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Manas Winfield March 30, 2012

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An abstract of
a thesis submitted to the Faculty of Emory College of Arts and Sciences
of Emory University in partial fulfillment
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Bachelor of Sciences with Honors

Neuroscience and Behavioral Biology

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Abstract

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Emotion regulation is important for our emotional well-being, with dysfunctional emotion regulation having been linked to psychopathology. Reappraisal is a particularly effective cognitive emotion regulation strategy that has been shown to reduce the late-positive potential (LPP), a neural marker of emotion processing. Previous neuroscientific research has focused on the reappraisal of negative stimuli in adults, and very little research has examined the development of reappraisal. In the present research, we recorded event-related potentials (ERP) in fourteen 8-year-old girls to measure their neural response to neutral images as well as positive and negative images that were accompanied by auditory narratives either matching the emotional content of the images or reinterpreting them as neutral. Participants also rated images for their subjective levels of emotional valence and arousal. Our results did not reveal the presence of an LPP, and the only significant differences in neural processing were between the response to reappraised positive images and neutral controls. Subjective ratings of the images showed marginally dampened levels of valence and arousal, although these results were not significant. These results suggest that emotion processing normally represented by the LPP may be affected during the reappraisal of positive images, and that the reappraisal of positive stimuli may be a distinct process compared to the reappraisal of negative stimuli.

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"Emotion Regulation and the Brain: The Reappraisal of Positive and Negative Images in School-Age Girls"

Emotion is inseparable from the human experience of life. The experience of emotion provides vital information about our existence as individuals in specific environments, while guiding our thoughts, behavior, and actions. Although emotion often serves an adaptive function, emotion can also be maladaptive. In situations where emotion is not adequately regulated, for example, emotion manifests in disordering ways (e.g., depression, anxiety disorders; Gross, 1998). It is essential, then, that humans display a plethora of emotion regulation strategies, which are reflected in various physiological processes and emerge at different periods of development. Reappraisal, among the more cognitive and effective regulatory strategies, regulates an individual's subjective experience and behavioral expression of emotion by changing the meaning of potentially emotional situations (Gross, 2002). Research on reappraisal's underlying brain mechanisms is at a nascent stage, however, and almost no research on the neural correlates of reappraisal has been conducted in children. We aim to fill these gaps in the scientific understanding of the development of emotion regulation processes by investigating the neural correlates of reappraisal in 8-year-old girls, who as females are at heightened risk for developing depression and anxiety disorders beginning in early adolescence (Mennin, Holaway, Fresco, Moore, & Heimberg, 2007). Furthermore, our study relates the neurophysiology of reappraisal to its subjective experience, and is the first study of its kind to examine the reappraisal of positive, in addition to negative, stimuli.

Emotion and Emotion Regulation

Before we explore why and in what ways emotion is regulated, and how reappraisal in particular operates, we should first ask: What *is* emotion? Though we all feel emotion, are cognizant of its presence in our lives, and are familiar with the colloquial usage of the word, the study of emotion has yet to provide a definitive answer. Part of the challenge for the countless philosophers, psychologists, and biological scientists who have tried to pin emotion down has been the difficulty of encompassing its multiple dimensions, both internal and external, into a single theory. Emotions are highly subjective, individual, internal experiences; and yet, they are universally identifiable and frequently precipitated by social interaction and other external, environmental factors. As Gross and Thompson note (2007), emotion arises as a function of the relative friction between an individual's goals and his or her situation. Wrapped up in each situation is the actuality of the surrounding environment and the meaning an individual gives to it. In addition to informing an individual about his or her situation, emotions catalyze the individual's response. Emotional responses to a given situation include phenomena as wide-ranging as changes in one's peripheral nervous system activation, motor activity, subjective feelings, thoughts, cognitive processes, behavioral expressions, and eventual actions.

The diversity in the qualities of emotional responses makes it difficult to characterize emotions as discrete entities. They can, however, be described more subtly by where they fall on the scales of two dimensions—valence and arousal (Russell, 1980). Valence refers to the level of pleasantness or unpleasantness of emotions, whereas arousal refers to emotions' overall level of activation or deactivation. Identifying the valence and arousal of emotions is the first step in being able to understand and describe subjective emotional experiences.

Although the multidimensional processes that comprise emotional responses often occur simultaneously, are spontaneous, and go unnoticed by the emotional agent, individuals display the behavioral plasticity to respond to emotional stimuli in various ways. Early in life, and through their lifespans, individuals make use of strategies to regulate emotion, modulating levels of emotional valence and arousal. Indeed, for almost every type of emotion we experience, there is a corresponding type of emotion regulation.

Emotion regulation broadly refers to the processes that enable an individual to control and adjust his or her emotions. These processes can influence various aspects of emotion—including involuntary physiological responses (i.e., heart rate, stress hormone levels, neural activity), inner subjective experience (i.e., feelings), related internal appraisals and logical processes (i.e., thoughts), and outward behavioral expressions (i.e., body language, facial expressions, actions). Via these avenues, emotion regulation processes may determine which discrete emotions are experienced, and the quality, intensity, and temporal "dynamics" of these emotions (Thompson, 1994). A multitude of specific emotion regulation strategies emerge throughout human development, each of which mediates emotion regulation in different ways and at various phases of the "emotion generative process" (Gross, 1998).

With the identification of such an abundance of apparent subtleties and factors in the regulation of emotion, it comes as no surprise that there are almost as many different emotion regulation categorization schemes as there are emotion regulation strategies. For example, emotion regulation strategies can be conceptualized as nonconscious or conscious (Williams, Bargh, Nocera, & Gray, 2009), reactive or deliberate (Woltering & Lewis, 2009), extrinsic or intrinsic (Fox & Calkins, 2003), antecedent-focused or response-focused (Gross & Thompson, 2007), and situational, attentional (e.g., distraction or concentration), cognitive (e.g., reappraisal), or behavioral (e.g., suppression, physical exercise, substance use; Gross, 1998). Since emotion regulation strategies develop over the course of the human lifespan, taking an ontogenetic approach will help tease apart the distinctions made in the emotion regulation literature.

Developmental Changes in Emotion Regulation

The very first forms of emotion regulation can be observed in newborns. Spontaneous reactivity to aversive environmental stimuli (e.g., crying and negative facial expressions) is simultaneously an early emotional expression *and* an example of early emotion regulation (Fox & Calkins, 2003). This automatic emotion regulation strategy is fully extrinsic, because the infant's ability to regulate his or her emotion depends on an external entity—the soothing of a nearby caregiver. As infants' faculties continue to develop, however, deliberate processes overshadow reactivity as an emotion regulation strategy.

Concurrent with increased control of their attention, infants begin gaining the ability to regulate their own reactivity. Self-soothing and self-stimulation have been observed in infants as young as 3 months (Rothbart, Ziaie, & O'Boyle, 1992), around the time infants learn to voluntarily shift their attention from one stimulus to another (Thompson, 1994). Although the earliest attentional emotion regulation strategies involve spontaneous, automatic diversions of attention (e.g., looking away from unpleasant and towards pleasant visual stimuli; Gross & Thompson, 2007), conscious, deliberate attentional control for the regulation of emotion begins to emerge in early childhood and develops into adulthood. A common intrinsic example of deliberate attentional emotion regulation can be observed when one redirects his or her mind away from thoughts of an inevitable, foreboding event.

As children continue to develop and acquire language as toddlers, their emotions and emotion regulation strategies take on greater complexity. By the age of 18 – 36 months, toddlers begin to build their vocabulary of the "emotion words" with which we denote emotion, talk about their own and others' emotional states (related to the past, present, and future), and verbalize their understanding of the "antecedents and consequences of emotional states" (Bretherton, Fritz, Zahn-Wexler, & Ridgeway, 1986). These budding abilities enable children to regulate their emotions by talking about emotional events with others (Zeman, Cassano, Perry-Parrish, & Stegall, 2006). It is important to note that, although many of the later-emerging regulatory strategies are deliberate and *intrinsic*, gaining the emotional support of others through dialogue is a deliberate, *extrinsic* strategy that can be observed throughout the lifespan. This should serve as another reminder of the constant interplay between the internal and external influences on an individual's emotional state, the capacity for one person's emotional state to affect another's, and as a result, the wide-ranging significance of successful emotion regulation.

Suppression and reappraisal are two intrinsic, deliberate strategies emerging later during the development of emotion regulation—around the time children reach school age. The former is characterized by deliberate behavioral suppression of an expressive response to an emotional state (John & Gross, 2004). The latter, however, is a cognitive process that involves the reinterpretation of an event in a way that decreases its potentially emotional effect (Gross, 2002). Gross's process model of emotion regulation strategies (Gross, 1998) provides a useful theoretical framework for understanding suppression and reappraisal. Gross distinguishes between antecedent-focused emotion regulation (e.g., reappraisal), whereby an emotional experience is regulated before its very onset; and response-focused emotion regulation (e.g., suppression), during which an emotional experience is mitigated after the fact (Gross, 1998). If, for example, the target of these two regulatory processes is the response to a negative emotional event (e.g., a child catches sight of a car accident on the side of the road), then suppression would result in the individual experiencing subjective feelings (e.g., fear, sadness) of negative emotion (and all associated physiological responses) followed by either a false emotional expression (e.g., forced laughter), or the suppression of any expression. In the case of reappraisal, however, the individual would reinterpret the meaning of the event (e.g., the car accident could not have been harmful to those involved), and might experience and express neutral or even positive emotion. The antecedent-focused and cognitive nature of reappraisal makes it an ideal emotion regulation strategy, one that can regulate emotion early on in the emotion-generative process and thereby conserve cognitive resources (John & Gross, 2004). Indeed, reappraisal has been shown to reduce the experience and expression of negative emotion without taking a physiological toll (Gross, 2002), making it one of the most effective and adaptive emotion regulation strategies. Suppression on the other hand, being an effortful and response-focused process, has been shown to impair cognition (including memory performance), disrupt sociality, and actually increase negative emotion (John & Gross, 2004).

Measuring Emotion Regulation

In recent years, neuroimaging techniques have increasingly been used to obtain objective measures of a variety of subjective mental phenomena including thought, memory, and emotion. At the forefront of these scientific investigations have been functional magnetic resonance imaging (fMRI) and event related potentials (ERP). These techniques enable researchers to examine brain activity in real-time. Of the two, fMRI allows for greater spatial resolution, measuring blood flow in the brain to determine levels of neural activation at specific brain areas. Alternately, ERP, although not ideal for localizing neural processing to exact neuroanatomical structures, has the advantage of recording brain activity at a much higher temporal resolution. Whereas fMRI can only provide data on a time-scale of seconds, ERP provides information about neural processes at a temporal resolution of milliseconds (Babiloni, et al., 2004). This feature of ERP makes it particularly useful in studying processes as instantaneous and mutable as emotion.

ERP measures the neural processes underlying cognition by recording brain electrical activity from electrodes at the scalp, utilizing electroencephalograph (EEG) technology. ERP represents raw continuous EEG waveforms that have been time-locked to particular events. These events represent an individual's neural response to the presentation of discrete experimental stimuli—for example: images, sounds, memory cues, or sentences. The ability to control and standardize these stimuli in a laboratory setting allows scientists the opportunity to investigate the nature of a specific mental phenomenon across participants on the neural level. Furthermore, the relative ease and noninvasiveness of recording ERPs allow researchers to use the neuroimaging technique to observe the underlying neural processes of the mental phenomenon of interest in any age group and thus, at all stages of the developmental spectrum (Nelson & Monk, 2001). These features, combined with excellent temporal resolution, make ERP an ideal tool for investigating the development of emotional reactivity and emotion regulation strategies.

Previous Research on the Neural Correlates of Reappraisal

Recent studies on emotion regulation have utilized both fMRI and ERP to investigate the neuroanatomical and electrophysiological substrates of cognitive emotion regulation strategies, including reappraisal. Studies of reappraisal using fMRI in adults have shown increased frontal lobe activation (associated with cognitive control and executive functioning) and decreased amygdala activation (considered central to emotion processing) during reappraisal tasks (Ochsner, Bunge, Gross, & Gabrieli, 2002; Phan et al., 2005). The lone fMRI study of reappraisal in children existing in the literature similarly revealed frontal lobe activation during the reappraisal of negative film excerpts in girls aged 8-10 years (Levesque, et al., 2004). These findings provide neurobiological evidence supporting the theoretical construct that reappraisal works at the cognitive level to regulate emotional processing, and that it is present as an emotion regulation strategy by at least age eight.

In addition to fMRI, ERP studies have contributed to a clearer understanding of the neural bases of cognitive emotion regulation and to knowledge of reappraisal's temporal features. Previous ERP studies have found the late positive potential (LPP) to be a consistent indicator of neural activation in response to emotional stimuli (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The LPP is an ERP component characterized by a sustained positive increase in amplitude observed around 200-300 ms after stimulus onset (Hajcak & Dennis, 2009), and which is modulated by emotional valence and arousal (DeCicco, Solomon, & Dennis, 2012). Moreover, the size of the LPP is reduced after the reappraisal of emotionally negative pictures in adults (Foti & Hajcak, 2008). To date, the two similar ERP studies to have been conducted with children yielded inconsistent results—Dennis and Hajcak (2009) found a reduced LPP in response to the directed reappraisal of negative pictures by 5- to 10-year-old boys and girls, whereas DeCicco et al. (2012) observed no effect of reappraisal on the LPP in 5- to 7-year-old girls in a slightly modified experimental paradigm. Thus it remains unclear how the brain processes reappraisal in school-age children, and further research is needed to assess how reappraisal affects the LPP in developing populations.

Present Research

Similar to the fMRI literature, ERP cognitive emotion regulation studies have focused predominantly on the reappraisal of negative stimuli in adult samples. Since only two ERP studies (Dennis & Hajcak, 2009; DeCicco, Solomon, & Dennis, 2012) and a single fMRI study (Levesque, et al., 2004) have addressed reappraisal in children, very little is known about the neural correlates of reappraisal during development. Our study will help build the foundation of basic knowledge necessary to understand the neurophysiology of reappraisal as an emotion regulation strategy in the developing brain. Knowledge of how the brain processes emotion regulation will also lead to an understanding of the biological underpinnings of emotion *dysregulation*, when emotion regulation processes become dysfunctional (Cole, Michel, & Teti, 1994). A better understanding of emotion dysregulation is especially vital seeing as it is a common element of psychopathology, featured in all Axis II and a majority of Axis I diagnoses in the DSM-IV (American Psychiatric Association, 1994; Gross, 1998). The inability to regulate negative emotional experience, in particular, has been linked to the emergence of symptoms of mood and anxiety disorders (Mennin et al., 2007).

Moreover, significantly higher rates of anxiety and mood disorders (e.g., depression) have been reported in females when compared to males, beginning in early adolescence (Cyranowski, Frank, Young, & Shear, 2000). Thus, girls were selected in this study because they are at heightened risk for these disorders, which makes observing biological measures of emotion regulation processes in girls a priority. School-age girls were selected because they are in a developmental period of emerging self-regulation skills (Fox & Calkins, 2003). Identifying the neural correlates of emotion regulation strategies such as reappraisal may lead to the discovery of a biological marker for dysfunctional emotion regulation. This could be useful in identifying children at risk for developing mood and anxiety disorders in their adolescence and adulthood, providing a basis for earlier, more effective treatments.

While in the present study we examine how negative stimuli are reappraised, we are also the first to measure the neural correlates of reappraised positive stimuli. Studying the reappraisal of positive stimuli will supply novel discoveries that may help explain more general processes underlying emotion regulation. This study lays the groundwork for understanding how one's neural response to the reappraisal of negative images into neutral interpretations may differ compared to the reappraisal of positive images into equally neutral interpretations.

One might expect the reappraisal of negative and positive stimuli to be represented differently in the brain, as the reappraisal of negative stimuli appears to be more critical to an individual's mental health. Though the under-regulation of positive emotion may also lead to negative consequences (Cole et al., 1994)—for example, the inability to control one's laughter at a funeral, resulting in disgrace—the under-regulation of negative emotion has been linked to the development of psychopathology more commonly (e.g., ruminative behavior has been shown to be predictive of symptoms of depression and anxiety; Nolen-Hoeksema, 2000). We hypothesize, however, that the viewing of positive and negative images that have been reappraised as neutral will elicit significantly different neural processing than images that were not reappraised. Specifically, we hypothesize that this will be reflected in the ERP data by the size of the LPP, which will be reduced in response to both positive and negative images that are reappraised. Our second hypothesis is that the reappraisal of these images will affect how participants subjectively experience the emotionality of the images several days later. We hypothesize that this will be reflected in the participants' dampened self-reported ratings of their subjective experience of emotional valence and arousal in response to positive and negative images. In summary, with the present research we aim to further our knowledge of the development of emotion regulation and elucidate how the reappraisal of positive and negative stimuli is processed in the brain.

Method

Participants

Fourteen 8-year-old girls (age range: 96 - 108 months; mean age: 100 months) were recruited from a directory provided by the Emory University Child Study Center. This directory catalogs families who have expressed interest in volunteering to participate in research. Participants made three visits to the laboratory, with approximately one week between Sessions 1 and 2, and three to five days between Sessions 2 and 3. The experiment was part of a larger study investigating emotion regulation and memory. To address the current research question, neural responses were recorded during the second session and self-reported emotion responses were collected during the third session. Data collected during other phases of the study are beyond the focus of the present research, and thus will not be discussed. Girls received a small toy at the completion of each session. In addition, participants received a $20 gift certificate as a token of appreciation upon completion of the final session. At the first session the participants gave verbal assent to the researcher, and the guardians gave written informed consent. The research model was reviewed and subsequently approved by the university Institutional Review Board.

Materials

Visual Stimuli. A set of 174 developmentally appropriate emotionally positive, negative, and neutral images was selected primarily from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005) supplemented with images of similar content. Of these 174 images, 156 were used as primary experimental stimuli (52 Negative, 52 Positive, 52 Neutral). In addition, 10 supplemental negative images served as potential replacement images in the case that guardians objected to a negative image from the primary set (see Procedure). Images that the guardians objected to were removed from the stimulus set for the participant and replaced with guardian-approved supplemental images. Eight non-experimental images consisted of five positive pictures that were placed at the end of the ERP presentation and three neutral images that were used during practice trials.

From the set of 156 primary experimental images, four sets of 96 images were generated. Each set consisted of 32 negative, 32 positive, and 32 neutral images. Within each of these categories, 16 images included humans and 16 did not include humans, in order to control for previously reported biases in affective processing of stimuli with humans (Proverbio, Adorni, Zani, & Trestianu, 2009). Furthermore, for each set of 32 experimental images in an emotion category (positive or negative), 16 images were assigned to the matching condition (8 human, 8 non-human) and 16 images were assigned to the reappraisal condition (8 human, 8 non-human). The 32 experimental neutral images were always assigned to the matching condition.

Auditory Stimuli. For each of the 156 primary experimental images, the 10 alternative negative images, and the three neutral practice images, audio recordings of corresponding narratives were created (range: 8-17 words, 4.5-7 seconds). For each of the 52 primary negative, 10 supplemental negative, and 52 positive images, two kinds of narratives were recorded. In one kind, the narratives described the scene in a way that matched the emotional content of the picture (matching condition), and in the other kind, the narratives described the scene in a way that reappraised the positive or negative scene in a neutral way (reappraisal condition). An example of a negative scene used in the experiment is the image of a car wreck. This negative scene was accompanied by a negative story in the matching condition (“This was a very bad car accident; they're checking if the driver is ok”), and a neutral story in the reappraisal condition (“This car was destroyed for a movie set; no one was inside”). Neutral images were always accompanied with neutral stories. The narratives were recorded as .wav files and played to the participants through speakers attached to the computer that was used to present the visual experimental stimuli. A full list of narratives is available in the Appendix.

Self-Assessment Manikin. An abbreviated version of the Self-Assessment Manikin (SAM; Bradley & Lang, 1994) was employed to measure participants' subjective experience of a 24-item subset (8 positive, 8 negative, 8 neutral) of the 96 images presented to them in the second session. The SAM includes two 5-point scales (ranging from 1-5)—one measuring valence (level of pleasantness or unpleasantness; Figure 1) and another measuring the level of emotional arousal that participants felt while viewing each image (Figure 2). Each scale was represented by line drawings of a human-like character depicting varying levels of emotional valence or arousal. The valence scale was comprised of images of the line-drawn character feeling very bad (rated 1), moderately bad (2), neutral (3), moderately good (4), and very good (5). Likewise, the arousal scale was made up of images of the same figure feeling very calm (1), moderately calm (2), neither aroused nor calm (3), moderately emotionally aroused (4), and very emotionally aroused (5).

Procedure

Before participants visited the laboratory, thumbnails of the 174 images were sent to guardians of the participants for their approval prior to use in the study.

Session 2: Neural Responses. Participants were fitted with an elastic Advanced Neuro Technology (A.N.T.) Waveguard EEG cap containing 32 shielded electrodes. To ensure that electrodes were properly configured on the scalp, participants were fitted with a cap sized appropriately according to their head circumference. The 10/5 system, an adaptation of the International 10/20 system (Jasper, 1958) was employed to determine the placement of the electrodes. Impedances were kept under 10 kΩ, with most falling under 5kΩ. The sampling rate was 256 Hz. The EEG signal was amplified 20,000 times with an A.N.T. amplifier. Two of the electrodes sewn into the cap were designated as mastoid electrodes. The mastoid electrodes rest over the mastoid bones (directly behind each ear) from where theoretically there is no brain activity. These electrodes are thus used as reference points. Data were mathematically referenced online to the common reference (average activity of all active sites) then re-referenced offline to the mathematically-averaged mastoids.

Prior to the presentation of the image set, the experimenters explained the subsequent task to participants. Participants were instructed to "Listen to the stories and think of the pictures that go along with the stories." Researchers had the participants engage in practice trials until they fully understood the directions and were ready for the experimental trials. The practice trials consisted of the viewing of neutral images that were not used during the testing phase.

Participants were seated approximately 24 inches away from the computer monitor upon which images were presented. The room lights were off during the presentation. The monitor was surrounded by a dark curtain so that participants could not see anything other than the screen. Participants viewed 96 emotionally positive, negative, and neutral scenes while EEG data were recorded. Across the four 96-image sets, each image was presented approximately equally often. In addition, the four sets were counterbalanced to ensure that each positive and negative image was used in both reappraisal and matching conditions equally across participants. Two randomized orders were generated for each of the four sets, resulting in a total of eight ordered sets. The eight randomized presentation orders were adjusted so that no more than two images of the same emotion appeared in a row, no more than two images in the reappraisal condition appeared in a row, and no more than five images in the matching condition appeared in a row. Each participant was randomly assigned to one of the eight presentation orders.
Images encompassed the entire monitor screen and were presented in color. Each scene was displayed initially for 2000 ms. This display was followed by the presentation of a blank screen

with only a fixation cross while a recorded audio narrative lasting approximately 4500-7000 ms was simultaneously played back through speakers. Subsequently, the original scene was presented again for 2000 ms. This 3-step presentation process for each image constituted one trial. Between each trial, there was an 800-1200 ms inter-stimulus interval (ISI). EEG activity was time-locked to the second 2000 ms viewing of each image.

Session 3: Self-Reported Emotion Responses. These data were collected from 12 participants, as two participants whose ERP data were included did not complete the SAM ratings. Participants were asked to rate their subjective experience of valence and arousal for each of the 24-item subset (8 positive, 8 negative, 8 neutral) of the 96 images presented in the first session. Only 24 images were used in the collection of SAM ratings to keep participant burden at a low level. Participants were shown each image and were asked to point to one of the five pictorial representations on the valence and arousal SAM scales. The experimenters explained the meaning of these representations thoroughly to participants before they proceeded to rate the images. Participants engaged in 1-2 practice trials in order to demonstrate understanding of the task. The images used during the practice trials were not used during the testing phases.

ERP Data Reduction

The EEG data were filtered with a bandpass filter excluding frequencies below 0.1 and beyond 30 hertz. By filtering out extremely low or high frequencies, data most likely resulting from environmental noise and non-neural activity was excluded. Eye-blink artifacts were identified and removed from the data using Independent Component Analysis (ICA) in the computer programs EEGLAB 6.03b (Delorme & Makeig, 2004; http://www.sccn.ucsd.edu/eeglab) running under the software MATLAB 7.7.0 (The MathWorks

Inc., 2010). After eye-blink artifacts were removed, continuous EEG data were divided into 2200 ms epochs beginning 200 ms before and ending 2000 ms after stimulus onset. To correct for any changes over time of the baseline EEG response, the average EEG data from the 200 ms prior to each trial was subtracted from the total activity in each epoch. In addition, trials that included data exceeding ± 200 μV (e.g., muscle movements) were excluded. Averaged waveforms were then constructed for each condition (positive-reappraisal, positive-matching, negative-reappraisal, negative-matching, neutral). All data reduction steps after eye-blink artifact removal were undertaken using the ERPLAB toolbox (http://erpinfo.org/erplab**)** running under MATLAB 7.7.0.

ERP Data Analysis

Averaged ERP data were divided into three time windows and grouped into four clusters of interest based on previous literature (Dennis & Hajcak, The late positive potential: a neurophysiological marker for emotion regulation in children, 2009) and visual examination of the ERP waveforms. The time windows were defined as follows: early: 300-800 ms; middle: 800-1400 ms; late: 1400-2000 ms. The four clusters were demarcated by hemisphere (left-right) and region (anterior-posterior). Clusters were defined as the following groupings of electrode sites: left anterior cluster: F7, F3, FC5, and FC1; right anterior cluster: F8, F4, FC6, FC2; left posterior cluster: T7, T3, CP5, CP1; right posterior cluster: T8, T4, CP6, CP2. The clusters and time windows selected for analysis are illustrated in Figures 3 and 4, respectively. Latency to peak amplitude was used to measure the temporal dynamics of the neural response for averaged ERP data in the early window for each of the four clusters. Mean amplitude measures were used to determine the size of the neural response in each of the three time windows and for each of the four clusters. All statistics were computed using SPSS (Version 19.0).

Results

Event-Related Potentials

The neural responses to the viewing of images in each of the emotion conditions are represented in Figures 5-8. These figures display the mean amplitudes as ERP waveforms, averaged across all participants at each of the four clusters of electrodes selected for data analysis. A 5 (emotion condition: negative reappraisal, negative matching, neutral, positive reappraisal, positive matching) x 2 (hemisphere: left and right) x 2 (region: anterior and posterior) x 4 (cluster site) repeated-measures analysis of variance (ANOVA) was conducted on ERP data from 14 participants. Latency to peak amplitude was analyzed in the early window, and mean amplitude was analyzed in early, middle, and late windows. Since this study is focused on neural and subjective responses to the reappraisal of positive and negative pictures, only the main effects and interactions relating to emotion condition are reported below. All significant results ($p < .05$), and results trending towards significance ($p < .10$), are included. Non-significant effects have been included to take into account this study's relatively small sample size, which may be masking effects that would be significant at larger sample sizes. Multiple posthoc comparisons were adjusted for with Bonferroni corrections. Greenhouse-Geisser corrections were applied for all violations of assumptions of sphericity.

Early Time Window (300 – 800 ms). A main effect of condition was not observed for latency to peak measures in the early window. There was, however, an interaction of Condition x Hemisphere x Anterior-Posterior regions that approached significance ($F(4, 52) = 2.99$, $p = .070$, $\eta^2 = .187$). To follow up this interaction, 5 (condition) x 2 (hemisphere) repeated-measures ANOVAs were calculated at each anterior-posterior region. A main effect of condition was not observed at either region. However, these analyses revealed a significant interaction of

Condition x Hemisphere in the anterior (*F*(4, 52) = 2.88, *p* = .032, η^2= .181) region, but not at posterior sites. To follow up this interaction at anterior sites, one-way repeated-measures ANOVAs with a 5-level factor of condition were calculated in each hemisphere in the anterior region. No main effects of condition were observed at either hemisphere.

In the analysis of mean amplitude in the early window, condition was found to significantly modulate mean amplitude *F*(4, 52) = 3.24, *p* = .019, η^2= .200. No significant interaction effects involving condition were observed. Posthoc pairwise comparisons revealed a significant difference in mean amplitude (*p* = .018) between positive reappraisal (*M* = -9.98, *SEM* = 2.35) and neutral conditions (*M* = -15.75, *SEM* = 2.36). No other pairs of conditions differed significantly. Thus, in the early window our significant findings were that positive pictures reinterpreted with neutral stories elicited a significantly larger, more positive-going neural response than neutral pictures that were accompanied by neutral stories.

Middle Time Window (800 – 1400 ms). There was a main effect of condition for mean amplitude in the middle window *F*(4, 52) = 5.78, *p* = .001, η^2= .308. No significant interaction effects involving condition were observed. Again, posthoc pairwise comparisons indicated a significant difference in mean amplitude (*p* = .021) between positive reappraisal (*M* = 1.42, *SEM* = 2.12) and neutral (*M* = -5.74, *SEM* = 1.73) conditions. There were no other significant differences between conditions, although the difference between neutral and negative reappraisal (*M* = -3.04, *SEM* = 1.90) approached significance (*p* = .065). Thus, in the middle window we observed findings consistent with our results in the early time window, with reappraised positive pictures eliciting a significantly larger neural response than neutral pictures that were accompanied by neutral stories.

Late Time Window (1400 – 2000 ms). Unlike the early and middle windows, a significant main effect of condition was not found for mean amplitude in the late window, although this main effect approached significance ($F(2.27, 52) = 2.66$, $p = .080$, $\eta^2 = .170$). Posthoc pairwise comparisons confirmed that there were no significant differences between conditions.

SAM Ratings

One-way repeated-measures ANOVAs with a 5-level factor of condition were calculated to examine differences in the self-reported ratings of valence and arousal from 12 participants. Greenhouse-Geisser corrections were applied for all violations of assumptions of sphericity. Mean scores of valence and arousal are presented in Figures 9 and 10.

Valence. As expected, the analysis of ratings of emotional valence revealed a significant main effect of condition ($F(1.879, 44) = 37.18$, $p < .001$, $\eta^2 = .772$). Posthoc pairwise comparisons indicated significant differences ($p < .05$) between all but two pairs of conditions (negative matching and negative reappraisal; positive matching and positive reappraisal). These results show that positive, negative, and neutral stimuli differed significantly in their levels of subjective pleasantness or unpleasantness. However, the experimental conditions (i.e., matching and reappraisal) within each emotional valence (i.e., positive and negative) did not significantly differ in how pleasant or unpleasant they were rated.

Arousal. Subjective ratings of emotional arousal, as with valence, differed significantly as a function of condition $F(4, 44) = 7.18$, $p < .001$, $\eta^2 = .395$. Posthoc pairwise comparisons revealed that pictures in the positive matching ($M = 4.33$, $SEM = 0.16$) condition were rated significantly more arousing ($p = .002$) than neutral pictures ($M = 2.88$, $SEM = 0.30$). The ratings of pictures in the positive matching condition were also significantly more arousing ($p = .035$

and *p* = .028, respectively) than the ratings of pictures in the negative matching (*M* = 3.17, *SEM* = 0.29) and negative reappraisal (*M* = 3.08, *SEM* = 0.31) conditions. In addition, positively reappraised (*M* = 3.92, *SEM* = 0.18) pictures were rated significantly more arousing (*p* = .016) than neutral pictures. No other pairs of conditions significantly differed with respect to their emotional arousal ratings. These results indicate that positive pictures were generally rated as more emotionally arousing than negative or neutral pictures, with positive pictures that were not reappraised having been rated significantly higher in arousal than negative pictures in the matching or reappraisal conditions. Neutral pictures received the lowest arousal ratings, though only pictures in the positive matching and positive reappraisal conditions were rated significantly more arousing.

Discussion

The present research examines the neurophysiological substrates of reappraisal in school-age girls, in order to gain insight into the development of emotion regulation strategies in populations at risk for disorders that feature elements of emotion dysregulation. Our study was only the third ERP study in the literature to investigate the neural mechanisms underlying the reappraisal of negative stimuli in children. In addition, this study was the first to measure the neural correlates of the reappraisal of positive stimuli. We predicted that positive and negative pictures that were reappraised with more neutral interpretations would elicit significantly different neural responses in comparison with positive and negative pictures that were not reappraised. We also predicted that these differences would be manifested as modulations of the LPP, whereby images in the reappraisal condition would produce a reduced LPP when compared to images in the matching condition. We predicted that this reduction of the LPP would correspond with dampened SAM ratings of the emotional valence and arousal of the reappraised images, when compared to those in the matching conditions.

In contrast to our predictions, we did not find significant differences in the neural responses to reappraisal and matching conditions—the only emotion conditions to differ significantly were the neutral and positive reappraisal conditions in the early and middle time windows. Also, our pattern of findings did not reveal the presence of an LPP—that is, there was no significant difference in the overall neural response to emotional versus neutral pictures. Therefore, our results failed to replicate findings from the two previous ERP studies of reappraisal in children: Dennis and Hajcak (2009), who found an LPP that was modulated by the reappraisal of negative pictures, and DeCicco et al. (2012), who found an LPP that was not significantly affected by the reappraisal of negative pictures. Furthermore, though positive and negative pictures in the reappraisal condition were rated as marginally lower in arousal and marginally more neutral in valence than positive and negative pictures that were not reappraised, these results were not significant.

Our experimental design, which extended the paradigm used by Dennis and Hajcak (2009) to include positive stimuli in addition to negative stimuli, may have contributed to our failure to replicate. We speculate that having to reinterpret positive pictures in a neutral way may have had an overriding effect on the way participants experienced all emotional stimuli throughout the viewing session, resulting in the absence of an LPP. Our observed patterns of neural activity could be representative of an unwillingness on the part of participants to reinterpret a positive stimulus as less positive. That is, there may be a greater aversion to an event that is less pleasant than hearing positive stories for positive pictures would be. Alternately, this effect might represent the ways in which the reappraisal of emotional pictures interacts with expectation. As the down-regulation of negative emotion is more vital to functioning, and a part of both private internal and social external experience, participants may have found negative pictures with neutral stories less unexpected. Participants may have experienced positive pictures with neutral stories as odd or unexpected, since there are fewer occasions in life where individuals must significantly down-regulate positive emotion. Given the more unusual nature of the task, participants may have experienced positive and negative stimuli in a less emotional way. The data from the SAM ratings of subjective emotional experience indicate that positive and negative stimuli were experienced as emotional several days after the reappraisal task. However, these data do not inform the question of whether or not this was the case during the reappraisal task itself.

To better understand why we did not observe an LPP and thus, why our findings diverged from those present in the literature, we consider two avenues of future research. The first of these involves conducting this experiment in future participants using identical procedures as before, but with the exclusion of positive pictures altogether. This experimental method would mirror that of Dennis and Hajcak (2009), and allow for a direct comparison with their findings. If, after modifying the procedure, the results replicate Dennis and Hajcak's, we would be able to rule out significant differences in experimental methods or procedures as an explanation for the lack of an LPP response in our participants. If these results were observed, we would have reason to believe that the presence of positive pictures in our experimental design was the driving force behind the incongruities between our findings and those of previous research.

The second future direction to take in order to tease apart which processes underlie the patterns of neural activity observed in our participants is to examine the ERP data at different phases of the directed reappraisal session. By splitting the data into three sections, each one corresponding to three consecutive 5-minute segments of the approximately 15-minute picture presentation, we will be able to gain some insight into the effect of the task over the course of the session. It could be determined, for example, whether or not participants experienced the reappraisal task as odd or unexpected, based on the size of the neural responses in the first five-minute segment of the session in comparison to that of the second or third. If the significant effects we observed for positive pictures were due to the unexpectedness of having to reappraise them as neutral, we would expect to observe these effects more strongly near the start of the presentation of stimuli. Analyses of these data sets may not be definitive, however, as each segment of the session being analyzed will include a very small number of trials.

Our failure to replicate previous studies that observed an LPP might, however, be due to the possibility that the mental processes our participants experienced during the reappraisal task are fundamentally different in nature from those commonly observed in studies of emotion processing. Although we did not observe the LPP, we did observe different patterns in the processing of positive pictures that had been reappraised with more neutral interpretations when compared to those that were accompanied by a positive story. Specifically, the neural response (i.e., the averaged amplitude of the waveforms) to the reappraisal of positive pictures was significantly larger and more positive consistently across the scalp when compared to neutral controls, while the response to positive pictures in the matching condition was not significantly larger than those in the neutral condition. We did not observe the same effect of reappraisal in negative pictures, although in the middle time window the difference in neural responses to reappraised negative pictures and neutral pictures approached significance.

Why might the patterns of brain activity in response to pictures that were reappraised be significantly different from neutral pictures that were not reappraised for positive, but not negative, stimuli? A possible explanation for these phenomena is that thinking of negative pictures in a neutral way could be experientially distinct from thinking of positive pictures in a neutral way. Although in both cases an emotional stimulus is being reappraised as neutral, the emotional valence of the stimulus appears to be key in explaining the difference in effects. Making a negative stimulus less negative is more appealing, it would seem, than making a positive stimulus less positive. Furthermore, although down-regulating positive emotion might often be necessary for smooth social interactions, down-regulating negative emotions is necessary for both adaptive responses in social situations and successful mood regulation in private. Our results indicated a more radical shift in how the brain processes the reappraisal of positive pictures than in the reappraisal of negative pictures. Furthermore, the significantly higher ERP mean amplitudes in response to positive pictures accompanied with neutral stories suggest that this mental event requires more neural resources and more synchronous neural activation. Future research employing the same paradigm but measuring the neural response to pictures in the reappraisal, matching, and neutral conditions in two separate sessions for negative and positive stimuli would allow for a more definitive explanation.

The results of our study add to those in the literature that form the first foundations of neuroscientific research into the development of reappraisal as an emotion regulation strategy. Our findings were inconsistent with the ERP studies of Dennis and Hajcak (2009) and DeCicco et al. (2012). We did not observe significant differences between the neural response to reappraisal and matching conditions, nor did we observe an LPP as we had predicted. The SAM ratings for reappraised images did not reveal a significant dampening of subjective levels of valence or arousal either, as we had predicted. We did, however, observe significant differences between the neural response to reappraised positive and neutral pictures in multiple time windows, consistent across the scalp. We speculate that the reappraisal of positive stimuli is a fundamentally different experience than the reappraisal of negative stimuli, and that the inclusion of positive stimuli contributed to our failure to replicate. Further research is needed to better understand how the reappraisal of positive stimuli might be processed differently in the brain. With very few studies having been done in children on cognitive emotion regulation strategies such as reappraisal, more research will help shed light on how we regulate emotion, and how emotion regulation develops through our lifespans. Greater knowledge of the neurophysiology of emotion regulation will result in a deeper understanding of emotion dysregulation, and holds the promise of leading to the identification of new biomarkers and strategies for treating related disorders.

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List of Figures

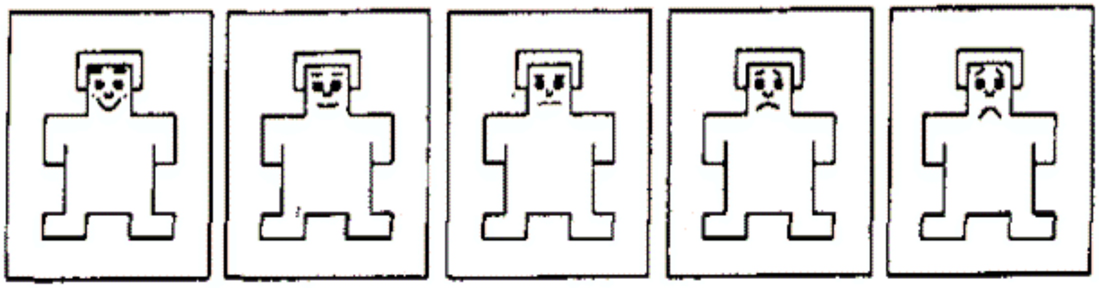

Figure 1. SAM valence rating scale. Representation of scale used to measure participants' subjective levels of emotional valence in response to stimuli (Bradley & Lang, 1994).

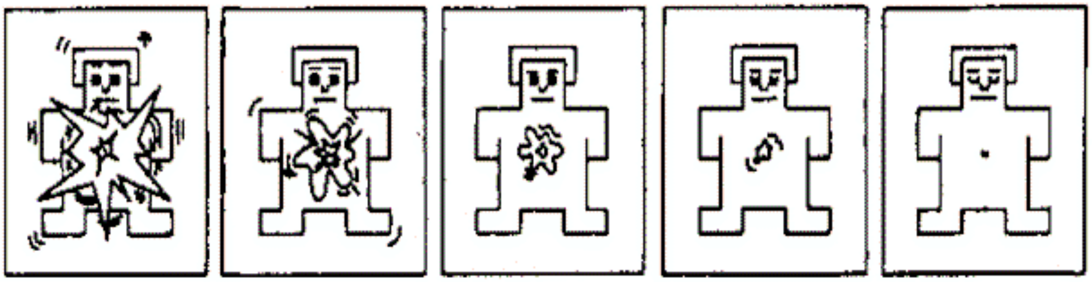

Figure 2. SAM arousal rating scale. Representation of scale used to measure participants' subjective levels of emotional arousal in response to stimuli (Bradley & Lang, 1994).

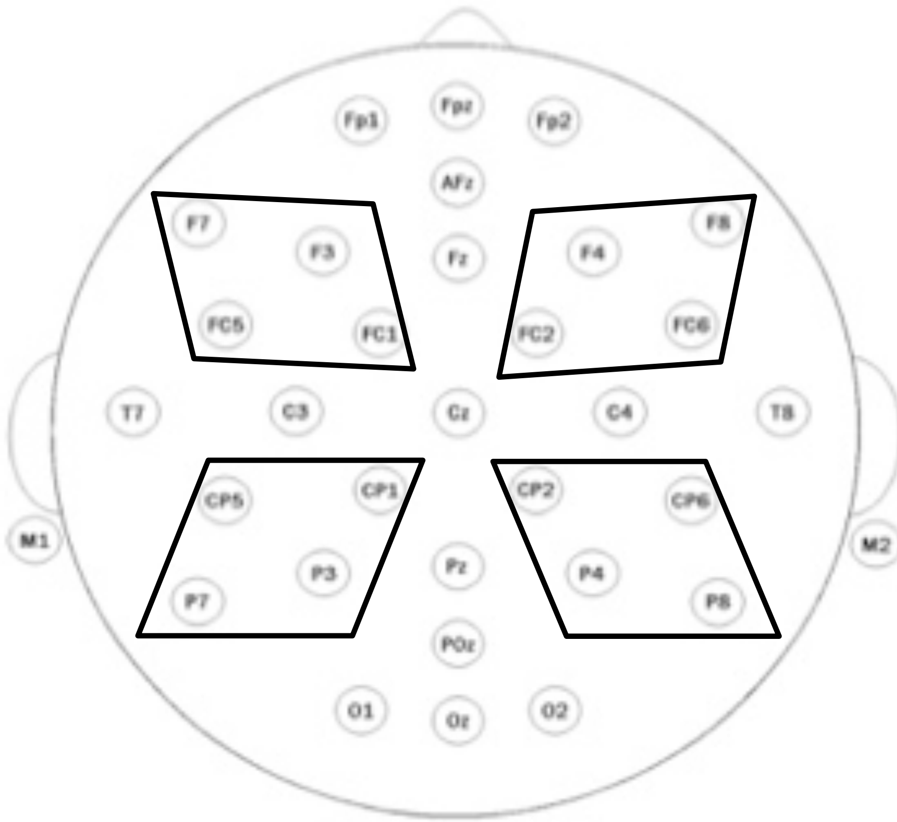

Figure 3. Electrode head plot. Clusters selected for analysis have been highlighted.

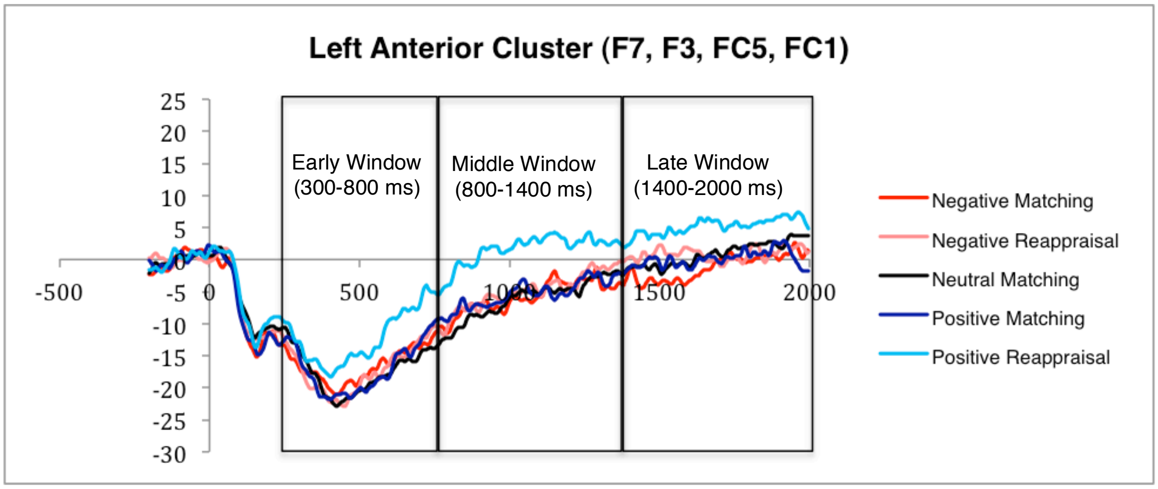

Figure 4. ERP waveforms from the left anterior cluster highlighting the time windows selected for analysis.

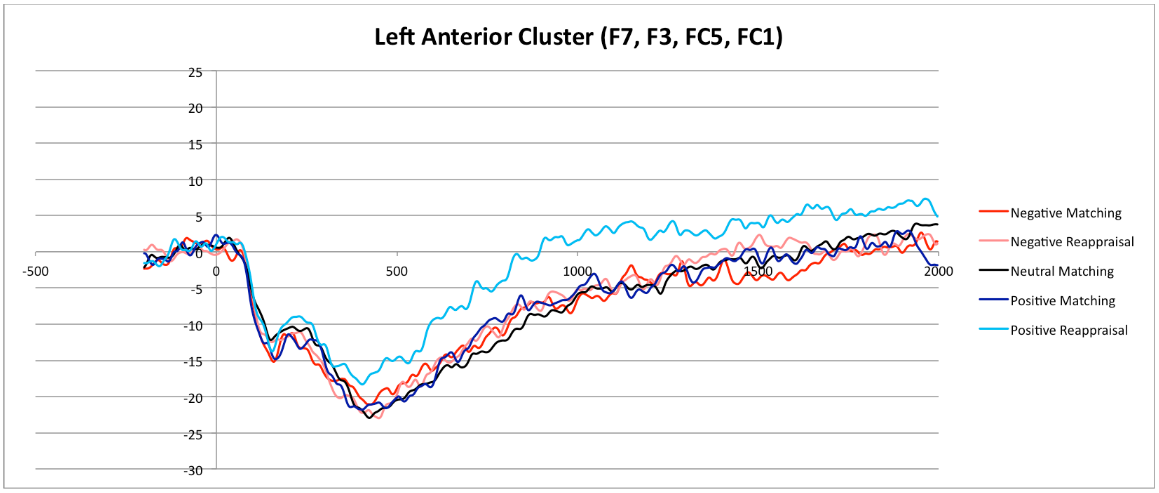

Figure 5. Averaged mean amplitudes (in µVs) of 2000 ms trials, recorded at the left anterior cluster.

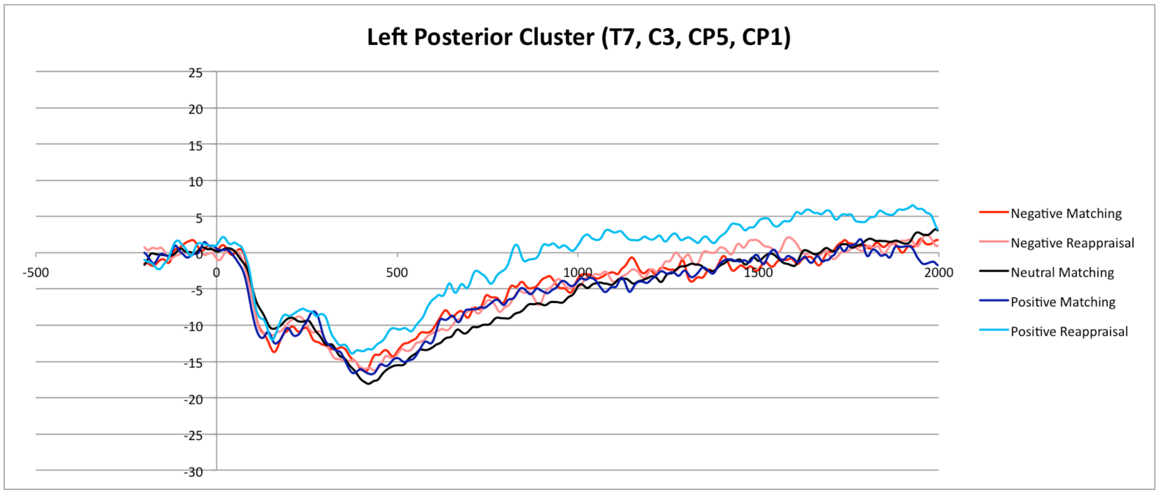

Figure 6. Averaged mean amplitudes (in µVs) of 2000 ms trials, recorded at the left posterior cluster.

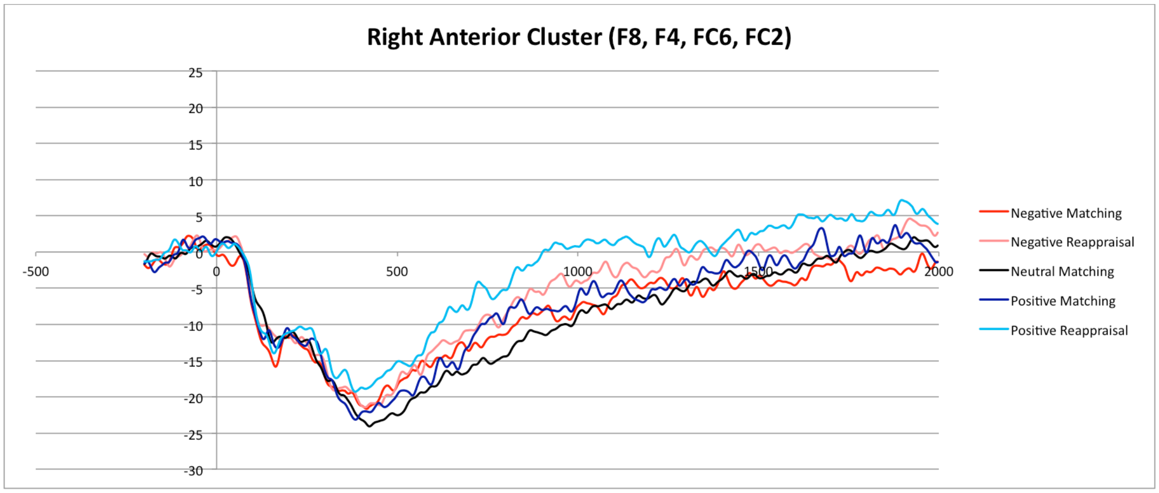

Figure 7. Averaged mean amplitudes (in µVs) of 2000 ms trials, recorded at the right anterior cluster.

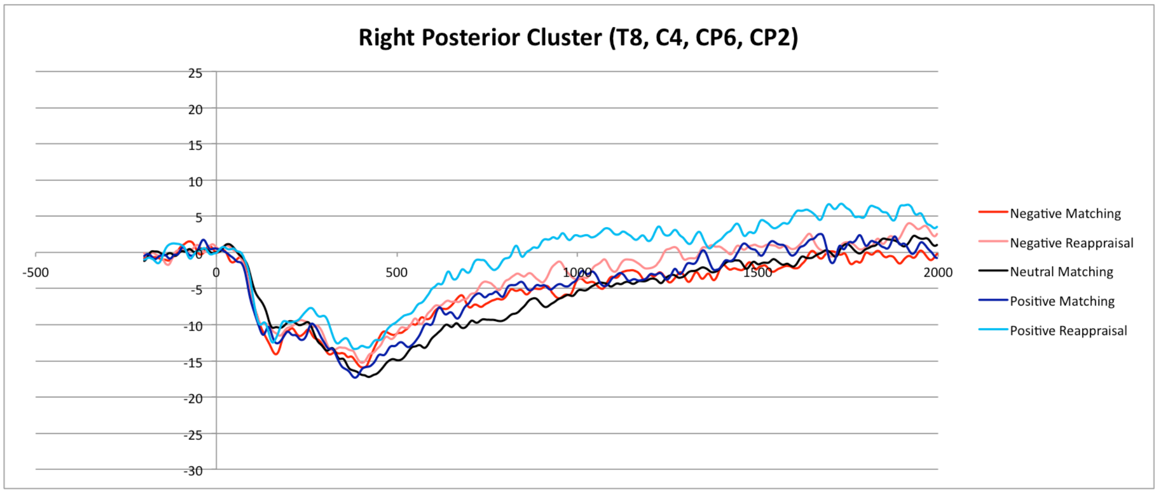

Figure 8. Averaged mean amplitudes (in µVs) of 2000 ms trials, recorded at the right posterior cluster.

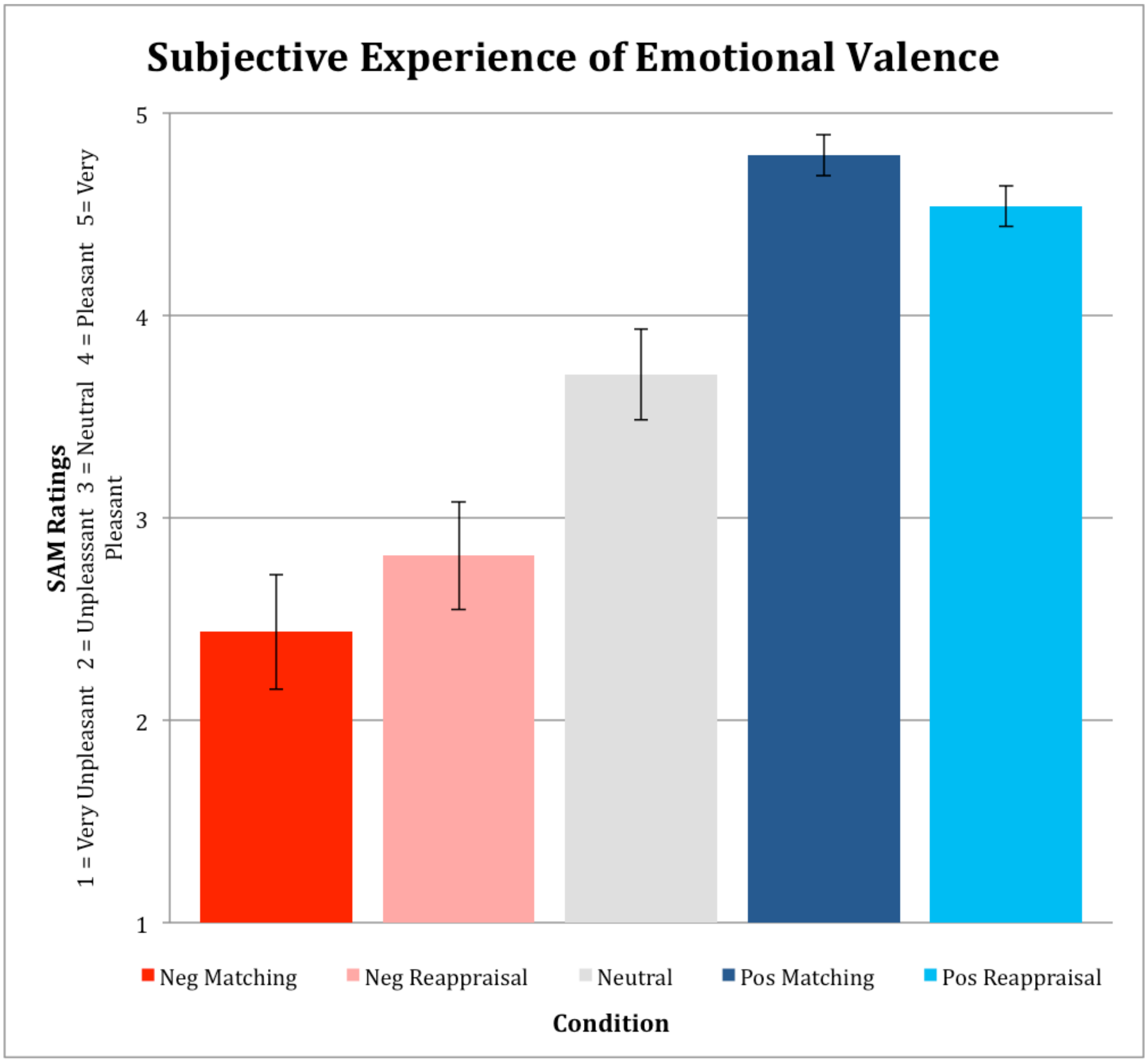

Figure 9. SAM valence ratings. The average valence ratings in response to stimuli from each condition across are participants are displayed in this bar graph.

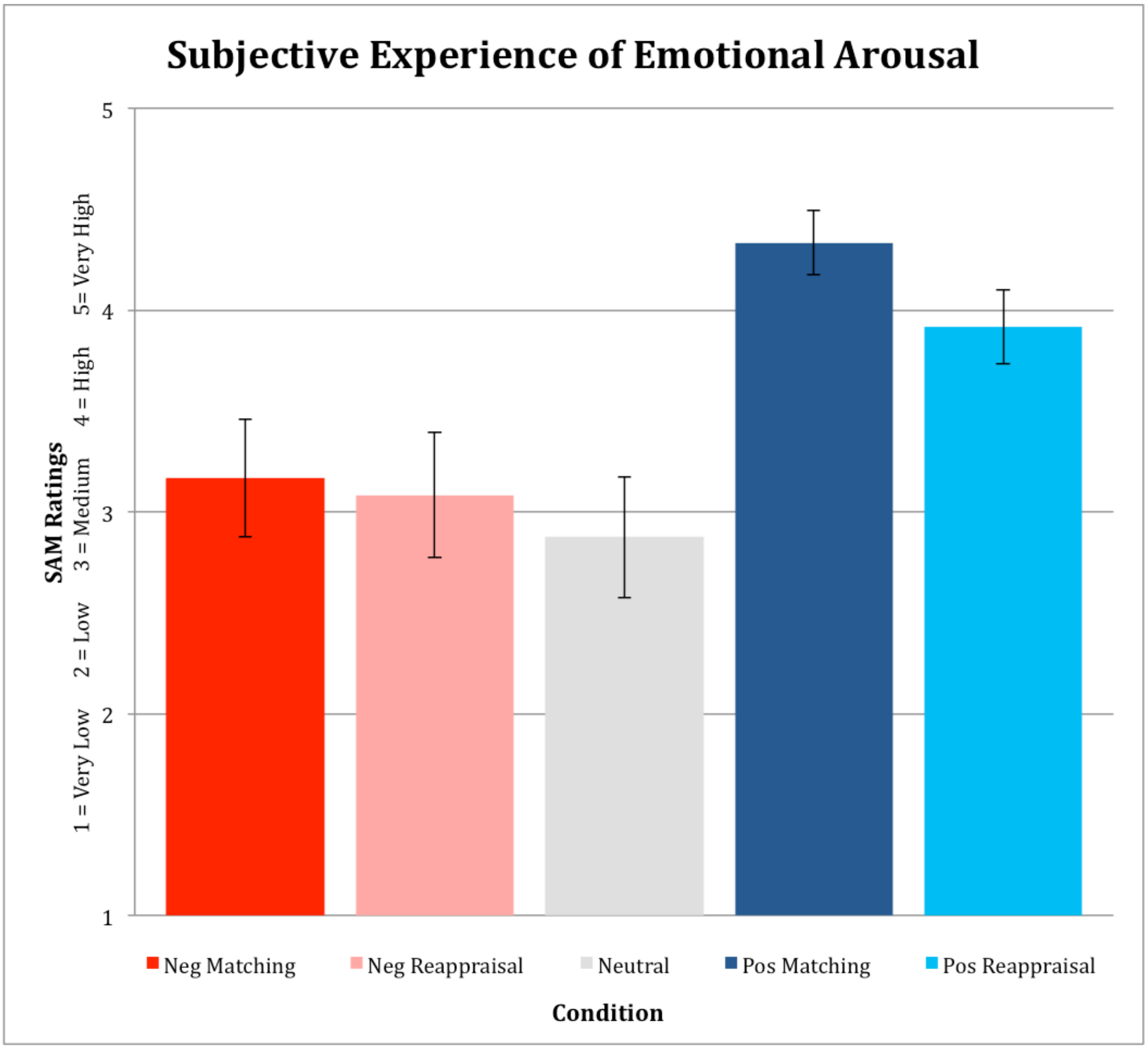

Figure 10. SAM arousal ratings. The average arousal ratings in response to stimuli from each condition across are participants are displayed in this bar graph.

Appendix

Stories accompanying neutral images

Image	Neutral story
ZH01	This farmer is checking to see if the soil is dry to check that his plants are growing.
ZH02	This girl is reading a book for class before she has to go to work.
ZH03	These people are having a cup of tea on their work break.
ZH04	These people are leaving the train station to catch their bus.
ZH05	This girl is completing an assignment for her writing class.
ZH06	This man is looking up information about the electronics on display.
ZH07	These students are brainstorming for a school project.
ZH08	These people are looking at the plans for a building.
ZH09	This mailman is using a mail cart to deliver the mail in the city
ZH10	These people are bringing their groceries back to the car.
ZH11	This boy is watching the bike so nobody steals it.
ZH12	This family is waiting for the school bus to come.
ZH13	This man is trying to figure out how to get to the museum.
ZH14	This man is designing a machine on the computer.
ZH15	This woman is checking her mailbox to see if she got any letters.
ZH16	These people each have their own marble to hold.
ZH17	This woman is cooking dinner to serve at her restaurant.
ZH18	This bus gets crowded when people are on their way to work.
ZH19	This woman is reading a magazine while she waits at the doctor's office.
ZH20	These kids are picking out books to read from the bookshelf.
ZH21	These people are looking at the cacti plants in the greenhouse.
ZH22	This woman is picking up grapes from the grocery store.
ZH23	This person is moving their pawn in a game of chess.
ZH24	These people are shopping for supplies at a hardware store.
ZH25	This man is painting the telephone box red.
ZH26	This woman is on the phone taking a message for her boss.
ZN01	These boats are used to go fishing on the lake.
ZN02	These satellite dishes are used to get television signals.
ZN03	This restaurant is open all day and serves many different types of food.
ZN04	This green staircase leads to the bedrooms upstairs.
ZN05	This wooden structure is very strong and holds the roof up.
ZN06	These potatoes are being sold at the farmer's market.
ZN07	This garage has many useful tools for fixing cars and building furniture.
ZN08	This classroom is empty because school just ended.
ZN09	These school supplies belong to someone in middle school.
ZN10	This globe has a lot of the world's cities written on it.
ZN11	This bike rack has a few spots open for more bicycles.
ZN12	These train tracks lead to a very busy train station and sometimes all the tracks are full.
ZN13	These baskets are used to store fruits and vegetables, but they are empty right now.
ZN14	This bridge is being repaired, so no cars can drive on it yet.
ZN15	This sink was just cleaned and has towels, soap, and tissues next to it.
ZN16	This fence is used to keep small animals from leaving.

ZN17 This abacus is used to do math problems.
ZN18 This fax machine is used to send papers to other offices.
ZN19 These laptops are being used to edit photos.
ZN20 This toy plane was made from a kit and now it hangs from the ceiling.
ZN21 These carvings are part of very old ruins.
ZN22 This fence is to keep animals out of the garden where plants are grown.
ZN23 This bird is looking for bugs in the grassy meadow.
ZN24 These shells come in different shapes and sizes.
ZN25 These vases are made out of clay and are very old.
ZN26 This fire hydrant was just painted yellow so it's easier to see.

Stories accompanying positive images

Image	Positive interpretations	Neutral interpretations
PH01	These football players just won the championship and are celebrating their victory.	These football players just ran out of the locker room to begin warming up for the game.
PH02	These women are on vacation and met some friendly parrots.	There are a lot of parrots at the park and they like to climb on people.
PH03	This couple is going on a bike trip to celebrate their wedding anniversary.	This couple is biking through the park to get to work.
PH04	This skier is jumping to the finish and will win the race.	This skier is practicing for his race and is being careful not to fall.
PH05	This family is having a lot of fun on their rafting adventure.	The rafting trip is over and these people are heading back to the dock.
PH06	This man is dancing and is entertaining a lot of people.	This man has been dancing for a long time and people are starting to leave.
PH07	These students have finally graduated after many years of hard work.	These people are at singing at their weekly choir meeting.
PH08	This boy is amazed after seeing what his friend just learned to do.	These boys are practicing their drills before their dance lesson.
PH09	This baby is excited by the pretty lights flashing on the toy.	This baby is learning how to crawl on top of her blanket.
PH10	This baby is excited to play with a new toy.	This baby is trying to reach for a toy.
PH11	This couple is looking forward to getting married soon.	These people are waiting for their flight at the airport.
PH12	This couple is celebrating their baby girl's birthday with close family.	This couple is talking to their neighbors before going inside.
PH13	This girl just got a Dalmatian as a surprise from her father.	This girl is saying goodbye to her dog before she goes to school.
PH14	These kids are having a great time on their field trip to the beach.	These kids looked up when they heard a helicopter go by.
PH15	These athletes are proud of the medals they just won at the Olympics.	These athletes are stretching during practice at the Olympics.
PH16	This man is enjoying the wind and the waves while windsurfing.	This lifeguard is on patrol in the ocean.
PH17	This boy is celebrating coming in first place in the race.	This boy got a ribbon for participating in the race.
PH18	These girls feel lucky to be so close to the Beluga whales.	These girls are studying the Beluga whales for a school project.
PH19	This person was the lucky winner of a sweepstakes for 400 dollars.	This person is holding fake dollars from a board game.
PH20	This basketball player just won the championship and is very happy.	This basketball player can't wait for the halftime show to end.
PH21	This girl is all dressed up and ready to lead the parade.	This girl is scratching the paint off her face because the parade is over.
PH22	These children are having fun with the	These children are waiting to play at the

	puppies they just got at the fair.	park with their dogs.
PH23	These swimmers are celebrating after winning first place in the competition.	These swimmers are posing for a team photo.
PH24	These girls are having a lot of fun playing in the snow.	These girls want to go inside now after getting snow on their faces.
PH25	These boys are playing a soccer game and their team is winning.	These boys are learning how to play soccer.
PH26	These girls are making delicious lemonade to sell to their neighbors	This girl is making her sister drink the sour lemonade.
PN01	This dog is enjoying the breeze on a nice day.	This dog wishes he could move around outside of the car.
PN02	These beautiful kites are going to fly high in the festival.	These flags tell people where they are allowed to go on the beach.
PN03	These pretty flowers have just bloomed again because its springtime.	This house has many different kinds of trees in the yard.
PN04	This galaxy could be full of many different types of exciting life.	This is what our galaxy looks like from space.
PN05	This place is so pretty that pictures of it are on postcards.	This place is so cold that it is hard for any animals to live here.
PN06	This picture of Earth was taken by one of the very first astronauts on a space mission.	This picture shows the weather patterns on Earth.
PN07	This mother panda learned to feed her child milk from a bottle just like humans.	This mother panda doesn't know how to open the bottle.
PN08	This baby tiger can't wait to go for a ride.	This baby tiger is carefully waiting for food.
PN09	These elephants are helping each other clean one another.	These elephants are touching each other with their trunks.
PN10	This fruit was freshly picked from the farm.	This fruit is made out of plastic and is used to decorate a table.
PN11	This kitten is taking its first few steps.	This kitten can't find anything to eat yet.
PN12	This giraffe is the tallest one at the zoo; everyone likes to watch it.	This is the only giraffe at the local zoo.
PN13	This chocolate tastes really good with the fresh strawberries.	These berries and chocolate were leftover from cooking breakfast.
PN14	This baby polar bear is warm because it is sleeping on its mom.	This baby polar bear is taking a nap.
PN15	This camel is glad that the sun has gone down so it can rest in the cool.	This camel stores water in its hump so it doesn't go thirsty when there's no water outside.
PN16	This koala is happy to be safe with its family.	This koala is looking for food to eat.
PN17	This is a tasty burger that was prepared by the best chef in town.	This burger is on a plate with a pickle and fries.
PN18	This bridge looks very pretty when it is lit	This bridge is the only way to drive to the

	up by the New Year's fireworks show.	island on the other side.
PN19	This baby seal is digging a hole so it can keep itself warm and cozy.	This baby seal is trying to climb back up on the ice.
PN20	These cute puppies are at the park and ready to play.	These puppies are up for adoption at the animal shelter.
PN21	These shiny gold bars are worth thousands of dollars.	These gold bars are kept in a safe.
PN22	This snowman was made by kids who were happy to get the day off at school.	This snowman will eventually melt when it gets warmer.
PN23	These cupcakes are in all different flavors and they all taste great.	These cupcakes have different types of food coloring.
PN24	These little foxes just met and are saying 'hi' to each other.	These foxes are eating their breakfast next to their cave.
PN25	This bird loves to perch on its friend the snowman.	This bird wants to eat the peanuts on the snowman's buttons.
PN26	This silly cat is trying to play the piano.	This cat is trying to smash a bug he spotted on the piano.

Stories accompanying negative images

Image	Negative interpretation	Neutral interpretation
NH01	This man is sad because his wife is very sick and will not get better.	This man's wife is starting to feel better and will be able to go home very soon.
NH02	This boy is very upset and sad because he found out that his pet ran away.	This boy's dad picked him up after he fell; he got scared, but is totally okay.
NH03	This girl is watching a scary movie and is afraid to watch.	This girl was watching TV but got tired and fell asleep.
NH04	All of these men are injured and some of them won't be able to walk again.	These men are waiting to see a doctor who will help them be able to walk again.
NH05	This soldier is sad because he and his friends were hurt in the war.	This soldier is so happy he is crying; the war is over and he is going home.
NH06	This was a very bad car accident; they're checking if the driver is ok.	This car was destroyed for a movie set; no one was inside.
NH07	This family is stuck in a flood and they are trying to get help.	This family is at the beach and they are waiting for a wave to come.
NH08	This boy just fell and scraped his knee.	This boy just woke up and he is yawning.
NH09	This is a dangerous fish with large, sharp teeth.	This is a fish at the market and cannot bite anyone.
NH10	There was a very heavy storm that flooded this man's house and his neighborhood.	A pipe broke in this man's house and he is emptying the water out the window.
NH11	This boy is having a cavity filled; he is in a lot of pain.	This boy is having his teeth cleaned; it feels funny but doesn't hurt.
NH12	This family is sad because their friend just passed away.	This couple is remembering all the good memories they had with their friend.
NH13	This car slipped off the road and is falling down the cliff.	This car is being safely pulled back onto the road.
NH14	These girls are being chased by a large hungry shark.	These girls just jumped off of their inflatable shark float.
NH15	These scary people are hiding in the dark.	These boys are wearing masks for a Halloween party.
NH16	These are yucky toes with fungus under the nails.	These toenails are about to be clipped and painted.
NH17	This woman is crying because her son was lost in the war.	This woman is upset about the war, but relieved that her son is ok.
NH18	These women are being hit by the policemen.	These women are being protected by the policemen's shields.
NH19	This man is about to eat a very poisonous sea animal.	This man is eating his favorite food and it is very tasty.
NH20	This boy is crying because his parents are fighting.	This boy just bumped his head and is holding an ice pack on it to feel better.
NH21	These girls played very badly and lost the soccer championship.	These girls are humming their team song for good luck before their soccer game.
NH22	These women are very angry about the election.	These women are full of emotions because the war is finally over.

NH23	This boy is very angry and frustrated because he is not allowed to play.	This boy is playing 'hide and seek' and is yelling 'ready or not here I come'.
NH24	These boys have to work in the factory and don't ever get to play.	These boys got to miss school and go to work with their dad for a day.
NH25	This man went to jail for biting people with his fangs.	This man dresses up like a tiger for a carnival show.
NH26	This bull is very angry and he is chasing after the man.	This man is challenging his lazy bull to a race.
NH27	This boy is sad because his father is leaving to go to another country.	This mother is holding the boy tight to keep him warm in the wintertime.
NH28	This building where many children went to school is burning down.	This structure was blown up on the set of an action film.
NH29	This woman is upset because the fish are dying from a disease.	This woman is relieved that there are a lot of fish to eat this fishing season.
NH30	These men are very sad because one of them dropped the baton in the relay race.	These men are exhausted after finishing the very long race.
NH31	This girl is at the doctor who is about to give her a shot.	This girl just swallowed a piece of ice and it feels very cold in her tummy.
NN01	This is a poisonous snake that is very dangerous.	This is a snake that is completely harmless; it doesn't even have teeth.
NN02	This is a picture of Jaws, a shark that has eaten many people.	This is a trained shark whose keeper is feeding him a fish.
NN03	This cruel turtle is slowly torturing the worm before eating it.	This turtle picked up the worm she found on the ground.
NN04	This terrible storm has destroyed many people's homes.	This storm is dying away; it is harmless and everyone is safe.
NN05	These disgusting bugs are crawling all over the food and ruining it.	These bugs are eating the delicious leftover pizza.
NN06	This disgusting garbage is right on the side of the road and smells awful.	This trash is about to be recycled so that it doesn't harm the environment.
NN07	This car flipped over and the driver is stuck inside.	This old car is at the junkyard, and people can use its parts to fix their cars.
NN08	This is a wild, dangerous dog that will attack anyone.	This dog just went to the dentist- look how clean her teeth are.
NN09	These are giant bugs that eat away at the foundations of houses.	These bugs are in a glass tank as part of an exhibit at the museum.
NN10	This moldy bread would make anyone who eats it sick.	This bread was baked with blue food-coloring, but it didn't mix properly.
NN11	This food that has been left out will attract a bunch of cockroaches.	These are the dishes that are leftover from dinner.
NN12	This was a terrible plane crash; people got badly hurt.	Luckily, everyone was okay after the plane crash.
NN13	This explosion happened suddenly; many people were badly burned.	This was the result of a wildfire; everyone was able to evacuate in time.
NN14	This building was rotting and	This old building was knocked down;

	completely fell apart; the family cannot live there anymore.	everyone was happy to see it go.
NN15	These scary masks were made from the heads of fierce animals.	These beautiful masks were made by a skilled artist.
NN16	These dangerous baboons have very sharp teeth that they use to attack other animals.	These baboons are making calls to their children, telling them they have found food.
NN17	These dirty cockroaches were found in a person's bed.	These different kinds of insects are on display in a museum.
NN18	These seagulls are eating dangerous trash that will damage their stomachs.	These seagulls have found a lot of good food that people have thrown out.
NN19	This ship is sinking and many people are drowning.	Another ship came just in time to save all these people; everyone will make it.
NN20	This dog will not be able to walk without limping.	This dog is making a quick recovery and will be able to play fetch soon.
NN21	These vicious fish are known to attack people bathing in rivers.	These fish will be enough to feed a hungry family.
NN22	This bear is hungry and might attack people.	This bear is on the endangered species list and is protected in a national wildlife reserve.
NN23	This house was wiped out by the hurricane, and its owners lost everything.	This house survived the storm because of how well it was constructed.
NN24	This jack-o-lantern is rotting away and covered in bugs.	This little jack-o-lantern was made from a baby pumpkin
NN25	This plane dumped poisonous pesticides and killed everything in the forest.	This plane is dropping water to put out the wild fire.
NN26	This bat bit someone and infected them with a deadly disease.	This bat stays in the cave most of the time and is harmless to humans.
NN27	This gross centipede is very slimy and is making a mess all over the desk.	This centipede is about to climb out the window to live outside
NN28	This strawberry has gone rotten and will make whoever eats it sick.	This strawberry can still be used for its seeds to grow more strawberries.
NN29	This dog is stronger than the other and will badly hurt it.	These dogs are playing with each other by the river.
NN30	This car is floating away in the flood with the driver inside.	This car will be able to drive again once the water drains.
NN31	This explosion was very large and destroyed many cities.	This explosion was part of a test; it happened in the middle of an empty field.