

Behavioral and Electrophysiological Markers of Selective Attention in Children of Parents with a History of Depression

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Background: Individual differences in selective attention may play a role in moderating psychological vulnerabilities by shaping the ability to self-regulate emotion. Children of parents with childhood-onset depression (COD) are at increased risk for socioemotional difficulties. This study examined potential differences in selective attention as a function of parental COD.

Methods: Children ($n = 33$, ages 6 to 10) participated in a Posner cued attention task under neutral and affective conditions. Behavioral (reaction time [RT]; errors) and event-related potential (ERP) data were collected during the task.

Results: Performance in the Posner task under the affective condition was marked by significant decreases in RTs, an increase in errors, and an increased validity effect (difference in RTs to the cued vs. uncued trials) relative to performance under neutral conditions. Children of parents with COD were slower in their response rates compared with control children. The at-risk children also showed larger P3 and slow wave amplitudes in anterior scalp sites, particularly during the affective Posner task.

Conclusions: These data suggest that there are subtle deficits in selective attention among the offspring of individuals with COD, requiring that they engage more processing resources to perform effectively. This may affect their ability to adequately regulate emotion under stress.

Key Words: Selective attention, childhood-onset depression, ERP, affective context, Posner paradigm

Clear individual differences in emotional reactivity to environmental stimuli are often evident in the first months of life (Fox NA et al 2001). Although early biases marked by negative affect can lead to socioemotional difficulties, early reactivity does not dictate outcome. This is, in part, due to executive self-regulatory skills that begin emerging in the first year of life to take on a central role in the control and expression of emotion into early and middle childhood (Rothbart 1989). Often attention is at the core of these regulatory mechanisms. For example, Rothbart (1981, 1986) observed that during episodes of focused attention infants exhibited increases in positive affect and decreases in distress. Attentional control also decreases negative emotionality in situations that evoke distress in infants (Rothbart et al 1990). Greater attentional focus and lower distractibility in infancy has been linked to higher positive affect, less social withdrawal, and lower levels of frustration in later childhood as well (Calkins et al 2002; Pérez-Edgar and Fox, unpublished data, 2003).

With the emergence of self-regulation, a child's behavior is somewhat freed from reactive biases and can respond more strategically to the context at hand (Fox and Calkins 2003; Posner and Rothbart 2000). However, if these self-regulatory skills are impaired due to internal deficits or poor environmental support systems, reactive biases may unduly influence the child's ability to process environmental stimuli, leading to poor socioemotional outcomes.

Children of parents with a history of depression are at higher risk

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for socioemotional maladjustment and psychopathology in childhood (Coghill et al 1986; Downey and Coyne 1990; Ghodsian et al 1984; Orvaschel et al 1988). This vulnerability appears to be transmitted through a number of environmental, biological, and psychological mechanisms (Cicchetti and Toth 1998; Goodman and Gotlib 1999). For example, depressed mothers tend to respond less contingently to their infants (Cohn et al 1990; Field et al 1990), and in turn, infants of depressed mothers express less positive emotions than infants of nondepressed mothers (Field 1992; Field et al 1988; Forbes et al 2004). Children of depressed parents are also more likely to show right frontal electroencephalogram (EEG) asymmetry, a marker for behavioral withdrawal, temperamental shyness, and depression (Field et al 1995).

Having a depressed parent may impair the development of self-regulation and executive attention, compromising the emergence of adaptive emotion regulation. A recent publication from our research group (Silk et al 2006) addressed this issue by observing children's emotion regulation strategies during a delay task designed to induce mild negative emotion. Young children of mothers with childhood-onset depression (COD), especially girls, were more likely to use passive waiting rather than active distraction during the delay. They were also more likely to focus on the delay item. The authors concluded that these children "may have difficulty disengaging attention from a distressing stimulus and may be less flexible in ability to shift and refocus attention" (page 74).

In the present study, we examined whether children of parents with COD have impaired attentional control and if patterns of attentional control differ under neutral and affective conditions. To do so, we employed an extensively used attention-cueing task (Posner and Cohen 1984) that reflects basic attentional control mechanisms while also being sensitive to the affective and motivational context of performance (Derryberry and Reed 1994, 2002). The Posner task has shown a stable pattern of findings across a wide array of methodologies. Individuals are consistently faster in responding to stimuli appearing in a previously cued location (valid trials) versus stimuli that are not cued (invalid trials) (Posner and Cohen 1984). Termed the validity effect, the gap in reaction times emerges as early as 3 months of age (Hood et al 1998) and is evident across variations in the form and location of the cue and targets (Derryberry and Reed 2002; Driver et al 1999).

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Despite this stability, performance on the cued attention task is not impervious to contextual and individual characteristics. This reflects the fact that selective attention is sensitive to both motivational states and idiosyncratic biases in the response to affect and stress (Ellenbogen et al 2002). The general consensus is that affect negatively impacts performance, as illustrated in the Simpson et al (2000) summary of the affect-cognition literature: “. . . when arousing negatively valenced stimuli are confronted but incidental to the performance of a cognitive task, performance on the task deteriorates, heightened autonomic responses are elicited, and many but certainly not all structures in the brain thought to be concerned with emotion processing exhibit changes in activity” (p 166).

In the current study, children were told that their overall performance on the task was being monitored. In the affective condition, the children were told that they would be required to give an embarrassing speech if they performed poorly. When preparing for the speech (the speech is never actually given), children show increases in the stress hormone cortisol (Schmidt et al 1999b), greater right frontal EEG activity, and an increase in heart rate (Schmidt et al 1999a). In the Posner task, these instructions lead to decreases in reaction time, increased errors, and an increased validity effect (Pérez-Edgar and Fox 2005). The increase in validity effect suggests that children have difficulty orienting attention, despite being motivated to do well in the task (Rich et al 2005).

The behavioral data (i.e., reaction times [RTs], error rates) were supplemented with event-related potentials (ERPs) collected during testing. These data are particularly useful because the core phenomena of emotion and attention are brief and require fast resolution to accurately reflect timing and intensity (Davidson 1994). The ERP is time-locked to the individual trial and can, in conjunction with behavioral data, shed light on both performance effectiveness (RT and error rates) and processing efficiency (ERP amplitude). A number of researchers (Eysenck and Calvo 1992; Murray and Janelle 2003) have noted that experimental effects are not always found in overall performance but are instead evident in the effort required to maintain a particular level of functioning. The use of multiple levels of analysis helps ensure that these effects will not be overlooked.

A growing number of studies have used ERP measures as indices of neural activity during the traditional Posner task. The data indicate that the presentation of a cue engages attention during early perceptual processing (Luck et al 1990), increasing the amplitudes of early perceptual components (e.g., P1, N1) for trials with valid cues. The findings are most pronounced for posterior electrode sites in both children (Perchet and García-Larrea 2000) and adults (Hillyard et al 1994). Preliminary work (Pérez-Edgar and Fox 2005) suggests that the addition of a stressor, as in the affective Posner task, will also affect ERP amplitudes. However, task- and group-related effects are centered in the anterior electrode sites, indicating that higher cognitive processes may come into play in emotional contexts.

To examine the potential points of difficulty for the at-risk children, the analyses focused on three ERP components: P1, P3, and a negative slow wave. The P1 component was used as a marker of early, rapid processing of spatial cues (Taylor 2002). As in previous studies, late ERP components were selected to examine higher-order attentional processes, namely, attention during stimulus evaluation (P3) (Rich et al 2005) and attention allocation in the response selection phase (slow wave) (West and Alain 2000).

In summary, the current study compared performance in a Posner attention-cueing task under both neutral and affective conditions, using behavioral (RT and errors) and psychophysiological (ERP) data. Of central interest was the role parental COD status would play in moderating performance across tasks. We expected

that all children would replicate the published literature when engaged in the traditional and affective Posner tasks. That is, both groups would show a strong validity effect increasing across tasks, and performance in the affective version of the task would be marked by relatively faster reaction times, increased errors (Rothbart et al 1995), and greater cortical activity in posterior electrode sites (Wallace and Newman 1998). We hypothesized that under the affective manipulation, the at-risk children would experience greater difficulty in performing the task (as seen in RTs and errors), accompanied by an increase in electrocortical activity, particularly in anterior electrode sites.

Methods and Materials

Subjects

Subjects for the current study were drawn from participants in a larger, multidisciplinary program project that included adults with a history of COD (i.e., probands) as well as their young offspring. Probands were recruited through various avenues, including participants from previous research projects, community advertisements, and individuals in outpatient treatment facilities. Control families were recruited through a marketing directory, newspaper advertisements, and other studies.

For the majority of probands and all control subjects, psychiatric history was determined via the Structured Clinical Interview for DSM-IV (SCID) (First et al 1995), administered by trained clinicians to subjects and separately to second informants. Independent psychiatrists reviewed these data, as well as childhood psychiatric and medical records, to reach “best-estimate” consensus diagnoses. A subset of subjects had been participants in a longitudinal, naturalistic follow-up study of COD and had undergone multiple psychiatric assessments and repeated consensus diagnoses over the course of up to 20 years (e.g., Kovacs et al 1997, 2003). This subsample was evaluated during childhood using the Interview Schedule for Children and Adolescents, Young Adult version (Sherill and Kovacs 2000) and later by the SCID as well. Childhood onset of depression was defined as major depressive or dysthymic disorder with first onset by the age of 14 years. At intake, nine of the proband parents also showed signs of comorbid disorders (e.g., bipolar disorder, major depression, anxiety and phobia, substance use).

To be enrolled as a control subject, the child’s parents had to have a lifetime history free of major psychiatric disorder. Individuals with episodes of highly circumscribed conditions not associated with functional impairment (e.g., a brief period of marijuana use in college, a phobia of snakes) were deemed eligible as control subjects. Additionally, all subjects had to be free of preexisting major systemic medical disorders and without evidence of mental retardation at their initial assessment.

For the current study, 33 children (20 male children) completed the Posner attention cueing task. Sixteen children had one parent diagnosed with COD. The remaining children were in the control group. Three children had data discarded: a child in the control group disqualified due to subsequent parental diagnosis, a child with technical difficulties at testing, and a third child with data over 2.5 standard deviations from the mean. This left 30 children (16 at risk) with complete behavioral data available for analysis. The mother served as the COD proband for 28 of the children.

Overall, mothers had a mean age of 31.2 years (SD = 4.2) at time of testing. All mothers except 2 had received a high school diploma or general equivalency diploma and 22 had some postsecondary experience or technical training. Fathers had a mean age of 34.3 years (SD = 5.9) and all but one had received a high school or

general equivalency diploma. Twelve fathers had some postsecondary training. All of the families noted English as the primary language spoken at home. The children ranged in age from 6 to 9 (mean = 7.8, SD = .80) years. Parents identified 13 children as Caucasian, 9 as African American, 1 as Asian, and 7 as multiracial. The two groups differed significantly only on parental age, $t_s > 2.57$, $p_s < .02$, such that parents of the at-risk children were younger than parents of the control children.

The children's developmental histories noted four children (three in the at-risk group) with phobias, two children (one at risk) with learning disabilities, six children (three control subjects) with attention-deficit/hyperactivity disorder (ADHD), two children (both at risk) with socioemotional problems, two children (one at risk) identified as talented/gifted, and seven children (four at risk) with speech/language difficulties. Due to overlap, this constituted 11 individual children (7 at risk) from the study. Preliminary analyses found no differences in task performance from the rest of the sample as a group or specifically for the children with ADHD, $F_s < 1.65$, $p_s > .21$.

Written informed consent was obtained from all parents before testing. The procedures noted were approved by the Institutional Review Board at the University of Pittsburgh.

Posner Tasks

Traditional Posner Task. Children were shown a fixation point appearing in the center of a computer monitor. They were then presented with three boxes outlined in white arranged horizontally across the screen. For the cue, one of the boxes turned from black to blue in color. The target, a small white box, then appeared in either the left-most or right-most box (interstimulus interval = 200 milliseconds). A valid trial had the cue and target appearing in the same location. In invalid trials, the cue appeared in the outermost box opposite from where the target appeared. Trials in which the cue appeared in the center box served as control trials. A total of 50 trials were presented with a 20%, 40%, 40% distribution of control, valid, and invalid trials, respectively. Trial order was chosen at random. The cue and target measured 6 cm × 4.2 cm and subtended 10° of visual angle.

Children were given a response box connected to the data acquisition computer. The box had three buttons, with each corresponding to the display boxes in the task. Children indicated the location of the target by pressing the corresponding button as quickly as possible using their thumbs. Stimuli presentation (inter-trial interval = 4000 milliseconds; time-out latency = 2000 milliseconds) was controlled by the STIM stimulus presentation system

from the James Long Company (Caroga Lake, New York). Reaction times and errors were collected for each trial.

Affective Posner Task. After completing the traditional Posner task, the children completed an additional set of 50 trials. This set of trials (the affective Posner task) was identical to the traditional Posner task with the addition of a speech instruction designed to affect the emotional context of testing. The children were told that their performance during the affective Posner task would determine if they had to give an embarrassing speech.

The children completed the traditional Posner task before the affective Posner task. This ensured that the motivational effects of the affective manipulation would not alter performance on the traditional Posner task, which served as a baseline (Lewis and Stieben 2004). Recent studies (e.g., Beevers and Carver 2003) examining the effect of negative mood on attention bias have used a similar protocol and did not find order effects.

Statistical Examination of Testing Effects. To verify the absence of an order effect, we pooled individual trials into 10-trial sets across both the traditional and affective Posner tasks. This allowed us to examine general trends in performance over the course of the study.

Paired-sample t tests comparing adjacent sets of trials found few significant changes in RTs, $t_s < 1.85$, $p_s > .07$ (Figure 1). However, we did find that RTs for set 6 were significantly faster than for the set of trials that preceded it, $t(29) = 4.71$, $p < .001$, $d = 1.93$. These sets of trials served as the last set of trials in the traditional Posner task (set 5) and the beginning of the affective Posner task (set 6) and were interrupted by the introduction of the affective manipulation. A repeated measures analysis of variance (ANOVA) found no significant main or interaction effects, $F_s < 1.68$, $p_s > .17$. No significant findings were evident when group was added to the analyses as a between-subjects factor, $F_s < 1.31$, $p_s > .27$.

These results indicate that the data presented below resulted from the experimental manipulations of the study and not the gradual effects of increasing boredom or practice. If so, one would have expected the data to trend in one general direction, either gradually increasing in RT as subjects became bored and disengaged or decreasing in RT as subjects became more proficient in the task. Instead, the only theoretically consistent performance difference was found when shifting the core task condition.

EEG Data

Electroencephalogram signals were collected with a Lycra stretch cap from frontal (F3, F4, F7, F8), central (C3, C4), temporal

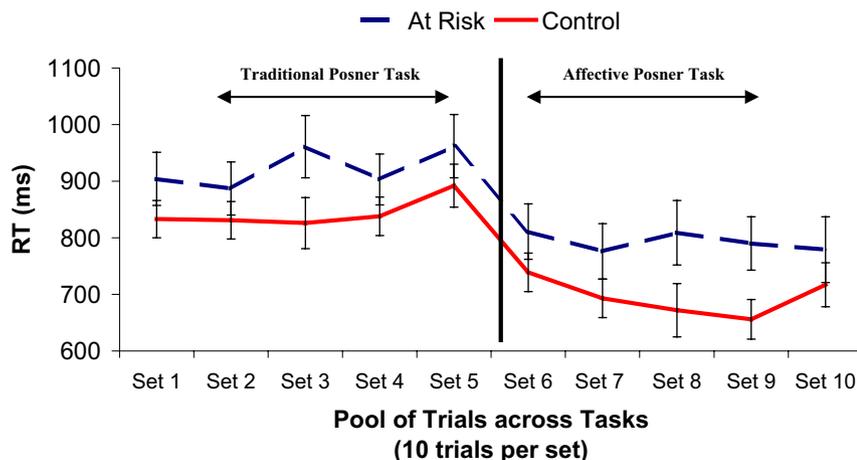


Figure 1. Reaction times across the trials in the traditional and affective Posner tasks, divided into 10-trial sets.

(T7, T8), parietal (P3, P4), and occipital (O1, O2) sites, referenced to vertex (Cz) using the International 10–20 System of Electrode Placement (Jasper 1958). As in other studies involving the relation of electrocortical activity to emotional and cognitive development (Marshall et al 2002), this study used average referencing in analyzing the EEG data. Although the use of average referencing with a smaller electrode array does increase the potential for misestimating, or shifting, the neutral point (Dien 1998), the current study was focused on making a preliminary determination of group-linked differences in process. This minimizes somewhat the potential negative effects of the reference procedure. In addition, the current study was the fourth study across independent laboratories using the task (Pérez-Edgar and Fox 2005; Rich et al, in press). Each has found a similar pattern of results, suggesting that the current data reflect a stable underlying pattern of processing.

Impedances were kept below 10 k Ω . The data from each channel were digitized at a 512 Hz sampling rate and calibrated to a .477-volt root-mean-square (rms) 10 Hz signal that was input into each channel before testing. Vertical eye movements were recorded from 6-mm tin electrodes placed above and below the right eye, while horizontal eye movements were monitored with tin electrodes placed at the external canthi of each eye. The bioamplifier was set for band-pass filtering with half power cutoff frequencies of .01 and 100 Hz (12 dB/octave rolloff). The gain was 5000 for the EEG channels and 2500 for the electrooculogram channels. Data were collected with equipment and software from the James Long Company (Caroga Lake, New York). Automated regression-based algorithms minimized blink artifacts (rise time: 100 milliseconds, fall time: 150 milliseconds, peak: 125 μ V) in the EEG and periods confounded by movement (100 μ V cutoff) or muscle tension were excluded.

Event-Related Potentials

Event-related potentials were collected to the presentation of each target, referenced to a baseline spanning from –100 milliseconds to stimulus onset. Analyses used correct trials artifact free for the 1000 milliseconds following target presentation, after smoothing with a 10 Hz low-pass filter. On average, 17.1 valid trials and 16.7 invalid trials were available per child for the traditional Posner task. This difference was significant, $t(27) = 2.08$, $p = .05$, as was the difference in useable trials (15.7 vs. 14.6) for the affective Posner task, $t(27) = 2.22$, $p = .04$. The differences across tasks were also significant, $t_s > 3.13$, $p_s < .001$. There were no significant differences involving group, $F_s < 1.36$, $p_s > .26$.

Event-related potential components were chosen for analysis based on a review of the grand average ERPs. Event-related potentials to the valid and invalid trials were compared for the P1 (50–200 milliseconds) and P3 (200–450 milliseconds) components. For each component, the peak amplitude within the designated time window was used for the analyses. In addition, the mean amplitude of the negative slow wave was calculated (450–900 milliseconds). Data were analyzed separately for each of the EEG collection channels.

In ERPs produced via average referencing, the ERP waves from the anterior (i.e., frontal and central) were inverted relative to the posterior sites. In discussing these data, the components were labeled based on their appearance in the ERPs produced by the posterior electrodes.

Statistical Analysis

Reaction times were edited for each child to remove error trials, as well as any trials with responses of less than 200 milliseconds or

with responses more than two standard deviations from his or her grand mean.

To minimize the risk for type I error in repeated measures ANOVAs, the Greenhouse-Geisser (GG) procedure was applied when appropriate (Geisser and Greenhouse 1958). The degrees of freedom indicated in the text are those before the GG correction, while epsilon (ϵ) was noted when less than 1.0. Subsequent post hoc comparisons employed the Tukey test.

Analyses of the EEG and ERP first began with an omnibus repeated measures ANOVA that included data from all electrode sites. This was done through a large 4 (Electrode location) \times 2 (Hemisphere) \times 2 (Validity) \times 2 (Task) \times 2 (Group) ANOVA. When a main effect of electrode location was noted, the ANOVAs were then run separately for each location.

Results

Behavioral Data

Error Rates. There were no significant differences across the groups, $F_s < .24$, $p_s > .63$. Overall, the children performed the task very well, with a correct response rate of 91% (SD = 11.0). Correct responses decreased from the traditional Posner task (95.3%) to the affective Posner task (89.6%), $F(1,28) = 9.79$, $p = .004$, $d = 1.18$.

Traditional Posner Task. An initial ANOVA with validity and parental depression group found no significant effects involving group, $F_s < .70$, $p_s > .41$. As in previous studies, the RTs to the invalid trials were significantly slower than RTs to the valid trials, $F(1,29) = 24.15$, $p < .001$, $d = 1.83$ (Table 1).

Affective Posner Task. The at-risk children were significantly slower in the affective task (768 milliseconds) than the control children (669 milliseconds), $F(1,28) = 8.24$, $p = .01$, $d = 1.09$ (Figure 1). In addition, a 2 (valid vs. invalid cue) \times 2 (traditional vs. affective task) ANOVA indicated that RTs decreased dramatically, $F(1,28) = 39.54$, $p < .001$, $d = 2.38$, and the size of the validity effect grew larger (44.4 milliseconds vs. 69.0 milliseconds), $F(1,28) = 5.15$, $p = .03$, $d = .86$, in the affective Posner task. This pattern did not change as a function of group, $F_s < .67$, $p_s > .42$.

Event-Related Potentials

Event-related potential analyses focused on potential group differences across the waveform (Figures 2, 3, and 4; Table 2).

P1. There were no group- or task-based differences for this early sensory component. As expected (Luck et al 1990), amplitudes were larger for the valid trials, $F(1,27) = 6.54$, $p = .02$, $d = .98$ (Figure 5A). This is due to the additive effect of having attention focused on a single location for both targets and cues in the valid trials. This effect was qualified by an interaction with electrode location due to the particularly large validity effect for the occipital sites, $F(3,81) = 2.80$, $p = .05$, $\eta^2 = .31$, $\epsilon = .86$.

P3. Findings were driven by an interaction between trial validity and group, $F(1,27) = 4.03$, $p = .05$, $d = .77$, and an interaction between validity and electrode site, $F(3,81) = 3.66$, $p = .02$, $\eta^2 = .35$, $\epsilon = .86$. The at-risk group showed no amplitude differences in the posterior electrode sites between valid and invalid trials. In contrast, the at-risk group showed significantly larger amplitudes to valid trials, relative to invalid cues, for the frontal, $F(1,27) = 4.92$, $p = .04$, $d = .85$, and central, $F(1,27) = 4.18$, $p = .05$, $d = .79$, sites. This was most pronounced in the affective Posner task, as seen in a trial validity by task by group interaction, $F(1,27) = 5.74$, $p = .02$, $d = .92$ (Figure 5B).

Slow Wave. Mean amplitude levels increased in the affective task for the frontal sites relative to the neutral condition, $F(1,27) = 5.35$, $p = .03$, $d = .89$. A significant validity by group interaction,

Table 1. Mean Reaction Times (Milliseconds) and Standard Deviations of the Mean in the Traditional and Affective Posner Tasks, by Trial Validity and Group

Trial Type	Overall	At Risk	Control	F Statistics
Traditional Posner Task				
Valid	819.7 (158.3)	837.5 (137.1)	800.7 (181.1)	G: .63
Invalid	864.1 (155.5)	889.2 (143.0)	837.4 (168.7)	V: 24.15 ^b
Neutral	840.8 (180.8)	876.5 (169.8)	802.7 (190.3)	G × V: .70
Affective Posner Task				
Valid	684.0 (103.9)	731.4 (108.9)	636.6 (75.3)	G: 8.24 ^b
Invalid	753.8 (113.9)	805.3 (130.4)	700.6 (63.4)	V: 61.57 ^b
Neutral	745.4 (143.0)	806.1 (164.3)	684.0 (86.6)	G × V: .31
				T: 39.54 ^b
				V × T: 5.15 ^a
				G × T: .87
				G × V × T: .11

F(*df*) = 28.
 G, Group; V, Validity; T, Task.
^a*p* < .05.
^b*p* < .01.

F(1,27) = 7.68, *p* = .01, *d* = 1.07, found that children in the control group showed large mean amplitudes for the valid trials. In contrast, the children in the at-risk group showed particularly large mean amplitudes for the invalid trials, producing a large “reverse” validity effect, as in P3. This was most pronounced in the frontal and parietal sites, *F*s > 7.33, *p*s < .01 (Figure 5C).

Discussion

The current study examined the impact of parental history of COD on children’s attentional performance under neutral and emotionally charged conditions. The data indicate that these at-risk children do not differ from their peers in selective attention under neutral conditions, in terms of either behavior (RTs and errors) or neural processing (P1 amplitude). However, with the introduction of an affective stressor, at-risk children appear to call on greater processing resources in executive regions and slow their behavioral responses to match the performance of their peers.

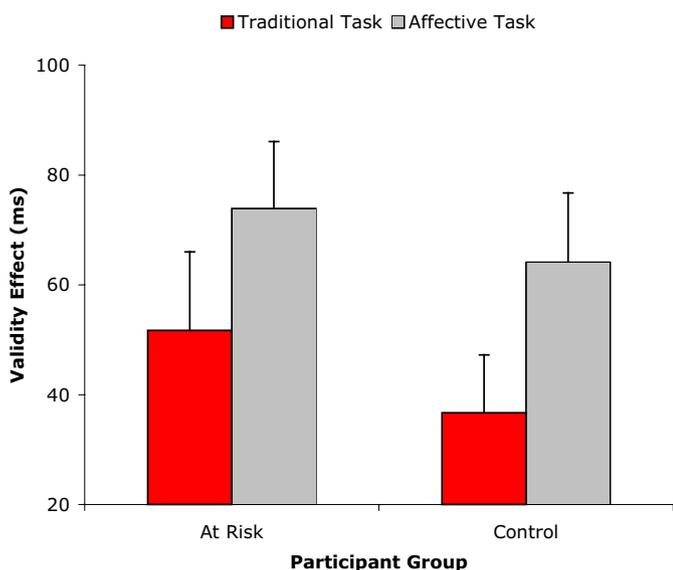


Figure 2. The validity effect (gap in reaction trials for the valid and invalid trials) for the at-risk and control children across the two versions of the Posner task.

The findings suggest that at-risk youngsters may have difficulty efficiently mobilizing executive attention under conditions of negative affective challenge. Because the flexible deployment of attention is a core process in the self-regulation of emotion (e.g., Eisenberg et al 2000), even subtle problems in attention may undermine the development of adaptive emotion regulation skills. These data help illustrate how low-level group differences can

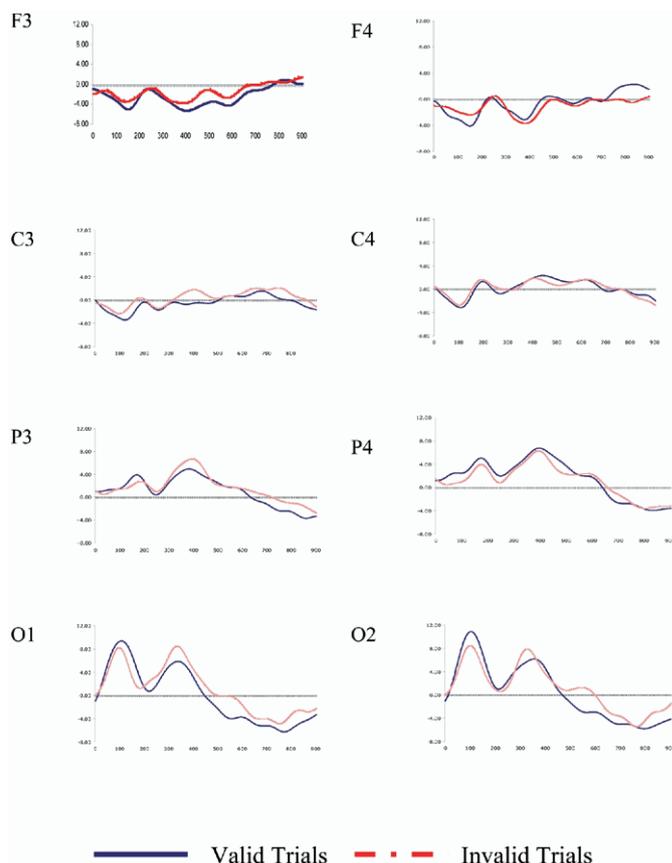


Figure 3. Event-related potentials generated by the traditional Posner task for valid and invalid trials. As expected, peak amplitudes for the early P1 component are enhanced in the valid trials.

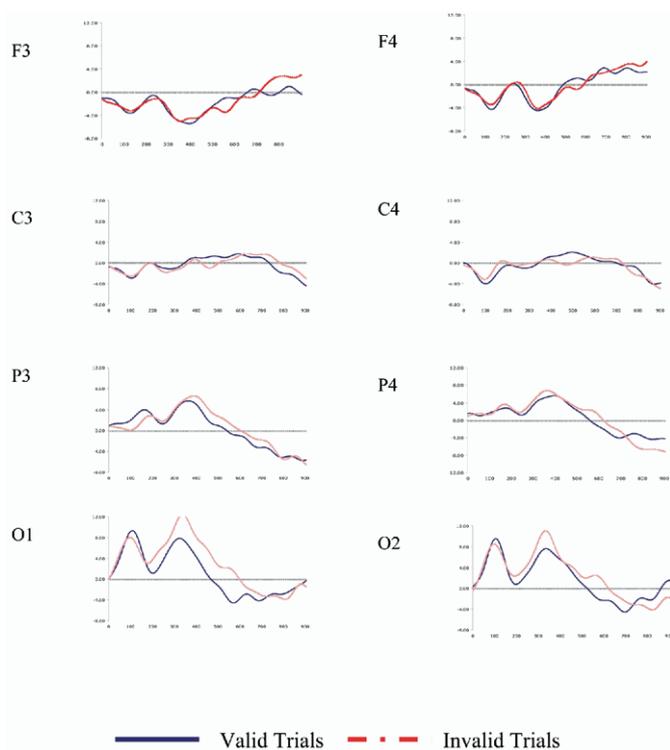


Figure 4. Event-related potentials generated by the affective Posner task for valid and invalid trials. Group differences in the later components (P3, slow wave) are more pronounced in the affective task, relative to the traditional affect-neutral testing procedure.

translate into functional differences at the behavioral level, as seen in the work of Silk et al (2006).

Cummings (1995) has suggested that “primarily academic or intellectual performance may be little affected by parental depression, or, alternately, influenced only when tasks are negatively arousing” (p 426). Stress-inducing contexts may tax the coping strategies of high-risk individuals, allowing for individual differences to emerge. Future attempts to predict the later onset of behavioral problems in high-risk children using individual differences in affect regulation may benefit from the inclusion of context-specific markers (Forbes et al 2006).

The data from the traditional Posner task replicated previous studies without regard to parental status (Derryberry and Reed 1994, 2002; Perchet and García-Larrea 2000; Perchet et al 2001).

As such, it does not appear that there are fundamental differences in attention orienting in these high-risk children.

In the affective Posner task, children found it more difficult to carry out the attentional shifts needed for the task, as marked by the increase in error rates and the larger validity effect. These data, coupled with recent studies of children and adults (Fox et al 2001; Pollak and Tolley-Schell 2003), suggest that the affective tasks require more neural resources than do tasks completed under neutral conditions. In addition, the data suggest that the at-risk children may face a subtle difficulty when performing in a stressful context. For example, the at-risk children responded significantly more slowly than the control children to reach behavioral parity. The psychophysiological data also suggest subtle difficulties.

The P1 component was used as a marker for early sensory-based attentional responses. As expected, amplitudes were larger for the valid trials relative to the invalid trials, without regard to group. Again, this seems to indicate an equivalency in basic attentional mechanisms for the children in the study. Recent work with children indicates that group differences at this level of functioning are normally only evident in children with core attentional deficits, as in ADHD (Perchet et al 2001) or severe mood dysregulation (Rich et al, in press).

The remaining ERP components reflect more cognitive or endogenous processing mechanisms involving stimulus evaluation time and attention allocation in the response selection phase. The validity effect was now qualified by an interaction with electrode site and group centered in the anterior sites. Amplitudes also increased with the introduction of the motivational stressor. These findings indicate that the children may differ in the selective processing of emotional stimuli, reflecting the activation of motivational systems in the brain (Cuthbert et al 2000; Ruchkin et al 1988), centered in brain regions associated with higher-order cognitive processes and motivational biases (Fox 1991).

The data indicate that the at-risk children are sensitive to the contextual changes in the task, although it may appear only subtly in the behavioral data. While the at-risk children may perform comparably to children without a familial history of COD under stressful conditions, they must deploy greater processing resources (increased frontal ERP amplitudes) and take greater care (increased RTs) to do so. Given high enough levels of stress or difficulty, one may predict that these children would no longer be able to effectively deploy compensatory mechanisms and performance would suffer more dramatically. Thus, the sustained stress of a compromised familial environment, as is often seen with parental

Table 2. Mean Event-Related Potentials Amplitudes Generated by the Traditional and Affective Posner Tasks for Two Components (P1, P3) and the Slow Wave at Each of the Electrode Locations (Frontal, Central, Parietal, and Occipital) Separately for Each Group

Electrode Location	P1		P3		Slow Wave	
	At Risk	Control	At Risk	Control	At Risk	Control
Traditional Posner Task						
Frontal	5.989 (.769)	5.501 (.826)	7.413 (1.091)	6.571 (1.172)	1.422 (1.156)	.589 (1.242)
Central	4.360 (.636)	4.280 (.684)	3.577 (.891)	3.506 (.957)		
Parietal	5.451 (.879)	5.931 (.944)	8.737 (1.302)	9.145 (1.398)	.581 (1.330)	-.410 (1.429)
Occipital	11.242 (1.565)	11.866 (1.681)	9.895 (1.901)	9.791 (2.042)	-3.518 (1.711)	-3.237 (1.838)
Affective Posner Task						
Frontal	5.640 (.788)	5.191 (.847)	7.719 (1.023)	7.429 (1.099)	-.488 (1.339)	.276 (1.438)
Central	4.532 (.725)	4.261 (.778)	4.584 (1.008)	2.776 (1.083)		
Parietal	6.125 (.934)	5.168 (1.004)	9.197 (1.025)	9.318 (1.101)	-.795 (1.117)	-2.116 (1.200)
Occipital	11.563 (1.506)	10.726 (1.618)	12.056 (1.844)	10.741 (1.981)	-2.348 (1.523)	-2.729 (1.636)

Means are presented in microvolts with standard errors in parentheses.

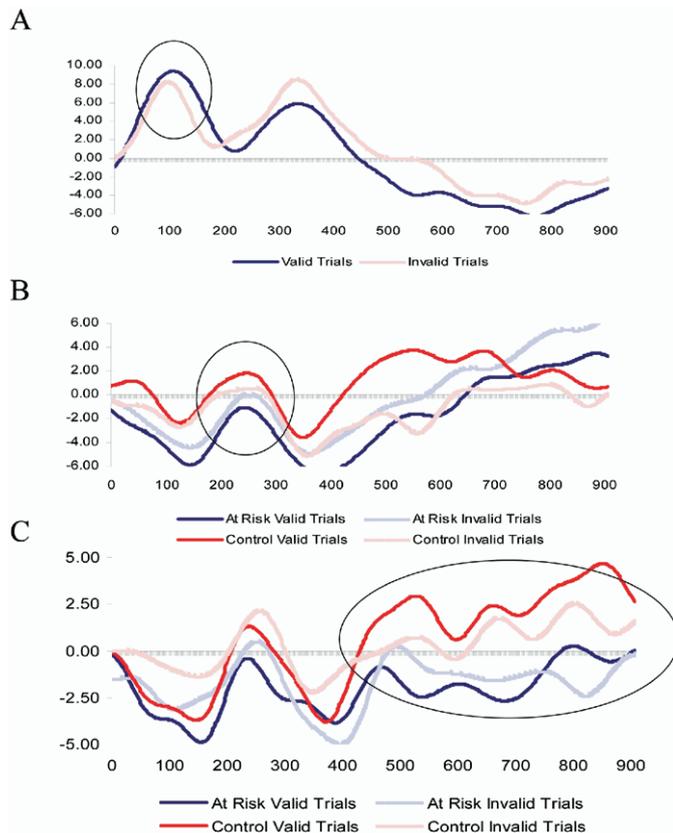


Figure 5. Individual event-related potentials from the traditional and affective Posner tasks. **(A)** Amplitudes at P1 for the valid and invalid trials in the traditional Posner task at O1. As expected, amplitudes are higher for the valid trials due to increased attentional load. **(B)** P3 amplitudes at F4 for the affective Posner task, noted separately for the at-risk and control groups. Unlike for P1, the at-risk children now exhibit increased amplitudes for the invalid trials. **(C)** Mean amplitudes for the slow wave are presented separately for the at-risk and control groups for the traditional Posner task at F4. Here, the children in the at-risk group are showing a “reverse” validity effect.

depression, may tax the child’s attentional mechanisms and leave the child more vulnerable to impaired emotional self-regulation.

Limitations

This discussion must be tempered by the limitations of the current study. First, in an effort to balance two competing methodological concerns, this study chose to protect the integrity of the affective manipulation by having the affective Posner task always follow the traditional task. This leaves open to question the role order effects may have played in the findings. While the strength of the observed behavioral and physiological differences between the two tasks indicates that order effects are not likely to have played a large role, the issue cannot be ruled out unequivocally.

Second, due to time constraints during testing, the task was limited to 100 trials in total. While this was sufficient for robust behavioral data, the ERP analyses would have benefited from a larger, more stable pool of data. The small number of trials may have reduced power, masking potentially significant task and group differences, particularly in components with small amplitudes. Although the current data are in line with similarly constrained data (Pérez-Edgar and Fox 2005; Rich et al, in press), more extensive psychophysiological data should help draw a closer link between observed behavior and underlying neural processes.

Summary

The current study supports the proposition that differences in self-regulation do not necessarily reflect fundamental differences in the structure, function, or control of attentional mechanisms. Rather, the deployment of attention is often bound to contexts that tap into individual concerns central to affective processes, illustrating the way in which cognition can be modified by individual differences in psychological profile (Calkins and Fox 2003). By looking at selective attention in specific contexts, we are able to observe a mechanism that could potentially moderate the risk factors linked to parental depression and could then, in turn, help sustain or buffer against behavioral maladjustment in the second generation (Schmidt and Fox 1994).

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