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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.

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 and 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 and 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 and 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 and 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

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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 and 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 and 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 and 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 and 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