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Sustained selective attention predicts flexible switching in preschoolers

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ABSTRACT

Stability and flexibility are fundamental to an intelligent cognitive system. Here, we examined the relationship between stability in selective attention and explicit control of flexible attention. Preschoolers were tested on the Dimension Preference (DP) task, which measures the stability of selective attention to an implicitly primed dimension, and the Dimension Change Card Sort (DCCS) task, which measures flexible attention switching between dimensions. Children who successfully switched on the DCCS task were more likely than those who perseverated to sustain attention to the primed dimension on the DP task across trials. We propose that perseverators have less stable attention and distribute their attention between dimensions, whereas switchers can successfully stabilize attention to individual dimensions and, thus, show more enduring priming effects. Flexible attention may emerge, in part, from implicit processes that stabilize attention even in tasks not requiring switching.

Introduction

An intelligent cognitive system depends on both stability and flexibility. Stability is relevant because similar contexts and tasks benefit from similar solutions. Adaptive intelligence, however, also

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requires dropping old solutions when some shift in task and context demands a change. Basic properties of the cognitive system seem to ensure both stability and flexibility. On the side of stability, the processing of immediate input emerges within the current state of the system such that there is a pull toward the just immediate past, a pull evident in phenomena such as priming (Gershkoff-Stowe, Connell, & Smith, 2006; Huttenlocher, Vasilyeva, & Shimpi, 2004; Naito, 1990; Thothathiri & Snedeker, 2008) and perseveration (Cragg & Chevalier, 2012; Deák, 2003; Smith & Samuelson, 1997; Smith, Thelen, Titzer, & McLin, 1999). On the side of flexibility, processes of habituation, the attraction of the unexpected, and internal control processes work to shift attention and thoughts in new directions (Addyman & Mareschal, 2013; Horst, Samuelson, Kucker, & McMurray, 2011; Kidd, Piantadosi, & Aslin, 2012; Miyake et al., 2000). Attention can be sustained selectively through implicit processes that stabilize attention, and it can be flexibly shifted through explicit control processes to fit new task goals (Cepeda, Kramer, & Gonzalez de Sather, 2001; Rueda, Posner, & Rothbart, 2005; Zukier & Hagen, 1978). The ability to both stabilize attention and flexibly shift attention in the service of a goal is a significant achievement in human cognition and one with a long and protracted developmental course that spans from infancy to adolescence (Best & Miller, 2010; Garon, Bryson, & Smith, 2008).

During the late preschool period, young children begin to show increasingly robust abilities in flexibly shifting their attention. One widely used task to measure flexible attention is the Dimension Change Card Sort (DCCS) task (Frye, Zelazo, & Palfai, 1995). On the DCCS task, children are asked to sort cards varying on two dimensions (usually shape and color; see Fig. 1). On the first phase of the task children are asked to sort the cards by one dimension, and on the second phase they are asked to switch and sort the same cards by the other dimension. Younger and older preschoolers sort by the first rule without error. However, when the rule changes, only older preschoolers adjust their behavior to the new rule. A recent meta-analysis found that only 41% of children switch successfully at 3 years of age on the post-switch phase of the DCCS task, whereas 88% of children do so at 5 years of age (Doebel & Zelazo, 2015). These findings suggest that older preschoolers can flexibly switch their attention to previously irrelevant information according to an explicit task rule.

At the same time that children's attention is becoming more flexible, allowing children to switch attention between dimensions, an older literature points to a similar progression in the ability to stabilize attention to individual dimensions. To examine attentional stability, this older literature measures children's ability to sort or classify stimuli by a single dimension, property, or attribute in the face of irrelevant or distracting information. For example, when asked to sort cards by one dimension, young preschoolers are more affected than adults by variation along the irrelevant dimension even though the relevant property is always explicitly stated in the instructions (Smith & Kemler, 1978). Younger children also appear to flit inconsistently from one property to the next or distribute attention unsystematically across dimensions, whereas older children seem to more consistently track a single property or dimension (Cook & Odom, 1992; Gelman, 1969; Lane & Pearson, 1982; Smith & Kemler, 1978; Strutt, Anderson, & Well, 1975; Thompson & Markson, 1998). This increased ability to focus on comparisons of objects along a single dimension has also been shown in tasks where children were not explicitly instructed about which attribute to selectively attend to (Smith, 1989; Thompson, 1994; Ward, 1980; see also Hanania & Smith, 2010). That is, even in uninstructed sorting tasks, older children selectively attend to a single dimension better than younger children, suggesting that the ability to stabilize selective attention during sorting or classification does not necessarily require explicit task demands. One idea is that for older perceivers, sustained selective attention to a single dimension is driven by implicit default processes (Garner, 1974). This idea finds support in studies showing that priming (an implicit process where repetition aids in maintaining attention to a stimulus, attribute, or dimension over time) is positively associated with the ability to filter out distractions during classification. For example, the repetition of a target stimulus has been found to facilitate classification of that stimulus in the presence of distracting information (Day & Stone, 1980; Enns & Cameron, 1987). Together, these findings suggest improvements during the preschool years in children's ability to stabilize attention selectively to relevant individual properties and that this ability may rely on developmental changes in implicit attentional processes.

How are developmental advances in stable selective attention and in flexible attention related? One possibility is that these abilities develop independently, with processes such as priming attention through repetition emerging before the ability to explicitly switch attention in response to changing