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Research Brief

Visuomotor Integration and Inhibitory Control Compensate for Each Other in School Readiness

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This study examined associations of children's initial cognitive skills (visuomotor integration, inhibitory control, and working memory) with their early school outcomes. For 467 preschoolers (average age 4.2 years), working memory made additive contributions to achievement, but not behavior. In contrast, children with *either* strong visuomotor integration *or* strong inhibitory control skills learned as much in print knowledge as children who were strong in both; this compensatory pattern also emerged for improvement in phonological awareness and teacher-rated classroom behavior.

Parents and teachers understand that children need many different skills to be ready for school. Similarly, researchers and early childhood experts endorse a multi-dimensional view of school readiness. This includes academic skills such as understanding pictures in a storybook and identifying letters, and behavioral skills such as completing arts-and-crafts activities that require working next to peers and cooperatively taking turns with materials.

As part of the executive functions that support planning and decision-making in the classroom, inhibitory control and working memory are strong predictors of children's early academic skills. In addition, visuomotor integration—which involves aligning perpetual including visual input with muscle movements—has emerged as a similarly consistent predictor of academic achievement. Several studies have shown that children's visuomotor integration, inhibitory control, and working memory are each independently important for children's school outcomes. See examples of the first two skills in ***Table 1***.

We conducted one of the first longitudinal studies that directly assessed preschoolers' executive function (EF) components and visuomotor integration alongside several school readiness outcomes. Specifically: do visuomotor integration and EF components predict children's early academic performance separately, or do they interact?

The cognitive load hypothesis suggests that different task demands, such as EF or motor requirements, compete for the same cognitive resources. Based on this, we wondered if children with either strong EF components or strong visuomotor integration would succeed in early academics and behavior, which often require both types of skills. We asked, do EF components and visuomotor skills function only as independent contributors to children's early school performance, or are they interdependent contributors?

Skills needed in.....

Visuomotor Integration (design copy)

- Comprehend instructions
- Focus attention on task
- Hold and manipulate writing utensil
- Plan where to start on the page
- Compare the design to be copied with own response
- Evaluate and re-direct pencil while copying

Inhibitory Control (pencil tap)

- Comprehend instructions
- Focus attention on task
- Hold and tap writing utensil
- Inhibit impulse to do exactly as the examiner does
- Remember rule ('tap once when I tap twice')

Table 1

The Study

Participants included 467 preschoolers aged 2 to 5 years from low-to-mid socioeconomic status (SES) and diverse ethnic backgrounds. The largest group of children was African American (43%); the next largest group was Hispanic (32%). The remaining children were Caucasian (14%), Asian (3%), Multiracial (5%) or no data (3%). On average, children were 4.2 years old. The average of their mother's education was 12.78 years, or just beyond a high school degree.

We collected data about independent variables at the beginning of the school year, and then data about

dependent variables at the beginning and end of preschool—on average around 5 months apart.

Independent variables were inhibitory control (pencil-tap), verbal working memory (digit span), and visuomotor integration (design copying), at the beginning of preschool.

On pencil tap, children were asked to *tap* their pencil once when the examiner tapped twice, or vice versa. On working memory, they were asked to *recite* a series of two-to-five digits in the reverse order to what the examiner spoke. On design copying, children were also asked to *copy* a series of eighteen figures from the booklet, ranging from simple lines and shapes to intersecting lines and multiple overlapping shapes.

Dependent variables were children's expressive and receptive vocabulary, print knowledge, and phonological awareness, all directly assessed; and teacher-reported preschool learning behaviors. Children were nested in 115 classrooms.

We analyzed the data using multi-level regression models—one for each outcome. We entered independent variables separately in the models, and also created two interaction variables: one for inhibitory control by visuomotor integration, and another for working memory by visuomotor integration.

Findings

We found that controlling for demographics and other cognitive skills, children with better initial working memory performed better on three out of four initial academic assessments and improved more in phonological awareness over time. In contrast, working memory was not significantly associated with variation in teacher-reported behavior; nor did it interact with visuomotor integration to predict outcomes, except for a modest interaction for phonological awareness.

We also found that children with either strong visuomotor integration or strong inhibitory control performed better on receptive and expressive language and phonological awareness initially. Further, they showed more improvement in print knowledge over time. ***(Figure 2)*** This result substantiates the cognitive load hypothesis, where strong visuomotor integration compensated for weak inhibitory control and vice versa. This pattern was also evident, though weaker, for improvement over time in phonological awareness and teacher-rated approaches to teaching.

Implications

This study revealed that children's ability to integrate perceptual and motor skills across modalities—known by researchers as visuomotor integration and commonly assessed by design copy tasks—is related to their better acquisition of print knowledge, even when their inhibitory control is weak.

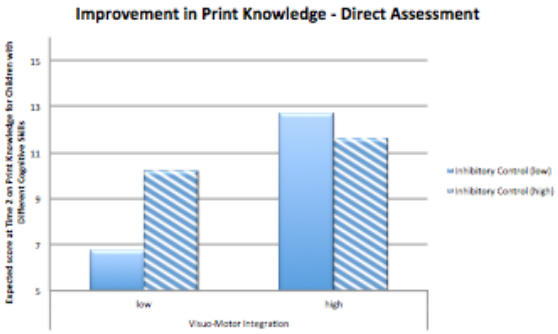

Figure 2

In other words, one early cognitive skill can compensate for low levels of another skill. Even with poor inhibitory control, children with strong visuomotor integration learned the same amount in print knowledge as children who were strong in both skills.

This study suggests that when inhibitory control is low, visuomotor integration appears essential for the acquisition of print knowledge, perhaps underlying emergent literacy and classroom behavior as well. One implication might be to develop preschool activities to support diverse foundational skills that enable children to perform classroom tasks with fine and visuomotor demands. Thus, future research should consider how practitioners can help children practice their visuomotor integration in tandem with inhibitory control in age-appropriate tasks.

This Research Brief based on the following study and should be cited as follows: Cameron, C.E., Brock, L., Hatfield, B.E., Cottone, E.A., Rubinstein, E., LoCasale-Crouch, J., Grissmer, D.W.

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