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Unique contributions of attentional control and visuomotor integration on concurrent teacher-reported classroom functioning in early elementary students

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ABSTRACT

In a diverse sample of 278 kindergarten and first grade students from two U.S. states, this study explored the concurrent associations between directly assessed cognitive processes linked to children's development and learning—attentional control and visuomotor integration—and two teacher-reported classroom functioning outcomes: self-regulation and problem behaviors. In addition, we examined the relative contribution of attentional control and visuomotor integration to teacher-reported classroom functioning outcomes. After controlling for the effects of child characteristics including age, gender, preschool attendance, ethnicity, free/reduced lunch status, and fine motor coordination abilities, results indicated that attentional control and visuomotor integration were each directly related to teachers' ratings of classroom self-regulation, but not to classroom problem behaviors. Even after accounting for children's attentional control abilities and teachers' ratings of problem behaviors, visuomotor integration was a strong and unique concurrent predictor of children's classroom self-regulation, as reported by their teachers. Implications of these findings for research and practice are discussed.

1. Introduction

How well children adjust to the heightened behavioral demands of classroom life during the transition to primary school is a growing concern in an age of increasing academic accountability (e.g., Bulotsky-Shearer, Dominguez, & Bell, 2012; Neuenschwander, Rothlisberger, Cimeli, & Roebers, 2012). Along with developmental changes, children also experience changes in their learning environments during the transition to formal schooling. This transition typically consists of moving from relatively unstructured environments to a more academic, teacher-directed, structured context, in which children are expected to sit and concentrate on seatwork for prolonged periods of time (Entwisle & Alexander, 1998; La Paro, Rimm-Kaufman, & Pianta, 2006; Rimm-Kaufman & Pianta, 2000). To make a successful transition to school, young children rely not only on academic skills, but also cognitive and behavioral skills such as following directions, regulating emotions and impulses, and focusing their attention on challenging, potentially frustrating tasks. Teachers report that many children struggle with the transition to formal schooling, and over half of their students struggle with social and academic demands when they enter school (Lin, Lawrence, & Gorrell, 2003; Rimm-Kaufman, Pianta, & Cox, 2000).

Although rarely taught explicitly in the classroom, cognitive processes including attentional control and visuomotor integration are emerging as critical foundations for children's academic achievement (e.g., Cameron et al., 2012; Carlson, Rowe, & Curby, 2013; Grissmer, Grimm, Aiyer, Murrah, & Steele, 2010; Korkman, Kirk, & Kemp, 1998). Attention drives children's performance on academic assessments and their functioning in learning contexts; that is, attention underlies whether children are able to engage in learning tasks and avoid competing behaviors. Thus, previous studies show that attentional processes are also robustly related to children's classroom functioning along with achievement

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(e.g., Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Cameron Ponitz, McClelland, Matthews, & Morrison, 2009; Hughes & Ensor, 2008; Hughes & Ensor, 2011; Neuenschwander et al., 2012).

Despite evidence for academic relevance of visuomotor skills (e.g., Liew, Chen, & Hughes, 2010) and the prevalence of activities requiring fine motor coordination in early childhood classrooms (Marr, Cermak, Cohn, & Henderson, 2003), little research has explored how visuomotor integration relates to teachers' perceptions of children's classroom functioning during the transition to formal schooling. The present study examined concurrent associations between kindergarten and first graders' attentional control and visuomotor integration and how their teachers perceived their classroom self-regulation and problem behaviors, as well as the relative contribution of attentional control and visuomotor integration to these indicators of classroom functioning. We were particularly interested in whether visuomotor integration would explain variance in children's classroom functioning, even after accounting for their attentional control.

1.1. Definitions of attentional control and visuomotor integration

Attention is a multi-dimensional construct that consists of several executive sub-functions, including selective focusing and sustaining of attention, shifting or dividing of attention, and regulation of arousal (Cooley & Morris, 1990; Mirsky, 1996; Petersen & Posner, 2012; Ruff & Rothbart, 1996). Along with other higher order thought processes including inhibitory control and working memory, attention is one aspect of executive functioning (EF). Attention is involved in directing how EF skills are executed to produce goal-oriented responses and complete complex tasks (Espy & Bull, 2005; Klenberg, Korkman, & Lahti-Nuuttila, 2001; Visu-Petra, Benga, & Miclea, 2007; Zelazo, Mueller, Frye, & Markovitch, 2003), including regulating behavior (Cameron Ponitz et al., 2009; McClelland et al., 2007).

For the purposes of this study, we use the term attentional control to refer to continual selective processing of visual stimuli. Such skills are typically assessed using visual search tasks such as paper-and-pencil cancellation tests, which have construct (Baron, 2004; Espy & Bull, 2005; Mahone & Schneider, 2012) as well as ecological validity, given how much of the primary school day is spent in paper-pencil tasks (Marr et al., 2003). The control of attention in these tasks requires children to cognitively engage (i.e., focus on the response sets that are currently active), as well as to disengage or inhibit response sets that were previously active. In other words, children must control their attention to resist a previously active response set from interfering with the current task at hand (Espy & Bull, 2005). Longitudinal studies indicate this type of attentional control (i.e., focused, selective, and sustained) develops and matures around the formal school transition period, as early as six years of age (Visu-Petra et al., 2007; Welsh, Pennington, & Groisser, 1991).

Similar to attentional control, visuomotor integration is a multi-dimensional construct comprised of several sub-components, such as synthesizing parts into a whole, constructing and manipulating representations, perceiving and understanding spatial orientation, and reproducing models using fine motor movements (Carlson et al., 2013; Korkman et al., 1998; Verdine, Irwin, Golinkoff, & Hirsh-Pasek, 2014). Visuomotor integration thus requires fine motor coordination, spatial, and executive attentional abilities (Beery & Beery, 2004). As such, integration combines interior processes with external actions, such as creating a mental representation of an external stimuli and replicating the stimulus with controlled small muscle movements as on a design copy task (Carlson et al., 2013; Korkman et al., 1998; Newcombe & Frick, 2010; Verdine et al., 2014). Fine motor coordination is considered a precursor to visuomotor integration (Kim, Duran, Cameron, & Grissmer, 2015), and correlations are significant and positive ($r = .47$, Carlson et al., 2013). Still, studies that are able to disentangle their contributions suggest the integration aspect of visuomotor skill is most relevant to academic performance (Carlson et al., 2013; Cameron et al., 2012; Grissmer et al., 2010). Central to our present study, which controls for fine motor coordination, success on visuomotor integration tasks also involves flexibility in shifting one's attention back and forth between parts of the objects and the entire object as a whole (Mervis, Robinson, & Pani, 1999).

Theoretical and empirical evidence, including findings from neuroimaging studies, consistently indicate that attentional processes and visuomotor integration are highly related (e.g., Diamond, 2000; Floyer-Lea & Matthews, 2004; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001; Staines, Padilla, & Knight, 2002). Often, tasks that require visuomotor integration skills also require attentional control (Becker, Miao, Duncan, & McClelland, 2014; Beery & Beery, 2004; Korkman et al., 1998). Furthermore, both develop in the prefrontal cortex (PFC), supporting the idea that these two skills are interrelated (Diamond, 2000). Specifically, selective and sustained attentional control involves the superior parietal lobe, temporal parietal junction, and superior colliculus (Posner & Raichle, 1998); similarly, the superior parietal cortex and superior colliculus also play a critical role in visuomotor integration (Iacoboni & Zaidel, 2004; Lefèvre & Galiana, 1992). In sum, visuomotor integration requires functional networks that overlap substantially with the neural structures that underlie cognition and EF, including attentional control, as well as working memory, and inhibitory control (Floyer-Lea & Matthews, 2004; Staines, Padilla, & Knight, 2002). As such, studies that examine children's attentional control should also consider their visuomotor integration skills.

1.2. Attentional control and visuomotor integration in early elementary school

In the classroom, children apply their attention constantly, such as when they must stay on task and work independently while avoiding distractions. Given its role in directing children's cognitive efforts to learning, attention consistently contributes to longitudinal academic and behavioral outcomes (Blair & Razza, 2007; Duncan et al., 2007; Grissmer et al., 2010; McClelland, Acock, Piccinin, Rhea, & Stallings, 2013; Welsh, Nix, Blair, Bierman, & Nelson, 2010). Whereas attention, broadly defined, may underlie a child's ability to pursue goals in the classroom, successful goal attainment also depends on the ability to navigate a busy environment; to parse new and complex visual information; and to manipulate classroom materials and tools. Therefore, it is not surprising that attention is an important contributing factor to children's visuomotor integration (Decker, Englund, Carboni, & Brooks, 2011).

Within the paradigm of embodied cognition theory, attentional control and visuomotor integration co-develop, as children use their body and motor movements to interact with their environment (Campos et al., 2000). For instance, as children learn to control, coordinate, and integrate their bodies and motor movements to behave appropriately within the classroom context, their experiences support the acquisition and performance of the multiple processes involved, including attentional and motor control and their integration (Campos et al., 2000). Moreover, automaticity theory posits that cognitive resources become available as one is able to automatize, or perform a task without using one's full attention, which in turn, makes it easier to simultaneously perform a second attention-demanding task (Floyer-Lea & Matthews, 2004). According to this theory, attentional control and visuomotor integration are co-dependent. In other words, these two processes compete for the limited amount of cognitive resources that are available (Cameron et al., 2012; Rapport et al., 2009). In elementary school,