	-.19	-.37*	-.06	-.19	-.33*	-.06	.23	.41**	.21	.14			
18.Adaptive	.06	-.11	-.14	.02	-.11	-.23	.03	-.12	-.12	.10	-.10	-.09	-.27	-.41**	-.53***	-.14	-.20		
19.Overall	-.07	-.05	.10	-.08	-.01	.09	-.09	-.08	.07	-.04	-.06	.12	.23	.62***	.66***	.41**	.62***	-.40**	--

*** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$

Table 3

Intercorrelations table for child participants controlling for gender.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total LPP																			
1. Pleasant	--																		
2. Neutral	.04																		
3. Unpleas.	.68***	.40																	
Early LPP																			
4. Pleasant	.80***	-.14	.53**																
5. Neutral	.01	.92***	.38	-.09															
6. Unpleas.	.55**	.23	.90***	.51*	.23														
Mid LPP																			
7. Pleasant	.98***	.07	.67***	.76***	.03	.56**													
8. Neutral	-.03	.98***	.31	-.24	.88***	.11	.00												
9. Unpleas.	.60**	.42	.98***	.44*	.39	.88***	.60**	.33											
Late LPP																			
10. Pleasant	.94***	.11	.63**	.58**	.06	.47*	.90***	.07	.57**										
11. Neutral	.12	.97***	.45*	-.08	.82***	.31	.16	.92***	.47*	.16									
12. Unpleas.	.73***	.43*	.95***	.57**	.40	.74***	.71***	.38	.89***	.70***	.46*								
Symptoms																			
13. Int.	.07	.14	.06	-.06	.22	-.08	.05	.19	.13	.15	.02	.08							
14. Anxiety	.12	.12	.11	.07	.03	.11	.16	.03	.14	.09	.25	.08	-.31						
15. Dep.	-.04	.14	.14	-.26	.06	.18	.01	.11	.13	.04	.19	.12	-.34	.67***					
16. Somat.	-.10	.38	-.04	-.09	.36	-.06	-.08	.27	-.01	-.10	.46*	-.06	-.13	.68***	.32				
17. Hyper.	.00	-.29	.13	-.01	-.16	.19	-.04	-.34	.16	.04	-.29	.05	-.07	.41	.43*	.07			
18.Adaptive	.25	-.09	-.18	.15	-.08	-.27	.19	-.08	-.17	.31	-.09	-.12	.17	-.16	-.28	.15	-.33		
19.Overall	.02	-.10	.13	-.01	-.02	.12	-.03	-.13	.11	.07	-.10	.14	-.25	.54**	.53*	.15	.84***	-.39	--

*** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$

Table 4

Intercorrelations table for young adult participants controlling for gender.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Total LPP																			
1. Pleasant	--																		
2. Neutral	.71***																		
3. Unpleas.	.77***	.70***																	
Early LPP																			
4. Pleasant	.96***	.71***	.83***																
5. Neutral	.70***	.97***	.70***	.74***															
6. Unpleas.	.71***	.70***	.97***	.81***	.74***														
Mid LPP																			
7. Pleasant	.99***	.66**	.73***	.93***	.66**	.67**													
8. Neutral	.68***	.99***	.65**	.66**	.96***	.65**	.64**												
9. Unpleas.	.75***	.66**	.99***	.81***	.66**	.96***	.70***	.61**											
Late LPP																			
10. Pleasant	.99***	.72***	.75***	.92***	.69***	.67**	.98***	.69***	.72***										
11. Neutral	.72***	.98***	.71***	.70***	.91***	.68***	.67**	.97***	.68***	.74***									
12. Unpleas.	.79***	.69***	.98***	.81***	.67**	.90***	.74***	.64**	.94***	.78***	.72***								
Symptoms																			
13. Int.	.13	.28	.19	.14	.29	.23	.15	.32	.14	.10	.24	.20							
14. Anxiety	.06	.16	.10	.07	.17	.15	.10	.20	.05	.03	.12	.12	.89***						
15. Dep.	.20	.42	.32	.21	.42	.37	.20	.45	.29	.18	.38	.29	.88***	.71***					
16. Somat.	.17	.53*	.29	.25	.55*	.36	.16	.55*	.26	.14	.48*	.27	.74***	.62**	.68***				
17. Hyper.	-.25	-.44	-.26	-.21	-.43	-.30	-.21	-.44	-.30	-.29	-.43	-.18	.38	.50*	.04	.09			
18.Adaptive	-.17	-.17	-.17	-.15	-.17	-.24	-.20	-.21	-.14	-.15	-.12	-.14	-.68***	-.63**	-.66**	-.28	-.15		
19.Overall	.06	.20	.17	.06	.19	.19	.08	.22	.13	.04	.17	.20	.94***	.86***	.87***	.69***	.40	-.49*	--

*** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$

Table 5

Partial correlations (controlling for gender) between total LPP at site Pz and clinical symptomology for all participants combined.

	Pleasant	Neutral	Unpleasant	Unpleasant by Category			
				Anger	Fear	Sadness	Disgust
Internalizing	-.01	.10	.07	.12	.20	-.10	.01
Anxiety	.07	.13	.06	.13	-.02	.07	-.03
Depression	-.01	.19	.16	.23	.10	.03	.06
Somatization	-.10	**.30***	.03	.06	.07	-.03	-.01
Hyperactivity	-.20	**-.35***	-.02	.02	-.07	-.11	.08
Adaptive	.08	-.10	-.14	-.19	-.05	-.12	-.01
Overall	-.06	-.06	.14	.18	.01	.06	.09

** $p < .01$.

* $p < .05$.

Table 6.
Partial correlations (controlling for gender) between early, mid, and late LPP at site Pz and clinical symptomology for all participants combined.

6a. Early LPP

	Pleasant	Neutral	Unpleasant Combined	Unpleasant			
				Anger	Fear	Sadness	Disgust
Internalizing	-.08	.17	.03	.15	.21	-.07	-.16
Anxiety	.03	.08	.09	.15	.06	.00	.00
Depression	-.10	.16	.20	**.29***	.22	.01	.01
Somatization	-.05	**.32***	.07	.14	.10	-.06	-.02
Hyperactivity	-.17	-.28	-.02	.09	.02	-.14	-.02
Adaptive	.07	-.10	-.24	-.21	-.12	-.11	-.08
Overall	-.06	-.01	.12	.26	.09	.01	-.06

** p < .01, * p < .05.

6b. Mid LPP

	Pleasant	Neutral	Unpleasant Combined	Unpleasant			
				Anger	Fear	Sadness	Disgust
Internalizing	-.02	.14	.09	.16	.23	-.11	.01
Anxiety	.10	.08	.05	.13	-.01	.08	-.05
Depression	.01	.18	.14	.22	.07	.05	.04
Somatization	-.11	.23	.02	.05	.06	.00	-.04
Hyperactivity	-.20	**-.37***	-.02	.03	-.10	-.07	.07
Adaptive	.05	-.11	-.12	-.20	-.04	-.14	.05
Overall	-.09	-.08	.12	.17	.00	.08	.03

** p < .01, * p < .05.

6c. Late LPP

	Pleasant	Neutral	Unpleasant Combined	Unpleasant			
				Anger	Fear	Sadness	Disgust
Internalizing	.03	.02	.07	.04	.13	-.10	.09
Anxiety	.05	.20	.04	.11	-.06	.09	-.03
Depression	.02	.20	.15	.17	.05	.03	.11
Somatization	-.11	**.34***	.02	.00	.05	-.03	.02
Hyperactivity	-.20	**-.33***	-.01	-.04	-.08	-.12	.14
Adaptive	.11	-.09	-.09	-.14	.03	-.10	-.01
Overall	-.04	-.06	.16	.11	-.03	.06	.21

** $p < .01$, * $p < .05$.

Table 7

Partial correlations (controlling for gender) between total LPP at site Pz and clinical symptomology when examining children and young adults separately.

	Children							Young Adults						
	Pleasant	Neutral	Unpleasant	Unpleasant				Pleasant	Neutral	Unpleasant	Unpleasant			
				Anger	Fear	Sadness	Disgust				Anger	Fear	Sadness	Disgust
Internalizing	.04	.10	.03	.15	.09	-.20	.05	.13	.26	.19	.24	.44	.11	-.08
Anxiety	.08	.12	.08	.16	-.08	.17	-.05	.06	.16	.10	.14	.31	-.01	-.06
Depression	-.06	.12	.16	.28	.02	.03	.07	.20	.40	.32	.41	.34	.23	.05
Somatization	-.08	.36	.02	.20	-.01	-.01	-.01	.17	**.53***	.29	.33	**.46***	.37	-.09
Hyperactivity	-.04	-.28	.18	.27	-.10	.02	.19	-.25	-.44	-.26	-.24	-.14	-.41	-.05
Adaptive	.30	-.07	-.18	-.22	.01	-.25	.01	-.17	-.17	-.17	-.25	-.25	-.07	.00
Overall	.01	-.10	.18	.27	-.07	.11	.11	.06	.20	.17	.20	.31	.05	.02

** $p < .01$, * $p < .05$.

Table 8

Partial correlations (controlling for gender) between LPP amplitude at site Pz during the early, mid, and late windows and clinical symptomology when examining children and young adults separately.

8a. Early LPP

	Children							Young Adults						
	Pleasant	Neutral	Unpleasant	Unpleasant				Pleasant	Neutral	Unpleasant	Unpleasant			
				Anger	Fear	Sadness	Disgust				Anger	Fear	Sadness	Disgust
Internalizing	-.09	.21	-.02	.19	.07	-.18	-.12	.14	.29	.23	.29	**.51***	.17	-.15
Anxiety	.01	.03	.07	.16	-.02	.04	-.04	.07	.17	.15	.13	.37	.08	-.06
Depression	-.26	.07	.19	.37	.12	-.05	.00	.21	.44	.37	**.46***	**.48***	.29	-.04
Somatization	-.06	.36	.01	.17	-.09	-.08	-.02	.25	**.55***	.36	.38	**.52***	.42	-.12
Hyperactivity	-.06	-.16	.21	.36	.06	.00	.05	-.21	-.43	-.30	-.25	-.20	-.43	-.04
Adaptive	.22	-.08	-.29	-.24	-.16	-.18	-.12	-.15	-.17	-.24	-.25	-.36	-.18	.02
Overall	-.01	-.03	.14	.34	-.01	.06	-.06	.06	.19	.19	.24	.36	.07	-.05

** p < .01, * p < .05.

8b. Mid LPP

	Children							Young Adults						
	Pleasant	Neutral	Unpleasant	Unpleasant				Pleasant	Neutral	Unpleasant	Unpleasant			
				Anger	Fear	Sadness	Disgust				Anger	Fear	Sadness	Disgust
Internalizing	.03	.15	.08	.19	.14	-.23	.12	.15	.32	.14	.25	.41	.11	-.20
Anxiety	.13	.04	.11	.17	-.06	.12	-.03	.10	.20	.05	.16	.29	-.03	-.16
Depression	.00	.10	.16	.26	-.03	.04	.10	.20	.45	.29	.43	.32	.23	-.03
Somatization	-.07	.24	.06	.12	-.02	.00	.03	.16	**.55***	.26	.34	.43	.38	-.18
Hyperactivity	-.07	-.33	.20	.30	-.14	-.06	.20	-.21	-.44	-.30	-.26	-.16	-.41	-.10
Adaptive	.23	-.07	-.18	-.24	.01	-.29	.07	-.20	-.21	-.14	-.28	-.23	-.04	.05
Overall	-.03	-.13	.17	.26	-.08	.12	.08	.08	.21	.13	.21	.29	.06	-.09

** p < .01, * p < .05.

8c. Late LPP

	Children							Young Adults						
	Pleasant	Neutral	Unpleasant	Unpleasant				Pleasant	Neutral	Unpleasant	Unpleasant			
				Anger	Fear	Sadness	Disgust				Anger	Fear	Sadness	Disgust
Internalizing	.13	-.02	.01	.06	.04	-.17	.08	.10	.24	.20	.19	.39	.05	.08
Anxiety	.07	.22	.05	.12	-.11	.21	-.06	.03	.12	.12	.11	.28	-.05	.05
Depression	.03	.17	.14	.19	.01	.06	.06	.18	.38	.29	.33	.25	.17	.18
Somatization	-.09	**.42***	.00	.00	.04	.02	-.04	.14	**.48***	.27	.26	.41	.30	.02
Hyperactivity	.02	-.27	.11	.14	-.13	-.01	.20	-.29	-.43	-.18	-.20	-.07	-.39	.00
Adaptive	.34	-.07	-.10	-.15	.08	-.23	.02	-.15	-.13	-.14	-.21	-.19	-.01	-.06
Overall	.06	-.10	.20	.19	-.08	.13	.20	.04	.17	.20	.15	.28	.02	.16

** $p < .01$, * $p < .05$.

Figure 1
Mean Total LPP Amplitude at Site Pz by Emotion Category for Males

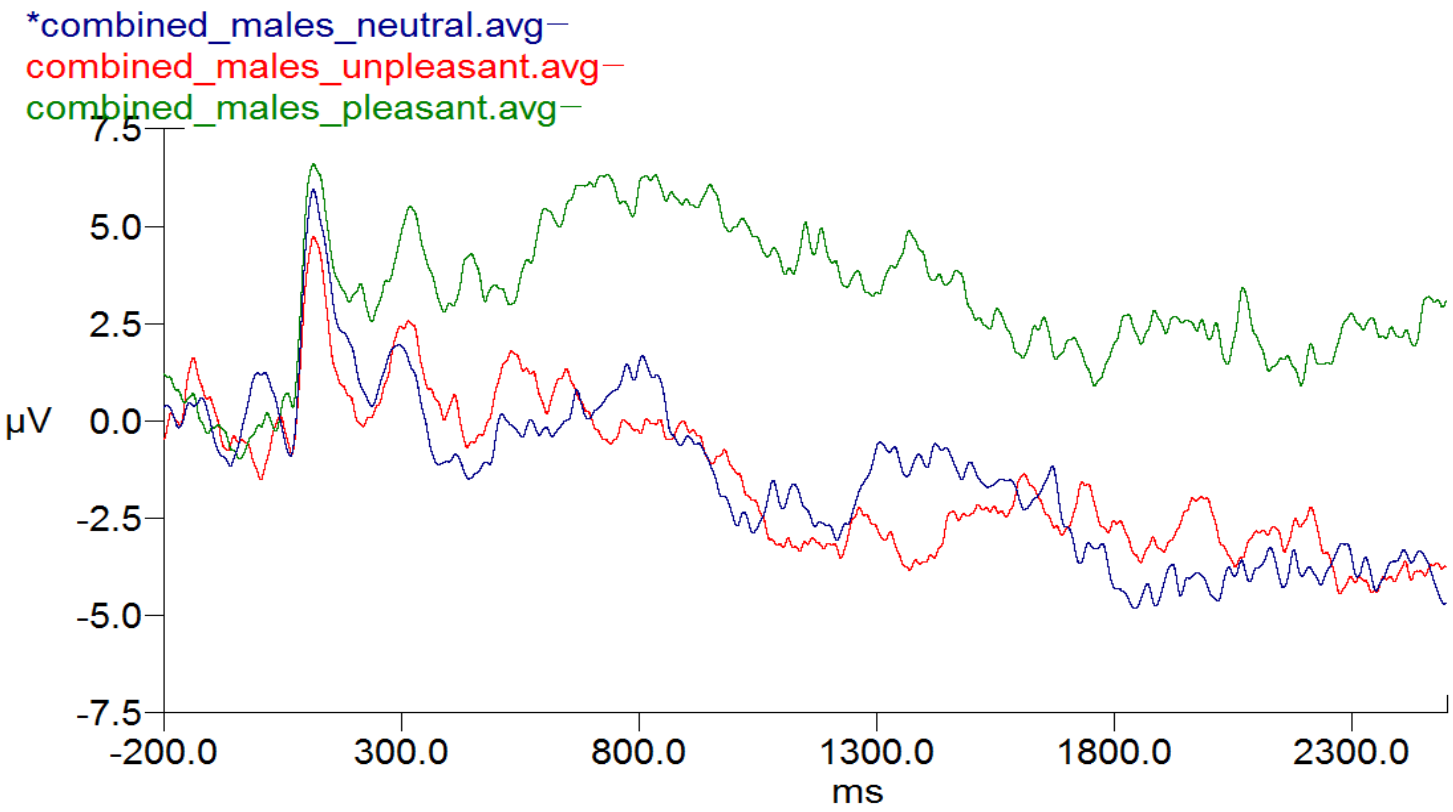


Figure 2
Mean Total LPP Amplitude at Site Pz by Emotion Category for Females

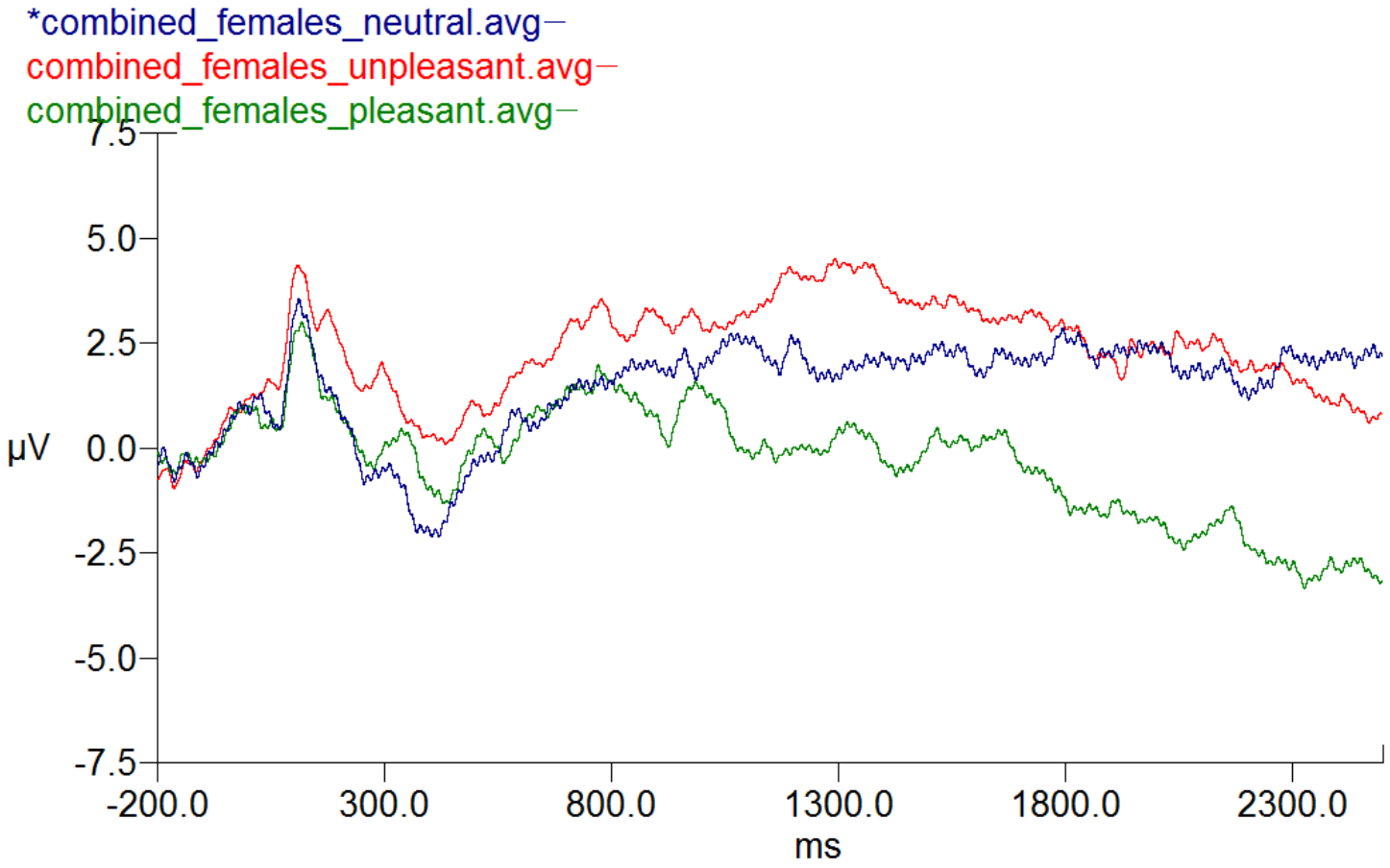


Figure 3
Mean Total LPP Amplitude to Pleasant Images at Site Pz by Gender

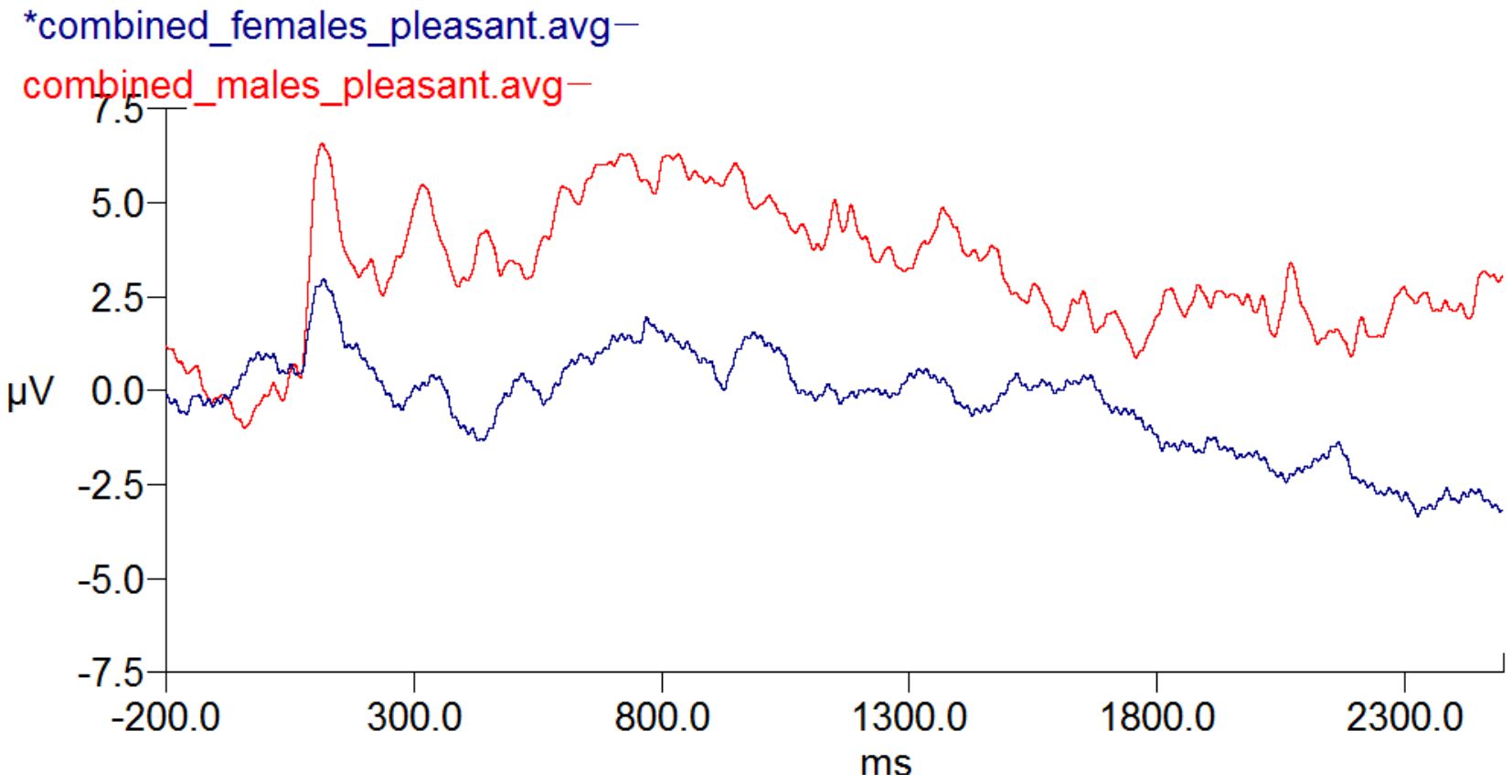


Figure 4
Mean Total LPP Amplitude to Neutral Images at Site Pz by Gender

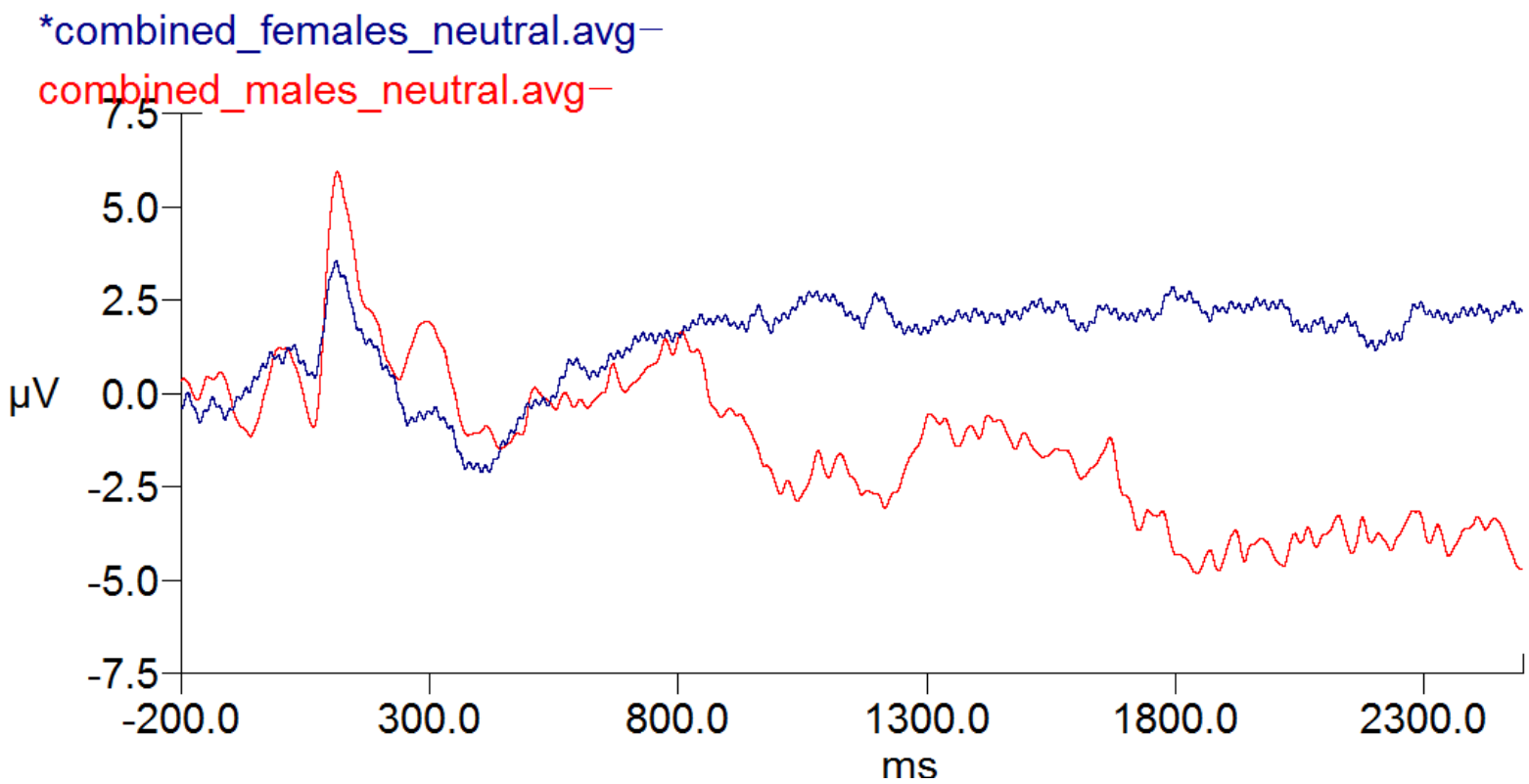
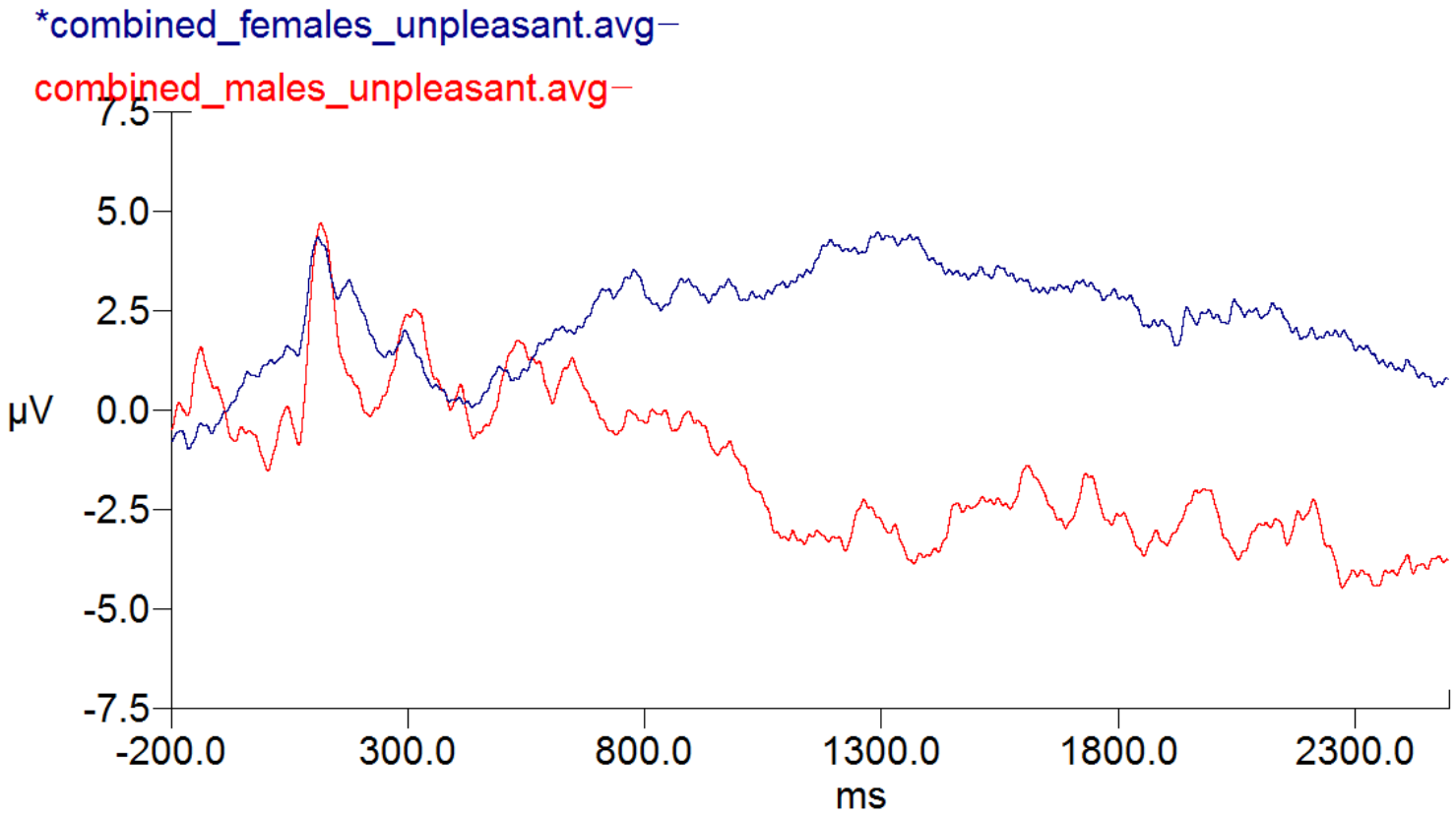


Figure 5
Mean Total LPP Amplitude to Unpleasant Images at Site Pz by Gender



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