

Executive attention and self-regulation in infancy

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Abstract

This study investigates early executive attention in infancy by studying the relations between infant sequential looking and other behaviors predictive of later self-regulation. One early marker of executive attention development is anticipatory looking, the act of looking to the location of a target prior to its appearance in that location, a process that involves endogenous control of visual orienting. Previous studies have shown that anticipatory looking is positively related to executive attention as assessed by the ability to resolve spatial conflict in 3–4-year-old children. In the current study, anticipatory looking was positively related to cautious behavioral approach in response to non-threatening novel objects in 6- and 7-month-old infants. This finding and previous findings showing the presence of error detection in infancy are consistent with the hypothesis that there is some degree of executive attention in the first year of life. Anticipatory looking was also related to the frequency of distress, to looking away from disturbing stimuli, and to some self-regulatory behaviors. These results may indicate either early attentional regulation of emotion or close relations between early developing fear and later self-regulation. Overall, the results suggest the presence of rudimentary systems of executive attention in infants and support further studies using anticipatory looking as a measure of individual differences in attention in infancy.

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In recent years several attention networks have been studied in adults (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005) and in children (Rueda, Fan, et al., 2004). The executive attention network is a brain network that has been related to error detection (Dehaene, Posner, & Tucker, 1994; Gehring, Goss, Coles, Meyer, & Donchin, 1993) and the ability to resolve conflict among different response tendencies (Botvinick, Braver, Barch, Carter, & Cohen, 2001). These abilities are thought to be critical for the development of self-regulation of thoughts and feelings, and the effortful control of behavior (Posner & Rothbart, 2007). The executive attention network is thought to show a developmental time course (Posner & Rothbart, 2007). However, research on the early development of the executive attention network has been limited due to difficulties in assessing executive attention in infancy.

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A number of cognitive tasks have been designed to study executive attention in adults. For example, the Attention Network Test (ANT) utilizes a flanker task, wherein the participant responds to a central target in the presence of either congruent or incongruent targets, to assess executive attention. Relative slowing to incongruent compared to congruent targets serves as a measure of conflict resolution. The ANT task and other measures of conflict resolution, such as the Stroop task, have been modified for use with children as young as two and a half years of age. However, these tasks rely on instructions for voluntary actions that participants under two years of age cannot easily understand or perform. Assessing executive attention prior to two and a half years of age requires tasks that place minimal demands on the child's language and motor skills.

Error detection, for example, can be assessed in infancy using behavioral paradigms. Wynn (1992) examined the development of numeracy using a behavioral paradigm and showed that infants look longer at apparent errors in simple addition. Building on this work, Berger, Tzur, and Posner (2006) used high density electrical recording to show that detecting an error in this task involves the same frontal brain areas in infants that have been implicated in executive attention in adults.

We have argued that another method for assessing executive attention in infancy may be anticipatory looking, measured through patterns of eye movement and elicited without verbal instructions (Rothbart, Ellis, Rueda, & Posner, 2003). In anticipatory looking paradigms, predictable sequences of visual stimuli are shown to participants (e.g., Haith, Hazan, & Goodman, 1988; Clohessy, Posner, & Rothbart, 2001). Eye movements are recorded and coded for evidence of *reactive looks*, occurring in response to the presentation of a stimulus, and *anticipatory looks*, occurring prior to the presentation of a stimulus.

Reactive looks are thought to reflect exogenous control of attention because they occur in response to the stimulus itself and may require only attentional processes associated with alerting and orienting. In contrast, anticipatory looks are thought to reflect voluntary control of attention in that the infant generates an eye movement toward a stimulus that is not yet present. With no external stimulus to elicit a response, saccades are likely to be initiated internally. Rothbart et al. (2003) showed that anticipatory looking in 24- and 30-month-old children was related to better conflict resolution in a modified spatial-conflict task and to self-regulation as assessed through parent ratings of children's effortful control. These findings support the idea that anticipatory looking can be used to assess early executive attention.

What remains untested is whether anticipatory looks to visual sequences can also be used as a measure of executive attention prior to 2 years of age. The current study addresses this question by observing how anticipatory looking to a visual sequence is related to measures predictive of current and future self-regulation in infancy. Previous longitudinal studies have found links between behavior in infancy and subsequent self-regulation in childhood. We have previously found that caution, measured by latency to approach novel objects in infancy, predicts higher levels of self-regulation when children are 7 years of age (Rothbart, Derryberry, & Hershey, 2000). Therefore, we hypothesized that the frequency of anticipations during looking would be positively correlated with two measures of cautious approach to novel objects: infants' latency in reaching toward novel objects and their duration of visual inspection prior to reaching.

Greater fearfulness in 2–3-year olds has also been shown to predict higher levels of effortful control later in childhood (Aksan & Kochanska, 2004). This finding has been interpreted as evidence that early emotional control systems, such as fear and caution, contribute to the development of control systems that develop later and are more cognitive. We used the presentation of masks to assess fearfulness and predicted a positive correlation between frequency of anticipatory looks and fearful responses to the mask.

We also hypothesized that infants who had developed rudimentary executive attention capacities, as demonstrated by more anticipatory looks, would show more attempts to regulate negative emotion in response to distress provoking stimuli. One such mechanism for emotion regulation is physical stimulation. Caregivers often use repetitive stroking, rocking, and other methods of physical stimulation in combination with vocalizations to reduce infants' distress (Calkins & Hill, 2006; Jahromi, Putnam, & Stifter, 2004). Physical self-stimulation through touching, hand clasping, and sucking can also be employed by the infant for self-soothing (Rothbart, Ziaie, & O'Boyle, 1992). We thought that infants showing higher levels of anticipatory looking would spend more time attempting to regulate distress through physical self-soothing. A second mechanism for emotional self-regulation in infancy is orienting away from distressing stimuli (Harman, Rothbart, & Posner, 1997). Thus, we hypothesized that infants showing higher levels of anticipatory looking would also show greater evidence of emotional self-regulation, in the form of looking away from distressing animal masks presented to the infant.

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