Examining the Association Between Executive Functioning and Academic Performance

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Introduction

Executive functioning is an umbrella term for complex cognitive processes involved in goal-directed behavior. Blair, Zelazo, and Greenberg (2005) describe executive functions as a number of cognitive processes that are integral to the emerging self-regulation of behavior and developing social and cognitive competence. In particular, these cognitive processes include working memory, inhibition of propositional responding, and the appropriate shifting and sustaining of attention for the purposes of goal-directed behavior (Hughes, 1998; Lehto et al., 2003; Miyake et al., 2000). Recent research on executive functions with children has led to an expansion of our understanding of the role executive functions play in cognitive development and behavior. For example, the development of executive functions is implicated in many developmental disorders and also in early developing psychopathologies (Barkley, 1997). Furthermore, healthy development of executive functions is key in developing social competence and academic readiness necessary for success at school (Blair & Greenberg, 2005). These findings make it imperative to understand the development of executive functioning and how executive functioning abilities may impact academic success. Much research has focused on changes during early childhood (Carlson, 2005). However, very little is known about the links between executive functions and academic skills during middle childhood.

The purpose of the current investigation was to examine the associations among three aspects of executive functioning (i.e., sustained attention, working memory, inhibition) and academic functioning among 6- to 11-year-old children. First, we predicted that performance on executive functioning tasks would increase with age. Second, we expected that sustained attention, working memory, and inhibition would be related. Third, we predicted that academic performance would increase as executive functioning abilities increase.

Method

Participants: Twenty-two 6- to 11-year-old children participated (M = 9 years, 3 months; SD = 1.71). Participants were recruited from a small Midwestern community.

Procedure: Participants completed two sessions approximately seven days apart. The first session included tasks measuring sustained attention, inhibition, and working memory. The second session included tasks measuring intelligence and academic performance.

Continuous Performance Test (CPT): In this task, participants were instructed to press the spacebar for every letter except X. Participants must sustain attention to respond repeatedly to letters displayed on the computer monitor. Errors of omission and commission were recorded.

Stroop: Participants were presented with colored words displayed on the computer monitor and asked to say the ink color of each word. In Wordlist 1, the printed words and ink colors were consistent. In Wordlist 2, the printed words and ink colors were inconsistent (see Figure 1). A difference score reflecting inhibition was created by subtracting response time for Wordlist 1 from response time for Wordlist 2.

Working Memory Task: Participants memorized locations for 20 objects in an open box (see Figure 1). Each object corresponded to a yellow dot. After participants memorized object locations, they placed the objects in the box as close as they could remember without the aid of the yellow dots. Placements were recorded to the nearest ½ inch, yielding a mean error score.

Wechsler Intelligence Scale for Children (WISC-IV): Three subtests from the WISC-IV were included: Digit Span, Vocabulary, and Matrix Reasoning. Performance was used to estimate Full Scale IQ.

Mathweb Mathematical Worksheets: Participants completed six timed mathematical worksheets at their grade level, measuring both computation and application ability. Worksheets were scored according to standard procedures, yielding median computation and application scores.

Results

Age: As expected, task performance increased with age. CPT omissions decreased with age, indicating that sustained attention performance increases as age increases. Participants’ ability to inhibit responses also increased with age, as indicated by the Stroop difference measure (the difference in time between Wordlist 1 and Wordlist 2). Working memory errors also decreased with age. Lastly, participants’ math computation performance increased with age (see Table 1).

Associations Between Executive Functioning Components: There was a strong correlation between CPT omission errors and the Stroop difference measure, indicating that as participants made more CPT omission errors, they also had more difficulty inhibiting. Correlations between the other executive functioning components were not significant (see Table 1).

Associations Between Executive Functioning and Academic Performance Measures: Inhibition was marginally correlated with both math computation and math application performance. As inhibition ability increased, math performance increased. Math computation and application performance also were positively correlated (see Table 1).

Figure 1: Examples of the Stroop and Working Memory Tasks

Table 1: Correlations Between Age, Executive Functioning Tasks, and Academic Performance Measures

<table>
<thead>
<tr>
<th></th>
<th>Age</th>
<th>FSIQ</th>
<th>CPT-Oms</th>
<th>CPT-Cum</th>
<th>StroopDiff</th>
<th>WM Error</th>
<th>MathCompute</th>
<th>MathApp</th>
</tr>
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<tr>
<td>Age</td>
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<td>-.20</td>
<td>.52*</td>
<td>-.89**</td>
<td>.51*</td>
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<tr>
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<td>.00</td>
<td>.17</td>
<td>.13</td>
<td>.16</td>
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<tr>
<td>CPT-Oms</td>
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<td>.75**</td>
<td>.06</td>
<td>.32</td>
<td>.19</td>
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<tr>
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<td></td>
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Discussion

The first goal of this study was to examine the relation between executive functioning and age. As expected, age was strongly related to performance, such that as age increased, so did performance on the CPT, Stroop, working memory task, and math computation. These findings confirm that executive functioning increases across middle childhood. Our second goal was to examine the association between executive function components. We found a strong correlation between inhibition and sustained attention performance, but not between the other components of executive functioning, indicating unity and diversity in executive functioning components (Miyake et al., 2000). Our third goal was to examine the associations between executive function abilities and academic performance. We found that inhibition related to math computation and application ability. These results are similar to Bull and Scerif’s (2001) findings that executive functioning strongly predicted math ability, such that children with lower inhibition and poorer working memory exhibited lower math ability.

One limitation of the current study is its small sample size. To further specify developmental trends related to executive functioning and academic performance, future research should use a larger sample size, additional executive functioning measures, and a longitudinal design. Nonetheless, these findings add to a growing body of research demonstrating the importance of executive functioning in academic success (Bull, Espy, & Wiebe, 2008; Riggs et al., 2006). As such, these results have implications for educational practice because they could inform interventions that lead to greater academic success. Additionally, these results have implications for understanding the basic mechanisms by which children’s cognitive abilities develop.

References


Bull, R., Espy, K. A., & Wiebe, S. A. (2008). Short-term memory, working memory, and executive functioning in preschoolers: Longitudinal predictors of mathematical achievement at age 7 (Bull, Espy, & Wiebe, 2008; Riggs et al., 2006). As such, these results have implications for educational practice because they could inform interventions that lead to greater academic success. Nonetheless, these findings add to a growing body of research demonstrating the importance of executive functioning in academic success (Bull, Espy, & Wiebe, 2008; Riggs et al., 2006). As such, these results have implications for educational practice because they could inform interventions that lead to greater academic success. Additionally, these results have implications for understanding the basic mechanisms by which children’s cognitive abilities develop.


Riggs, K., 595-616. 205-228.

References

All participants took part in the present study. All participants were recruited from a Midwestern community. Consent for publication was obtained from all participants before data collection. All data were analyzed using standard statistical procedures. All results were reported using effect sizes. All statistical analyses were conducted using SPSS (version 22). All raw data are available upon request.