Socio-emotionally Significant Experience and Children's Processing of Irrelevant Auditory Stimuli

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Abstract

Theory and research indicate considerable influence of socio-emotionally significant experiences on children's functioning and adaptation. In the current study, we examined neurophysiological correlates of children's allocation of information processing resources to socio-emotionally significant events, specifically, simulated marital interactions. We presented 9- to 11-year-old children (n = 24; 11 females) with 15 videos of interactions between two actors posing as a married couple. Task-irrelevant brief auditory probes were presented during the videos, and event-related potentials (ERPs) elicited to the auditory probes were measured. As hypothesized, exposure to higher levels of interparental conflict was associated with smaller P1, P2, and N2 ERPs to the probes. This finding is consistent with the idea that children who had been exposed to more interparental conflict attended more to the videos and diverted fewer cognitive resources to processing the probes, thereby producing smaller ERPs to the probes. In addition, smaller N2s were associated with more child behavior problems, suggesting that allocating fewer processing resources to the probes was associated with more problem behavior. Results are discussed in terms of implications of socio-emotionally significant experiences for children's processing of interpersonal interactions.

Key words: socio-emotionally significant experiences, children, event-related potential (ERP), probe ERP paradigm, adjustment problems

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1. Introduction

Emotionally significant events elicit changes in multiple biological systems that facilitate responding (Panksepp, 2008). These changes alter attentional and perceptual processes involved in processing of incoming stimuli (LeDoux & Phelps, 2008). Processing of information about emotion has been shown in children to be influenced by past social experiences (Pollak et al., 2005; Susman, 2006). Further, children's relatively limited capacities to process emotion information (Pollak & Fries, 2001) may mean that previous social experiences are particularly important influences on children's allocation of information processing resources during emotionally significant interpersonal interactions. Children's experiences with the relationship between their parents, as one type of socio-emotionally significant experience, have important implications for child functioning and adaptation, particularly when the interparental relationship is high in conflict (Davies & Cummings, 2006). Yet little is known about the influence of children's exposure to interparental conflict on children's allocation of information processing resources when observing interpersonal interactions.

Measuring ERPs generated to task-irrelevant auditory probes during presentation of ongoing stimuli, the probe ERP paradigm, enables examination of information processing capacity (Shucard et al., 1977). In the current study, we used the probe ERP paradigm to examine children's allocation of information processing resources while they viewed simulated interpersonal interactions. We tested associations between measures of children's exposure to interparental conflict and the ERPs. Previous studies have shown that interparental conflict is a highly significant experience for children. For example, out of a list of twenty events identified by children as particularly distressing, children ranked interparental conflict as the third most distressing (Lewis et al., 1984). Moreover, witnessing interparental conflict is a common experience for children, with nearly 89% of children in one community sample witnessing at least one conflict between their parents in a typical 15-day period (Cummings et al., 2003). In addition, interparental conflict predicts children's adjustment problems (Davies & Cummings, 2006). Thus, given the significance and prevalence of children's experiences with interparental conflict, in the current study, we presented children with short videos of interactions between two actors posing as a married couple. We measured children's exposure to interparental conflict and tested its relation to ERPs generated to task-irrelevant auditory probes presented during the videos. In addition, we tested associations between the probe ERPs and child adjustment problems, in order to link children's processing of interpersonal interactions with children's functioning.

Theoretical models have linked children's executive functioning with children's family-related experiences (Jouriles et al., 2012), and recent studies have begun to examine associations between family relationships and children's emotion-related information processing. For example, Briggs-Gowan et al. (2015) found that children whose mothers reported high levels of intimate partner violence showed attention biased toward happy faces on the dot-probe task. However, studies thus far have not determined whether children's exposure to interparental conflict is associated with children's allocation of information processing resources while viewing interpersonal interactions, which is the focus of the current study.

1.1 Auditory Probe ERP Paradigm

Ongoing task engagement limits the capacity to process information about additional incoming stimuli, resulting in a decrease in processing efficiency (Wickens et al., 1983). Thus, the rationale underlying the auditory probe ERP paradigm is that the cognitive resources required to complete the ongoing task reduce the efficiency of neural systems to process the auditory probes, resulting in smaller probe ERP amplitudes, particularly during high-load cognitive tasks (Papanicolaou & Johnstone, 1984; Suzuki et al., 2005). If the probes are not relevant to the task (referred to as a task-irrelevant probe ERP paradigm), the task itself is unaltered, enabling examination of information processing as a function of characteristics of the task (Kramer et al., 1995).

This paradigm also enables allocation of information processing resources to be examined as a function of potentially relevant differences between individuals (e.g., Everhart et al., 2004), including differences in exposure to socio-emotionally significant experiences. Advantages of this approach compared with many commonly used ERP tasks include its versatility and applicability to activities that have ecological validity (Papanicolaou & Johnstone, 1984). For example, probe ERP paradigms can be utilized while videotaped dynamic stimuli are presented, enabling the researcher to portray events in a more naturalistic and contextualized way than, for example, static pictures.

1.2 ERP Components and Findings from Probe ERP Studies

Several ERP components are conceptually relevant to the current investigation. The P1 and N1 ERPs are thought to reflect attentional processes associated with early sensory processing (Key et al., 2005). For auditory stimuli, the P1 peaks as early as 50 milliseconds (ms) post-stimulus onset, the N1 peaks around 100 ms post-stimulus onset, and both have peaks at several scalp electrode sites, including the central scalp (Key et al., 2005). Following P1 and N1, the P2 is a positive-polarity ERP that peaks around 200 ms post-stimulus onset in adults, with a parieto-occipital scalp distribution (Finnigan et al., 2011). The P2 has been linked with later sensory processing, attention, and feature detection (Key et al., 2005). The N2 is a negative-polarity ERP that occurs around 200 - 350 ms post-stimulus onset in adults (Folstein & Van Petten, 2008), and is thought to reflect orienting and stimulus discrimination (Key et al., 2005). Frontocentral scalp-centered N2 has been linked most consistently with detection of novel stimuli and with cognitive control and inhibitory processes, whereas a parietal scalp-centered N2 has been associated with aspects of deploying attention (Folstein & Van Petten, 2008). The P3 is a positive-polarity ERP with nominal latencies of 300 ms or later in adults (Fabiani et al., 2007). Separate P3a and P3b components can be distinguished, with a frontocentral P3a reflecting orienting of attention, and a centroparietal P3b (often referred to as the P3) reflecting stimulus discrimination and categorization (Key et al., 2005; Polich, 2007).

In previous studies, ERP amplitudes were smaller during more difficult tasks than during easier ones, with studies showing this pattern for various ERP components, specifically the N1, N2, MMN, and P3 (Kramer et al., 1995), the N1, P2, P3 and late positive potential (LPP) (Miller et al., 2011), the P3a (Harmony et al., 2000), and the P3 (Wickens et al., 1983). Using this approach to examine processing of a variety of video clips and still images, Suzuki et al. (2005) found smaller P3 amplitudes when participants viewed interesting video clips than when they viewed neutral videos or still images.

Applying the probe ERP paradigm to emotional and neutral stimuli, in one study, participants heard tones while they viewed pleasant, unpleasant, and neutral photos (Cuthbert et al., 1998). Participants generated smaller P3s to tones presented while they viewed emotional photos (pleasant or unpleasant) than to tones during neutral photos. Cuthbert et al. interpreted this finding as suggesting that, compared to neutral cues, more attention is directed to emotional cues because of their greater significance for adaptive functioning. In one of the few studies to use the probe ERP paradigm with youths, Gulotta et al. (2013) presented positive, negative, or neutral movie segments to a sample of 15- to 21-year-olds. Gulotta and colleagues' conceptualization was that the negative movie segments may lower the threshold for detecting the probes, resulting in larger ERPs during negative movie segments. Interestingly, they found larger N2 and P3a amplitudes during negative segments than during neutral segments, but smaller P2s during negative and positive segments than during neutral segments.

Examining differences between individuals in allocation of information processing resources, Jutai and Hare (1983) used the probe ERP paradigm to examine prison inmates' allocation of attention. Participants who had higher psychopathy scores generated smaller N1s to probes presented while they played videogames. The authors interpreted this finding as reflecting greater attentional focus on activities and stimuli of more proximal interest, and more tuning out of other stimuli. This suggests allocation of information processing resources differs in ways linked to psychological adjustment problems, and it provides a foundation for examining other types of individual difference characteristics.

1.3 ERPs and Socio-emotionally Significant Experience

Although studies have not used the probe ERP paradigm to examine associations between such socio-emotionally significant experiences as interparental conflict exposure and children's information processing capacity, one study did use the probe ERP paradigm to examine associations with positive aspects of parent-child relationship functioning. Specifically, Pesonen et al. (2010) tested associations between ERPs and parent-child behavioral synchrony during free play in a sample of 2- to 3-year-olds and their mothers. Children were presented with probes while they sat on their mothers' laps and watched a movie or looked at books. Larger P3a amplitudes to the probes were associated with more mother-child synchrony. Thus, this finding suggests that a positive aspect of family functioning, mother-child synchrony, may facilitate greater development of attention regulation, reflected in larger P3a amplitudes to the probes. In summary, this methodological approach, which has been used infrequently in studies with children, is very useful for testing associations between processing of dynamic stimuli and family experiences.

1.4 The Current Study

We examined 9- to 11-year-old children's ERPs to irrelevant auditory stimuli presented while viewing videos of simulated marital interactions. The middle childhood period was selected because, as a result of typical cognitive development by this age, children are increasingly capable of abstract thought and reasoning about complex situations, enabling greater understanding of important social and familial relationships. Based on previous research, we were interested in the P1, N1, P2, N2, and P3a, because we wanted to examine ERPs reflecting early sensory attention (P1 and N1), later sensory processing and attention (P2), orienting and stimulus discrimination (N2), and later attentional orienting (P3a). We tested correlations between these ERPs and child- and mother-reported interparental conflict. Moreover, given previous findings of ongoing processing after stimulus offset, we were also interested in responses to probes after the videos ended. Specifically, Schupp et al. (1997) found that the P3 for probes presented in a 6-second post-image period was smaller for emotion photos (pleasant or unpleasant) than for neutral photos, suggesting continued processing of emotional stimuli after stimulus offset. Thus, we examined ERPs to probes presented during and after the videos.

Anticipating that more negative interpersonal exchanges in the videos would elicit different responses from children than positive or neutral exchanges, we designed the stimulus set to include videos depicting a spectrum of interpersonal behavior ranging from relatively negative behavior directed toward the partner to relatively positive behavior directed toward the partner, including neutral interpersonal exchanges. We hypothesized that children would generate smaller ERP amplitudes to probes during and after negative videos, compared with positive and neutral videos. The rationale for this hypothesis was that children would devote relatively more information processing resources to negative videos than to positive or neutral videos, and would therefore have fewer information processing resources available to divert to the probes, resulting in smaller ERP amplitudes. This hypothesis is consistent with the rationale underlying the probe ERP paradigm (Papanicolaou & Johnstone, 1984; Suzuki et al., 2005; Wickens et al., 1983), and it is consistent with results of previous studies (e.g., Cuthbert et al., 1998; Schupp et al., 1997). Based on Gulotta et al.'s (2013) findings, however, a viable alternative hypothesis would involve larger probe ERPs during negative videos compared with neutral videos. As described earlier, Gulotta et al.'s (2013) conceptualization was that a negative emotional context (produced in their study by negative movie segments) may lower the threshold for detecting the probes, resulting in larger ERPs during processing of negative stimuli. Thus, there is also a basis for an alternative hypothesis in our study of larger ERPs during negative interpersonal videos than during neutral ones.

Further, regarding differential experiences with interparental conflict, we hypothesized that higher levels of interparental conflict exposure would be associated with smaller ERP amplitudes to the probes, both across video types (positive, negative, neutral) and for probes during and after the videos. Similar to the rationale for predicting differences between video types, the rationale for this hypothesis was that children exposed to higher levels of interparental conflict would devote more information processing resources to the videos (and fewer resources to the probes) compared with other children, resulting in smaller ERP amplitudes. This hypothesis is consistent with the general pattern of Pesonen and colleagues' (2010) findings, with larger P3a amplitudes being associated with positive family functioning, suggesting greater attentional control and engagement with other aspects of the external environment. In the current study, we hypothesized that smaller ERPs would be associated with negative family functioning, suggesting greater focus on concerns related to family relationships and less engagement with aspects of the environment beyond the family.

In addition, we tested associations between ERPs and child adjustment. Based on previous findings of ERP-child adjustment associations (e.g., Stieben et al., 2007), we expected to find associations in our study. Further, anxiety and depression are associated with perseverative cognitive processes (Sorg et al., 2012), which may be reflected in a greater focus on interpersonal salient events, such as the videos in the current study. Although previous studies have not used the probe ERP paradigm to examine differences associated with child adjustment, the findings of Jutai and Hare's (1983) study of adults suggested that smaller ERP amplitudes would be associated with higher levels of adjustment problems in the current study. Thus, we hypothesized that children who have more internalizing and externalizing symptoms would generate smaller probe ERPs in the current study.

2. Material and methods

2.1 Participants

Participants were 24 children (13 males, 11 females) and their mothers. Children's ages ranged from 9 to 11 years (*M*=10.55, *SD*=0.91). In order to be eligible to participate, children had to be living with their biological parents, who had to be married to each other. In addition, children were ineligible if they did not have normal or corrected-to-normal vision or hearing (based on parent report), did not read at a 4^{th} to 5^{th} grade reading level or higher based on parental report, or had a known neurological condition (such as epilepsy) or had experienced a traumatic brain injury. One child was taking stimulant medication (Adderall). Participants were recruited via flyers posted in public and via newspaper ads in Bloomington, Indiana. Twenty-two of the children were Caucasian and the other 2 were multi-racial. The sample was mostly upper-middle class, with 54% of the sample having household incomes greater than $65,000/year, but there was some variability in socioeconomic status, as 21% of the sample had incomes of $40,000/year or less, and 25% had incomes of $40,001 to $65,000/year.

The EEG equipment was shown to mothers and children when they arrived at the lab, and then mothers provided written informed consent and children provided assent. Mothers were compensated $80 and children were compensated $20. The experimental protocol was approved by the Indiana University Institutional Review Board (IRB).

2.2 Stimulus Preparation and Testing

Stimulus testing was conducted with an independent sample of nineteen 9- to 11-year-old children. The experimental protocol for stimulus testing was approved by the IRB, and mothers provided written informed consent and children provided assent. The simulated interparental interaction videos were created by Dr. Mark Cummings and colleagues (Goeke-Morey et al., 2003). Each video segment depicted two actors pretending to be a couple, enacting different ways of handling marital conflict situations. The segments ranged in length from 5170 to 12270 ms (M = 8939.33 ms), and each segment portrayed one specific conflict tactic (e.g., verbal hostility, calm discussion) enacted by one of the actors. Two fictional scenarios, in which a difference of opinion emerged between the actors, provided background contexts for the video segments. One of the scenarios involved the purchase of a new television and the other involved the couple’s house needing to be cleaned.

Stimulus testing began with an experimenter providing detailed verbal descriptions of the scenarios, providing the background stories for the videos. Children were asked to pretend the actors in the videos were their parents. Children viewed 26 video segments, plus 2 practice segments. After each segment, children answered the following questions about that segment:

a) Did you think what Dad did was good?

b) Did you think what Mom did was good?

c) Did you think what Dad did was bad?

d) Did you think what Mom did was bad?

Responses were provided on a 4-point Likert scale ranging from 0 (*No, not good/bad at all*) to 3 (*Yes, really good/bad*). Based on these ratings, we identified the 5 videos rated as the most negative (high ratings of the actors' behavior as bad, low ratings of the actors' behavior as good), and we identified the 5 most positive videos (high ratings as good, low ratings as bad). For neutral videos, we identified the 5 videos in which less than half of the sample rated either actor's behavior as a 2 (*Good/Bad*) or 3 (*Yes, really good/bad*).

2.3 Experimental Procedures

To minimize the need for exploratory eye movements to view the stimuli, children were seated approximately 60 inches from a 24-inch computer screen so that each video occupied approximately 4° of visual angle horizontally (the longest dimension). Children were given detailed instructions for completing the task. An experimenter described each scenario in detail, and each description was followed by a practice trial. To encourage children to attend to the videos, children were asked to press the spacebar of a keyboard resting on their laps "if things that you don't like happen in the video." Children were informed that they might hear some tones during the videos, and that the tones could be ignored. They were also asked to pretend that the actors in the videos were their parents. The 15 video segments selected based on stimulus testing were presented in random order using Presentation software (Neurobehavioral Systems, Inc., Berkeley, CA).

The auditory probes, which were created using the sound editor Audacity 2.0.0 (http://audacity.sourceforge.net/), were 600-Hz pure tones with a 100-ms duration (including 10-ms rise and fall times). To reduce expectancy effects, time intervals between probes varied across the videos. The first probe in each video segment occurred at least 1500 ms after the beginning of the segment, subsequent probes were presented at varying intervals of no less than 1500 ms, and the last probe in each segment was presented at least 1100 ms before the end of the segment. Two to five probes were presented during each video. Based on previous findings of continued responses to probes after stimulus offset (Schupp et al., 1997), we also presented 2 probes during a 10-second interval following each video, during which time a black screen with a white fixation cross appeared. The first of these 2 probes occurred 2000 to 5000 ms after the video ending, and the second occurred 7000 to 8000 ms after the video ending (at least 2000 ms before the end of the 10-second fixation period). White noise machines were used to dampen sounds from outside the testing room, and the ambient noise level with the white noise machines operating averaged 56 dB SPL. The average volume of the videos was approximately 64 dB SPL. The probes were presented through speakers at 80 dB SPL, measured before each experimental session using a sound pressure level meter (Radio Shack Model #33-2055) positioned 60 inches in front of the monitor.

2.4 Electrophysiological Data Acquisition and Analysis

A Net Amps 300 high-impedance EEG amplifier and NetStation software (V4.4) were used to record EEG from 128-electrode HydroCel Geodesic Sensor Nets (Electrical Geodesics

Inc., Eugene, OR), with a sampling rate of 250 Hz and a DC – 100 Hz bandpass filter. The EEG recording was referenced to an electrode on the vertex (with a midline frontocentral ground electrode). Impedances were kept below 70 kΩ, per manufacturer's instructions. Using NetStation V4.4 software (EGI Inc., Eugene, OR), recorded EEG data were subsequently filtered offline with a 0.3 – 40 Hz bandpass filter.

EEG data were exported from the EGI software as binary files, and further processing was completed using EEGLAB 12.0.2.5b (Delorme & Makeig, 2004) and ERPLAB 4.0.2.3 (Lopez-Calderon & Luck, 2014) operating in the MATLAB R2012b (MathWorks, Natick, MA) environment. This processing included visual inspection to identify electrodes that had non-optimal scalp contact. Following this initial manual screening of the EEG data, Independent Components Analysis (Makeig et al., 2004) was run (excluding bad channels), generating 32 components, to identify and remove eye blink artifacts (Hoffmann & Falkenstein, 2008). Data from bad channels were then replaced using EEGLAB's spherical interpolation procedure, and the data were re-referenced to an average reference. Subsequently, the data were segmented into 1300-ms epochs, which included a 200-ms pre-stimulus baseline and 1100 ms following each probe. Baseline correction was performed using the 200-ms pre-stimulus period. Trials with voltages exceeding ±200 µV were removed using ERPLAB's simple voltage threshold function. Remaining trials were averaged together within trial type. By removing trials with voltages exceeding ±200 µV after conducting ICA, we were able to preserve as many EEG trials as possible for ICA, which requires many data points. The mean percentage of channels retained was 97% (range: 92-100%); the mean percentage of trials retained was 90% (range: 77-97%).

Subsequent to data processing, a manufacturer-issued latency correction factor was applied, to adjust for effects of the Net Amps hardware's anti-aliasing filter interacting with

NetStation software, which was dependent on sampling rate (Electrical Geodesics, Inc., communication November 26, 2014). For our (default) sampling rate of 250 Hz, an 8-ms correction factor was applied, shifting all ERP peak latencies negatively; the corrected latency data were used for the analyses and are presented here. ERP amplitude data and response times were not affected by this interaction.

The time windows for ERP activity were identified through visual inspection of the ERP waveform morphologies and scalp topographic voltage maps of grand averaged and individual participant ERP data, as well as being informed by typical time windows for this age range in previous studies. Viewing the grand-averaged ERP data averaged across trial types, we identified the beginning and ending time points of the first positive deflection as the P1, the first negative deflection as the N1, the second positive deflection as the P2, the second negative deflection as the N2, and the third positive deflection as the P3a. After verifying that these time points were consistent with those of other studies of children (e.g., Güler et al., 2012; Johnstone et al., 1996; Knowland et al., 2014; Papageorgiou et al., 2009; Zenker & Barajas, 1999), we computed the ERP components for each participant separately for each trial type (negative, positive, neutral). The ERPs were computed as the average of the samples within the identified time windows, averaging across clusters of 5 central electrodes (EGI electrode numbers 7, 31, 55, 80, 106) and 5 parietal electrodes (EGI electrode numbers 54, 61, 62, 78, 79) on the midline that were identified *a priori* based on previous studies with this age group (see Figure 1 for electrode locations). Specifically, the P1 was computed over central scalp locations during videos (72-122 ms post probes) and after videos (87-117 ms), the N1 at central sites during videos (122-162 ms) and after videos (117-162 ms), the P2 at parietal sites during videos (162-242 ms), the N2 at central sites during videos (262-322 ms) and after videos (297-362 ms), the N2 at parietal sites after videos (292-392 ms), and the P3a at parietal sites during videos (272-322 ms).

Peak latencies were identified for each participant as the time points associated with the maximum deflections within the time windows indicated above. However, previous work has shown other methods of measuring latencies, combined with the jackknife technique, are more accurate and have greater statistical power, without inflating the Type I error rate. The jackknife technique involves creating a set of grand-average waveforms in which each grand-average includes all but one participant's waveform (Miller et al., 1998). That is, all possible combinations of grand averages are created, in which each grand average is missing a different participant. Latencies are then measured from each grand average, and entered in statistical analyses such as ANOVA, with corrections to adjust for the artificially reduced error variances. In a simulation study, Kiesel et al., (2008) found the jackknife technique combined with measurement of fractional peak latencies or fractional area latencies was the most accurate and most powerful, without sacrificing control of the Type I error rate (see also Luck, 2014). Stahl and Gibbons (2004) applied this technique to tests of correlations, and demonstrated with a mathematical proof that the adjustment needed to interpret such correlations is to multiply the correlations by -1. Further, their simulation tests demonstrated for correlation tests that the jackknife technique combined with fractional peak latencies performed very well. Thus, in the current study, in addition to the conventional single-participant-based peak latency measure, we used jackknife-based subsamples combined with fractional peak latency measures, specifically 50% of peak amplitude. For participants who had already reached 50% of peak amplitude prior to the time window, the beginning of the time window was used as their latency; for participants who did not reach 50% of peak amplitude by the end of the time window, the end of the time window was used as their latency (Kiesel et al., 2008). For three of the ERP components (N1 at central sites and P3a at parietal sites during videos, and N2 at central sites after videos) the fractional peak latency was a constant (i.e., all participants had the same latency), precluding statistical tests on those components. Therefore, we also computed the 50% fractional area latency measure (using the jackknife-based subsamples) for those components. The fractional area measure was also a constant for the N1, but not for the N2 and P3a, enabling analysis of those two components' latencies.

2.5 Questionnaires

2.5.1 Interparental conflict.

During the EEG recording, mothers completed the O'Leary-Porter Scale (OPS; Porter & O'Leary, 1980), a 10-item measure of children's exposure to interparental conflict, completed on a 5-point Likert scale from 1 (*never*) to 5 (*very often*), with higher scores corresponding to higher levels of interparental conflict. A sample item is "How often do you and/or your spouse display verbal hostility in front of your child?" The OPS has good psychometric properties (Porter & O'Leary, 1980), and Cronbach's α in our sample was 0.79. Overall conflict levels in our sample (M=18.63, SD=4.92) were comparable to those of other samples (e.g., Porter & O'Leary, 1980, means = 18.30 (SD=5.82) to 23.69 (SD=7.91).

After the EEG recording, children completed the Children's Perceptions of Interparental Conflict Scale (CPIC; Grych et al., 1992), providing a child-report measure of interparental conflict. The CPIC consists of 48 items completed using a 3-point scale consisting of 0 (*false*), 1 (*sort of true*), and 2 (*true*). The Conflict Properties subscale is a 16-item measure of children's perceptions of the frequency and intensity of their parents' conflict, and of the degree to which parents' conflicts are resolved, with higher scores corresponding to higher levels of conflict. It includes such items as "My parents get really mad when they argue." The Conflict Properties subscale has demonstrated good internal consistency, test-retest reliability, and validity (Grych et al., 1992). Cronbach's α in this sample was .92.

2.5.2 Child adjustment.

Mothers provided reports of children's adjustment using the Child Behavior Checklist (CBCL; Achenbach, 1991). The Internalizing and Externalizing subscales include 113 items completed on a 3-point scale, indicating whether or not each statement is true of their child from 0 (*not true as far as you know*) to 2 (*very true or often true*), with higher scores corresponding to higher degrees of symptoms. The Internalizing subscale reflects somatic complaints (e.g., headaches), anxiety and depression (e.g., nervous, high strung or tense), and withdrawal (e.g., doesn't get involved with others); the Externalizing subscale reflects aggressive (e.g., gets into many fights, disobedient) and delinquent behavior (e.g., vandalism). The test-retest reliability and validity of the CBCL are good (Achenbach, 1991). Cronbach's αs were .86 for Internalizing and .82 for Externalizing.

3. Results

3.1 Descriptive Statistics and Behavioral Findings

ERP descriptives (measurement intervals, means, and standard deviations), as well as associations of ERP measures with age and gender, are reported in Table 1. For the questionnaire data, means, standard deviations, intercorrelations, and associations with age and gender are reported in Table 2. To examine the behavioral responses, we computed the percentage of trials in which children pressed the keyboard's spacebar (indicating that something happened in the video that they did not like). Spacebar-presses occurred during 91.67% of negative videos, 51.67% of neutral videos, and 9.17% of positive videos. This pattern suggests greater disliking of events in more negative, less positive videos, providing further validation of the stimulus categories as negative, neutral, and positive. In addition, latencies to spacebar-press were shorter for negative videos (*M*= 3541.86 ms; *SD*=2415.36 ms) than for neutral videos (*M*=5013.10 ms; *SD*=2862.39 ms), which in turn were shorter than for positive videos (*M*=7883.64 ms; *SD*=8177.52 ms). Given the subjectivity of this task (i.e., identifying unpleasant video content), and given that children did not make consistent errors in spacebar-pressing, we did not remove neutral or positive trials with button presses, nor did we remove negative trials without button presses.

3.2 Tests of Differences between ERPs for Different Trial Types

The ERP mean amplitude and latency data were analyzed in SPSS version 22 (IBM 2013). Significant results were identified at p values of less than 0.05. To test our hypotheses regarding differences in ERPs for the different video types, we computed repeated measures general linear models (GLMs), with video type (negative, positive, neutral) as a within-subjects factor, and child age and gender as control variables. The results showed no significant differences in ERP amplitudes from the different trial types. Therefore, we combined the data across trial types for subsequent analyses. The grand-averaged waveforms for the central and parietal sites, for during and after the videos, are shown in Figure 2.

3.3 Tests of Correlations of ERP Components with Interparental Conflict and Adjustment Problems

3.3.1 Interparental conflict.

Kendall's τ correlation was used to examine associations between ERP measures and exposure to interparental conflict. Because age and gender were associated with several of the ERP measures (Table 1), to control for age and gender while maximizing power in this small sample, we created residualized scores for the questionnaires, amplitudes, and single-participant-based latencies by regressing them on child age and gender and using the residualized scores in the analyses. However, we did not compute age- and gender-adjusted residuals in the jackknife-based latency variables, because although it would be possible to compute, for each jackknife-based grand average, the average age across the participants making up that grand average, the same would not be possible for gender, since it is a categorical variable. Therefore, we present the results using residualized latencies from the conventional single-participant approach to latency measurement, as well as the results for the unresidualized latencies from the jackknife technique.

Regarding tests using Kendall's τ, as shown in Table 3, smaller P1 amplitudes at central sites and smaller P2 amplitudes at parietal sites during the videos were associated with larger CPIC Conflict Properties scores. The P1-CPIC Conflict Properties association is depicted in Figure 3, using a median split, for illustrative purposes, to create groups reflecting high and low scores on the CPIC Conflict Properties scale (see Figure 4 for topographic voltage maps). In addition, smaller (less negative) N2 components at central sites after the videos were associated with larger OPS scores.

Interparental conflict exposure was also associated with ERP latencies. For the single-participant-based peak latencies, larger CPIC scores were associated with shorter latencies of the P3a measured at parietal sites during videos (see Table 4). For the latency measures from jackknife-based subsamples, larger OPS scores were also associated with shorter P3a latencies, but larger CPIC scores were associated with longer latencies of the P1 measured at central sites during videos (Table 5, all unresidualized variables). Correlations of residualized questionnaires with these unresidualized latencies (from jackknife-based subsamples) were similar, but the

OPS-P3a association became non-significant ($p = .06$). There were no other significant associations between interparental conflict variables and ERP amplitudes or latencies.

3.3.2 Child adjustment.

Testing associations between ERP components and child adjustment, we found that, for probes presented after the endings of the videos, smaller (less negative) N2 components at central electrode sites were associated with larger CBCL Externalizing scores, as were smaller N2 components at parietal sites (Table 3). There were no significant results for the other ERP amplitudes or for Internalizing, and associations between single-participant-based peak latencies and child adjustment variables were non-significant. However, for the jackknife-subsample-based latencies, larger CBCL Internalizing scores were associated with shorter latencies of the P2 measured at parietal sites during videos (Table 5), but that association was non-significant when using the residualized Internalizing measure (with the jackknife-subsample-based latency measure) ($p = 0.13$).

4. Discussion

There were no significant findings pertaining to video type (negative, positive, neutral), counter to our hypothesis. However, as hypothesized, higher levels of child-reported interparental conflict were correlated with smaller central P1 and parietal P2 amplitudes to probes during videos, and higher levels of parent-reported interparental conflict were correlated with smaller (less negative) N2s at central sites for probes presented after the endings of the videos. Smaller N2s at central electrode sites after videos were also correlated with more externalizing behavior problems, as were smaller N2s at parietal sites (after videos). In addition, shorter P3a latencies from single-participant peak latency measurement were associated with higher levels of child-reported interparental conflict, and shorter P3a latencies from the jackknife-based fractional area measure were associated with higher levels of mother-reported interparental conflict.

The current study is among the first to use the probe ERP paradigm to examine the associations of early adversity with children's allocation of information processing resources. Interparental conflict exposure was associated with ERP components reflecting several stages of processing, from the P1, which has been linked with attentional processes associated with early sensory processing, to the P2, linked with later sensory processing, attention, and feature detection, and the N2, reflecting cognitive control and deploying of attention (Folstein & Van Petten, 2008; Key et al., 2005). In addition, results showed associations with both child- and mother-reported exposure to interparental conflict, although not for the same ERP components. Notably, the correlation between child- and mother-reported conflict was moderate in magnitude ($\tau=0.36$, $p<.05$). Thus, mothers and children appear to share some similarities in perceptions of conflict levels, but also to differ in either perceptions of conflict or reporting bias. That is, mothers and children may have differed in the extent to which they underreported conflict. Mothers may well experience stronger social desirability pressures than their children when it comes to reporting on such family characteristics as interparental conflict. In any case, the mother-child correlation in our sample was similar to, but a little more modest than, other samples (e.g., $r=0.53$, $p<.001$ in Cummings et al., 2006; for comparison using unresidualized variables in our sample: $r=0.41$, $p<.05$).

Our findings of smaller amplitudes for several of the ERP components (P1 and P2 during videos, N2 after videos) in children who had more challenging socio-emotional experiences with their parents' relationship is consistent with prior work using this method (e.g., Papanicolaou & Johnstone, 1984). We assume for now that this socio-emotional challenge would lead to a higher percentage of cognitive resources being devoted to viewing the videos, resulting in reduced efficiency in processing irrelevant stimuli (the probes) and smaller amplitudes for these ERPs. An alternative possibility is that genetic factors could account for both the interparental conflict and children's neurophysiological responses to the stimuli, given findings that, for example, genetic factors contribute to both interparental conflict and child adjustment problems (Harden et al., 2007). However, even when genetic mechanisms are observed, family processes remain an important influence on children in combination with genetic mechanisms (e.g., Dick et al., 2011).

Theoretical perspectives have emphasized the negative influence of adverse caregiving environments on children's emotional development (Blair & Raver, 2012; Susman, 2006), as well as the heightened vulnerability of early brain development to adversity as a result of greater plasticity during childhood (Susman, 2006). Early experiences appear to alter physiology, evidenced by both studies of non-human (e.g., Weaver et al., 2004) and human animals (e.g., Ito et al., 1993). For example, during viewing of emotionally significant pictures, differences in cortical activity were found between adults on the basis of the level of adversity early in life (Matz et al., 2010). Further, EEG coherence has been found to mediate associations between maltreatment history and psychological adjustment (Miskovic et al., 2010). The findings of the current study may reflect a similar direct association between early experience and changes in brain function that are ultimately tied to changes in cognition. These findings may also point to a cognitive mechanism (allocation of information processing resources) that may help draw connections between findings linking early experience with changes in physiology (e.g., Weaver et al., 2004) and findings linking early experience with changes in psychological functioning (e.g., Davies & Cummings, 2006). That is, with repeated exposure, elevated conflict may trigger neurophysiological changes that lead to cognitive changes, such as changes in children's allocation of information processing resources, which may in turn produce changes in behavior and psychological functioning. Theory conceptualizes children's interpretations of interparental conflict as "radar systems" for signals of potential threat to the well-being of the family (Davies & Cummings, 2006, p. 93), and suggests the potential for over-vigilance and sensitivity to signs of interparental difficulties (Davies et al., 2014). Thus, in the current study, children exposed to more interparental conflict may have allocated more attention to the videos, potentially because of heightened vigilance, which may have led them to devote more processing resources to monitoring for signs of threat.

Just as our findings indicate that high levels of interparental conflict were associated with smaller amplitudes of several ERPs, by the same token, they indicate that low levels of conflict were associated with larger ERPs. Thus, our findings are similar in pattern to Pesonen et al.'s (2010) finding that a positive aspect of family functioning, parent-child behavioral synchrony during free play, was associated with larger P3a amplitudes to the probes. Clearly, there are differences between the experience of positive relationship functioning and the absence (or low levels) of negative relationship functioning. Nonetheless, the pattern of our results is consistent with the idea that the interparental relationship, as well as other important social relationships, when functioning well, provides children with a secure base from which to explore the environment and focus energies on social, academic, and other domains (Cummings et al., 2006). Thus, findings from the current study suggest a neuropsychological mechanism that might underlie such associations.

Our findings differ somewhat from those of Gulotta et al. (2013), who found larger N2 and P3a amplitudes (but smaller P2s) during negative segments than during neutral segments.

Because auditory processing of task-irrelevant stimuli is altered by context (Sussman & Steinschneider, 2006; Wronka et al., 2008), Gulotta et al. (2013) suggested that a negative emotional state induced by the negative movie segments may have lowered the threshold for detecting external stimuli, producing the larger ERPs observed during negative movies in their study. One potential explanation of the difference in findings in our study compared with that of Gulotta et al. may be suggested by the differences in video lengths between the two studies. Specifically, our video clips were relatively short (approximately 5-12s), whereas the movie segments used by Gulotta and colleagues were 40s each. Our videos might not have been long enough to induce a negative emotional state, and thus, the negative videos might not have lowered the threshold for detecting the probes.

The results for externalizing problems indicated that smaller N2s (a component thought to reflect cognitive control) to the probes in post-video intervals were associated with more aggressive and delinquent behavior. Thus, children's greater allocation of processing resources to simulated interpersonal interactions appears to be associated with children's externalizing problems. Interestingly, the results for externalizing problems pertained to probes presented after the videos had ended. The pattern of findings suggests that the videos were sufficiently engaging that all children allocated similar levels of attention to them as long as they were on the screen, but that differences related to externalizing emerged primarily during the period after a video. Building on previous studies showing ongoing processing of emotionally significant stimuli after stimulus offset (Schupp et al., 1997), the current findings suggest that externalizing problems were associated with diverting fewer processing resources to probes after the videos ended and conceivably more continued cognitive processing of the videos. It is also noteworthy that the N2 at central sites to probes after the videos was associated with both interparental conflict (based on mother report) and externalizing problems. The other ERP amplitudes that were associated with interparental conflict (P1 at central sites during videos, P2 at parietal sites during videos) were not associated with externalizing. This difference may suggest that, whereas multiple stages of cognitive processing may be related to interparental conflict, including early and later sensory processing, attention, and feature detection, and cognitive control processes, only the latter (cognitive control) processes are associated with externalizing problems. The results also suggest an interesting question: Does the N2 serve as a mechanism underlying associations between interparental conflict exposure and child externalizing problems? This possibility could be tested in future studies with larger samples.

Regarding ERP latencies, higher levels of child-reported interparental conflict were associated with shorter peak latencies for the P3a during videos, based on the single-participant peak latency measures. However, the latency measures drawn from the jackknife technique indicated it was higher levels of mother-reported interparental conflict that were associated with shorter P3a latencies. Notably, the pattern across both the single-participant- and jackknife-based measures was consistent, in that higher levels of conflict exposure were associated with shorter P3a latencies. The jackknife-based measures also indicated that higher levels of child-reported interparental conflict were associated with *longer* P1 latencies during videos. These results may be due to several factors, including potentially differing effects related to children's versus mothers' perceptions of interparental conflict, as well as the different stages of cognitive processing reflected in the P1 and P3a. Delayed processing of the probes at an early stage of processing (reflected in the P1) may be consistent with a greater focus on the videos during early sensory processing, whereas more rapid processing of the probes at a later stage of processing (reflected in the P3a) may have resulted from subsequent reorienting of attention from the videos to the probes.

Notably, higher levels of interparental conflict were associated with both smaller P1 amplitudes and later P1 latencies, further supporting the idea that children from higher-conflict homes allocated more processing resources to the videos, compared with other children. The jackknife-based measures also revealed an association between shorter P2 latencies and higher levels of internalizing problems. Thus, more rapid attentional processing and feature detection to probes during these interpersonal videos may be associated with more internalizing symptoms. Such a pattern could help account for findings in the literature suggesting differences in attention to, and detection of, threat cues in individuals with anxiety and depression (e.g., Price et al., 2016; Reeb-Sutherland et al., 2015). Additional research is needed to examine these patterns further.

It is also noteworthy that the tests for differences in ERPs as a function of video type (negative, positive, neutral) were nonsignificant. It is possible that our study did not have sufficient power to detect true differences between the video types. Indeed, previous research showing a bias in attention for negative stimuli relative to positive stimuli in adults (Smith, Cacioppo, Larsen, & Chartrand, 2003) provides a basis for anticipating that children would devote greater processing resources to negative interpersonal interactions than to positive ones. Tests with larger samples could reveal differences between the video types that did not emerge in the current study, which would be informative regarding children’s processing of interpersonal interactions. However, it is also possible that children actually do allocate information processing resources similarly during interpersonal interactions regardless of the emotional valence of the interactions. This would be particularly interesting in light of recent findings that children generate larger P3bs to photographs depicting interpersonal anger than to those depicting interpersonal happiness or neutrality (Schermerhorn, Bates, Puce, & Molfese, 2015). Considering the functional correlates of the P3b (stimulus discrimination and categorization), this would mean that, whereas children's discrimination and categorization appear to differ for stimuli depicting interpersonal anger compared with stimuli depicting interpersonal happiness and neutrality, children's allocation of information processing resources may not differ on the basis of stimulus emotionality. Given their potential significance, interpersonal interactions may well elicit comparable levels of information processing resources regardless of their emotional qualities, with differences appearing when children endeavor to discriminate and categorize interactions.

This study has several limitations. Our study, like many other ERP studies, particularly those with children of this age, had a small sample. To maximize statistical power with our limited sample, although we tested individual differences, we did so using continuously scaled between-subjects variables, as opposed to categorical grouping variables. In addition, rather than computing more complex statistical models with multiple predictor variables per model, we limited our main analyses to simple tests of correlation, using residualized scores to control for age and gender while maximizing power. Moreover, we examined all observed ERP amplitudes and two latency measures, resulting in a somewhat large number of tests. However, because investigation of ERPs in contexts of interparental conflict is a new area of study, it was important to do so in order to identify which ERPs would show associations with interparental conflict. Future studies will be able to draw on the results of the current study to focus on specific ERP components. In addition, although we computed tests of associations of multiple measures of interparental conflict with the ERP measures, similarities in the overall pattern of findings for both measures of conflict give credence to the results. Specifically, although different ERP components were related to mother-reported versus child-reported conflict, smaller ERP amplitudes were associated with higher levels of conflict exposure across both mothers' and children's reports. Ultimately, efforts will be needed to attempt to replicate the findings, and a larger sample would allow more definitive tests. Further investigation with a larger sample would also allow tests of more complex questions. For example, in the current study, findings that higher levels of mother-reported conflict and externalizing problems were associated with smaller N2 amplitudes to probes after video offset suggested that conflict and externalizing are associated with differences in how much children continue to process the videos after viewing them. However, given our sample size, it was not possible to test whether conflict and externalizing are associated with significantly greater ongoing processing of videos after they have ended than while children are viewing them. Such patterns, which could be tested in a larger sample, could point to mechanisms underlying children's functioning, that is, more sustained cognitive processing of interpersonal interactions, including potentially distressing interactions.

In addition, the videotaped depictions of simulated interparental interactions may have somewhat limited ecological validity. That is, our results might not generalize well to actual interactions between children's own parents. Although we asked children to pretend that the actors in the videos were their parents, it is not known whether children were able to do so, and one would assume different levels in children's ability to do so. However, our use of videos is also a strength, as the stimuli were carefully prepared, and these dynamic stimuli, presented in the context of plausible interparental conflict scenarios, offer an advance in ecological validity relative to ERP studies using still photos as stimuli.

This study, despite its limitations, provides new insights regarding mechanisms underlying the influence of socio-emotionally significant experiences on child functioning. The findings suggest that children who were exposed to more interparental conflict, or who had more symptoms of externalizing problems, devoted more information processing resources to interpersonal interaction stimuli. This pattern of findings highlights potential mechanisms underlying the influence of socio-emotionally significant experiences, including adverse caregiving environments, on children's allocation of information processing resources, which itself appears to provide a potential mechanism in the development of externalizing problems.

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Table 1.

ERP Amplitudes (μV) and Latencies (ms).

	Measurement interval (ms)	Mean (*SD*)	Age τ	*t*
P1 Central During Amp	72-122	0.37 (0.77)	-0.01	0.32
P1 Central After Amp	87-117	0.77 (1.34)	-0.20	2.67*
N1 Central During Amp	122-162	-0.19 (0.88)	0.07	-0.70
N1 Central After Amp	117-162	-1.25 (2.11)	-0.20	-0.83
P2 Parietal During Amp	162-242	0.63 (1.02)	0.00	-0.87
N2 Central During Amp	262-322	-0.61 (0.99)	-0.09	-0.69
N2 Central After Amp	297-362	-1.89 (2.17)	-0.43**	-0.97
N2 Parietal After Amp	292-392	-1.17 (2.27)	-0.08	0.48
P3a Parietal During Amp	272-322	-0.04 (0.97)	-0.17	-1.39
P1 Central During Lat	72-122	101.11 (8.74)	0.11	0.07
P1 Central After Lat	87-117	101.56 (6.61)	0.07	-0.83
N1 Central During Lat	122-162	144.61 (8.81)	0.09	0.37
N1 Central After Lat	117-162	138.72 (7.51)	0.21	0.98
P2 Parietal During Lat	162-242	203.44 (11.76)	-0.17	-0.81
N2 Central During Lat	262-322	290.94 (14.37)	0.17	-0.32
N2 Central After Lat	297-362	329.72 (13.73)	-0.19	0.09
N2 Parietal After Lat	292-392	339.56 (17.57)	0.15	2.49*
P3a Parietal During Lat	272-322	293.89 (11.26)	-0.13	1.22

Note. μV = microvolt; ms = millisecond; *SD* = standard deviation; During = probes during videos; After = probes after videos; Amp = amplitude; Lat = latency. Latency variables are peak latencies measured using the single-participant technique. τ = Kendall's τ rank correlation coefficient. *t* tests (two-tailed) compared males and females.*$p < .05$. **$p < .01$.

Table 2.

Interparental Conflict, Child Adjustment, and Associations with Age and Gender.

	Mean (*SD*)	CPIC Conf Prop τ	OPS τ	CBCL INT τ	Age τ	*t*
CPIC Conf Prop	9.93 (7.38)	--			-0.26	-1.12
OPS	18.63 (4.92)	0.36*	--		-0.06	-0.50
CBCL INT	6.97 (6.64)	.12	.15	--	-0.24	0.42
CBCL EXT	8.73 (5.98)	.02	.29	.49**	-0.05	0.36

Note. CPIC Conf Prop = Conflict Properties subscale of Children's Perceptions of Interparental Conflict; OPS = O'Leary Porter Scale; CBCL INT = Child Behavior Checklist Internalizing Subscale; CBCL EXT = Child Behavior Checklist Externalizing Subscale. τ = Kendall's τ rank correlation coefficient. *t* tests (two-tailed) compared males and females.*$p < .05$. **$p < .01$.

Table 3.

Correlations between ERP Amplitudes and Interparental Conflict and Child Adjustment.

	CPIC Conf Prop τ	OPS τ	CBCL INT τ	CBCL EXT τ
P1 Central During	-0.29*	0.13	-0.01	0.14
P1 Central After	0.02	-0.08	0.01	-0.01
N1 Central During	-0.20	0.22	0.06	0.16
N1 Central After	0.05	0.09	0.09	0.22
P2 Parietal During	-0.33*	-0.11	0.12	0.05
N2 Central During	-0.14	0.11	-0.12	0.15
N2 Central After	0.00	0.32*	0.19	0.35*
N2 Parietal After	0.07	0.25	0.19	0.32*
P3a Parietal During	-0.07	0.24	-0.11	0.14

Note. All variables are the residuals from regressing the original scores on child age and gender. During = probes during videos; After = probes after videos; CPIC Conf Prop = Conflict Properties subscale of Children's Perceptions of Interparental Conflict; OPS = O'Leary Porter Scale; CBCL INT = Child Behavior Checklist Internalizing Subscale; CBCL EXT = Child Behavior Checklist Externalizing Subscale. τ = Kendall's τ rank correlation coefficient. *****$p < .05$.

Table 4.

Correlations between Single-participant ERP Latencies and Interparental Conflict and Child Adjustment.

	CPIC Conf Prop τ	OPS τ	CBCL INT τ	CBCL EXT τ
P1 Central During	0.05	-0.11	0.07	-0.12
P1 Central After	0.17	-0.01	-0.01	0.04
N1 Central During	-0.09	0.14	-0.06	0.07
N1 Central After	-0.25	0.01	0.08	0.02
P2 Parietal During	-0.01	-0.05	0.04	0.04
N2 Central During	0.04	-0.14	0.20	0.25
N2 Central After	0.14	0.18	-0.05	-0.15
N2 Parietal After	0.10	0.13	-0.01	-0.12
P3a Parietal During	-0.29*	-0.12	0.10	0.04

Note. All variables are the residuals from regressing the original scores on child age and gender. Latency variables are peak latencies measured using the single-participant technique. During = probes during videos; After = probes after videos; CPIC Conf Prop = Conflict Properties subscale of Children's Perceptions of Interparental Conflict; OPS = O'Leary Porter Scale; CBCL INT = Child Behavior Checklist Internalizing Subscale; CBCL EXT = Child Behavior Checklist Externalizing Subscale. τ = Kendall's τ rank correlation coefficient. *$p < .05$.

Table 5.

Correlations between Jackknife-subsample ERP Latencies and Interparental Conflict and Child Adjustment.

	CPIC Conf Prop τ	OPS τ	CBCL INT τ	CBCL EXT τ
P1 Central During	0.39*	0.17	0.21	0.17
P1 Central After	-0.12	-0.27	-0.03	-0.17
N1 Central During	*a*	*a*	*a*	*a*
N1 Central After	-0.10	0.20	0.05	0.15
P2 Parietal During	-0.06	-0.03	-0.36*	-0.06
N2 Central During	-0.05	0.01	0.01	0.32
N2 Central After	0.00	-0.05	-0.22	-0.05
N2 Parietal After	0.03	0.10	0.06	0.13
P3a Parietal During	-0.02	-0.37*	0.00	-0.19

Note. Latencies for N2 Central After and P3a Parietal During were computed using jackknife-subsample average waveforms combined with the 50% fractional area latency measure; all other latencies were computed using the jackknife-based approach combined with the 50% fractional peak onset latency measure. *a* denotes latencies that are constants, for which correlations cannot be computed. During = probes during videos; After = probes after videos; CPIC Conf Prop = Conflict Properties subscale of Children's Perceptions of Interparental Conflict; OPS = O'Leary Porter Scale; CBCL INT = Child Behavior Checklist Internalizing Subscale; CBCL EXT = Child Behavior Checklist Externalizing Subscale. τ = Kendall's τ rank correlation coefficient. *$p < .05$.

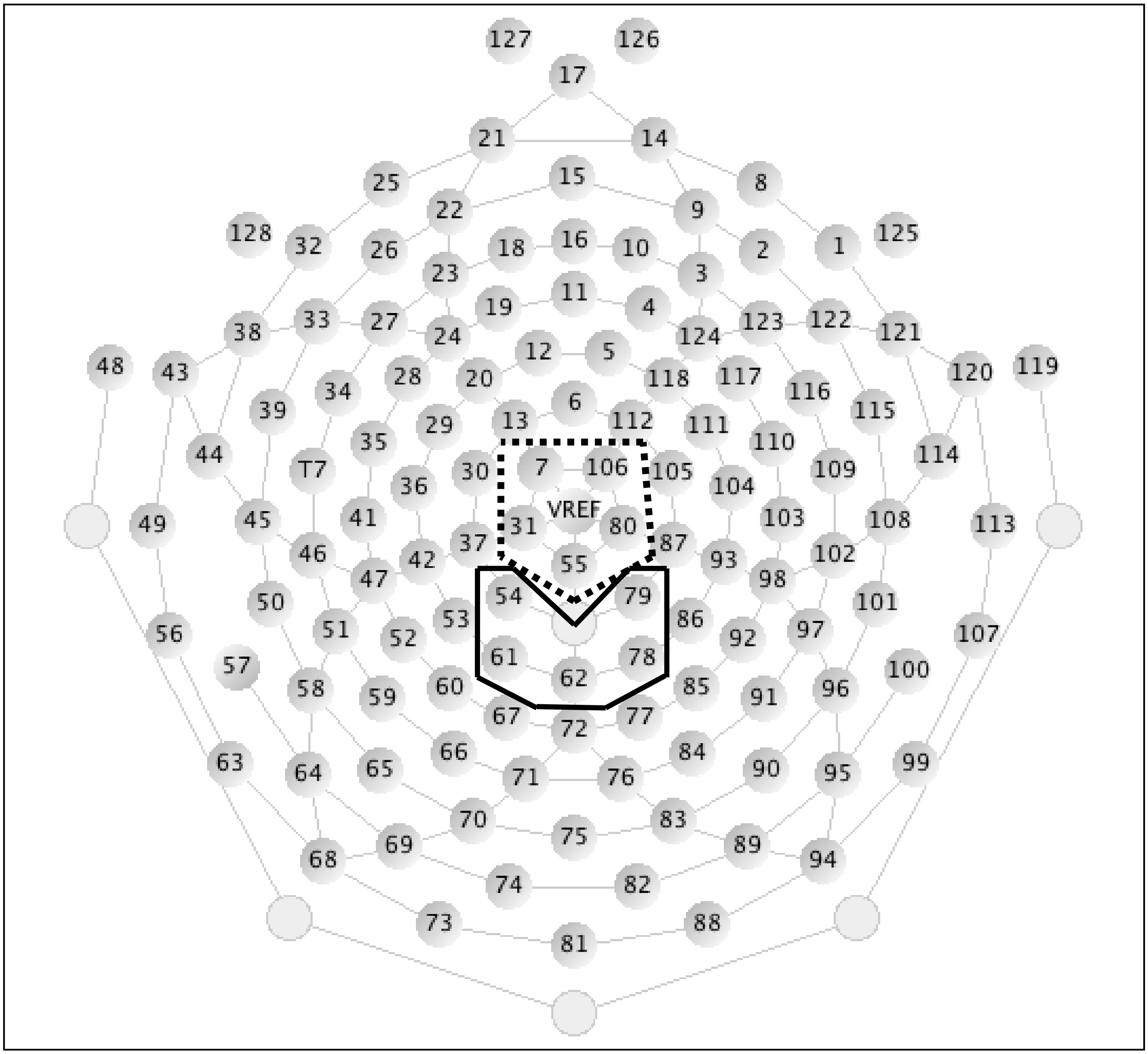
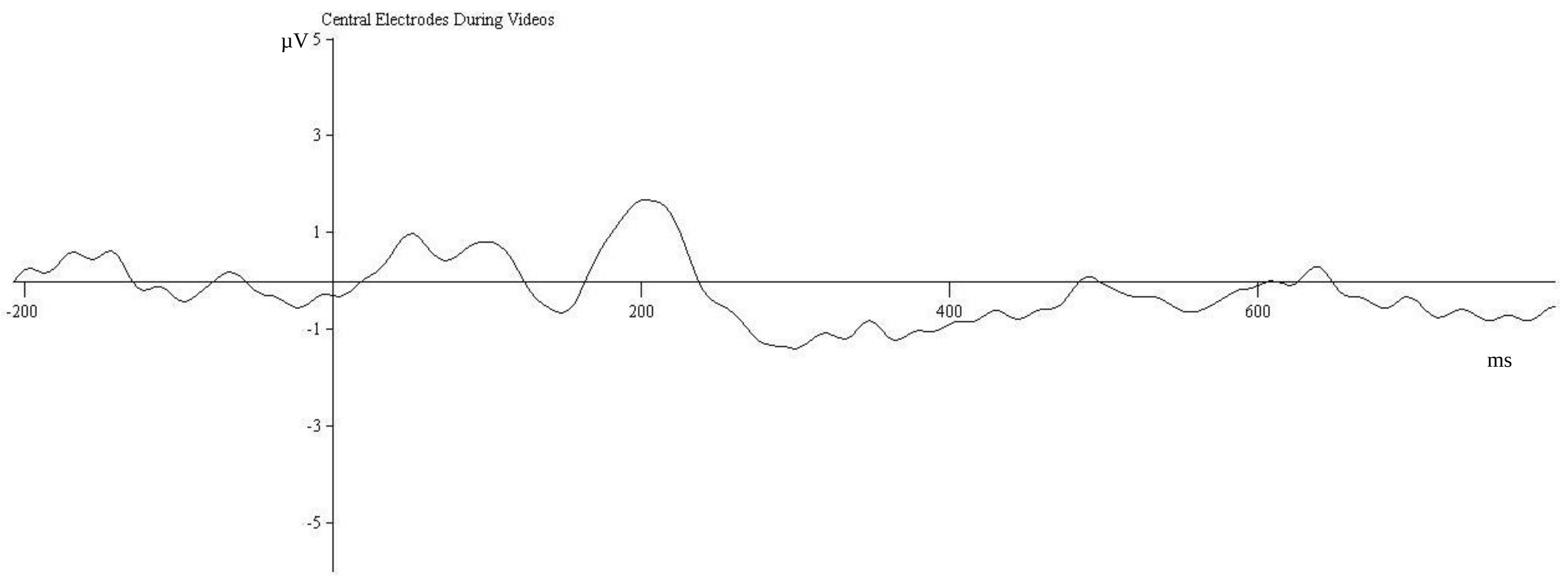
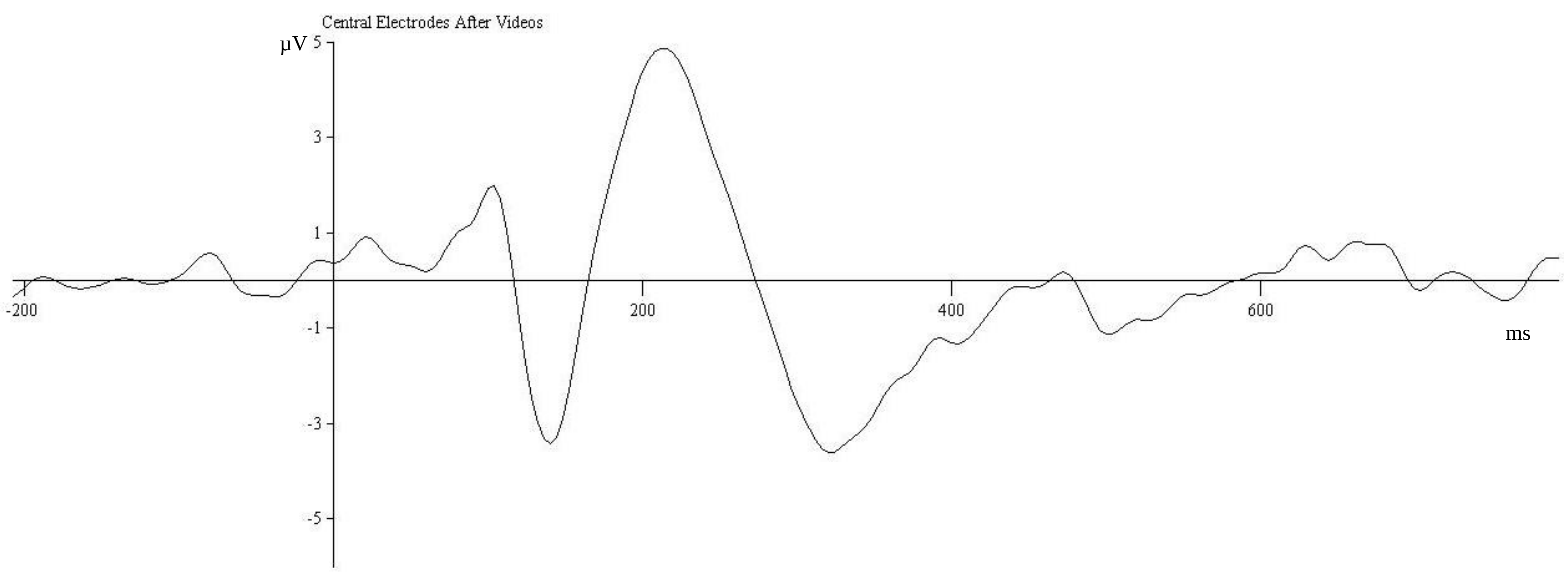


Figure 1. Layout of EGI electrode net and locations of electrodes used to derive ERP measures. Dashed black outline denotes midline central electrodes (excluding VREF, the reference electrode). Solid black outline denotes midline parietal electrodes.


Central Electrodes During Videos
µV 5
3
1
-1
-3
-5
-200
200
400
600
ms


Central Electrodes After Videos
µV 5
3
1
-1
-3
-5
-200
200
400
600
ms

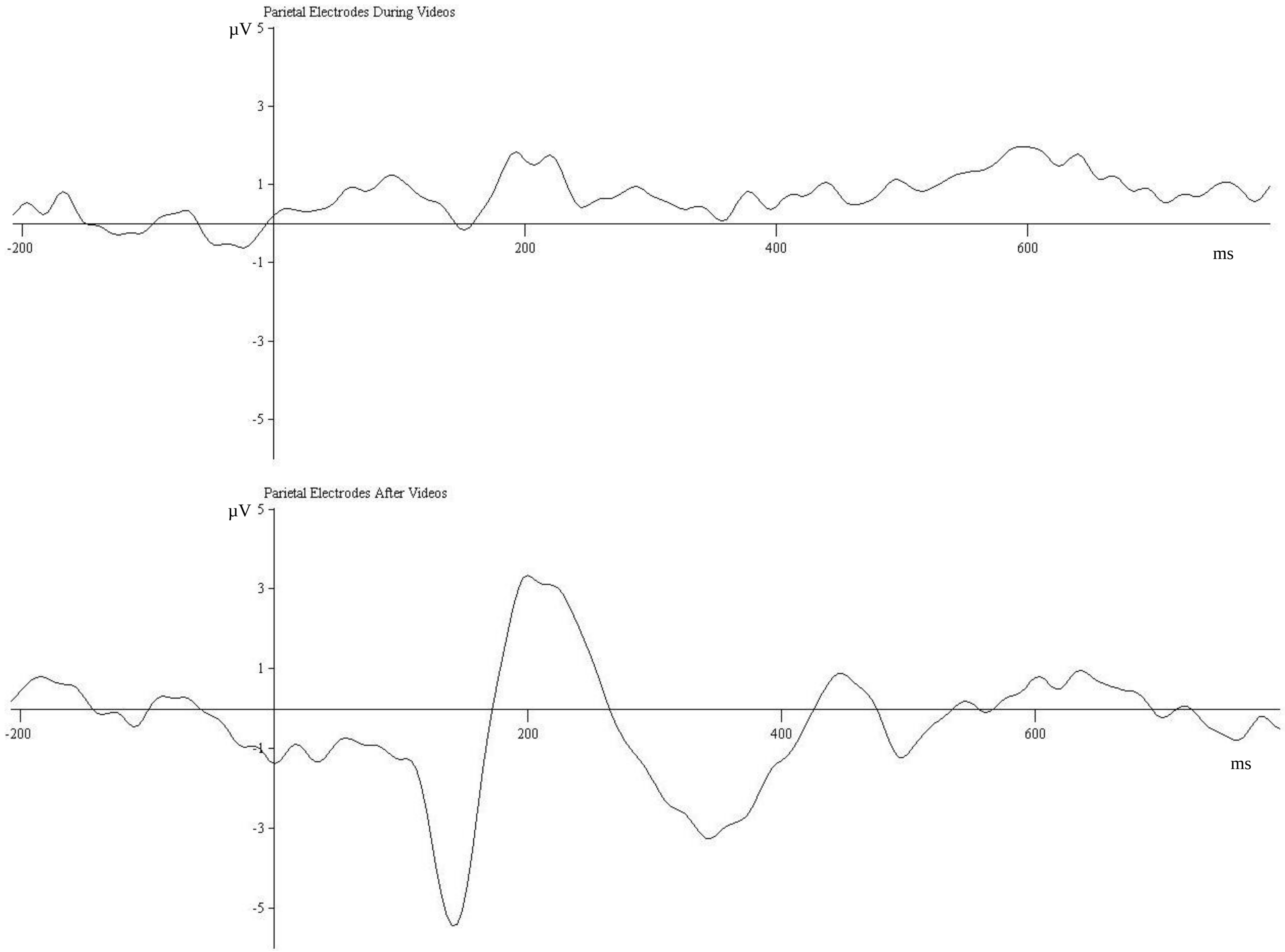


Figure 2. Grand-averaged ERP waveforms obtained during and after videos at central and parietal electrode clusters. µV = microvolts; ms = milliseconds.

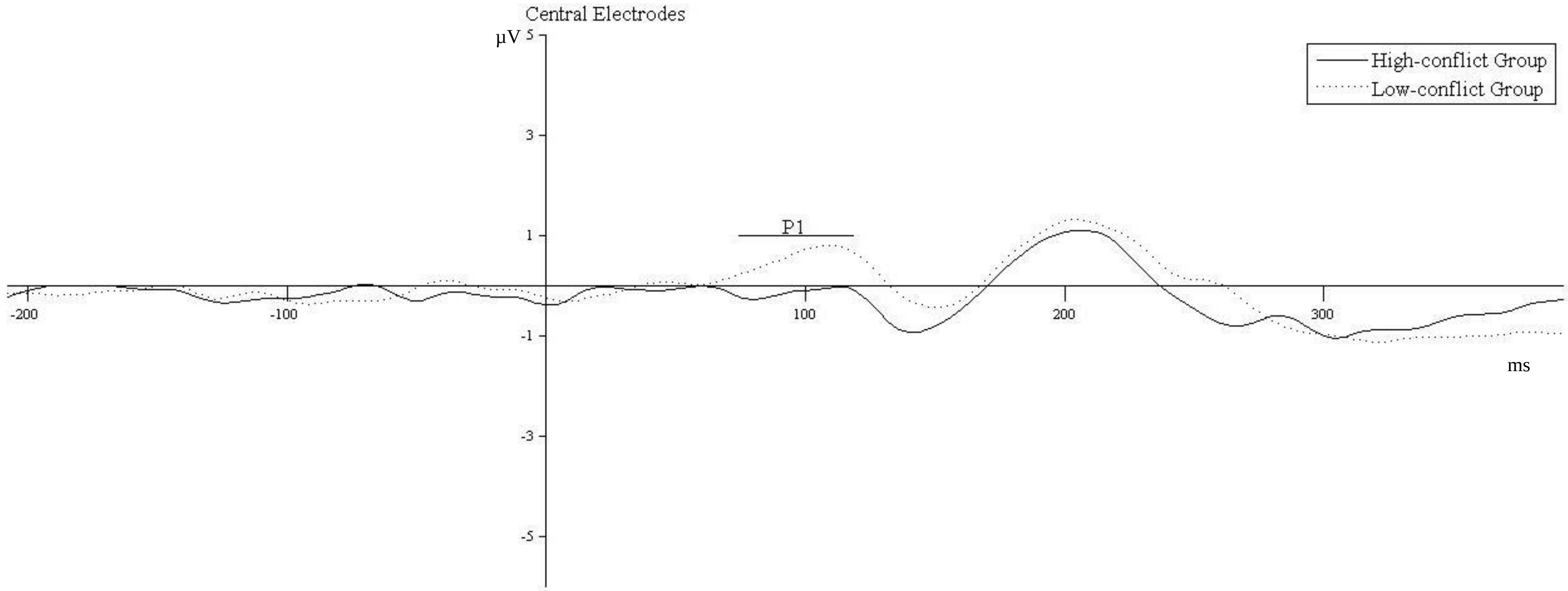


Figure 3. Grand-averaged P1 waveforms during videos as a function of CPIC Conflict Properties. High-conflict Group = children scoring above the median on the Conflict Properties subscale of Children's Perceptions of Interparental Conflict (CPIC); Low-conflict Group = children scoring below the median on the Conflict Properties subscale of Children's Perceptions of Interparental Conflict (CPIC). μV = microvolts; ms = milliseconds. The horizontal bar indicates the time window for P1 (72-122 ms).

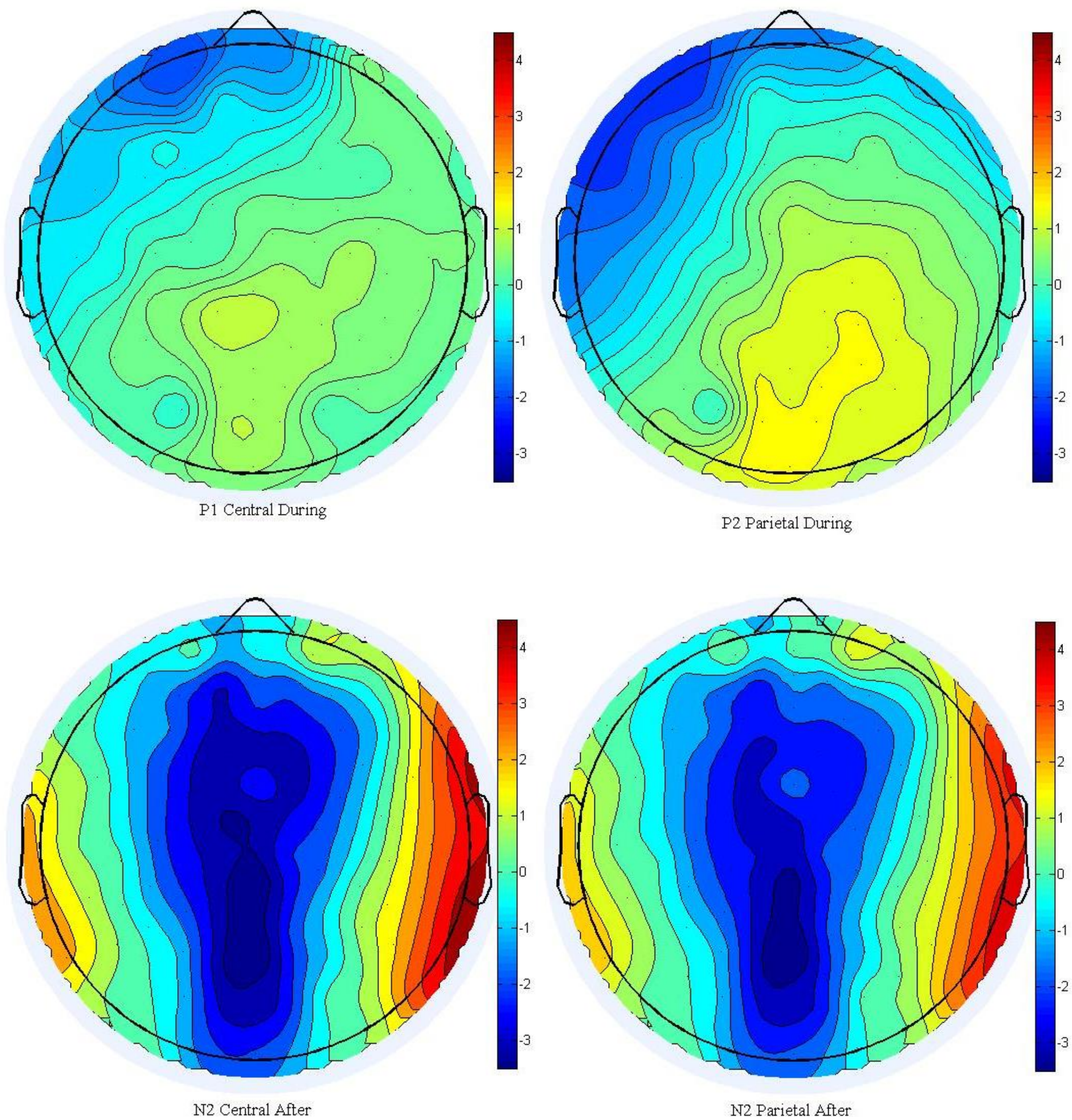


Figure 4. Topographic voltage maps of ERP components at the respective temporal peaks of the P1, P2, and N2. During = During Videos; After = After Videos. The topographic maps are displayed in a top-down view with left hemisphere on left, and nose at top. The color scale defines amplitude in microvolts.