Relations Between Inhibitory Control and the Development of Academic Skills in Preschool and Kindergarten: A Meta-Analysis

Nicholas P. Allan, Laura E. Hume, Darcey M. Allan, Amber L. Farrington, and Christopher J. Lonigan
Florida State University

Although there is evidence that young children’s inhibitory control (IC) is related to their academic skills, the nature of this relation and the role of potential moderators of it are not well understood. In this meta-analytic study, we summarized results from 75 peer-reviewed studies of preschool and kindergarten children (14,424 children; 32–80 months old [M = 54.71 months; SD = 9.70]) across a wide range of socioeconomic status. The mean effect size (r) across studies was .27 (95% confidence interval [.24, .29]), indicating a moderate and statistically significant association between self-regulation and academic skills. The association between IC and academic skills was moderated by type of IC behavior task (i.e., hot vs. cool behavior task), by method of assessing IC (i.e., behavior task vs. parent report), and by academic subject (i.e., literacy vs. math), but not by other methods of assessing IC (i.e., behavior task vs. teacher report, parent report vs. teacher report) or by grade (i.e., preschool vs. kindergarten). The results of this meta-analysis suggest that there are preferred methods for assessing IC (i.e., cool behavior tasks, teacher reports) that should be considered when examining the relations between IC and academic skills in young children.

Keywords: self-regulation, meta-analysis, prekindergarten/preschool, kindergarten, education

Supplemental materials: http://dx.doi.org/10.1037/a0037493.supp

The importance of acquiring academic skills and the perils of early failure are well-documented (e.g., Duncan et al., 2007; McGee, Prior, Williams, Smart, & Sanson, 2002; Spreen, 1988; Stone & LaGreca, 1990). For example, early reading and math skills are the strongest predictors of later academic achievement (e.g., Duncan et al., 2007). Further, children’s academic skills trajectories appear to remain fairly stable after first grade (e.g., Entwisle & Hayduk, 1988). Therefore, it is crucial to understand and assimilate research on factors that influence the acquisition of academic skills prior to first grade (i.e., during the preschool and kindergarten years). Researchers have begun to recognize the importance of self-regulation for transitioning into and early success in the structured classroom environment (e.g., Blair & Razza, 2007; Esplet al., 2004). However, the literature lacks a comprehensive review of the associations between self-regulatory skills such as inhibitory control (IC) or effortful control (EC) and early academic skills. The current study provides a quantitative review of existing research on the concurrent relation between IC/EC and early academic skills in preschool and kindergarten.

Self-regulation refers to the internal and transactional processes that individuals use to guide their goal-directed behavior over time in varying contexts (Karoly, 1993). Whereas some researchers have used this term when conducting research exploring the relation between self-regulation and early academic skills (e.g., Howse, Lange, Farran, & Boyles, 2003; Matthews, Ponitz, & Morrison, 2009), researchers traditionally use terms derived from their respective field of research. For example, cognitive psychologists typically use the broad construct of executive functioning (EF) when discussing self-regulation and related cognitive aspects associated with self-regulation (e.g., Carlson, 2005; Garon, Bryson, & Smith, 2008). Developmental psychologists refer to EC and the executive attention system that underlies EC (e.g., Rothbart & Bates, 2006). The primary difference between EF and EC is that EF is a broader construct than EC, encompassing several distinct cognitive constructs, including working memory and shifting, which are distinct from an IC component in adults and children (McAuley & White, 2011; Miyake et al., 2000).

There is accumulating evidence that the divide between the disparate self-regulatory terms of IC and EC is not substantive. These terms are defined as the ability to inhibit prepotent thoughts or actions flexibly, often in favor of a subdominant action, typically in goal-directed behavior (e.g., Blair, Zelazo, & Greenberg, 2005; Carlson & Moses, 2001; Rothbart, 2004; Rothbart & Bates, 2006). From a neural structures perspective, overlapping neural substrates, including the prefrontal and anterior cingulate cortex, are associated with both IC and EC (e.g., Fan, Flombaum, McCandliss, Thomas, & Posner, 2003; Garavan, Ross, Murphy, Roche, & Stein, 2002; Zelazo & Müller, 2002).
Researchers have argued that there are empirical differences between IC and EC, based on the modest to moderate correlations that have been reported between these constructs (Blair & Razza, 2007). However, the magnitudes of these correlations are likely due to the different measurement tools used when assessing these constructs. Studies ostensibly examining the relations between IC and EC typically compare direct assessment behavior tasks (i.e., peg-tapping; Diamond & Taylor, 1996) to questionnaire measures (i.e., subscales from the EC scale of the Children’s Behavior Questionnaire [CBQ]; Putnam & Rothbart, 2006; e.g., Blair & Razza, 2007; Rothbart, Ellis, Rueda, & Posner, 2003). Although researchers interested in EC have historically used temperament questionnaires and researchers interested in IC have employed more behavioral tasks, temperament researchers have begun to use behavior tasks (e.g., Kochanska, Murray, & Harlan, 2000) and EF researchers interested in IC have begun to employ questionnaire measures (e.g., Clark, Pritchard, & Woodward, 2010). When behavior tasks and questionnaires have been included within discipline (i.e., as either EC or IC measures), the correlations are similar and sometimes lower than those reported between behavioral tasks defined as IC tasks and EC questionnaires (e.g., Clark et al., 2010; Kochanska, Murray, & Coy, 1997). In a series of studies examining the factor structure of several tasks that were a combination of EC and IC tasks, Allan and Longigan (2011, 2014) reported that all the tasks were best represented as a single factor. Because of this accumulating evidence, many researchers now acknowledge that EC, IC, and related terms, such as action control and response modulation, are virtually interchangeable (Allan & Longigan, 2011, 2014; Block, 1996; Diamond, 2006; Nelson, de Haan, & Thomas, 2006; see Zhou, Chen, & Main, 2012, for review). Due to the commonalities among these terms (and for the sake of clarity), we refer to them as IC.

The preschool and kindergarten years are crucial and transitional years for both IC and early academic skills. The preschool and kindergarten years have been implicated as a period of rapid self-regulation development (Rothbart & Bates, 2006; Zelazo & Carlson, 2012). A successful transition into increasingly structured environments as children progress from early childhood settings into early elementary school, including basic academic skills acquisition, requires the development and refinement of self-regulatory skills such as IC. Whereas many children transition successfully into this environment, a substantial percentage of children struggle because of difficulties in regulating their behavior. For example, a large, national sample of teachers (N = 3,595) reported that 16% of children had difficulties with the transition into formal schooling (Rimm-Kaufman, Pianta, & Cox, 2000). Further, 46% of teachers reported that more than half of the children in their classroom had specific behavior problems that affected these children’s ability to succeed in kindergarten. Researchers examining the association between IC and early academic skills have reported modest to moderate associations across multiple methods of assessment (e.g., Allan & Longigan, 2011; Blair & Razza, 2007; Valiente, Lemery-Chalfant, & Swanson, 2010). It is increasingly apparent that an understanding of children’s success in the early years of formal schooling requires an understanding of the relation between IC and early academic skills (Blair, 2002; Howse, Calkins, Anastopoulos, Keane, & Shelton, 2003).

An understanding of the relation between IC and early academic skills requires some specification of the possible mechanisms by which self-regulation may impact these emerging academic skills. An executive attention system is said to underlie IC (Posner & Rothbart, 2007). Behaviorally, this system allows young children to “progressively exert more voluntary control over their thoughts and behavior” (Garon et al., 2008, p. 35). Thus, the executive attention system allows children to orient toward classroom learning activities more efficiently as this system develops from the preschool through the kindergarten years. More specific relations between IC and certain academic skills have been suggested. Specifically, it has been suggested that IC is more associated with math skills than with literacy skills, given the presumed role of the prefrontal cortex in IC and other aspects of self-regulation and math (e.g., Willoughby, Kupersmidt, & Voegler-Lee, 2012). More complex relations between IC and academic skills also have been proposed in which IC, by virtue of regulating children’s emotional responses, influences academic achievement by facilitating positive teacher-child interactions (e.g., Hamre & Pianta, 2001; Ursache, Blair, & Raver, 2012).

Multiple methods of assessment, with different associated benefits and drawbacks, have been used to study the relation between IC and early academic skills. Questionnaires such as the CBQ (Rothbart, Ahadi, Hershey, & Fisher, 2001) and the Inhibition subscale from the Behavior Rating Inventory of Executive Function–Preschool Version (BRIEF–P; Gioia, Espy, & Isquith, 2002) are usually completed by parents or teachers. The focus of these measures is on typically occurring behaviors within the classroom or the home environment conceptualized across a wide spectrum of occurrence (i.e., from extremely untrue of the child to extremely true of the child). However, questionnaires are hampered by rater subjectivity, the influence of past history (or lack thereof) between the rater and the child, and variations in the expression of behaviors across environments and with raters. In contrast, direct assessments of IC using behavior tasks (i.e., grass/snow, peg tapping; Carlson & Moses, 2001; Diamond & Taylor, 1996) are assumed to measure children’s IC objectively and are more likely to assess cognitive processes involved in IC. However, because behavior tasks are usually administered at a single time, patterns of behavior cannot be captured and factors related but not central to IC (e.g., processing speed) and factors unrelated to a child’s general self-regulatory abilities (e.g., time of testing, child fatigue) may influence results. Further, because early childhood is a period of rapid self-regulatory development (Rothbart & Bates, 2006), tasks that are appropriate for younger children may not be appropriate for older children and vice versa (Garon et al., 2008; Ponitz, McClelland, Matthews, & Morrison, 2009). As there are no summative reviews including both questionnaires and behavior task methods of assessment, it is difficult to determine whether there are differences between measures and their relations to academic skills that might make one approach preferable to another.

There are also potential differences in the relation between IC and academic skills within methods of assessment. Regarding questionnaires, it might be expected that teacher-ratings of IC

---

1 Modest, moderate, and large correlations are defined at .10, .30, and .50, respectively, by convention (Cohen, 1992).
would be more associated with measures of academic skills than
would be parent ratings, given that teachers observe children’s
behavior in relation to academic tasks. There is mixed evidence for
this expectation. For example, Blair and Razza (2007) reported
that teacher-rated IC measured in preschool was moderately
associated with math and letter knowledge measured in kindergarten,
but parent-rated IC was not associated with any academic skills.
Eisenberg et al. (2010) reported that mother-rated IC was not
associated with preschool children’s vocabulary skills. In contrast,
Valiente et al. (2010) found modest correlations between parent-
rated IC and math and literacy abilities of kindergarten children.
Whereas the evidence suggests that teacher-rated IC is moderately
associated with children’s early academic skills, it is unclear
whether this association is present between parent-rated IC and
children’s early academic skills as well.

In recent years, researchers have suggested that academic mea-

sures are differentially associated with behavior tasks designed
to measure IC, depending on the level of emotional valence associ-
ated with the task (e.g., Brock, Rimm-Kaufman, Nathanson, &
Grimm, 2009; Willoughby, Kupersmidt, Voegler-Lee, & Bryant,
2011). This distinction parallels the argument that emotion regu-
lation is controlled by “bottom-up” processes, distinct from the
“top-down” processes controlling more decontextualized regula-
tion (Zelazo & Carlson, 2012) “Hot” IC is purported to be neces-
sary when children are involved in tasks or activities that involve
emotions or emotion regulation. In contrast, “cool” IC is purported
to be necessary in tasks or activities that are decontextualized and
abstract. In assessment of IC-using behavior tasks, the distinction
has been most clearly drawn in that tasks that reward or punish a
child (through giving or taking away prizes or giving larger prizes
for longer periods of IC) are considered hot and tasks that do not
include rewards or punishments for performance are considered
cool (Zelazo, Qu, & Kesek, 2009). An example of a hot IC task is
snack delay, in which a child is presented with the option of
receiving a small portion of a snack immediately or a larger por-

tion after a certain period of time (Mischel, Shoda, & Rodriguez,
1989). An example of a cool IC task is the head-to-toes task,
in which children are issued commands to touch either their head
or toes, and they have to do the opposite of this command (Ponitz
et al., 2008).

Researchers have suggested that cool IC is more associated with
academic skills than is hot IC because of the similarity in emo-
tional valence in cool tasks and academically oriented activities
(Brock et al., 2009); however, findings are equivocal regarding this
distinction. In a sample of 173 kindergarten children, Brock et al.
(2009) reported moderate correlations between cool IC and fall
and spring math and reading skills (rs from .37 to .46) and nonsignificant to modest correlations between hot IC and fall and
spring math and reading skills (rs from .12 to .19). Further, Brock
et al. and others (e.g., Willoughby et al., 2011) have reported that
only cool IC uniquely predicted the academic skills of preschool
and kindergarten children. However, in a factor analysis involving
hot and cool tasks, Allan and Lonigan (2011) did not find the two
types of tasks to be separable. Further, other researchers have
found modest to moderate correlations between tasks that would
be considered hot and early academic skills (e.g., Carlson, Man-
dell, & Williams, 2004; Howse, Lange, et al., 2003). Although it
is clear that there are relations between IC as measured by behav-
ior tasks and preschool and kindergarten academic skills, it is

unclear whether the emotional valence of the task moderates these
associations.

The Current Study

Numerous researchers have demonstrated that IC is important in
the development of early academic skills; however, the best meth-
ods of assessing IC when exploring this relation are as of yet
unclear. This lack of clarity hinders the ability to target effectively
IC in teaching strategies, curricula, and interventions to improve
young children’s academic skills. The purpose of this metana-
lytic study was to provide an estimate of the overall relation
between IC and academic skills in preschool and kindergarten
children and to examine the influence of the method of assessing
IC on this relation. Based on past research (e.g., Allan & Lonigan,
2011; Blair & Razza, 2007; Valiente et al., 2010), we expected that
a modest to moderate effect size would emerge. Regarding method
of assessment, it was expected that (a) behavior tasks (i.e., direct
assessment) would be more strongly associated with academic
measures than would be questionnaires, (b) teacher questionnaires
would be more associated with academic measures than would be
parent questionnaires, and (c) cool tasks would be more associated
with academic measures than would be hot tasks. Although few
studies have included examination of whether there are differences
in the relation between IC and early math and literacy skills, it has
been suggested that IC may be more strongly associated with math
skills than with literacy skills (Willoughby, Blair, Wirth, Green-
berg, 2012). Because no studies have explored this dissociation
between IC and type of outcome directly, it was examined as an
exploratory question in this study.

Method

Literature Search and Coding

A broad search of the literature was conducted using ERIC and
PsycINFO for articles published prior to September, 2013. Articles
were sought that included a term related to IC (i.e., “executive
function,” “executive control,” “executive attention,” “cognitive con-
trol,” “attention control,” temperament,” “self-regulation,” and “in-
habit”) along with a term related to academic skills (i.e., “aca-
demic,” “math,” “literacy,” “reading,” “vocabulary,” and “numeracy”). The search was restricted to preschool age (i.e.,
children 2–5 years old) and school age (i.e., children 6–12 years
old). To be included in this meta-analysis, a study had to include
criteria. First, studies that were specific to populations with neurological or
biological disorders were removed, resulting in 41 studies ruled
out. This criterion was used because it is likely that the relations
between IC and academic skills would be moderated by the spe-
cific characteristics of these populations. Studies that did not
include preschool- or kindergarten-age children were removed,
resulting in 64 studies ruled out. Qualitative reviews were
removed, resulting in 44 studies ruled out. Studies had to have at

This document is copyrighted by the American Psychological Association or one of its allied publishers.
This article is intended solely for the personal use of its author and as a personal copiy for the individual user.
It is not to be disseminated broadly.


least one IC measure. Behavior tasks were included if they required children to delay or inhibit a response to a stimulus. The first author reviewed all articles to ensure that this criterion was met. Parent and teacher-report measures were included if they targeted IC. There were 184 studies that were included because they did not meet this criterion. Studies also had to have at least one academic measure. There were 111 studies ruled out because they did not meet this criterion. Studies had to include correlations, resulting in 110 studies ruled out, and these correlations had to be specific to preschool or kindergarten children. This criterion resulted in 104 studies ruled out. The review of studies across criteria resulted in a total of 79 studies. However, four studies were eventually removed because the correlations provided were also provided in another study included in this meta-analysis. In all, this process resulted in a total of 75 studies that included 14,424 participants. Each study was independently coded by the first author, resolved any coding conflicts, and moderated variables of interest. Demographic variables included ethnicity, age, and country in which the study took place. Effect size and related variables included the inhibitory control and academic measures used, individual effects, and sample size per effect. Moderators included type of inhibitory control measure (i.e., teacher report, parent report, behavior task), type of academic measure (i.e., literacy, math), and grade level (i.e., preschool or kindergarten). Raters agreed on codes 92.5% of the time. Discussion among the raters, with the ultimate decision being made by the first author, resolved any coding conflicts.

Inhibitory Control Measures

IC measures were either other-report measures or behavior tasks. Other-report measures were completed by either parents or teachers or, in one instance, by a trained research assistant who had observed the child’s behavior. Behavior tasks were completed by the child, either in a lab setting, in the child’s school, or at the child’s home. Behavior tasks were classified as hot if there was an external motivator for performance, typically consisting of a reward (i.e., snack, stickers, money) and as cool if there were no external motivators for performance. Performance rewards included being given a prize for a correct response, having to wait for a larger prize, or having to delay a behavior while awaiting a reward or prize, although nearly all hot tasks were delay tasks. Performance rewards did not include the typical small prizes given to children just for participating. In most studies, hot tasks were identified as such by the authors. Tasks used in each study are listed by study in Table S1 in the online supplemental material.

Academic Measures

Academic measures were typically administered in the child’s classroom or in a lab setting by trained research assistants. Academic measures consisted of commonly used academic assessment tools (i.e., several Woodcock–Johnson–III Academic Achievement subtests; Wechsler Preschool and Primary Scale of Intelligence subtests; Wechsler, 1989; Woodcock, McGrew, & Mather, 2001) or were modified versions of common assessment tools. There was a single task that was not administered by research assistants. Eisenberg et al. (2010) used mother-completed vocabulary checklists from the MacArthur Communicative Development Inventories (CDI; Dale, Price, Bishop, & Plomin, 2003; Fenson et al., 2000). Academic measures used in each study are listed by study in Table S1 in the online supplemental material.

Ethnicity and Age

Of the 14,424 participants, 43% of children were reported to be White, 14% African American, 6% Hispanic/Latino, 8% Asian, and 4% of other or of mixed race. Race/ethnicity was not reported for 24% of participants. Children’s reported within-study mean ages ranged from 32 to 80 months. Across studies, the average age of children was 54.71 months (SD = 9.70).

Computing Effect Sizes

Bivariate correlations between IC and academic measures served as effect sizes (r). Prior to combining effects, all correlations were converted to Fisher’s z scores to reduce the impact of the correlation on the effect size variance calculation (see Borenstein, Hedges, Higgins, & Rothstein, 2009). After analysis, all effects were converted back to correlations. Many studies included multiple measures of IC, academic skills, or both. Because multiple correlations within the same study are based on the same children, they are not independent and share variance or error present in the study. To compute a more precise measure of effect sizes, if more than one correlation was included in a study, we combined the correlations to yield one effect size per study. However, when studies provided correlations on unique samples of children (e.g., Lan, Legare, Ponitz, Li, & Morrison, 2011), one effect size was calculated per group. This occurred in seven of the 75 studies included in this meta-analysis, resulting in a total of 85 individual effects.

In each moderator analysis, correlations were combined to yield one effect size per study based on the variables being examined such that each sample contributed one effect size per variable of interest to the analysis. For example, when examining the type of IC task (hot or cool) as a moderator, all correlations relating to hot tasks within a sample were combined. This approach was outlined by Cooper (1989) and allows the researcher to maximize information present within a study and, at the same time, minimize violations of the assumptions of independence of effect sizes (see also Degner & Dalege, 2013). Each study could produce a different number of effect sizes based on the variables present within the study resulting in a different number of effect sizes being compared in each moderator analysis. For example, in the study by Bull, Espy, Wiebe, Sheffield, & Nelson (2011), multiple IC outcomes were combined to contribute one effect size in the moderator analysis examining the type (hot or cool) of IC task (i.e., all IC measures were cool), but Bull et al.’s outcomes were combined to contribute two effect sizes in the moderator analysis examining the type of academic tasks (i.e., some academic measures assessed literacy, whereas others assessed math).

To combine effect sizes, the procedures outlined by Gleser and Olkin (1994) were followed. Correlations between multiple measures of IC (and multiple measures of academic skill) were incorporated into variance estimates for each study’s average effect size, which provided confidence intervals that were robust to multiple correlations within studies (see also Borenstein et al.,
If correlations among IC measures (or among academic measures) were not reported, the average correlation between IC measures (or between academic measures) across all the studies included in the meta-analysis was used in the variance equation. Study effects were assumed to differ across studies; therefore, random-effects models were used in all analyses. Consequently, mean effect size estimations and their confidence intervals accounted both for differences within studies and for differences between studies.

### Results

As can be seen in Table 1, the overall effect of IC on academic skills was modest, positive, and significant \((r = .27)\), with a 95% confidence interval (CI) indicating that 95% of true study-average effect sizes ranged from 0.24 to 0.29. A forest plot (see Figure 1) shows the vast majority of effect sizes (and their confidence intervals) are to the right of the vertical line of no effect \((r = 0.00)\), indicating a positive relation between self-regulation and academic skills.

The heterogeneity of effect sizes \((Q;\text{Cochran}, 1954)\) was calculated to examine how effect size estimations varied between studies. The \(Q\) value is calculated by summing square deviations of study effect size estimates while weighting each effect size estimate by its inverse variance. The value of \(Q\) was 347.70 \((p < .001)\), and 75.84% of the observed variance reflected actual differences in study effects \((\text{Higgins, Thompson, Deeks, & Altman, 2003})\). These calculations suggested that study-effect estimations varied significantly and accounted for only a moderate amount of true variance. The forest plot (see Figure 1) depicts how much effect sizes (and corresponding confidence intervals) varied within this meta-analysis.

### Subgroup Analyses Examining Moderators

Results of all moderator analyses are presented in Table 1. Mean effect sizes were computed for groups of studies that shared certain characteristics \((\text{e.g., behavior task or questionnaire})\). These subgroups were compared to determine if effect sizes differed between the groups. The effect of IC on academic outcomes varied significantly based on whether the task was classified as hot or cool. The summary effect of cool tasks \((r = .28, 95\%\ CI [.25, .31])\) was larger than the summary effect of hot tasks \((r = .17, 95\%\ CI [.12, .24]; p < .01)\). The mean effect from behavior tasks of self-regulation on academic outcomes \((r = .28, 95\%\ CI [.25, .31])\) was significantly higher than the mean effect from parent \((r = .16, 95\%\ CI [.08, .25]; p = .01)\) but not teacher reports of self-regulation \((r = .22, 95\%\ CI [.13, .30]; p = .15)\). The mean effects from parent versus teacher reports of self-regulation, however, did not differ significantly from each other.

Moderator analyses also were conducted to examine whether effect sizes varied based on the type of academic skills that were assessed and the grade-level \((\text{e.g., preschool or kindergarten})\) of participants. The effect of IC on academic skills differed significantly as a function of whether the academic skills were literacy-

<table>
<thead>
<tr>
<th>Variable</th>
<th>(Q_p (df))</th>
<th>(k)</th>
<th>(r)</th>
<th>95% CI</th>
<th>(LL)</th>
<th>(UL)</th>
<th>(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>347.70</td>
<td>85</td>
<td>.27</td>
<td>.24</td>
<td>.29</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Inhibitory control measure</td>
<td>8.63 (1)</td>
<td>81</td>
<td>.17</td>
<td>.12</td>
<td>.24</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Hot</td>
<td>8.63 (1)</td>
<td>81</td>
<td>.28</td>
<td>.25</td>
<td>.31</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Cool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral task vs. parent report</td>
<td>6.81(1)</td>
<td>87</td>
<td>.28</td>
<td>.25</td>
<td>.31</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Behavioral task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavioral task vs. teacher report</td>
<td>2.10 (1)</td>
<td>85</td>
<td>.28</td>
<td>.25</td>
<td>.31</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Behavioral task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher report</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Type of reporter</td>
<td>.81 (1)</td>
<td>22</td>
<td>.16</td>
<td>.08</td>
<td>.25</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Parent</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic subject</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within literacy measures</td>
<td>5.68 (1)</td>
<td>91</td>
<td>.25</td>
<td>.22</td>
<td>.28</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Behavioral task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within math measures</td>
<td>4.64 (1)</td>
<td>36</td>
<td>.35</td>
<td>.30</td>
<td>.41</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Behavioral task</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reporter</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kindergarten</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. \(Q_p = \) the weighted sum of square deviations of the subgroup means about the grand mean; \(df = \) degrees of freedom; \(k = \) number of individual effects; \(r = \) mean effect size; CI = confidence interval; LL = lower limit; UL = upper limit. Total \(k\) per analysis differed because each study could contribute a different number of effect sizes based on the collection of variables present within the study.
related \( (r = .25, 95\% \text{ CI} [.22, .28]) \) or math-related \( (r = .34, 95\% \text{ CI} [.29, .39]; p < .01) \). Compared to literacy-related skills, math-related skills exhibited higher correlations with measures of IC. The effect of IC was further examined within literacy and math skills separately. The summary effect of behavior tasks on literacy skills \( (r = .25, 95\% \text{ CI} [.22, .28]) \) was higher than the summary effect of other-report questionnaires on literacy skills \( (r = .17, 95\% \text{ CI} [.10, .23]; p = .02) \). Likewise, the summary effect of behavior tasks on math skills \( (r = .35, 95\% \text{ CI} [.30, .41]) \) was higher than the summary effect of other-report questionnaires on math skills \( (r = .22, 95\% \text{ CI} [.11, .33]; p = .03) \). The effect of IC on academic skills was not significantly different between preschool \( (r = .29, 95\% \text{ CI} [.24, .32]) \) and kindergarten \( (r = .27, 95\% \text{ CI} [.22, .33]; p = .75) \) populations.

**Evaluating Possible Bias**

Although a thorough review of the literature was conducted, the pool of studies that were included in this meta-analysis may not represent all studies conducted in this field of research. It is possible that studies evaluating the relation between IC and academic skills in young children have gone unpublished or were not located for this meta-analysis. Studies with significant results are more likely to get published than are studies with nonsignificant results, suggesting that the mean effects calculated in this meta-analysis may have been higher than the true mean effect (Rosenthal, 1979). To determine if the mean effect-size calculated was robust against this potential bias, we computed Orwin’s (1983) Fail-Safe \( N \). To reduce the mean effect to .20, only 29 studies with null findings \( (r = .00) \) would be needed. However, to reduce the mean effect to near zero \( (r = .01) \), 2,210 studies with null findings would be needed.

The possibility of publication bias was also assessed with a funnel plot (see Figure 2). Because studies were fairly symmetrically spaced around the overall mean effect size, it is unlikely that publication bias was present. Effect sizes near zero appear to be occurring in studies with both large and small sample sizes, indicating it is unlikely that there is a bias toward nonpublication of

---

**Figure 1.** Forest plot for inhibitory control and academic skills meta-analysis derived from a random effects model. Each line and tick mark represents an individual effect size for between-subjects comparisons. Top to bottom presentation order is consistent with Table 1. The diamond shape at the top plot is the overall effect size (.27) for all 85 average weighted effects.

**Figure 2.** Funnel plot of the correlations used to evaluate the overall effect in the random effects model. The \( x \) axis is the study average weighted effects \( (r) \), and the \( y \) axis is the weighted standard error associated with each effect. The center vertical line represents the overall mean effect.
Discussion

The results of this meta-analysis indicated that there was a modest overall relation between IC and academic skills of preschool and kindergarten children. Academic skills were more strongly associated with behavior tasks designed to measure cool IC than with behavior tasks designed to measure hot IC, consistent with several explanations of differences between hot and cool behavior tasks. Behavior tasks were more strongly related to academic outcomes than were parent-questionnaire measures of IC, but behavior tasks were not more strongly related to academic outcomes than were teacher-questionnaire measures of IC. This finding suggests that important information regarding the relation between IC and academic skills can be obtained using both behavior tasks and teacher reports. Behavior tasks were more strongly associated with both literacy and math measures than were other reports. Finally, IC in general was more strongly associated with early math skills than with early literacy skills.

Cool Versus Hot Inhibitory Control

The results of this meta-analysis supported the hypothesis that cool IC tasks are more related to academic skills than are hot self-regulation tasks. These results are consistent with the few studies in which investigators directly compared associations between academic skills in young children and hot versus cool IC (e.g., Brock et al., 2009; Willoughby et al., 2011), although there is ongoing debate as to whether hot and cool EC are separate constructs as well as how best to define hot EC (e.g., Allan & Lonigan, 2011, 2014; Brock et al., 2009; Willoughby et al., 2011). There are several possibilities as to why cool IC is more associated with academic skills than is hot IC. The primary distinction between hot and cool IC is that cool tasks are decontextualized, with limited emotional or motivational significance, whereas hot tasks are typically characterized by their emotional or motivational significance (Zelazo & Müller, 2002). This lack of affective or motivational significance is consistent with the lack of affective or motivational significance involved in testing of young children’s academic skills, which typically require more intrinsic motivation to do well. Therefore, it is possible that hot tasks capture children’s optimal performance because even children who are not motivated intrinsically are willing to put forth their best efforts for the prizes or rewards. This suggestion is consistent with previous research that has compared the performances of children with attention-deficit/hyperactivity disorder (ADHD) to the performances of typically developing children and has determined that although typically developing children outperform children with ADHD on tasks with no rewards, children with ADHD perform similarly to typically developing children when rewards are given for task performance (e.g., Carlson & Tamm, 2000; Konrad, Gauggel, Manz, & Scholl, 2000; see Luman, Oosterlaan, Knol, & Sergeant, 2005, for review). Although there is some debate, researchers have found that rewarding children for academic performance leads to improvements in academic performance (e.g., J. Cameron & Pierce, 1994; Deci, Koestner, & Ryan, 2001). If rewards do increase academic and self-regulatory performance to capture children’s more optimal performance, then using more decontextualized IC tasks and academic measures may capture children’s average, limited motivation potential and using more affective or motivationally salient IC tasks and academic measures may capture their true potential in these domains.

It is also possible that the developmental nature of self-regulation in young children is partially responsible for the stronger relation between cool IC and academic skills, in comparison to the relation between hot IC and academic skills. The capacity for self-regulation undergoes a protracted development, with significant development occurring in the preschool years (Rothbart et al., 2003). For example, tasks designed to measure IC in preschoolers are often too easy for kindergarten children (Carlson, 2005), Diamond (2006) and Zelazo et al. (2009) argued that emotional and behavioral regulation are not yet fully integrated in young children, suggesting that the added level of difficulty in regulating emotional responses to hot tasks interferes with children’s ability to regulate their behavior. Carlson, Davis, and Leach (2005) provided evidence for this argument in a series of experiments involving a hot IC task, less-is-more, in which children were asked to point to a smaller reward so that they would receive the larger reward. In the first experiment, 4-year-old children performed significantly better than did 3-year-old children on the task. In the second experiment, which used a less emotionally salient condition (i.e., symbols instead of real rewards were used), 3-year-old children were more likely to point correctly than were the 3-year-old children in the condition using real rewards. Therefore, emotional and behavioral self-regulation may become more integrated as children grow older.

Behavior Tasks Versus Questionnaires

There was no statistically significant difference in the association between IC and academic skills when IC was measured using behavior tasks or teacher reports. However, IC as measured by behavior tasks was significantly more associated with early academic skills than was IC as measured by parent report. Studies that have included multiple methods of rating IC (i.e., behavior tasks, parent reports, teacher reports) have generally reported significant modest to moderate associations between academic skills and IC as measured by behavior tasks and teacher reports but nonsignificant to modest associations between academic skills and IC as measured by parent reports (e.g., Blair & Razza, 2007; Leerkes, Paradise, Calkins, O’Brien, & Lange, 2008; Thorell & Nyberg, 2008). The findings of this meta-analysis as well as the finding that both teacher reports and behavior tasks were significantly associated with academic skills does not provide support for the argument that direct measures are preferable to questionnaire measures (e.g., McClelland et al., 2007; Rimm-Kaufman et al., 2000). It does suggest, however, that either behavior tasks or teacher reports of IC are preferable to parent reports of IC when one is examining the relation between academic skills and IC.

Because there was no statistically significant difference in the relation between IC and academic skills when behavior tasks or teacher reports were used to measure IC, both methods may be useful in understanding this association. Further, because academic skills in these studies were assessed predominantly by trained research assistants, the relation between teacher reports of IC and academic skills was not due to teachers rating children’s IC...
based on children’s performance on the academic measures used as outcome variables. Although few researchers have included both teacher reports and behavior tasks when measuring IC, there is some evidence that each type of measure captures unique and important aspects of IC (e.g., Allan, Lonigan, & Wilson, 2013; Valiente et al., 2010). For example, Allan, Lonigan, and Wilson (2013) reported that the overlap between a teacher-report and a latent IC construct was only moderate in a sample of preschool children. Matthews et al. (2009) used a behavior task and a teacher questionnaire to examine the effects of IC on academic gains across 1 year for 156 kindergarten children. They found that teacher-reported IC and the behavior task both uniquely and significantly predicted gains in math but that only the behavior task predicted literacy gains. Blair and Razza (2007) reported that both a teacher report and behavior task were uniquely associated with math and letter knowledge skills in a sample of low-income kindergarten children.

It is possible that the unique association behavior tasks and teacher reports of IC each share with academic skills is due to the context specificity of each method of assessing IC. Because behavior tasks assess behavior under specific circumstances and teacher reports assess everyday behavior, (Liebermann, Giesbrecht, & Müller, 2007). It appears that teacher reports, which capture average levels of classroom IC, and behavior tasks, which capture IC more objectively, both identify important and unique information regarding the relation between IC and early academic skills, suggesting that direct measures and other-report measures of IC are likely not interchangeable or useful to combine in a multi-method framework given that they appear to represent different aspects of IC (e.g., Toplak, West, & Stanovich, 2013).

Math Versus Literacy Skills

Across all methods of measuring IC, the IC construct was more strongly associated with math skills than with literacy skills. Researchers have speculated that IC might be more strongly associated with early math skills than with early literacy skills (e.g., Willoughby, Blair, et al., 2012) because similar brain regions (i.e., the prefrontal cortex) have been implicated in solving math problems and completing IC tasks (Blair & Razza, 2007; Bull, Espy, & Wiebe, 2008; Espy et al., 2004). However, although IC was more strongly related to math, IC also was related to literacy skills, indicating that IC is not a domain-specific, but rather a domain-general, skill, associated with all learning-related activities.

Preschool Versus Kindergarten Relations

The relation between IC and academic skills was similar in preschool and kindergarten children. Whereas the preschool and kindergarten years have been identified as a period of rapid development for IC skills (Rothbart & Bates, 2006), few studies have explicitly examined whether the relations IC shares with academic skills are different across this time frame. The assumption, albeit implicit, seems to be that although IC skills develop rapidly during the preschool and kindergarten years, this developmental process does not influence the relation between IC and other developmental outcomes. Support for this assumption, at least with respect to academic skills, was provided in the current study.

**Limitations**

There were several important moderators that could not be examined in this meta-analysis. For example, gender differences have been report on both direct and indirect assessments of IC (e.g., Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006; Matthews et al., 2009). However, because no studies included in this meta-analysis reported correlations separately by gender, it could not be included as a moderator. Additionally, because we were interested in establishing the concurrent correlations between IC and academic skills, we could not disentangle causality. It might be that the relation between academic skills and IC occurs because having well-developed academic skills leads to the development of IC. To our knowledge, no studies have examined whether academic skills influence IC growth in young children. Another variable could also account for the relation between IC and early academic skills. For example, socioeconomic status and home–environment quality, which are associated with both IC and academic ability (e.g., Dilworth-Bart, 2012; Sarsour et al., 2011), may account for the association between IC and academic skills. Given that Willoughby, Kupersmidt, et al. (2012) found no relations between difference scores of IC and difference scores of academic measures in preschool children when fixed-effects models were used to model the effects of unmeasured confounding variables, further consideration of potential confounding variables is needed.

**Implications and Conclusion**

IC appears to be a domain-general skill associated with both math and literacy skills in young children. The strength of the relation between IC and academic skills is similar across preschool and kindergarten children. Cool behavior tasks are most associated with academic measures used for both research and screening purposes, especially if time and resources are limited. Teacher-reported IC is also associated with academic skills. When feasible, researchers should include both behavior tasks and teacher reports to assess IC as there appears to be unique information associated with the type of measure used. Future research should be conducted to establish the causal influence of IC on early academic skills.

**References**

References marked with an asterisk indicate studies included in the meta-analysis.


Dilworth-Bart, J. E. (2012). Does executive function mediate SES and...


Received March 16, 2013
Revision received June 2, 2014
Accepted June 18, 2014