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

Koraly Pérez-Edgar, Nathan A. Fox, Jeffrey F. Cohn, and Maria Kovacs

***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 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).

From the Department of Psychology (KP-E), George Mason University, Fairfax, Virginia; Department of Human Development (NAF), University of Maryland, College Park, Maryland; Department of Psychology (JFC), University of Pittsburgh, Pittsburgh, Pennsylvania; and Department of Psychiatry (MK), University of Pittsburgh School of Medicine, Pittsburgh, Pennsylvania.

Address reprint requests to Koraly Pérez-Edgar, Ph.D., Department of Psychology, George Mason University, MS3F5, 4400 University Dr., Fairfax VA 22030; E-mail: kpe@umd.edu.

Received July 15, 2005; revised November 22, 2005; accepted February 16, 2006.

0006-3223/06/$32.00
doi:10.1016/j.biopsych.2006.02.036

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 (Sherrill 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