Cortical Associates Of Emotional Reactivity And Regulation In Children Who Stutter

By

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To my wonderful husband, Erdem, for his endless love, patience, and support

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CHAPTER I

INTRODUCTION

Over the past several years, researchers have studied the association between emotions and childhood stuttering, with findings suggesting that emotions play a role in early childhood stuttering (e.g., Anderson, Pellowski, Conture, & Kelly, 2003; Arnold, Conture, Key, & Walden, 2011; Eggers, De Nil, & Van den Bergh, 2009, 2010; Embrechts, Ebben, Franke & van de Poel, 2000; Felsenfeld, van Beijsterveldt & Boomsma, 2010; Johnson, Walden, Conture, & Karrass, 2010). Attempting to account for these findings, Conture and Walden (2012) proposed the Dual Diathesis Stressor (DD-S) model that focuses on the relation between childhood stuttering and emotional reactivity, that is, "the ease by which emotions are aroused, which can involve reactions to novel stimuli, and/or orienting to internal or external stimulation" (Rothbart, 2011) as well as emotional regulation, that is, "the processes by which we influence which emotions we have, when we have them, and how we experience and express them" (Gross, 1998). Briefly described, the DD-S model suggests that variable emotional stressors (i.e., challenges) may activate CWS's relatively stable emotional or temperamental diathesis (i.e., vulnerability). Activation of such a diathesis, the model suggests, is associated with disruptions in fluent speech-language planning and/or production.

Although neither this model nor related findings prove that emotion is the main, primary or sole "cause" of childhood stuttering, both the model and associated empirical findings suggest that any comprehensive account of childhood stuttering should include consideration of emotional processes. Subsequent to the publication of the DD-S model, several other empirical studies have tested various of its tenets, with both pre-DD-S and post-DD-S studies employing differing methodologies, namely (a) caregiver reports, (b) coded behavioral observations, and (c) psychophysiology measures. Organized around these various (a-c) methodologies, below is a brief review of essential findings regarding the association of emotion and childhood stuttering.

First, evidence from *caregiver reports* has suggested that children who stutter (CWS), relative to children who do not stutter (CWNS) display (a) lower inhibitory control, and higher anger/frustration (Eggers et al., 2010), (b) greater emotional reactivity and greater difficulty in emotion regulation (e.g., Karrass, Walden, Conture, Graham, Arnold, Hartfield & Schwenk, 2006), (c) greater difficulty in flexibly controlling and shifting attention when necessary (Eggers et al, 2010; Felsenfeld et al., 2010; Karrass et al., 2006), and (d) less adaptability to change (Anderson et al., 2003). Overall, results from these five empirical studies employing parental reports to normed questionnaires suggest that CWS differ from their CWNS peers in emotion reactivity and emotion regulation processes.

In contrast, Kefalianos, Onslow, Ukoumunne, Block, and Reilly (2014), in a study of the temperament of a large cohort of CWS and CWNS at 2, 3, and 4 years of age replicated Anderson et al.'s (2003) and Howell et al.'s (Howell, Davis, Patel, Cuniffe, Downing-Wilson et al. 2004) findings of no significant talker-group differences in approach/withdrawal scores. Likewise, it has also been reported that young CWS, when compared to CWNS, were less negative and more adaptable (Lewis & Goldberg, 1997) and more likely to exhibit the temperamental constellation of an "easy child" (Williams, 2006). Interestingly, however, as mentioned by Arnold et al. (2011), in the Williams's study "…a higher proportion of CWS, compared to CWNS, fit the temperamental constellation of "slow to warm up" (p. 277).

Second, empirical studies using *direct behavioral observations* in laboratory settings to study more variable/ state-like/ situational aspects of emotion and childhood stuttering reported that CWS, relative to their CWNS peers, exhibit (a) more negative emotional expressions during a disappointing gift procedure (Johnson et al., 2010), (b) difficulty flexibly shifting attention from a stimulus (Bush, 2006); (c) more negative emotion and self-speech during an emotionally frustrating task (Ntourou, Conture, Walden, 2013), and (d) less ability to habituate to task-irrelevant environmental stimuli (Schwenk, Conture, & Walden, 2007).

In more recent empirical studies, besides those that reported between-group (CWS vs. CWNS) differences in emotional reactivity to situational stressors, researchers have also studied the association between CWS's emotions and their frequency of stuttering. Findings from these studies indicated that young CWS (a) exhibited greater emotionally reactive behaviors prior to and during stuttered versus fluent utterances (Jones, Conture, & Walden, 2014b), (b) increased stuttering frequency in association with decreased duration and frequency of behavioral regulatory strategies (Arnold et al., 2011), and that greater emotional reactivity is accompanied by lesser emotion regulation (Walden, Frankel, Buhr, Johnson, Conture, Karrass, 2012). Likewise, Choi, Conture, Walden, Lambert and Tumanova (2013) studied young CWS and CWNS relative to behavioral inhibition (BI, a temperamental characteristic of exhibiting initial avoidance and distress in unfamiliar places, situations or the presence of unfamiliar people [Kagan et al., 1984 in Choi et al., 2013]) and reported that when compared to their CWNS peers, more CWS exhibited higher BI and fewer exhibited lower BI. Overall, evidence from direct behavioral observations indicates that CWS differ from their CWNS peers in the manifestation of their emotion regulation and reactivity processes and that CWS's increased stuttering is associated with decreased emotion regulation.

Third, more recently various *psychophysiology* methods were employed to study the association between emotional processes and childhood stuttering. An advantage of the use of psychophysiological methods is that it enables researchers to study psychological processes of interest that are not completely available to the experimenters' direct behavioral observation or caregivers' recollection. Therefore, psychophysiology is thought to augment and/or complement parental reports and behavioral observations of the emotional processes of CWS and CWNS. To date, there has been relatively limited number of reports from psychophysiology studies of emotions and young CWS.

With that caveat in mind, extant psychophysiological findings indicate that CWS, relative to CWNS, exhibit (1) no significant between group differences in EEG frontal asymmetries (Arnold et al, 2011[1]); (2) less baseline vagal (parasympathetic) activity indicating less emotion regulation, as well as greater sympathetic and parasympathetic activity (i.e., co-activation of the two, associated with counter-adaptive responses in challenging situations (Porges, 2011) during speaking (Jones, Buhr, Conture, Tumanova, Walden, & Porges, 2014a); (3) significantly lower (Ortega & Ambrose, 2011) or no significant differences in salivary cortisol (van der Merwe, Robb, Lewis & Osmond, 2011), (4) significantly higher emotional arousal (as indexed by tonic skin conductance

[1] It is important to note that although the Arnold et al's (2011) empirical study of cortical associates of emotion in CWS reported no significant between group differences in these associates, there are significant differences in methodology between the current study and Arnold et al. (2011) study.

level) in 3-year-old CWS and significantly lower emotional arousal in 4-year-old CWS (Zengin-Bolatkale, Conture, Walden, 2015), and (5) significantly higher emotional reactivity (as indexed by mean tonic skin conductance level) during narratives following the negative and positive, compared to baseline, emotional stress conditions in preschool-age CWS (Choi, Conture, Walden, Jones, & Kim, 2016). Overall, results from psychophysiological studies appear to suggest that CWS and CWNS differ on some measures of emotional reactivity and emotion regulation processes.

It should be noted that some of the above measures of psychophysiology of young CWS and CWNS assess either autonomic nervous system (ANS) responses or hypothalamic-pituitary-adrenal (HPA) hormonal secretions. Clearly, these psychophysiological studies have made significant contributions to our understanding of the association between emotion and childhood stuttering, especially in relation to less accessible, covert or physiological associates of emotion. Such measures of ANS (e.g., skin conductance level) and HPA (e.g., salivary cortisol) activity record events on the order of seconds or minutes. However, some of the key emotion reactivity and regulation processes, particularly those involving central or cortical processes, occur in the order of milliseconds, events too rapid to be easily detected by the ANS and HPA methodology used in most psychophysiology studies of childhood stuttering reported to date.

In contrast to the more peripheral measures of emotion, scalp-recorded event related potentials (ERPs) have excellent temporal resolution in the order of milliseconds. Such rapid temporal resolution enables the researcher to capture very quick changes in cognitive events related to emotional reactivity and emotion regulation. It is important to note that this is not to suggest that ANS/HPA recordings provide non-relevant insights into emotional processes associated with stuttering. Rather, it is to suggest that ERPs—more central measures of rapidly occurring events associated with stuttering—complement and augment what we are learning about the emotional associates of stuttering from empirical studies using psychophysiology, direct behavioral observations and caregiver reports. To further such augmentation, there would appear to be a need for empirical studies employing cortical assessment (i.e., ERPs) of emotional activity of young CWS. Results of this approach, together with the findings from other methodologies mentioned above, should provide us with converging lines of evidence that should aid in the development of a more comprehensive understanding of the association between emotion and childhood stuttering.

One ERP that appears particularly well suited for examining emotional processes is the late positive-potential (LPP). The LPP emerges approximately 300 ms following stimulus onset, with its amplitude larger following the presentation of both pleasant and unpleasant compared to neutral stimuli (e.g., Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Foti & Hajcak, 2008; Hajcak, Nieuwenhuis, 2006; Hajcak & Olvet, 2008; Schupp, Cuthbert, Bradley, Cacioppo, Ito, & Lang, 2000). Findings from previous research indicate that LPP is sensitive to emotional stimuli in both adults and children. Likewise, as observed with adults, LPP amplitudes were larger to pleasant and unpleasant relative to neutral stimuli in 5 to 10 year-old children (Hajcak & Dennis, 2009). Furthermore, besides its use in the study of emotion reactivity, LPP amplitude also has been used to study children's emotion regulation (e.g., Babkirk, Rios, Dennis, 2015; DeCicco, Solomon, Dennis, 2012; Dennis & Hajcak, 2009). This is salient to the study of emotion and childhood stuttering because not only is childhood stuttering been shown to be associated with emotional reactivity (e.g., Choi et al., 2016; Zengin-Bolatkale et al., 2015), it is also been reported to be associated with emotion regulation (e.g., Walden et al., 2012).

Indeed, current theories of child temperament and emotional regulation emphasize the inter-related but different roles of reactivity and regulation (Derryberry & Rothbart, 1997; Posner & Rothbart, 2000). Furthermore, different emotion regulation strategies are believed to influence the strength of emotional reactivity (Campos, Frankel, Camras, 2004; Gross, 2002). Therefore, it is important, when possible, to measure both emotion reactivity and regulation when studying children's emotions and/or temperament. One such emotion regulation strategy is cognitive reappraisal, which is achieved by changing the emotional interpretation of a stimulus or event (Foti & Hajcak, 2008; Gross & John, 2003; Ochsner & Gross, 2005). Late positive potential amplitudes have been shown to be sensitive to emotion regulation strategies such as directed reappraisal in children and adults (e.g., Babkirk et al., 2015; Dennis & Hajcak, 2009; Foti & Hajcak, 2008; MacNamara, Ochsner, & Hajcak, 2011). Specifically, it has been reported that LPP amplitudes are reduced following the use of an emotion regulation strategy (e.g., directed reappraisal of an unpleasant stimuli in a more positive light). Overall, therefore, LPP is a highly replicable and stable measure that varies with emotional reactivity as well as emotion regulation.

Thus, the general purpose of the present investigation was to empirically study the emotional reactivity and regulation of young children who do and do not stutter. Specifically the present writer studied young CWS and CWNS's emotional reactivity and emotional regulation by means of two different indices: (1) their LPP amplitude (a cortical event that occurs in a brief timeframe [i.e., milliseconds]) while viewing pleasant, unpleasant, neutral pictures and listening to short reappraisal stories for the unpleasant pictures and (2) their parents' responses to the Children's Behavior Questionnaire (CBQ) (Rothbart, Ahadi, Hershey, Fisher, 2001).

The 4 to 6- year-old CWS and CWNS participants' LPP amplitudes were obtained as they viewed a standardized set of colored pleasant, unpleasant and neutral pictures from the International Affective Picture System (IAPS; Lang, Bradley, Cuthbert, 2005), involving two different conditions. This initial condition of viewing pleasant, unpleasant and neutral pictures was used to examine emotional reactivity. This initial condition was followed by a second condition in which participants experienced directed reappraisal, which is defined as an antecedent-focused, cognitive-linguistic strategy for regulating emotions by reformulating the meaning of a situation (e.g., Goldin, McRae, Ramel, & Gross, 2008). In the present study, directed reappraisal was accomplished by having each participant listen to brief pleasant and neutral stories associated with the unpleasant pictures prior to viewing them for the second time.

Specifically, four primary theoretical/ empirical issues were addressed (See *Table 1*). The first issue investigated whether the cortical associates of emotional reactivity of young CWS differs from that of their CWNS peers when viewing *pleasant* pictures. It was hypothesized that CWS, when compared to CWNS, would exhibit greater amplitude of the late positive potential (LPP, an evoked response potential (ERP) sensitive to emotional stimuli) during viewing of pleasant pictures. The second issue addressed whether cortical associates of emotional reactivity (as indexed by LPP amplitude) of young CWS differs from that of their CWNS peers when viewing *unpleasant* pictures. It was hypothesized that relative to their CWNS peers, young CWS would exhibit higher LPP amplitudes (i.e., greater emotional reactivity) to the unpleasant pictures. The third issue addressed whether the cortical associates of CWS's emotional regulation, would differ from that of their CWNS peers would during viewing of unpleasant pictures that followed directed reappraisal instructions (e.g. "Next is a picture of a snake that is completely harmless. It doesn't even have teeth."). It was hypothesized that CWS, when compared to CWNS, would show less reduction in the LPP amplitudes during directed reappraisal that would occur during the viewing of the unpleasant stimuli (i.e., less reduction in emotional reactivity). The fourth and final issue addressed whether cortical measures of emotion reactivity and emotional regulation were associated with caregiver report measures of emotional reactivity and emotional regulation. It was hypothesized that for both CWS and CWNS, caregiver reports of emotional reactivity (i.e., Surgency and Negative Affect) and emotion regulation (i.e., Effortful Control) would be correlated with participants' cortical indices of emotional reactivity and regulation.

Table 1
The current study's four research issues, hypotheses, dependent and independent variables and associated analytical methods.

First research issue: *Determine whether emotional reactivity of CWS differs from that of their CWNS peers when viewing pleasant pictures.*	
First research hypothesis: CWS would exhibit greater mean amplitudes of late positive potential (LPP) than CWNS when viewing pleasant pictures.	
Independent variable	CWS vs. CWNS
Dependent variable	LPP amplitude during viewing of pleasant pictures
Analytical method: Mixed models ANOVA	
Second research issue: *Determine whether CWS, compared to their CWNS peers, exhibit greater emotional reactivity when viewing unpleasant pictures. .*	
Second research hypothesis: CWS would show greater mean amplitudes of late positive potential (LPP) than CWNS when viewing unpleasant pictures.	
Independent variable	CWS vs. CWNS
Dependent variable	LPP amplitude during viewing of unpleasant pictures
Analytical Method: Mixed models ANOVA	
Third research issue: *Determine whether CWS, compared to their CWNS peers, make less efficient use of directed reappraisal for emotion regulation.*	
Third research hypothesis: Young CWS would show less reduction in the LPP amplitudes during the reappraisal epochs of the unpleasant stimuli than their CWNS peers.	
Independent variable	CWS vs. CWNS
Dependent variable	LPP amplitude during pleasant and neutral reappraisal trials
Analytical method: Mixed models ANOVA	
Fourth research issue: *Determine whether cortical measures of emotional reactivity and emotion regulation processes are associated with caregivers' reports of the same emotional processes.*	
Fourth research hypothesis: Caregiver reports of emotion reactivity and regulation would be correlated with the cortical indices of emotional reactivity and regulation of both CWS and CWNS.	
Independent variable	Scores on CBQ scales (i.e., Negative Affectivity, Surgency, and Effortful Control)
Dependent variable	Mean LPP amplitudes during picture viewing (unpleasant and pleasant) and reappraisal conditions
Analytical Method: Linear Regression	

CHAPTER II

METHOD

Participants

Seventeen children who stutter (CWS, 3 females) and 19 children who do not stutter (CWNS, 5 females) served as participants in the final data corpus for this study. Children were between 4 years 0 months and 6 years and 11 months of age. CWS's chronological age (M=63.12, SD=8.76) did not significantly differ from that of CWNS (M=67.53 SD=10.67) $t(34)$= 1.34, p=.187.

Initially, 20 CWS (5 females), and 27 CWNS (9 females) participated in this study. Data from 1 CWS and 2 CWNS (1 female) were excluded due to excessive movement related artifacts in the EEG data. One female CWS and 5 CWNS (1 female) did not want to participate in the ERP tasks, and 1 female CWS and 1 female CWNS failed to reach eligibility criteria (described below) for speech and language testing. Two of the CWS who participated in the emotional reactivity task did not want to do the emotion regulation task. Therefore, results of the emotion regulation task were based on data from 15 CWS (3 females). Lastly, due to non-compliance, and incomplete responding, CBQ data were unavailable for 4 CWS and 3 CWNS, resulting in available data from 13 CWS and 16 CWNS for assessment of Hypothesis 4.

Participants were paid volunteers who either participated in a previous study in our lab, or whose parents learned of the study from advertisements in Vanderbilt University news boards, flyers, or in a free, local monthly parent magazine in Middle Tennessee, or were referred to the Vanderbilt Bill Wilkerson Hearing and Speech Center for an evaluation. The study's protocol was approved by Vanderbilt University's Institutional Review Board, and for all participants informed consent by parents and assent by children were obtained.

Figure 1 below depicts the entire experiment from talker group classification through experimental manipulation of emotion.

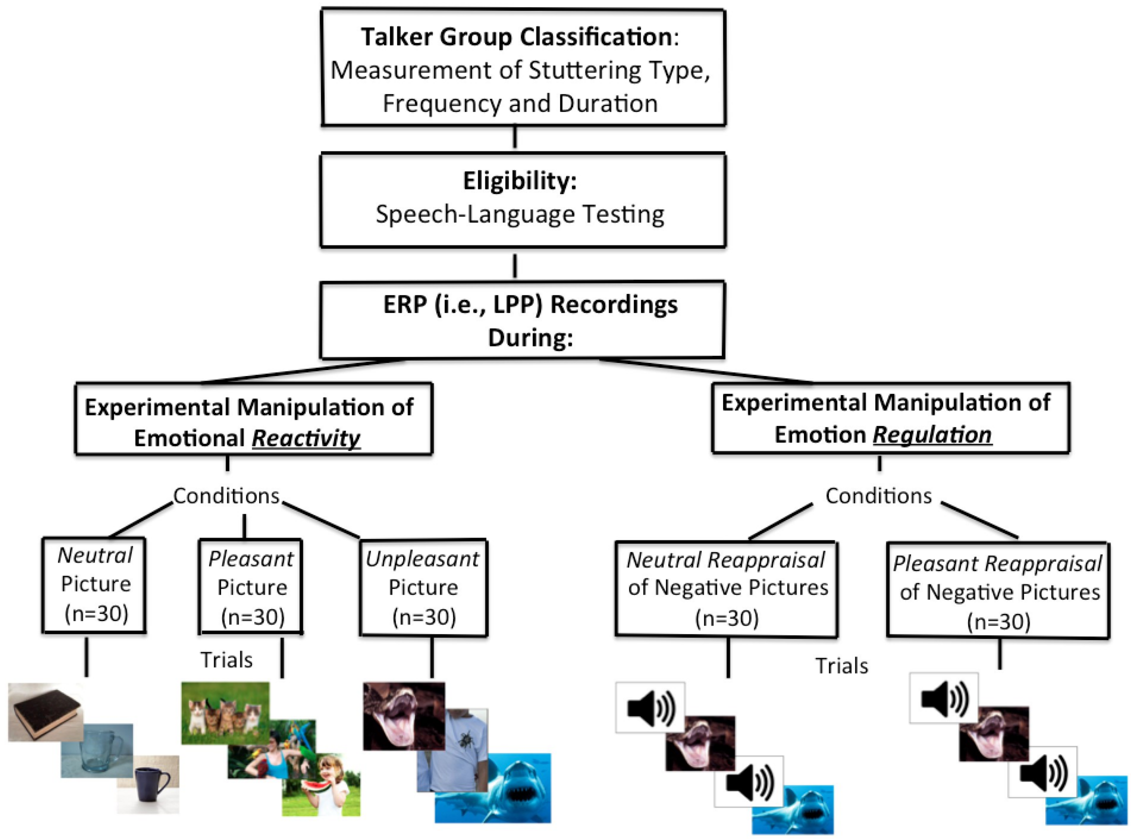

Figure 1. A diagram of the experimental procedures employed in the current study.

Classification and Inclusion Criteria

In order to reduce the possibility of confounds with clinically significant speech-language and hearing concerns, all participants' articulation, receptive and expressive language skills, as well as hearing abilities were assessed using standardized measures. Specifically, the "Sounds in Words" subtest of the Goldman-Fristoe Test of Articulation-

2 (GFTA-2; Goldman & Fristoe, 2000) was used to measure participants' speech sound articulation; the Peabody Picture Vocabulary Test-Third Edition (PPVT-IV; Dunn & Dunn, 2007) was used to assess receptive vocabulary; and the Test of Early Language Development-3 (TELD-3; Hresko, Reid, & Hamill, 1999) was used to measure receptive and expressive language abilities.

Children who scored below the 16th percentile (i.e., approximately one standard deviation below the mean) on any of these standardized speech or language tests were not included in the current study. In addition, bilateral pure tone hearing screenings were conducted to rule out hearing concerns. Participants were excluded if they did not perform within normal limits on this hearing-screening test (American Speech–Language–Hearing Association, 1990).

Participants were classified as CWS if they (a) exhibit three or more stuttered disfluencies (i.e., sound/syllable repetitions, sound prolongations, or monosyllabic whole-word repetitions) per 100 words of conversational speech (Conture, 2001; Yaruss, 1998), and (b) score 11 or greater (i.e., severity of at least "mild") on the Stuttering Severity Instrument-3 (SSI-3; Riley, 1994). Participants were classified as CWNS if they (a) exhibited two or fewer stuttered disfluencies (i.e., sound/syllable repetitions, sound prolongations, or monosyllabic whole-word repetitions) per 100 words of conversational speech, and (b) score 10 or lower on the SSI-3 (i.e., severity of less than "mild").

*Measurement Reliability for Stuttering***.** Approximately twenty percent of the final data corpus (i.e., 8 participants) were randomly selected and re-coded by a speech-language pathologist independent from the original coder. This independent speech-language pathologist's sample was used to determine inter-judge reliability for stuttering.

Intraclass correlation coefficient (ICC) for stuttered disfluencies was .96, with a 95% confidence interval of .87 – .98, indicating high agreement among coders.

Caregiver report of temperament

Each participant's caregivers were asked to complete the Children's Behavior Questionnaire (CBQ) to assess temperamental factors related to emotional reactivity and emotion regulation (Rothbart, Ahadi, Hershey, Fisher, 2001). According to Rothbart et al. (2001), temperament refers to the "constitutionally based, individual differences in reactivity and self-regulation," and is considered to be a part of an individual's "enduring biological make up" but is also considered to be influenced over time by "maturation, and experience" (p. 1395).

In the present study, the commonly employed (195-item, standard) version of the CBQ questionnaire was used to measure various facets of child temperament (with the CBQ involving 15 separate sub-scales, e.g., activity level, fear, inhibitory control, etc. that yield three broad factors, i.e., Surgency, Negative Affectivity, and Effortful Control). All items on this 195-item questionnaire use a 7-point Likert scale.

For the purposes of this study, the factor level domains of Surgency/ Extraversion, Negative affectivity, and Effortful Control factors were used for analysis. Surgency/Extraversion is also known as positive emotional reactivity and this factor is indexed by averaging the scores of the following four sub-scales: activity level, high intensity pleasure, impulsivity, and shyness. Negative Affectivity is also known as negative emotional reactivity and this factor is indexed by averaging the scores of the following five sub-scales: anger, discomfort, fear, sadness and soothability. Effortful

Control refers to self-regulation of attention, inhibitory control and behavioral inhibition and this factor is indexed by averaging the scores of the following four sub-scales: attention focusing, inhibitory control, low-intensity pleasure and perceptual sensitivity.

Stimulus materials

Stimulus materials were developmentally appropriate pictures from the International Affective Picture System (IAPS; Lang et al., 2005). The IAPS pictures have been widely used for studying emotional processing in children (e.g., Dennis & Hajcak, 2009; Hajcak & Dennis, 2009; Solomon, DeCicco, Dennis, 2012). Pictures used in the current study were identical to those employed by Hajcak and Dennis (2009) in their study of typically developing children (see Appendix A for a list of the IAPS pictures and reappraisal stories used in the present study). In addition, the positive reappraisal stories used in the present study were adapted from Dennis & Hajcak (2009). Recently, the same pictures used in the present study were successfully used to study emotional processing in children between the ages of 5 to 7 years by Solomon et al. (2012).

Pictures used in the present study consisted of 30 *pleasant* pictures depicting scenes or objects such as ice cream, Disneyworld, etc.; 30 *unpleasant* pictures depicting scenes or objects such as an accident, a snake, etc.; and 30 *neutral* pictures depicting scenes or objects such as household objects. All stimuli were presented using E-prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) on a PC computer and a 17” monitor, with the screen to participant eyes approximately 25” and pictures subtended the entire vertical and horizontal dimensions of the screen of the computer monitor.

As described by Hajcak and Dennis (2009), the 90 color pictures to used in the present study are those that children might see in their daily lives (e.g., on the television or in the television news). Norms for picture valence and arousal ratings have been determined for adult viewers (Lang et al., 2005). Unfortunately, norms for picture valence and arousal are not available for children due to children's lack of reliability in reporting such values (for further details see Dennis & Hajcak, 2009).

Valence ratings by adults. Valence ratings of the 90 IAPS pictures in this study were determined for *adult* viewers. Specifically, regarding normative adult ratings (Lang et al., 2005), the picture categories differ in terms of *valence* ratings (*M*= 7.45, *SD*= 0.58, for pleasant pictures; *M*= 5.29, *SD*= 0.74, for neutral pictures; and *M*= 3.36, *SD*= 0.73, for unpleasant pictures). In addition, based on adult ratings, the emotional pictures are reliably higher on normative *arousal* ratings (*M*= 4.76, *SD*= 0.75, for pleasant pictures; *M*= 5.70, SD= 0.69, for unpleasant picture content; and *M* =2.81, *SD*= 0.65, for neutral pictures).

Valence ratings by children in previous studies. While norms for picture valence and arousal are not available for young children the age of the participants in the present study, attempts have been made to acquire self-reported ratings of the IAPS pictures. In a previous study (Hajcak and Dennis, 2009), 5 to 8- year-old typically developing children self-rated the pictures used in the present study. Hajcak and Dennis (2009) reported that children's self-reported *valence* ratings of these pictures (*M* = 3.23 for pleasant pictures; *M*= 2.31 for neutral pictures; *M*= 1.08 for unpleasant pictures) were consistent with adult normative ratings while children's self-reported ratings of *arousal* and their electrophysiological results did not agree. Specifically, children self-rated pleasant (*M* =

2.61) pictures more arousing than neutral (*M*=1.48) pictures but not unpleasant (*M*=1.81) pictures and they did not find unpleasant pictures more arousing than neutral pictures. However, children's LPP to pleasant and unpleasant pictures were significantly higher than neutral pictures.

Valence ratings by children in the present study. In the present study, after the experimental testing, an abbreviated version of the Self Assessment Manikin scale (SAM, Bradley & Lang, 1994; Lang et al., 2005) was used for approximately 40 % (n = 15) of the participants (6 CWS and 9 CWNS) to rate randomly selected 5 neutral, 5 pleasant, and 5 unpleasant pictures for valence.

The valence scale of the abbreviated SAM depicts five characters who range from happy to unhappy, and below the scale are numbers '1' to '5' with '1' corresponding to the happiest figure and '5' corresponding to the least happy figure, and '3' located in between. Fifteen participants were asked to rate each of the randomly selected pictures on this scale based on *how happy or sad* it made them feel.

Results of the present study's 15 participants' valence ratings differed as a function of picture type: pleasant pictures (M=1.55; SD=.53) were rated as more pleasant than unpleasant (M=3.67; SD=.84), $t(14)$= 8.24, p<.0001) and neutral (M=2.47; SD=.62), $t(14)$= 4.89, p< .0001) pictures. Additionally, neutral pictures were rated as more pleasant than unpleasant pictures, $t(14)$=3.8, p< .003. Overall, as predicted, valence ratings increased from pleasant to neutral and from neutral to unpleasant pictures.

Procedure

Pre-task set-up

Each participant (child) and their caregiver(s) were provided a brief introduction to the laboratory and the task. Subsequently, children were seated in front of a 17" computer monitor, where they were given the option to watch cartoons as the electroencephalograph (EEG) electrodes are placed on their scalp (to record the study's main dependent variables (i.e., ERPs, this study's cortical index of emotion reactivity and regulation). In order to reduce anxiety and/or concerns children might have about the equipment, set-up, or the experiment, children were told that they were "astronauts getting signals from outer space."

ERP Task: Emotional reactivity

For the purposes of the present study, and as previously described, emotional reactivity was defined as the ease by which emotions are aroused to internal or external stimulation (Rothbart, 2011). To measure cortical indices of emotional reactivity, participants engaged in a passive picture-viewing task. To obtain this cortical measure during this task, and as described above, the experimenter placed an EEG cap on the participants' scalps. Once in place, the impedance levels of the sensors of the cap were checked while participants were asked to look at a fixation mark (+) on the monitor. Following this, children completed the experimental tasks (i.e., viewing of neutral, pleasant and unpleasant age-appropriate pictures).

For the experimental tasks, all 90 pictures were presented in a randomized fashion using E-Prime's computer-based randomization tool. Children were asked to passively view these pictures. Each of the 90 pictures were displayed only once throughout this task and were on the screen for 2500 ms, followed by a random inter-stimulus interval (ISI) between 700 and 1300 ms. Unlike previous studies involving a fixed ISI (e.g., 500 ms ISI used in Hajcak & Dennis, 2009), the ISI in the present study was not fixed. A non-fixed interval was used to avoid possible habituation to the picture presentation onset due to the predictability and/or, rhythmicity of a constant ISI, the latter thought to possibly engender participant boredom and/or lack of attention. On average, the emotional reactivity task took approximately 8 minutes to complete.

Once the experimenter initiated the task, all trials began automatically; however, the experimenter monitored each participant throughout each task for signs of inattention, uneasiness, excessive muscle tension or movement. Stimulus presentation was suspended if and when the experimenter noticed such signs, and stimulus presentation was resumed after children were redirected.

ERP Task: Emotion Regulation

As described above, for the purposes of this study emotional regulation was defined as the processes we use to influence which emotions we have, when we have them, and how we experience and express them (Gross, 1998). Following the first (emotional reactivity) task where participants passively viewed the 90 pictures, participants performed a second (emotional regulation) task involving directed reappraisal (e.g., DeCicco et al., 2012).

In this second (emotional regulation) task, the 30 unpleasant pictures previously viewed during the first (emotion reactivity) task were presented to each participant again, one at a time, following two different directed reappraisal stories (i.e., the 30 negative pictures were presented twice, once following a “neutral” and once following a “positive reappraisal story). First, the thirty negative pictures were presented with a neutral story prior to seeing the picture (e.g. “Now you are going to see a picture. It is in black and green”). Following that, the thirty pictures were presented a second time with a positive reappraisal story (e.g. “This is a picture of a harmless snake. It doesn’t even have teeth.”). The order of the type of story (i.e., neutral or positive) was random for all participants. There were 60 trials in this task (i.e., 30 unpleasant pictures viewed under neutral and positive reappraisal story conditions).

At the beginning of the reappraisal task, children were instructed, “For our next game, we are going to see some of the same pictures. Listen to the stories and think of the pictures so they match the stories. Remember to stay still and just look at the screen.” Children were reminded to not blink or move around much when viewing the pictures and listening to the stories. EEG was recorded continuously for the whole emotion regulation task. An audio recording of a neutral or positive interpretation (i.e., story) of the unpleasant pictures (with the same audio recording used for all children) was played for approximately 3-5 seconds while a cartoon image of an ear was presented on the blank screen. Participants heard each reappraisal story followed by a 500 or 700 ms delay prior to picture onset. The pictures associated with the stories were then presented for 2500 ms, with a 1200 or 1500 ms inter-trial interval between each stimulus and the next story. On average, the emotion regulation condition took approximately 10 minutes to complete.

ERP Recording (data collection)

The recording of event-related potentials (ERPs) was conducted using a high-density array of 128 Ag/AgCl electrodes embedded in soft sponges (Geodesic Sensor Net, EGI, Inc., Eugene, OR). Electrode impedance levels were below 40 kOhm before and after testing. Data were sampled at 250 Hz with the filters set to 0.1-100 Hz throughout the testing. All electrodes were referred to Cz (vertex) during data collection and they were re-referenced offline during data analysis (Picton et al., 2000). All bioelectric signals were digitized on a Macintosh computer.

ERP Analysis (pre-descriptive and pre-inferential data analysis considerations)

Analysis of ERP data was conducted offline using Net Station 5.3 Software (EGI, Inc., Eugene, OR). All data were band-pass filtered with cut-offs at 0.1 and 30 Hz and referenced to an average of all electrodes. Segmentation of the EEG data for each trial was performed using Net Station software, where the template for segmentation was set for each trial, starting 500 ms prior to each picture onset and continuing for 2500 ms. Artifacts caused by participant blinks, eye movements, etc. were corrected using the default automated algorithms included in Net Station and then followed by a manual review.

Removal of eye and other movement artifacts: Automated screening criteria in Net Station software was as follows: to remove from the final data corpus any EEG/ERP recordings confounded by eye or movement artifacts, for the eye channels, voltage in excess of 140 μV was considered as an eye blink and voltage above 55 μV was considered as eyeball movements. "Bad" channels were defined as any channel with voltage exceeding 200 μV (Key & Stone, 2012). Within each trial (i.e., passive viewing of one picture), if more than 15% of the electrodes were determined to be bad, the entire trial was excluded from the analysis.

For the remaining artifact-free trials, ERPs were constructed separately by averaging the artifact-free trials for each of the three picture types (i.e., unpleasant, neutral, and pleasant conditions). Moran, Jendrusina, and Moser (2013) found that LPP had good internal consistency and remained stable after 8 trials added to the average, suggesting that LPP can be sufficiently quantified with relatively few trials. Therefore, in the current study, for a data set to be included in the statistical analyses, individual condition averages had to be based on at least 8 trials.

Between-group differences in number of trials across conditions: In the present study, there were no significant between- group differences in the number of trials included in the final data corpus for pleasant, unpleasant, and neutral emotional reactivity conditions. Specifically, for pleasant picture viewing condition, the number of trials included in the analysis did not significantly differ between CWS (M=13.06, SD=5.01), and CWNS (M=12.15, SD= 4.1), $F(1, 34)$=.273, p=.605. For unpleasant picture viewing condition, the number of trials included in the analysis did not significantly differ between CWS (M=12.47, SD=4.5), and CWNS (M=13.84, SD=4.2), $F(1, 34)$= .874, p=.357. For the neutral picture viewing condition, the number of trials included in the analysis did not significantly differ between CWS (M=11.9, SD=3.7), and CWNS (M=12.5, SD=4.03), $F(1, 34)$=.153, p=.698.

Furthermore, there were no significant between-group differences in the number of trials included in the final data corpus for positive and neutral reappraisal conditions.

Specifically, for the positive reappraisal condition, the number of trials included in the analysis did not significantly differ between CWS (*M*=11.87, *SD*=3.35), and CWNS (*M*=13.9, *SD*=4.12), $F(1, 32)= 2.39$, $p=.132$. Lastly, for the neutral reappraisal condition, the number of trials included in the analysis did not significantly differ between CWS (*M*=11.6, *SD*=3.1), and CWNS (*M*=12.2, *SD*=4.1), $F(1, 32)=.123$, $p=.728$.

The late positive potential is a sustained, rather than a brief response. Therefore, it is common for empirical studies of LPP amplitude to examine three separate time windows across the LPP, from the early to late temporal portions of the response. Therefore, in keeping with methodology typically employed with LPP data analysis, LPP amplitude was defined as the average activity in 3 time-windows following stimulus onset: early (500-1000 ms), middle (1000-1500 ms), and late (1500-2000 ms.) following the onset of the picture stimulus (e.g., Hajcak & Dennis, 2009). The specific electrodes for the LPP regions were selected to represent the central parietal (i.e., Pz) location, where LPP has been documented to be maximal (See Appendix B). Mean LPP amplitudes were computed by averaging across the electrodes within central parietal location, separately by time window (early, middle, late) by using a custom package (Moore, 2015) implemented in RStudio (RStudio Team, 2015).

Statistical Analyses

Table 1 describes the four hypotheses and related issues, independent and dependent variables and projected analytical methods. The following provides further detail pertinent to each of the four hypotheses described in Table 1.

To assess the *first hypothesis* (i.e., whether CWS would exhibit greater LPP amplitudes during *pleasant* picture viewing trials relative to CWNS), a *Group* (2: CWS and CWNS) x *Time Window* (3: early, middle, late) mixed model ANOVA was performed for the pleasant picture trials. In this analysis, LPP amplitude during pleasant picture trials was the dependent variable, Talker Group was the independent variable and Time Window was selected as the repeated measure. The amplitude of LPP to the neutral pictures (in the corresponding time windows) and gender were covariates. Amplitude of LPP during neutral pictures was chosen as a covariate in attempts to account for potential baseline differences in *picture* processing.

To assess the *second hypothesis* (i.e., whether CWS would exhibit greater LPP amplitudes during *unpleasant* picture viewing trials compared to their CWNS peers) a *Group* (2: CWS and CWNS) x *Time Window* (3: early, middle, late) mixed model ANOVA was performed for the unpleasant picture trials. In this analysis, LPP amplitude during unpleasant picture trials was the dependent variable, Talker Group was the independent variable and Time Window was selected as the repeated measure. The amplitude of LPP to the neutral pictures (in the corresponding time windows) and gender were covariates.

To assess the *third hypothesis* (i.e., CWS would show less reduction in the LPP amplitudes during the reappraisal epochs of the unpleasant stimuli than their CWNS peers), a *Group* (2: CWS and CWNS) x *Condition* (2: pleasant interpretation and neutral interpretation) x *Time Window* (3: early, middle, late) mixed model ANOVA was performed. In this analysis, LPP amplitude during positive and neutral reappraisal trials was the dependent variable; Talker Group was the independent variable, while Condition and Time Window were selected as repeated measures. The amplitude of LPP to negative pictures (in the corresponding time windows) during Emotional Reactivity task (i.e., no reappraisal condition) and gender were covariates. The amplitude of LPP to the unpleasant pictures during emotional reactivity paradigm was chosen as a covariate in attempts to quantify emotion regulation, that is, processing of emotion using positive and neutral reappraisal of the unpleasant pictures relative to the processing of emotion when viewing the unpleasant pictures with no reappraisal stories.

To assess the *fourth hypothesis* (i.e., children's cortical measures of emotional reactivity are associated with these processes reported by caregivers (i.e., CBQ scores on *negative affectivity, surgency/extraversion* and *effortful control* scales), linear regression methods were applied. In this analysis, LPP amplitudes during pleasant and unpleasant picture viewing trials and LPP amplitude during positive and neutral reappraisal conditions were dependent variables, while scores on CBQ subscales were independent variables.

CHAPTER III

RESULTS

Descriptive Information

Participants' Stuttered, Non-stuttered, Total speech disfluencies and Stuttering Severity

One-way ANOVA compared young CWS and CWNS on measures of speech disfluency. As would be expected, based on participant classification criteria, there was a significant difference in stuttered disfluencies per 100 words between CWS (M = 5.38 SD = 2.21) and CWNS (M = .84, SD = 0.74), F (1, 34) = 71.47, p < .0001. There was no significant difference between CWS (M = 4.39, SD = 2.48) and CWNS (M = 3.6, SD = 2.01), F(1, 34) = 1.123, p =.297 in non-stuttered disfluencies per 100 words. There was a significant difference between CWS (M = 9.78, SD = 2.71) and CWNS (M = 4.44 SD = 2.43), F (1, 34) = 38.79, p < .0001 in total disfluencies per 100 words, Likewise, there was a significant difference between *SSI-4 scores* for CWS (M = 14.94, SD = 3.73) and CWNS (M = 6.11, SD = .46), F (1, 34) = 105.04, p < .0001. These descriptive data pertaining to young CWS and CWNS's speech (dis)fluency were consistent with comparable measures obtained from a larger scale investigation of these two talker groups (Tumanova, Conture, Lambert & Walden, 2014).

Speech and Language

One-way ANOVA compared young CWS and CWNS on standardized speech and language tests. There was no significant difference between CWS (M = 102.31, SD = 9.11) and CWNS (M = 104.7, SD = 8.04) in speech sound articulation, as measured by the *GFTA-2* (*F*(1,33) = .67 *p*= .42. In addition, there was no significant difference between CWS (*M*= 112, *SD*=13.45) and CWNS (*M*=116.11, *SD*= 8.81) in *PPVT-IV* (*F*(1,34) = 1.49, *p* = .231). Children who stutter (*M*=113.52 *SD*=10.05) and CWNS (*M*=114.58, *SD*=9.69) did not differ in receptive subtest of *TELD*-3 *F*(1,34) =.102, *p* = .752. Lastly, there was no significant difference between CWS (*M*=102.43 *SD*=8.8) and CWNS (*M*=108.84*, SD*=10.25) in expressive subtest of *TELD*-3 *F*(1,32) =3.54, *p* = .069. All participants in the present study passed the hearing screening.

Findings related to A Priori Hypotheses

Emotional Reactivity Task

Prior to analytically addressing a priori hypotheses regarding between-group differences in emotional reactivity, as is the convention in this line of investigation, analyses for all present participants (CWS+CWNS) were conducted. These analyses were used to determine whether the LPP was sensitive to emotional valence of the stimuli in this population (i.e., young children who do and do not stutter).

In keeping with this convention, Figures 2 and 3 present the mean stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) during passive viewing of pleasant, unpleasant, and neutral pictures for CWS and CWNS, respectively. For all participants (CWS+CWNS), LPP amplitudes – across the three time windows (early, middle, & late) - were larger for pleasant (*M*= 1.49, *SE*= .49) and unpleasant (*M*=2.44, *SE*=.44) versus neutral (*M*= 0.094, *SE*=.47) stimuli *F*(2, 196)= 6.54, *p*=0.002.

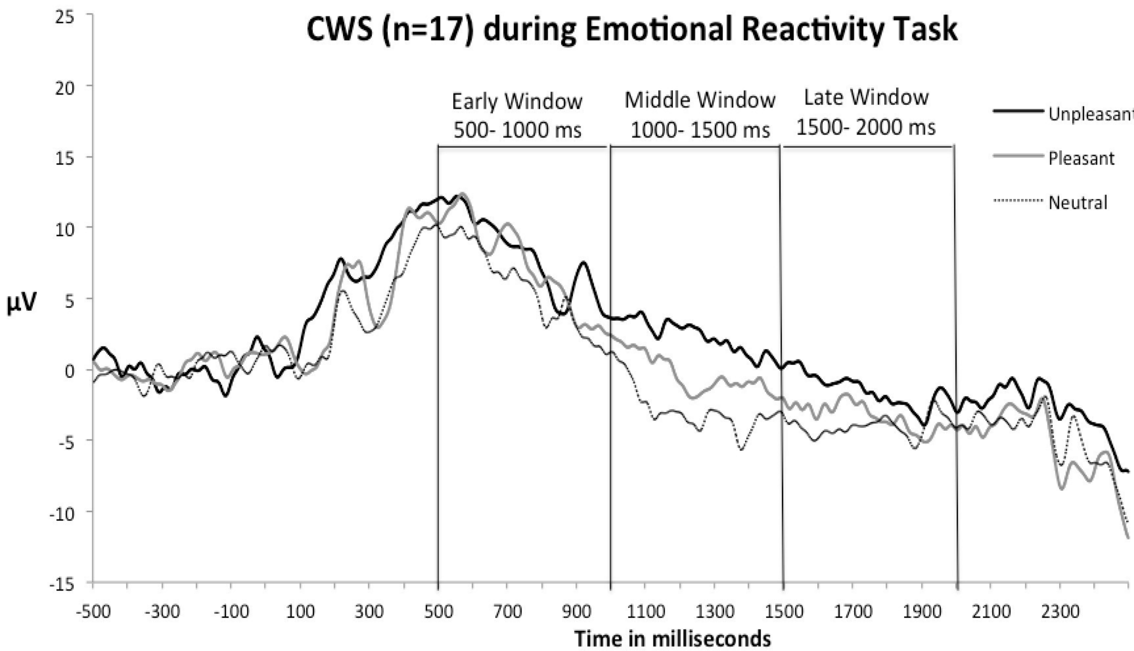

Figure 2. For CWS (n = 17), stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) during passive viewing of pleasant, unpleasant, and neutral pictures.

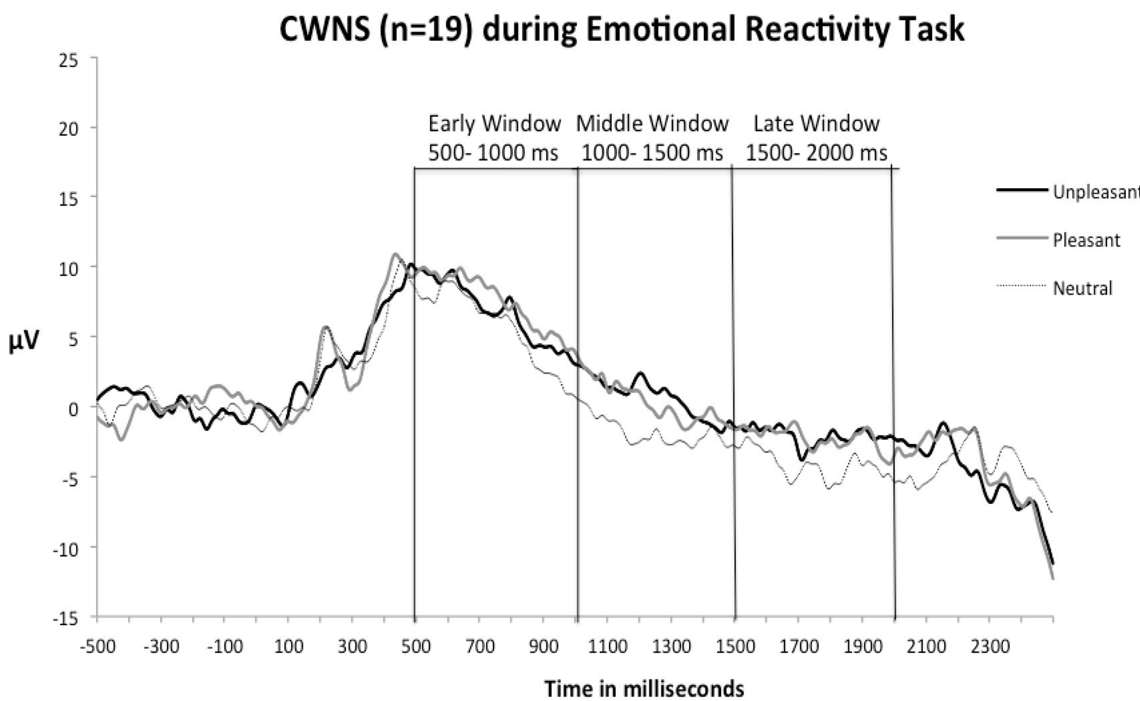

Figure 3. For young CWNS (n = 19), stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) during passive viewing of pleasant, unpleasant, and neutral pictures.

Between-group (CWS vs. CWNS) differences in Emotional Reactivity, as measured by LPP amplitudes (Hypotheses 1, and 2).

Pleasant Pictures (Hypothesis 1)

A Group (2: CWS and CWNS) x Time Window (3: early, middle, late) mixed models ANOVA tested Hypothesis 1 that CWS's LPP amplitudes to the pleasant picture condition would differ from that of CWNS.

For the analysis of Hypothesis 1, the amplitude of LPP to the neutral pictures (in the corresponding time windows) and gender were covariates. LPP to the neutral pictures was specifically chosen as a covariate in attempts to quantify relative processing of emotional versus neutral stimuli (thus accounting for potential baseline differences in *picture* processing).

The main effect for Time Window ($F(2, 79.46)= 8.01$, $p= .001$) was significant, suggesting that for all participants (i.e., CWS + CWNS) there was a significant difference among the early, middle, and late time windows of LPP to positive pictures However, there was neither a significant main effect for Talker Group ($F(1, 97.55)= .242$, $p=.624$) nor significant interaction effect of Talker Group x Time Window ($F(2, 70.59)= .255$, $p=.776$).

Unpleasant Pictures (Hypothesis 2)

A Group (2: CWS and CWNS) x Time Window (3: early, middle, late) mixed models ANOVA tested Hypothesis 2 that CWS's LPP amplitudes to the unpleasant picture condition would differ from that of CWNS.

As with analysis of Hypothesis 1, amplitude of LPP to the neutral pictures (in the corresponding time windows) and gender were covariates. Amplitude of LPP to the neutral pictures was chosen as a covariate in attempts to quantify relative processing of emotional versus neutral stimuli (thus accounting for potential baseline differences in *picture* processing).

There was a significant main effect for Talker Group $F(1, 96.5) = 4.922$, $p = .029$, that is, CWS (M=3.806, SE=.620) exhibited significantly larger LPP to the unpleasant pictures than CWNS (M=2.102, SE=.540) across the three time windows. Likewise, there was a significant main effect for Time Window ($F(2, 82.7) = 6.562$, p=.002) as well as interaction of Talker Group x Time Window ($F(4, 76.8) = 3.866$, p=.006).

Simple effects tests were conducted to follow up the significant Talker Group x Time Window interaction effect. No between-group differences were found at either the early window ($F(1, 32) = 1.42$, p=.243) or late window ($F(1, 32) = .189$, p=.667). In the middle time window of LPP (i.e., 1000-1500 ms), CWS (M=2.91, SE=.87) exhibited significantly greater LPP to the unpleasant pictures compared to CWNS (M=.174, SE=.82) $F(1, 32)$=5.054, p=.032 (*see* Figure 4).

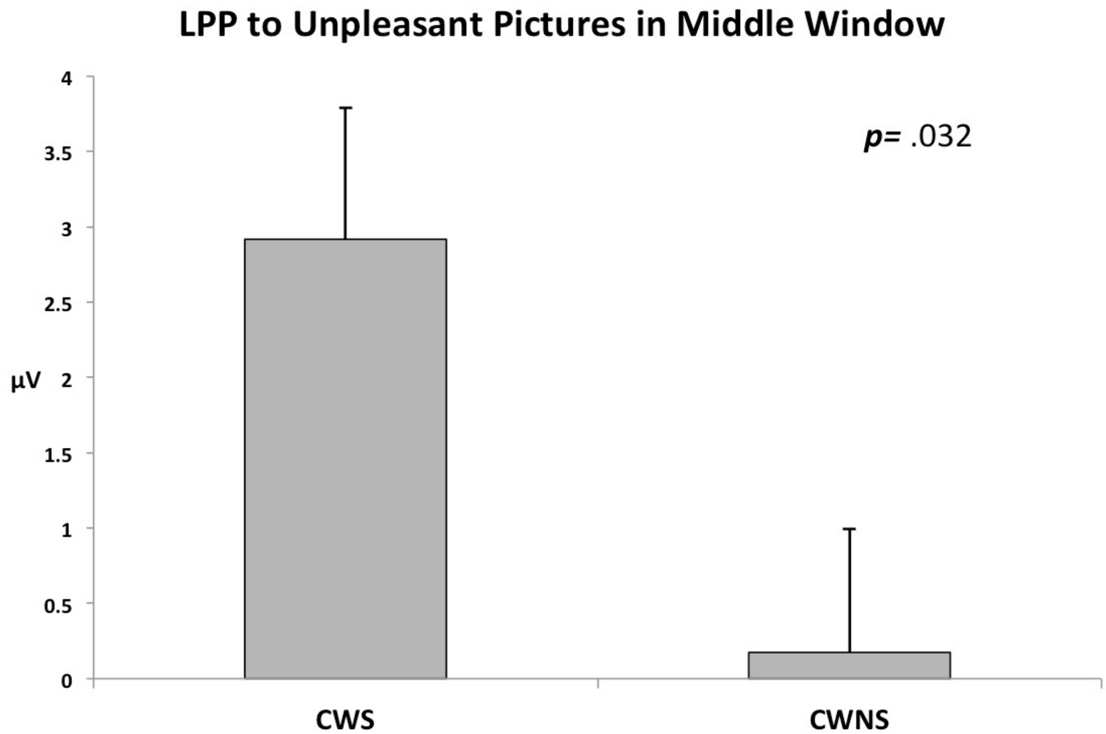

Figure 4. For CWS (n=17) vs. CWNS' (n=19), estimated marginal means and error bars (standard error of the mean) regarding LPP amplitudes during unpleasant pictures with gender and participants' LPP amplitude to neutral pictures as covariates.

Emotion Regulation Task

Prior to analytically addressing a priori hypotheses regarding emotion regulation, as is the convention in this line of investigation, analyses for all present participants (CWS+CWNS) were conducted. These analyses were used to determine whether the LPP was sensitive to experimental manipulation in this population. In keeping with that convention, Figures 5 and 6 present the mean stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) during pleasant and neutral reappraisal conditions during emotion regulation task in contrast to the unpleasant picture viewing condition during emotional reactivity task (i.e., passive viewing of negative pictures with no reappraisal) for CWS and CWNS, respectively.

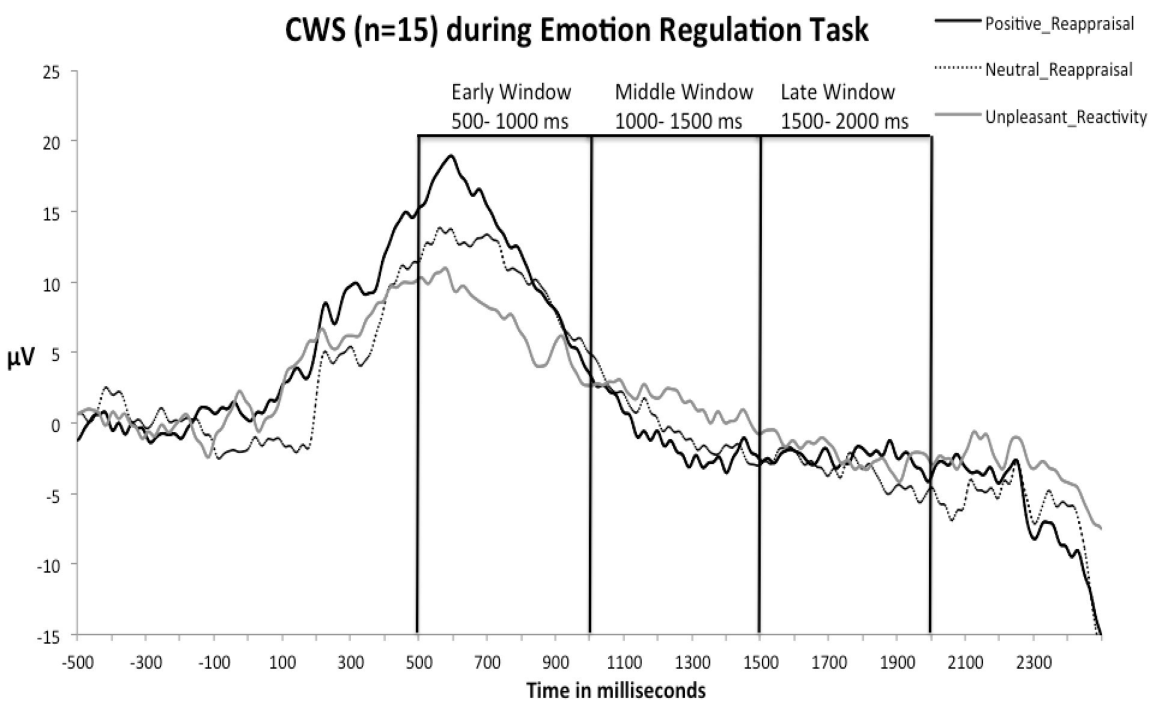

Figure 5. For CWS (n = 15) for whom reliable LPP data were available, stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) at pleasant and neutral reappraisal conditions during emotion regulation task in contrast to the unpleasant picture viewing condition during emotional reactivity task.

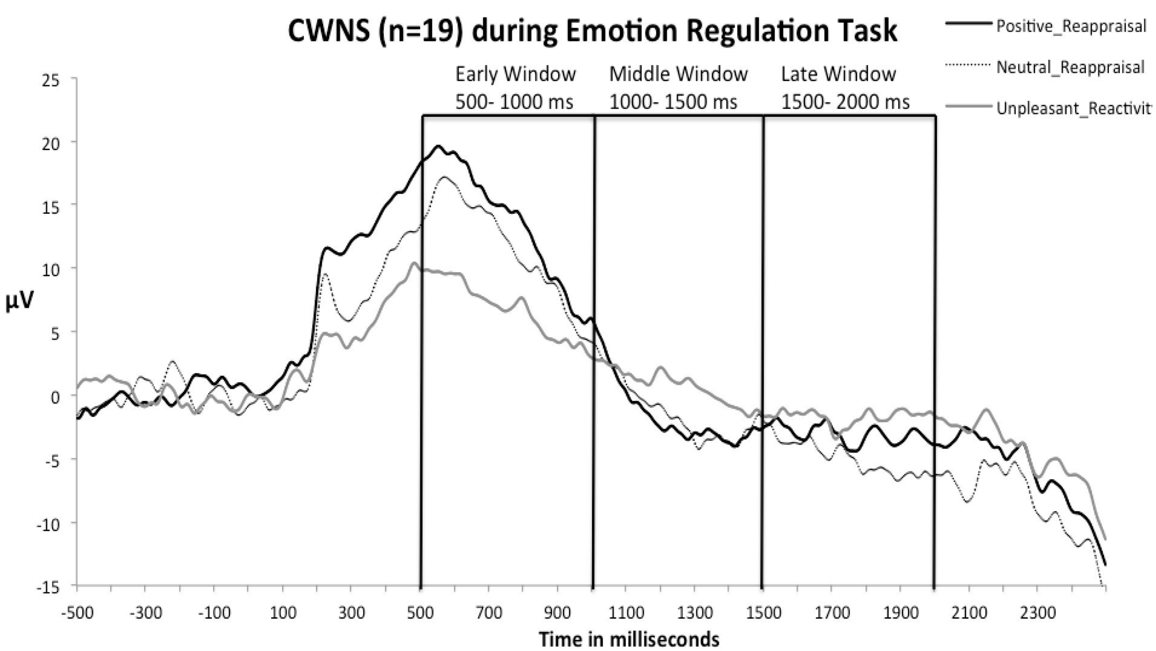

Figure 6. For CWNS (n = 19), stimulus-locked ERPs (i.e., LPP) at the central parietal electrode cluster (i.e., Pz) at pleasant and neutral reappraisal conditions during emotion regulation task in contrast to the unpleasant picture viewing condition during emotional reactivity task.

Findings indicated that for all participants, LPP amplitudes were significantly larger for positive (M= 13.24, SD= 8.2) and neutral (M=11.24, SD=7.46) reappraisal versus unpleasant reactivity (M= 7.01, SD=5.14) conditions in the *early time window* of LPP $t(33)$= -4.028, p<.0001 and $t(33)$= -2.95, p= .006, respectively. There were no such significant differences for the middle or the late time windows for all participants (i.e., CWS + CWNS).

Between-group (CWS vs. CWNS) differences in emotion regulation, as measured by LPP Amplitudes (Hypothesis 3).

Positive Emotion Regulation (as measured by LPP amplitude during the condition of Positive Reappraisal of Unpleasant Pictures)

A Group (2: CWS and CWNS) x Time Window (3: early, middle, late) mixed model ANOVA tested Hypothesis 3 that CWS's LPP amplitudes to the pleasant interpretations of negative pictures would differ from that of CWNS.

For the analysis of Hypothesis 3 (relative to positive reappraisal), LPP to the negative pictures during the emotional reactivity paradigm (in the corresponding time windows) and gender were covariates. The amplitude of LPP to the negative pictures during emotional reactivity paradigm was specifically chosen as a covariate in attempts to quantify emotion regulation, that is, processing of emotion using positive reappraisal of the unpleasant pictures relative to the processing of emotion when viewing the unpleasant pictures with no reappraisal/reinterpretation.

The main effect for Time Window ($F(2, 62)$= 21.65, p< .0001) was significant for all participants (CWS +CWNS) suggesting that there was a significant difference among the early, middle, and late time windows of LPP during positive reappraisal condition. However, there was no significant main effect for Talker Group ($F(1, 63.8) = 1.28$, $p = .263$) and no interaction of Talker Group x Time Window ($F(2, 57.43) = .137$, $p = .872$).

Neutral Emotional Regulation (as measured by neutral reappraisal of Unpleasant Pictures.

A Group (2: CWS and CWNS) x Time Window (3: early, middle, late) mixed models ANOVA tested Hypothesis 3 that CWS's LPP amplitudes to the neutral interpretations of negative pictures would differ from that of CWNS.

For the further analysis of Hypothesis 3 (in relation to neutral reappraisal), LPP to the negative pictures during the emotional reactivity paradigm (in the corresponding time windows) and gender were covariates. The amplitude of LPP to the negative pictures during emotional reactivity paradigm was specifically chosen as a covariate in attempts to quantify emotion regulation/ the relative processing of emotion using neutral reappraisal/ reinterpretation of the unpleasant pictures to viewing of the unpleasant pictures with no reappraisal/reinterpretation.

There was a significant main effect for Time Window ($F(2, 68.6) = 18.48$, $p < .0001$), suggesting that there was a significant difference among the early, middle, and late time windows of LPP during positive reappraisal condition for all participants. However, there was no significant main effect for Talker Group ($F(1, 71.6) = .900$, $p = .346$) and no interaction of Talker Group x Time Window ($F(2, 59.28) = .300$, $p = .742$).

It should be noted that the above analyses (regarding reappraisal) compared the two reappraisal conditions to the very first condition where the participants viewed the unpleasant stimuli (i.e., during emotional reactivity task, with no reappraisal story). This comparison allowed the experimenter to contrast LPP amplitude in the two reappraisal conditions to the LPP amplitude associated with their initial reactivity to the unpleasant stimuli. However, it is also possible to compare CWS to CWNS's LPP amplitude during the positive reappraisal condition relative to their LPP amplitudes during the neutral reappraisal condition. As shown in Appendix C, no between-group difference was found for either approach, that is, when comparing reappraisal conditions to the emotional reactivity condition or when comparing to the reappraisal conditions to the neutral reappraisal condition.

Relation of Emotional Reactivity and Regulation as measured by LPP amplitude) and as measured by Caregiver Report of Children's Temperament (Hypothesis 4).

To test Hypothesis 4 that caregiver reports of emotion reactivity and emotion regulation would be correlated with the cortical indices of emotional processes of both CWS and CWNS, Pearson correlation coefficients (r) were computed for each talker group. The effect of picture type on the LPP (LPP unpleasant-neutral and LPP pleasant-neutral) and the three factors (i.e., Surgency/Extraversion, Negative Affectivity and Effortful Control), from Children's Behavior Questionnaire (CBQ; Rothbart, 2001) were correlated for the three time windows for LPP (See *Table 2*).

For the following analyses of emotional reactivity and regulation (as indexed by LPP amplitude), difference scores were used as the dependent variable because they allow the measurement of relative processing of emotional versus neutral pictures (thus accounting for baseline differences in *picture* processing). Additionally, based on reports from previous studies, LPP difference scores have been shown to be sensitive to individual differences in such temperamental measures as anxiety (e.g., MacNamara & Hajcak, 2009). Table 2 shows the results of these correlational analyses. The p-values of correlations were adjusted using the SAS Proc Multtest procedure to mitigate family-wise false discovery rate (i.e., Type 1 error; Benjamini & Hochberg, 1995; Westfall, Tobias, Rom, Wolfinger, & Hochberg, 1999).

Table 2.
For those CWS (n=13), and CWNS (n=16) for whom CBQ data were available, Pearson product-moment correlations between LPP difference scores (i.e., positive reappraisal – negative reactivity conditions) and Negative Affectivity, Surgency, and Effortful Control from CBQ. Difference scores (e.g., unpleasant picture viewing condition – neutral picture viewing condition) for LPP amplitude were as follows: (1) unpleasant-neutral reactivity, (2) pleasant-neutral reactivity, (3) positive reappraisal-unpleasant reactivity, and (4) neutral reappraisal-unpleasant reactivity conditions.

Difference Score		Negative Affectivity		Surgency		Effortful Control	
		CWS	CWNS	CWS	CWNS	CWS	CWNS
(1) Unpleasant-neutral reactivity	early	-0.126	0.058	0.384	0.329	-0.647**	-0.41
	middle	0.146	-0.083	0.021	0.129	-0.136	-0.292
	late	0.318	0.26	-0.351	-0.057	-0.129	0.021
(2) Pleasant-neutral reactivity	early	-0.311	0.204	0.595**	-0.028	-0.396	-0.103
	middle	-0.190	0.192	-0.039	-0.061	0.363	-0.189
	late	0.145	0.076	-0.291	0.107	0.283	-0.318
(3) Positive Reappraisal-Unpleasant Reactivity	early	-0.582**	0.238	0.138	-0.406	0.193	0.427*
	middle	-0.516*	0.383	0.085	-0.277	-0.03	0.264
	late	-0.709**	0.035	0.151	-0.194	-0.246	0.215
(4) Neutral Reappraisal-Unpleasant Reactivity	early	-0.141	-0.168	-0.218	-0.057	-0.033	0.105
	middle	-0.13	0.109	-0.179	0.116	-0.026	-0.111
	late	-0.25	-0.207	-0.12	0.092	-0.337	0.013

Note: After False Discovery Rate correction (Benjamini, Hochberg, 1995), ** indicates $p<.05$, and * indicates p<.1.

Correlations between cortical (LPP amplitude) measures of emotional <u>*reactivity*</u> *and caregiver reports of temperamental characteristics.*

CWS**:** For the **unpleasant** pictures, there was a significant negative correlation between CWS's Effortful Control score on CBQ and their LPP in the early window to the unpleasant pictures r=-.647, p=.025, corrected for false discovery rate (hereafter referred to as "corrected"). Thus, for unpleasant pictures, greater temperamental effortful control as reported by parents was associated with lower emotional reactivity as measured by LPP.

For the **pleasant** pictures, there was a significant positive correlation between CWS' Surgency score on CBQ and their LPP amplitude in the early window r=.595, p=.036, corrected. Thus, for pleasant pictures, greater temperamental surgency/ positive affectivity as reported by parents was associated with greater emotional reactivity as measured by LPP.

CWNS: There were no significant correlations between LPP amplitude during unpleasant and pleasant pictures and caregiver reports of CWNS's temperament.

Between-group comparison of correlations: Using Fisher r-to-z transformation (Fisher, 1921; Howell, 2011), the significance of the difference between CWS and CWNS's correlation coefficients were assessed. This was done for only the statistically significant correlations (i.e., those presented in the paragraphs above). For the *unpleasant* pictures, there was no significant difference between CWS's (r=-.647) and CWNS's (r=-.41) correlations of Effortful Control score on CBQ and their LPP in the early window z=-0.8, p=.42. Likewise, for the *pleasant* pictures, the difference between CWS's (*r*=.595) and CWNS's (*r*=-.028) correlations of Surgency score on CBQ and their LPP in the early window approached but did not reach significance *z*=1.7, *p*=.08.

Correlations between cortical measures of emotion regulation (LPP amplitude during Reappraisal Conditions) and caregiver reports of temperamental characteristics.

Difference scores were used as the dependent variable for the reappraisal conditions (e.g., positive reappraisal- negative reactivity) because they allow the measurement of participants' cognitive reappraisal/ emotion regulation relative to their initial emotional reactivity to the negative pictures (i.e., in the absence of a reappraisal story).

CWS: For the positive reappraisal condition (i.e., positive reappraisal – negative reactivity), there were significant negative correlations between CWS' Negative Affectivity score on CBQ and their LPP amplitude in the early window *r*=-.582, *p*=.05, and the late window *r*=-.709, *p*=.0125, with both correlations corrected. The significant negative correlations between CWS's temperamental negative affectivity and their LPP during positive reappraisal conditions are taken to suggest that CWS with greater temperamental negative affectivity showed reduced LPP amplitudes to the negative pictures during positive reappraisal condition.

CWNS: There were no significant correlations between LPP amplitude during reappraisal conditions and caregiver reports of CWNS's temperament.

Between-group comparison of correlations: Using Fisher r-to-z transformation (Fisher, 1921; Howell, 2011), the significance of the difference between CWS and CWNS's correlation coefficients were assessed. This was done for only the statistically significant correlations (i.e., those presented in the paragraphs above). For the positive reappraisal condition, there was a significant difference between CWS's (r=-.582) and CWNS's (r=.238) correlations of Negative Affectivity score on CBQ and their LPP amplitude in the early window z=-2.16, p=.03. Likewise, for the positive reappraisal condition, there was a significant difference between CWS's (r=-.709) and CWNS's (r=.035) correlations of Negative Affectivity score on CBQ and their LPP in the late window z=-2.19, p=.028.

The difference scores (positive reappraisal – negative reactivity) used in the correlations above would, of course, change if they were based on positive reappraisal – neutral reappraisal (as described in Appendix C). This change in difference score is potential for changing the within-group correlations between positive reappraisal and temperamental characteristics as well as between-group comparison of correlation coefficients. The impact of changes in difference scores on such correlations and their contrasts is shown in Appendix C, Table C1.

CHAPTER IV

DISCUSSION

Summary of Main Findings

The present study resulted in four main findings. First, for the unpleasant pictures, CWS, when compared to their CWNS peers, exhibited significantly greater LPP amplitude. Second, for unpleasant pictures, in the early time window (i.e., 500 to 1000 ms) of the LPP, CWS exhibited a significant correlation between Effortful Control score on the CBQ and their LPP amplitudes. Third, for the pleasant pictures, in the early time window of the LPP, CWS exhibited a significant correlation between their Surgency score on the CBQ and their LPP amplitudes. Fourth, there were significant correlations between CWS' Negative Affectivity score on the CBQ and their LPP amplitudes during the positive reappraisal condition. The implications of each of these findings are discussed below followed by a general discussion.

Between-group differences in emotional reactivity (as indexed by LPP amplitude) to unpleasant pictures (first main finding)

The first main finding – that supports hypothesis 2 that there would be between-group (CWS vs. CWNS) differences in LPP amplitude during the viewing of unpleasant pictures - indicated that CWS, compared to their CWNS, exhibit greater LPP amplitude to the unpleasant pictures. One possible explanation for this finding is that CWS, when compared to CWNS, may exhibit greater reactivity to negative situations as a *habitual trait*. This explanation is consistent with empirical findings that CWS, relative to their CWNS peers, exhibit (a) more negative emotional expressions during a disappointing gift procedure (Johnson et al., 2010), (b) more negative emotion during an emotionally frustrating task (Ntourou et al. 2013), (c) higher anger/frustration (Eggers et al., 2010) as well as (d) greater emotional reactivity (Karrass et al., 2006) based on caregiver reports.

An alternative explanation for CWS's greater emotional arousal to negative pictures is that CWS might have *reduced emotion regulation* relative to CWNS, an account consistent with findings from empirical studies using caregiver reports. For example, Eggers et al. (2010) reported that CWS, when compared to CWNS, exhibited significantly lower emotional regulation, as indexed by lower inhibitory control (i.e., "the ability to plan and to suppress approach responses under instruction or in uncertain situtations," Rothbart, 2011), but higher anger/frustration. In addition, CWS, relative to CWNS, have been reported to display (a) higher emotional reactivity but lower emotion regulation (Karrass et al., 2006) and (b) less adaptability to change (Anderson et al., 2003). Likewise, in a psychophysiological study of emotion reactivity and regulation, Jones et al (2014) reported that at baseline, young CWS, when compared to their CWNS peers exhibited lower amplitude respiratory sinus arrhythmia (a physiological activity associated with emotional regulation). The present experimental design (i.e., reappraisal conditions) as well as caregiver report data help us speculate about various possibilities, for example, that CWS exhibit higher emotional reactivity, or CWNS exhibit lower emotional reactivity or CWS's exhibit both higher reactivity and lower regulation. Such speculations are discussed in the sections below.

Correlations between LPP and parental report of emotional reactivity and emotion regulation (second, third and fourth main findings).

Emotional Reactivity

The second main finding that tests hypothesis 4 - both CWS and CWNS caregiver reports of emotional reactivity would be correlated with the cortical indices of emotional processing- was only found for CWS. Specifically, CWS's temperamental effortful control (a factor level construct that relates to emotional regulation, and was indexed by parental response to the CBQ in the present study) was positively correlated with their cortical reactivity to negative pictures. This finding suggests that CWS with more effortful control skills were more likely to show less emotional reactivity to negative stimuli. This finding seems to make sense in that effortful control is thought to help an individual down-regulate their emotional reactivity to arousing stimuli, events, etc. And although some may question the value of parent reports of children's temperamental characteristics, it has been suggested that "while parent report measures do contain some subjective parental components, available evidence indicates that these measures also contain a substantial objective component that does accurately assess children's individual characteristics" (Henderson & Wachs, 2007, p. 402). Even so, it remains unclear why these correlations were only found for CWS; however, below we will speculate about some possibilities.

The third main finding, in support of hypothesis 4, was also only found for CWS. Specifically, CWS's temperamental surgency/extraversion was positively correlated with the amplitude of LPP when viewing the pleasant pictures (third main finding). This would appear to suggest that CWS with more temperamental surgency (sometimes considered to be an index of "positive affectivity" Choi, Conture, Walden, Jones, Kim, 2016) exhibited more cortical reactivity to pleasant pictures. Perhaps, one might speculate, more surgent CWS exhibit less emotional regulation in the presence of pleasant pictures and hence exhibit more emotional reactivity when viewing such pictures.

Emotion regulation

The fourth, and last main finding, in support of hypothesis 4, was also only found for CWS. Specifically, CWS with greater temperamental negative affectivity showed reduced LPP amplitudes to the negative pictures during positive reappraisal condition. This was taken to suggest that CWS with greater temperamental negative affectivity were more likely to benefit from the positive reappraisal stories, enabling them to better down-regulate their emotional reactivity to unpleasant pictures.

Present findings that CWNS's temperamental measures of negative affectivity, surgency, and effortful control were not correlated with their cortical associates of emotional reactivity and regulation challenges a straightforward explanation. Perhaps in the present sample, the parents of CWS were more attuned to assess their children's emotional processes/temperament than the parents of CWNS. Another explanation could be that the stimuli and experimental manipulation of emotion in the present study was not arousing enough for CWNS to exhibit emotional responses more in keeping with their temperament proclivities. Regardless, to the best of the present author's knowledge, these findings are the first to have documented significant, meaningful correlations between cortical measures and parental reports of emotional reactivity and regulation in young children who stutter.

General Discussion

Amplitude of LPP during unpleasant picture viewing

There are several possible accounts for why CWS, when compared to their CWNS peers, exhibited greater LPP amplitudes to unpleasant pictures, of which we discuss immediately below, the three most likely accounts.

The first account suggests that young CWS's increased LPP amplitude during unpleasant picture viewing reflects the possibility that they have learned to exhibit greater emotional reactivity due to their frequent negative experiences with stuttering. This "spread of reactivity" hypothesis would seem to predict that CWS develop a tendency to exhibit greater emotional reactivity – whether measured behaviorally, cortically, and / or psychophysiologically – because these children frequently experience unpleasant stimuli when they speak. These stimuli could be internal (e.g., inability to fluently, rapidly initiate speech, etc.) and/or external (e.g., listeners interrupting and/or talking for them, etc.) in nature and encountered during CWS's verbal communication.

Certainly, one cannot categorically rule out the possibility that at least some young CWS develop greater negative affectivity due to their experiences with stuttering. If such was the case, however, for CWS as a group, one would expect to find a significant relation between indices of experience with stuttering and greater LPP amplitude. Instead, present findings indicate no significant correlation (r= .07, p=.8) between LPP amplitude and CWS's time since onset of stuttering (the latter one reasonable means to measure duration of experience with stuttering). Furthermore, it would seem difficult to employ this "spread of reactivity" hypothesis to account for present findings given that the young CWS we studied were at or near the onset of their stuttering, that is, present participants have had a relatively reduced amount of experience with stuttering.

The second account suggests that between-group differences in LPP amplitude are due to the fact CWS and CWNS differ in their emotion regulation skills. It should be noted, that emotional reactivity occurs in the context of emotion and attention regulation (Gross, 1998; Rothbart, 2011). Emotion regulation refers to the processes involved in modifying negative and positive emotions in relation to their intensity, duration, how they are expressed and when they occur (Gross, 1998). According to this "regulatory" hypothesis, CWS, when compared to CWNS, exhibit higher LPP amplitude when viewing unpleasant pictures because CWS have lower regulatory skills. Although other empirical studies employing behavioral and/or psychophysiological measures would seem to support such conjecture, the present study found no significant between-group differences in reappraisal/ emotional regulation in terms of LPP amplitudes. Further, the present study's use of reappraisal stories – one of several different emotional regulation strategies that children could possibly use – may have been too developmentally advanced for 4- to 6- year-old children. Perhaps, children of the age of those studied in the present study were not cognitively mature enough to down-regulate their emotion by using the reappraisal stories presented to them. Such a possibility has been raised by others studying LPP in young children (e.g., Dennis & Hajcak, 2009; DeCicco, O'Toole, Dennis, 2014; DeCicco, Solomon, Dennis, 2012; cf. Hua, Han, Zhou, 2015). If such regulatory skills are not adequately developed and/or established in children the age of the present participants (again, suggesting that they are less able to "take advantage" of emotion reappraisal), this regulatory hypothesis may not be the best means to explain between-group differences in LPP amplitude (i.e., negative reactivity) during unpleasant pictures.

The third account suggests that young CWS, when compared to their CWNS peers, are more emotionally reactive to unpleasant stimuli due to their temperament. This "temperamental" or "biologically-based filter" hypothesis suggests that CWS, when compared to CWNS, differ in terms of aspects of their temperament, that lead them to "filter" (and hence react) differently to negative or unpleasant stimuli relative to their CWNS peers. In contrast to the aforementioned "spread of reactivity" hypothesis that emphasizes the amount or duration of children's experience with stuttering, this "temperamental" hypothesis places the emphasis on children's "constitutionally" based processes that selectively filter the quantity and quality of events/stimuli the child experiences. Thus, just as experience with stuttering cannot be categorically ruled out as explanatory vehicle for CWS's greater reactivity to unpleasant pictures, neither can one categorically rule out the possibility that temperamental "filters" contribute to these findings. Indeed, inherent in the definition of temperament is the notion of individual differences in emotional reactivity and regulation. Or, as Rothbart (2011) described Escalona's (1968) notion of *effective experience,* "…events in children's lives are experienced only as they are filtered through the individual child's nervous system, so that an environmental event is not the same for all" (p. 30). Hence, children's individual differences in such "filtering systems" undoubtedly shape their reactions to internal and/or external stimuli. As empirical work in this area progresses, perhaps some blend of the “spread of reactivity” and “biologically-based filters” hypotheses may be found to best explain findings like those of the current study. However, at present, such explanations must await results of future empirical studies to help determine the relative contributions of these “nature” (temperamental) and “nurture” (spread of reactivity) emotional processes.

Correlations between CWS's LPP amplitude and caregiver reports of their temperamental characteristics

Following correction for false discovery rate, four correlations were found significant for CWS, but no correlations were found significant for CWNS. Below, we will discuss each of these correlational findings in a bit more detail.

Overall, present study's findings suggest that CWS' negative affectivity (temperamentally-based negative emotion), surgency (temperamentally-based positive emotional reactivity), as well as effortful control (temperamentally based emotion regulation) as indexed by parental reports, “filter” their cortical activity differently than that of their CWNS peers. Specifically, CWS with greater temperamental emotion regulation (as indexed by Effortful Control on the CBQ) showed lower LPP amplitude (i.e., lower cortical reactivity) to unpleasant pictures. This finding provides further support for how emotional reactivity occurs in the context of emotion regulation, and that one's temperamentally-based emotion regulation skills “filter” their cortical reactivity.

In addition, CWS with greater temperamental surgency/ positive emotion showed higher LPP amplitude to pleasant pictures. Also, when presented with pleasant reappraisal stories, CWS with greater negative affectivity appeared to better down-regulate their reactivity to unpleasant pictures (i.e., exhibit lower LPP amplitude). Both findings might be taken to suggest that CWS were more attuned to processing or "filtering" pleasant stimuli.

Caveats

One limitation of the present study was the relatively small sample size and relatively limited age range of participants. The relatively small sample size of the present study may limit the generalizability of findings to the broader group of CWS and CWNS. Likewise, the present study's sample was limited to 4- to 6-year-old children. Going forward, a larger sample with a wider age range (e.g., preschool-age children as well as school-age children) could allow for further empirical investigations of developmental/ maturational changes in emotion regulation skills. For example, it would allow for a more robust comparison between younger and older children in terms of the use of reappraisal strategies to down-regulate emotions.

Another limitation may have been the method used to study emotional regulation. In the present study, we used directed reappraisal as a means to measure participants' emotion regulation. Both the young CWS and CWNS participants in the present study did not appear to use reappraisal stories to down-regulate their emotions. This may have been the case that, as suggested by LPP findings from previous studies with typical children, children in preschool and kindergarten are still developing their ability to make use of advanced emotion regulation strategies like cognitive reappraisal (e.g., DeCicco et al., 2012).

Therefore, present findings may not readily support nor refute the hypothesis that the association of emotional arousal and childhood stuttering was due to the possible moderating or mediating effect that emotion regulation has on this association. However, it should be noted – even after correction for false discovery rate – present findings indicated a significant between-group difference in correlations, for both the early and late time window of LPP, between negative affectivity and LPP amplitude during the positive reappraisal condition, a condition thought to impact children's emotional regulation. This could be taken to suggest that parent reports of CWS's negative affectivity are related to the impact positive reappraisal has on CWS'S ERP activity. Even so, future research, especially of preschool-age children, may benefit from augmenting the emotion regulation strategy of reappraisal with other such strategies such as distraction and labeling (e.g., Moyal, Henik, Anholt, 2013).

A third limitation is that the present study employed one measure of children's emotional reactivity and regulation – EEG recordings of LPP amplitude – without consideration of other independent measures of emotional reactivity such as skin conductance (SC; Boucsein, 1992) and emotion regulation such as respiratory sinus arrhythmia (RSA; Porges, 2011) to examine the impact of the experimental stimuli and reappraisal strategies.

CHAPTER V

CONCLUSION

Present findings that CWS exhibited greater LPP amplitude to unpleasant pictures than their CWNS peers appear consistent with non-physiological findings suggesting an association between emotion and childhood stuttering. Furthermore, significant correlations between parental reports of various temperament-related constructs and CWS's LPP amplitude point out the possibility that aspects of CWS's temperament play a contributing (although not necessarily singular) role in cortical reactivity to emotional stimuli. For example, CWS's parent reports of their child's negative affectivity were significantly correlated with the difference between their children's LPP amplitudes when viewing unpleasant pictures with and without positive reappraisal (a correlation that significantly differed from that for CWNS). Therefore, it is possible that CWS's parents' observations/reports reflect activity at more covert levels of their child's functioning.

In conclusion, to our knowledge, the present empirical study was one of the first of its kind to investigate cortical associates of emotional reactivity and emotion regulation in a sample of young children who do and do not stutter. Also, to our knowledge, the current investigation was one of the first empirical studies to report correlations between CWS's cortical associates of emotional processes and caregiver reports of their temperament. That other, similar studies, should follow this initial investigation, would be most welcome, with the pooling of knowledge from this and subsequent similar studies contributing to a more comprehensive understanding of the association between emotion and childhood stuttering.

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APPENDICES

Appendix A.

Stimuli for Emotional Reactivity (Table A1) and (2) Emotion Regulation (Table A2) Tasks

Table A1. Emotional Reactivity Task: The numbers of IAPS pictures used in the present study.

Unpleasant:	1050, 1120, 1201, 1300, 1321, 1930, 2120, 2130, 2688, 2780, 2810, 2900, 3022, 3230, 3280, 5970, 6190, 6300, 7380, 9050, 9250, 9404, 9421, 9470, 9480, 9490, 9582, 9594, 9600, 9611
Pleasant:	1460, 1463, 1601, 1610, 1710, 1750, 1811, 1920, 1999, 2070, 2091, 2165, 2224, 2311, 2340, 2345, 2791, 4603, 5831, 7325, 7330, 7400, 7502, 8031, 8330, 8380, 8461, 8490, 8496, 8620
Neutral:	5220, 5711, 5740, 5750, 5800, 5820, 7000, 7002, 7004, 7006, 7009, 7010, 7025, 7031, 7035, 7041, 7050, 7080, 7090, 7100, 7140, 7150, 7175, 7190, 7224, 7233, 7235, 7236, 7595, 7950

Table A2. Emotion Regulation Task: Reappraisal Stories of Unpleasant Pictures

IAPS Picture	Neutral Reappraisal Stories	Positive Reappraisal Stories
1050	Please look at the following picture. It has green and black colors.	This is a snake that is completely harmless; it doesn't even have teeth.
1120	Next, you will see a picture of an animal that has a big mouth.	This snake is also harmless. He is just hungry and begging for a snack.
1201	Next is a picture of an animal and a person in a white shirt.	This person really likes to let his harmless pet spider crawl on his shoulder.

1300	Look at the screen. Next picture is in dark brown and black colors.	This dog just went to the dentist – look how clean her teeth are.
1321	Next, you will see a picture of an animal in nature. It has thick brown fur.	Look at the next picture. This is a friendly and harmless bear that is yawning.
1930	Please look at the following picture. It is a picture of an animal in water.	This is a well-trained, friendly shark whose keeper is feeding him a fish.
2120	Look at the following picture of a man wearing a black sweater.	This man has held his breath to make a red face. He is being funny by showing how red his face can get.
2130	Next is a picture of a woman wearing a coat. She has black hair.	This woman had her picture taken right when she was about to sneeze.
2688	Next picture shows an animal and a man located far away from the camera.	The doctor is shooting medicine into the bear. It will get better thanks to the friendly doctor.
2780	Next picture shows a man who painted his face using white and black colors.	This is a friendly actor who is in a play about cats. He is smiling at you.
2810	This is a picture of a child who is ten years old. He has brown hair, and his eyes are closed.	This boy is playing 'hide and seek' and is yelling 'ready or not here I come'.
2900	This is a picture of a boy who is in kindergarten. He has blonde hair and a white shirt.	This boy's dad picked him up after he fell; he got scared, but is now totally okay.
3022	Look at the following picture. This is a picture of a man with long hair.	Look at the next picture. This person is on a very fun ride and he is so excited.
3230	Please look at the screen. Next is a picture of an old person.	This man was sick, but he is okay now and on his way to getting all better.
3280	This is a picture of a woman and a little boy. The woman is wearing glasses and gloves.	This boy is having his teeth cleaned; it feels funny but doesn't hurt.
5970	This picture is in gray and black. It is a picture of a storm.	This storm is going away; it is harmless and everyone is safe.
6190	Please look at the monitor and wait for the next picture. It is a picture of an object.	This is a toy gun; the person holding it is playing cops and robbers.
6300	Next picture is in black, white and gray colors. It shows a man’s hand.	This man is using the tool to fix the wall. He is being very helpful to his friends.

6370	Please look at the next picture. It is a picture of a gray mask.	This person is visiting his friend; he is wearing a mask because it is cold.
7380	This is a picture showing some animals and a plate of food.	These bugs are completely harmless. They're a little hungry and eating the delicious leftover pizza.
9050	Next is a picture of a group of people and a plane in the back.	Look at the following picture. Luckily, everyone was okay after the plane crash.
9250	Please look at the next picture. This is a picture of three women.	These doctors have saved the woman's life. The woman will be all okay thanks to them.
9421	Next is a picture that shows two men wearing army uniforms.	This solider is so happy he is crying; the war is over and he is going to his family.
9470	Next is a picture of a white, big, old building. It used to be a hotel.	This very old building was knocked down; everyone was really happy to see it go.
9480	Look at the following picture. This picture has brown, white, black and green colors.	These are bones of ancient people. They are very helpful for scientists to learn about the past.
9490	Following shows a picture of a person covered in something gray.	This is a pretend mummy for a movie set; it is fake and very funny looking.
9582	Following is a picture of a boy who is closing his eyes and opening his mouth.	The doctor just finished working on his teeth; he feels all better.
9594	This picture shows a person's arm and someone wearing white gloves and a blue robe.	This person gives blood all the time because it helps people who are sick.
9600	Next picture shows a very big, white ship in the big, blue waves of an ocean.	Another ship came just in time to save all these people; everyone will make it just fine.
9611	Next picture has blue, brown, white, yellow and red colors.	A brand new plane will be built from this old one – people are working on it together.

Appendix B.

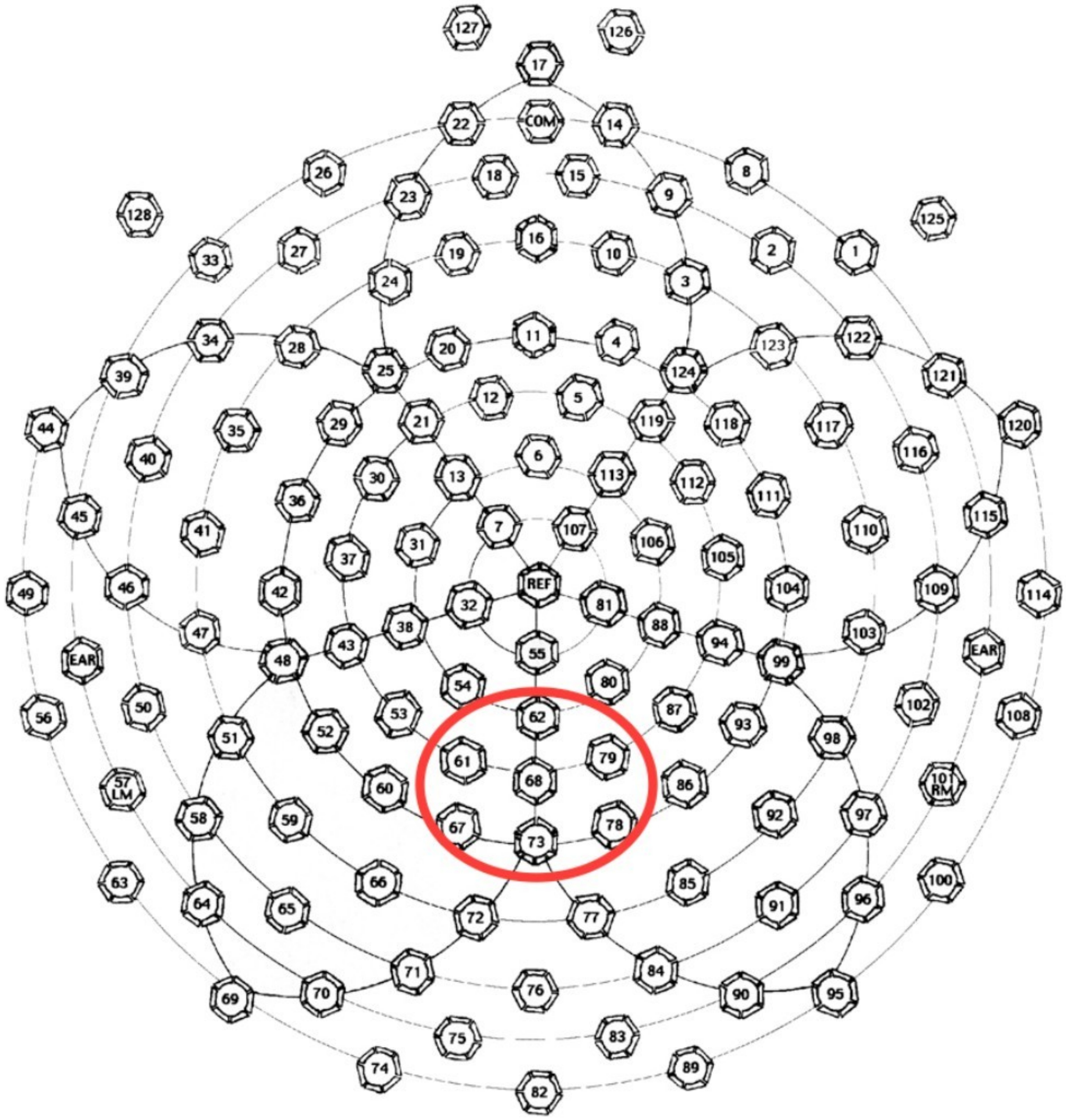

Figure B1. The present study's measure of LPP was based on the average evoked response potentials across the 7 electrodes within the red circle. This cluster of electrodes corresponds to central-parietal location (Pz).

Appendix C.

In the present study, the influence of reappraisal on the LPP amplitudes during Emotion Regulation task was investigated by assessing LPP during positive reappraisal and neutral reappraisal conditions in contrast to a no-reappraisal condition (i.e., with LPP during unpleasant picture viewing during Emotional Reactivity task as a covariate for both analyses). This approach will be referred to as "Original Analysis" in the paragraphs below.

In contrast, one may use an alternative approach to analyze the impact of reappraisal stories on the LPP amplitudes for unpleasant picture viewing during the Emotion Regulation task. This "alternative approach" allows between-group comparison during positive reappraisal condition by using neutral reappraisal condition as a covariate. Using this alternative approach permits the researcher to investigate the impact of *positive* stories in comparison to *neutral* stories on the LPP amplitudes during the Emotion Regulation task. What follows is data obtained by the original approach, in contrast to the alternative approach for Hypothesis 3 and Hypothesis 4.

Hypothesis 3: Between-group (CWS vs. CWNS) differences in Positive Reappraisal (PR), as measured by LPP Amplitudes. Hypothesis 3 was tested using the Original Approach (presented above, in this study) and the Alternative Approach. Below are the results of the Original Analysis (PR with Negative Reactivity/no reappraisal and gender as covariates) versus (2) Alternative Analysis (PR with Neutral Reappraisal and gender as covariates) (Hypothesis 3).

(1) *Original Analysis* (Positive reappraisal with unpleasant reactivity as a covariate): There was no significant main effect for Talker Group ($F(1, 63.8)= 1.28$, $p=$

.263) and no interaction of Talker Group x Time Window (*F*(2, 57.43)= .137, *p*= .872) (See Figures 5 and 6).

(2) *Alternative Analysis* (Positive Reappraisal with Neutral Reappraisal as a covariate): There was no significant main effect for Talker Group (*F*(1, 86.5)= .181, *p*= .672) as well as interaction of Talker Group x Time Window (*F*(2, 70.47)= .027, *p*= .973) (See Figure C1 below).

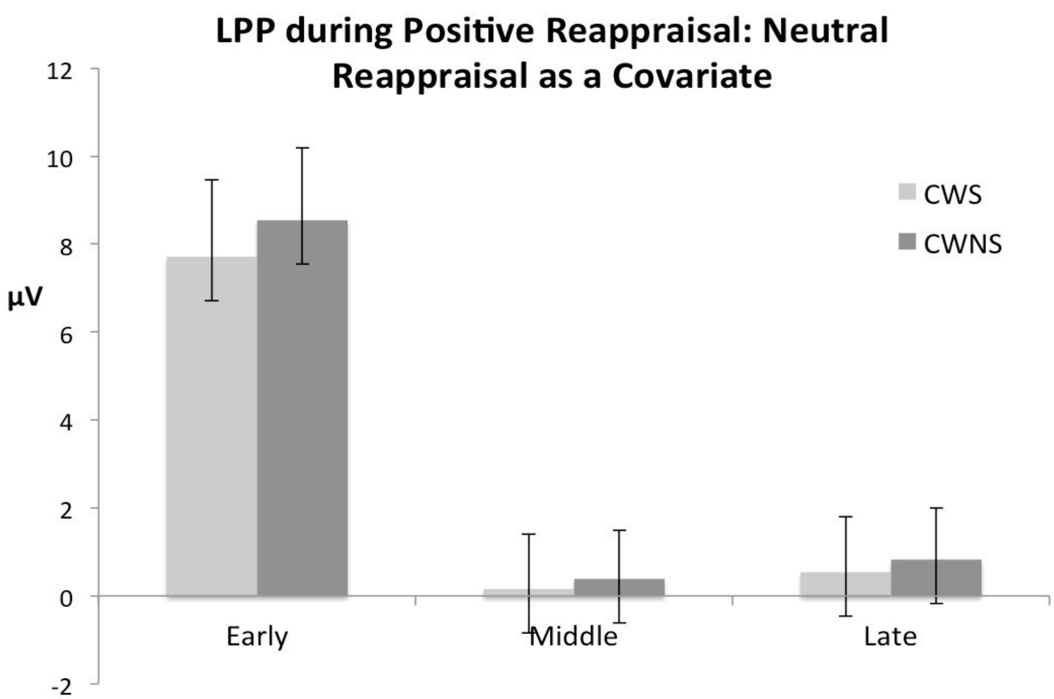

Figure C1. For CWS (n = 15) and (CWS = 19), estimated marginal means and error bars (standard error of the means) of LPP during positive reappraisal condition, with neutral reappraisal and gender as covariates (compare to Figures 5 and 6 in the text).

Hypothesis 4: Within-Group Correlations between Positive Reappraisal-Neutral Reappraisal (i.e., the Alternative Approach) and Temperamental Characteristics. The Original Analysis reported results of within group correlations between positive reappraisal- negative reactivity/ no reappraisal and temperamental characteristics. Below are the results of the Alternative Analysis for correlations between positive reappraisal- neutral reappraisal and temperamental characteristics.

CWS: For the positive reappraisal condition (i.e., positive reappraisal – neutral reappraisal), there were significant negative correlations between CWS' Negative Affectivity score on CBQ and their LPP amplitude in the early window r=-.683, p=.014, and the middle window r=-.581, p=.047, with both correlations corrected for false discovery rate (hereafter referred to as "corrected" see Table C1 below). The significant negative correlations between CWS's temperamental negative affectivity and their LPP during positive reappraisal conditions are taken to suggest that CWS with greater temperamental negative affectivity showed reduced LPP amplitudes to the negative pictures during positive reappraisal condition.

CWNS: There was a significant positive correlation between CWNS's Negative Affectivity score on CBQ and their LPP amplitude in the early window r=.561, p=.024, corrected, suggesting that CWNS with greater temperamental negative affectivity also showed increased LPP amplitudes to the negative pictures during positive reappraisal condition. There were significant negative correlations between CWNS' Surgency score on CBQ and their LPP during positive reappraisal in the early window r=-.5 p=.049, and the middle window r=-.542, p=.03, both correlations corrected. Lastly, there was a significant positive correlation between CWNS' Effortful Control score on CBQ and their LPP amplitude in the middle window r=.516, p=.041, corrected.

Hypothesis 4: Between-Group Differences of Correlations between Positive Reappraisal-Neutral Reappraisal and Temperamental Characteristics

Using Fisher r-to-z transformation (Fisher, 1921; Howell, 2011), the significance of the difference between CWS and CWNS's correlation coefficients were assessed. This was done for only the statistically significant correlations (i.e., those presented in the paragraphs above). For the correlations between Negative Affectivity scores on CBQ and positive reappraisal condition, there were significant differences in the early window between CWS's (r= -.683) and CWNS's (r=.561) correlations z=-3.49, p=.0005, and in the middle window between CWS's (r= -.581) and CWNS's (r=.394) correlations z=-2.57, p=.005.

For the correlations between Surgency scores on CBQ and positive reappraisal condition, there were significant differences in the early window between CWS's (r= .455) and CWNS's (r=-.5) correlations z=2.47, p= .0068, and in the middle window between CWS's (r= .353) and CWNS's (r=-.542) correlations z=2.32, p=.01. Lastly, there was no significant difference between CWS's (r= -.01) and CWNS's (r= .516) Effortful Control scores on CBQ and their LPP to the positive reappraisal condition in the middle window z= -1.38, p=.08.

Table C1. Within-Group Correlations between Positive Reappraisal - Neutral Reappraisal and Temperamental Characteristics

Pearson product-moment correlations between LPP difference scores and Negative Affectivity, Surgency, and Effortful Control from CBQ for CWS (n=13), and CWNS (n=16). Difference scores related to positive reappraisal-neutral reappraisal conditions.

Difference Score		Negative Affectivity		Surgency		Effortful Control	
		CWS	CWNS	CWS	CWNS	CWS	CWNS
Positive Reappraisal-Neutral Reappraisal	early	-0.683**	0.561**	0.455	-0.5**	0.32	0.465
	middle	-0.581**	0.394	0.353	-0.542**	-0.01	0.516**
	late	-0.484	0.387	0.293	-0.408	0.108	0.263

Note: ** indicates p<.05

Summary of Main Findings Using the Alternative Approach

For Hypothesis 3, which assessed between-group differences during Emotion Regulation task, neither the original approach (i.e., with unpleasant picture viewing/ no reappraisal condition as a covariate) nor the alternative approach (i.e., with neutral reappraisal condition as a covariate) yielded significant between-group differences during positive reappraisal condition of the emotion regulation task. Regarding Hypothesis 4, the original approach (i.e., positive reappraisal – unpleasant reactivity/ no reappraisal) yielded significant negative correlations between CWS's Negative Affectivity and their LPP amplitude during positive reappraisal condition in the early and middle time windows, but no significant correlations between CWNS's LPP amplitude during positive reappraisal condition and the aspects of their temperament. In contrast, the alternative approach (i.e., positive reappraisal- neutral reappraisal) yielded significant positive correlations CWNS' LPP during positive reappraisal and their Negative Affectivity and Effortful Control scores on CBQ. The alternative approach also yielded a significant negative correlation between CWNS' LPP during positive reappraisal and their Surgency score on CBQ. Lastly, the significant negative correlations for CWS using the original approach were also retained when the alternative approach was used.