Assessing Teacher Understanding of Student Executive Function Skills: A Survey-Based Investigation

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ABSTRACT

The aim of this study was to understand whether elementary school teachers' judgments of their students' cognitive skills correspond with lab-based measures of these same skills, as well as academic achievement. Questions adapted from the Child Behavior Questionnaire—Very Short Form and Long Form versions (Putnam & Rothbart, 2006), along with original questions about working memory were compiled in a survey. Questions pertaining to three executive function (EF) skills – working memory, response inhibition, and attentional control – were organized into three subset measures. These measures were then tested for internal consistency, and correlated with lab-based measures of each EF domain. These teacher-reported measures were also correlated with measures of both math and literacy achievement. All three measures demonstrated strong internal consistency. Two of the three teacher-reported measures, working memory and response inhibition, correlated significantly with their lab-based counterpart. Furthermore, all three teacher-reported measures correlated significantly with at least one measure of academic achievement. Our results suggest that teachers' behavioral evaluation of students' cognitive skills correlate with lab-based measures of EF domains, and in some cases also predict academic achievement. These insights can be leveraged to optimize the academic outcomes of elementary school students.

INTRODUCTION

Executive function (EF) encompasses a variety of separate but related cognitive skills including self-control, working memory, and cognitive flexibility (Diamond, 2012). Executive processes develop throughout childhood, and play a key role in cognitive functioning, behavioral and emotional control, and sociability (Anderson, 2010). These skills allow people of all ages to process information and adjust their behavior in ways appropriate for different contexts. School is a social context where controlling behavior and cognitively manipulating information is key to success, particularly in the transition to schooling and the early schooling years. The ability to regulate behavior by leveraging EF has been shown to predict superior math and literacy outcomes in elementary aged children (Blair & Razza, 2007). If teacher-reported EF skills correlate with lab-based measures of EF and academic achievement, it suggests teachers can accurately grasp the cognitive and academic skills of their students. Previous research has linked teacher-reported EF skills to lab-based EF measures (Dekker et al., 2017). If this is the case, teachers will be able to position students for success via individualized instruction.

One domain of EF that has been studied extensively is working memory. Working memory is the ability to monitor, store, and manipulate incoming information to complete cognitive tasks (Miyake et al, 2000). People of all ages utilize this function every day to answer questions, piece together different sources of information, and think critically. Working memory plays a critical role in many aspects of thought, and has been demonstrated to predict children's academic achievement. For example, Bull & Scerif (2010) found that a higher working memory capacity is related to better mathematics outcomes for young children. Furthermore, children who display lower mathematical abilities were shown to perform poorly on working memory tasks (Bull & Scerif, 2010). However, mathematical cognition is not the only skill affected by working memory. This EF domain has also predicted increased performance on standardized assessments of language comprehension (Cain, Bryant, & Oakhill, 2004). Considering that working memory has been shown to be key for both mathematical and literacy ability, it is important to monitor children's working memory abilities to understand how they can succeed in school.

Working memory is one of three important EF factors that we were interested in studying in the context of academic success. Attentional control is another aspect of EF that affects children's ability to succeed in school. Attentional control includes the capacity to selectively attend to specific stimuli and focus attention for long periods of time (Anderson, 2002). This EF domain appears to emerge in infancy and develop rapidly in early childhood (Anderson, 2010). The fact that attentional control develops much earlier than other EF domains suggests that differences in attention may explain variability in elementary school achievement. Previous studies have shown that strong attentional control correlates with reading and mathematics outcomes across cultures (Lan et al., 2011). Studies have also examined how measures of children's' EF are correlated with their ability to pay attention. One popular framework is to examine differences in EF skills between individuals with and without attention-deficit/hyperactivity disorder (ADHD). Groups with ADHD exhibited significant impairments in working memory and response inhibition tasks, and these effects were not explained by group differences in intelligence, academic achievement, and symptoms of other disorders (Wilcutt et al., 2004). Furthermore, previous research has found that stronger scores on attention-shifting measures in preschool are related to math and literacy ability in kindergarten (Blair & Razza, 2007). This reveals that the ability to focus one's attention is an important EF skill to develop for success in school.

Response inhibition is another essential domain within EF. Often referred to interchangeably with inhibitory control, this concept refers to the suppression of inappropriate behaviors that are no longer required, which supports flexible and goal-directed behavior in different environments (Verbruggen & Logan, 2008). In a school environment, the ability to control one's behavior is of utmost importance. Students are constantly expected to conduct themselves appropriately, especially when in front of their teachers, who have the authority within the classroom context. Failure to do so consistently would greatly interrupt teaching routines. The relation between children's response inhibition skills and academic success has been shown across many disciplines. Inhibitory processes have been implicated in reading, comprehension, vocabulary, and mathematics ability (Clair-Thompson & Gathercole, 2007). Considering this wide swath of correlation with academic outcomes, we consider response inhibition a key EF domain for elementary school children. Outside of an experimental context, response inhibition can be gauged by one's susceptibility to distraction. Lesions of the prefrontal cortex, the brain area believed to be responsible for executive skills, can produce impulsivity, distractibility, and deficits on EF tasks (Wilcutt et al., 2004). This reveals that response inhibition and other executive abilities can be observed both at the neurological and behavioral levels.

One behavioral tool that is often used to gain insight into children's executive skills is the Child Behavior Questionnaire (CBQ). The CBQ was originally developed to provide a caregiver report assessment of children's temperament, self-regulation, and reactivity (Putnam & Rothbart, 2010). In the original CBQ, parents were asked to rate their child on a 7-point scale from "extremely untrue" to "extremely true" on nearly 200 items. The reliability of this scale was subsequently validated by numerous studies (Putnam & Rothbart, 2010). Due to the length of the original CBQ, researchers wished to create more concise versions of the scale for use in different academic contexts, so short and very-short forms of the questionnaire were developed. Factor analyses have revealed that these measures shed light into children's EF abilities, and domains assessed include emotional tendencies, response inhibition, attention, and impulsivity (Putnam & Rothbart, 2010). These new scales were rigorously tested for internal consistency, reliability, longitudinal stability, and correlation with the original CBQ. Although these shorter versions of measurement resulted in a loss of breadth and exhibited lower internal consistency than the parent scale, the alphas of all but one scale – sadness – were greater than .70, widely considered the benchmark for sufficient internal consistency (Putnam & Rothbart, 2010; Nunnaly, 1978). This reveals that the short and very-short versions of the original CBQ are viable measures of children's temperament and cognitive skills. These revisions are useful because the original CBQ is time consuming, may require compensation to participants for completion, and includes measures that may not be within the scope of the research at hand. The conciseness of these revised scales has made it easier for researchers who lack the resources to use the original CBQ.

The CBQ has been adapted further for teachers. Minor changes to the wording of questions were made to make items appropriate for the classroom context, but questions were not altered to the point that they changed the concept measured by the question (Schussler, 2012). Like parents, teachers spend extensive time in close proximity to students. These extended daily interactions make understanding the behavioral tendencies of each student essential for teachers. Previous research by Dekker et al. (2017) has shown that only teachers' behavioral assessment of working memory correlated with a corresponding lab-based measure. Teacher-reported working memory and attentional control explained differences in literacy achievement. However, only teacher reports of working memory significantly correlated with mathematics achievement (Dekker et al., 2017). We were hoping to build on this research to see if teachers have a more thorough understanding of each student's behavior. If teachers can behaviorally determine multiple EF skills in a manner similar to lab-based measures, they would be able to identify the behavioral tendencies detrimental to the learning process. In understanding the areas where each student needs to improve, teachers would be able to tailor their strategy when working one-on-one with students. An understanding of children's specific behavioral strengths and weaknesses and their relation to both math and literacy abilities will allow teacher's to maximize each child's ability to learn, which may improve academic achievement for students in elementary school.

METHODS

Teachers and students were recruited from four elementary schools in Southeastern Michigan, as part of a larger ongoing study. As a part of their involvement in the study, they were asked to respond to surveys about participating students in their class. In total, 18 teachers responded to the survey, providing individualized data for 102 students. Mean participant age was 5.76 years, with a standard deviation of .36 years. Because not all teachers responded to each question and we lacked behavioral measures for some participants, the number of students included in our analyses varied from 88 to 102 students.

Original questions as well as questions adapted from the CBQ were included in the survey. Questions from the CBQ included two EF domains: attentional control and response inhibition. The attentional control battery consisted of five questions adapted from the CBQ teacher very short form version, whereas the response inhibition battery consisted of three questions adapted from the CBQ parent long form version. Because the CBQ scales did not include questions regarding children's working memory capacities, we created a scale of questions purportedly tapping into indices of working memory, consisting of four original questions. The CBQ uses a seven-point scale, ranging from untrue" to "extremely true." However, we modified the questions to include five-point response scale, ranging from "never" to "always." We made this change to make it easier for teachers to gauge their students' behavior by reducing the response options. For each grouping of questions, we ran a factor analysis and created three additional measures within our data set. These were used in our statistical analyses.

We utilized six lab-based measures of EF to compare with our teacher responses. Short-term memory was measures using the Forward Digit Span (DS-F), a subtest of the Wechsler scale (Wechsler, 1991). In this task, children are told a sequence of numbers, and asked to repeat the sequence back to the experimenter. After each successful trial, the sequence increases in length by one number. There are two sections of testing, and each correctly repeated sequence earns one point on this assessment. Working memory was measured using the Backward Digit Span (DS-B), a subtest of the Wechsler scales (Wechsler, 1991). In this task, children are told sequences of numbers, and are asked to repeat the numbers in the reverse order. After each successful trial, the sequence increases in length by one number. Like DS-F, there are two sections of testing, and each correct sequence earns one point on this assessment. Because children have to manipulate information stored in memory, the Backward Digit Span task is considered a measure of working memory, not short-term memory.

Response inhibition was examined using the Head-to-Toes, Knees-to-Shoulders (HTKS) battery developed by Ponitz, McClelland, Jewkes, Connor, Farris, & Morrison (2008). In this game, children are told to do the opposite of what the experimenter has told them. In the initial task, subjects are asked to touch their head (or toes), and the correct response is to do the opposite and touch their toes. If subjects can correctly respond to this task, an advanced trial is initiated where commands to touch the knees or shoulders are added. In this task, children are forced to inhibit their initial reaction to the experimenter’s prompt as well as utilize working memory and focused attention to perform the correct response. The fun nature of the game works well with young subjects, and analyses have proven its relevance for multiple EF functions.

Attentional control was examined using the Pair-Cancellation test (PC) taken from the Woodcock-Johnson III Tests of Cognitive Abilities (Woodcock, McGrew & Mather, 2000). In this test, children are presented with rows of pictures of dogs, balls, and cups. They are given three minutes to circle all pairs in which a picture of the ball is followed by a picture of the dog. Students are scored based on how many pairs they correctly recognized out of 69 possible correct answers.

Academic achievement in literacy and math was examined using Woodcock–Johnson III Tests of Achievement (Woodcock & Mather, 2000). To measure math achievement, we utilized the Applied Problems subscale. This test requires children to answer questions by analyzing visual quantities, answering questions about money and time, and solving quantitative word problems. To measure literacy achievement, we utilized the Letter-Word Identification subscale. This test requires children to name letters and words, with increasing difficulty.

RESULTS

To ensure the validity of our questionnaire measures, we assessed the reliability of each question group. Cronbach's alpha values of .853, .912, and .960 were calculated for our attentional control, response inhibition, and working memory scales, respectively. Each of these values was greater than .70, widely considered the benchmark for good internal consistency (Nunnaly, 1978).

For a full report of correlations, see Table 1. We found that teacher reports of working memory were significantly related to every lab-based EF measure except DS-F, and the relation to HTKS was the strongest. Working memory reports were also significantly associated with math and literacy achievement, and the relation to math achievement was the strongest. This measure was more strongly correlated with each of these achievement measures than the other two teacher-reported measures.

Teacher reports of response inhibition were significantly correlated with HTKS and PC scores. This measure was most strongly correlated with HTKS performance. However, teacher reports of response inhibition were not associated with performance on either digit span task. These reports were also significantly associated with both math and literacy measures of academic achievement, and the relation to math achievement was strongest.

Teacher reports of attentional control were only significantly associated with one lab-based EF measure: HTKS. These reports were also related to math achievement; however, these reports were not related to literacy achievement.

DISCUSSION

The fact that teachers' behavioral assessment of working memory correlated with our lab-based measure of this skill reveals that teachers can accurately judge the working memory skills of their students. It is also notable that although teacher-reported working memory correlated with DS-B performance, they did not correlate with DS-F performance. In fact, none of our teacher report scores correlated with the DS-F task. This reveals that working memory and short-term memory are separate cognitive domains. This makes sense in the context of our current understanding of these two cognitive skills. Working memory involves active manipulation of information, whereas short-term memory is the ability to hold information for short periods (Miyake et al, 2000). However, our lab-based measures of short-term and working memory measures were correlated. This shows that although teacher-based and lab-based measures of EF are similar, there is something unique about the context of the digit span tasks that is causing this effect.

It is also interesting to compare differences in correlation between teacher assessment of working memory, lab-based measures of working memory, and academic outcomes. Our lab-based measure of working memory was more strongly correlated with both math and literacy achievement than teacher-reported working memory. Although both measures correlate with academic outcomes, this suggests the lab-based measures are a more robust way to understand achievement.

Our results also reveal the importance of working memory for cognitive skills and academic success. Teacher-reported working memory was more strongly correlated with both math and literacy outcomes than teacher-reported response inhibition and attentional control. Furthermore, the working memory teacher report was associated with three of four lab-based EF measures. Our response inhibition report only correlated with two lab-based EF measures, and our attentional control report correlated with just one EF lab-based measure. This suggests that working memory is an essential skill for a wide range of cognitive skills, as well as achievement in school. Our findings support previous studies that have linked working memory with higher mathematical and literature comprehension outcomes (Bull & Scerif, 2010; Cain, Bryant, & Oakhill, 2004).

Furthermore, our results suggest that teachers should emphasize the development of working memory skills to ensure their students achieve highly in the classroom.

Similarly, our survey-based teacher assessment of response inhibition correlated with our lab-based measure of this cognitive skill. This suggests that teachers can accurately gauge the inhibition abilities of their students. It is also notable that our response inhibition battery was correlated with our lab-based measure of attentional control. This result suggests that these two EF skills are related. This conclusion is supported by previous research, which has linked both response inhibition and attentional control with the right inferior frontal gyrus (Hampshire, Chamberlain, Monti, Duncan, & Owen, 2010).

It is very interesting that our teacher-reported measure of response inhibition was more strongly correlated with literacy achievement than our lab-based response inhibition measure. This suggests that teachers may be able to better capture the applied inhibition skills of students than our lab-based measures. However, the same cannot be said for math achievement, which was more strongly correlated with HTKS performance, our lab-based measure of response inhibition.

Teacher-reported attentional control was the only survey-based measure that did not significantly correlate with our lab-based measure of the same cognitive skill. However, this correlation was approaching significance. This marginal significance may be a result of a disproportionately smaller number of survey responses to the questions aimed at tapping into children's attentional control skills. It is entirely possible that if our analyses included a larger number of surveys, this correlation would be significant. However, teacher reports of attentional control did have a significant relation to math achievement. This suggests that the ability to focus one's attention is a key skill for students achieving well in numerical academic subjects.

According to our analyses, working memory and response inhibition skills are most essential to achievement in school. Teacher assessment of working memory had the strongest correlation with both math and literacy achievement. Additionally, teacher assessment of response inhibition had the second strongest association with math and literacy skills. Teacher assessment of attentional control had the weakest correlation with math achievement, and its association with literacy achievement was not significant. This suggests that teachers should focus their instruction on developing working memory and response inhibition skills for their students to succeed in school.

All three of our teacher-reported measures of EF skills were significantly correlated with performance on the HTKS battery. This suggests that HTKS encompasses elements of all three of these EF skills. Administering HTKS includes much social interaction between subject and experimenter, and subjects must attend to instructions while simultaneously deciding which action to perform. Therefore, it makes sense that many cognitive skills would contribute to this task. Out of the three teacher-reported measures, working memory was most strongly correlated with HTKS scores. Similarly, out of the four lab-based EF measures, DS-B, a working memory measure, was most strongly correlated with HTKS scores. This reveals that although multiple EF skills are needed to succeed in this task, working memory may be the most important.

The fact that teacher-reported measures of working memory, response inhibition, and attentional control were significantly correlated with lab-based measures of these functions suggests that teachers can successfully gauge each student's EF skills by observing their behavior. Even though most lab-based measures had stronger correlations with achievement than their teacher-reported counterparts, these time-consuming batteries may not be needed for researchers to effectively understand individual and group differences in EF. This fundamental understanding of each student's cognitive strengths and weaknesses will allow teachers to tailor their instruction to benefit students who need more work in specific areas. Previous studies have shown that low performers in elementary school made larger improvements to both cognitive functioning and academic achievement as duration of support increased (Campbell & Ramey, 1994). If teachers can qualitatively recognize deficiencies in cognitive skills, they could intervene while students are at an earlier stage of development. This could greatly bolster later academic achievement outcomes.

Our study had many limitations, including a small sample size. We are currently working to improve the number of teacher survey responses gathered. An increase in sample size will allow our conclusions to become more robust, and may change our analyses. Furthermore, although each teacher-reported measure was internally consistent, the surveys used to compute these variables consisted of five items at most. Ideally, more questions should be added to each battery to increase the validity of these measures.

This study serves as a snapshot of how teachers understand their students' EF skills. If we can see how these predictions change over time using a longitudinal study, we may gain even more insight into whether it is easier or more difficult to behaviorally gauge students' EF skills as they get older. Furthermore, we would be interested in seeing how teacher-reported cognitive skills correlate with neurological indices of EF. If a connection were made, it would further support our conclusion that teachers can effectively understand differences in their students' EF skills by gauging their behavior.

CONCLUSION

The ability of teachers to understand their students' academic and cognitive abilities is key to optimizing teaching methods. We developed teacher-reported measures of working memory, response inhibition, and attentional control, and found that each was internally consistent. Furthermore, we found that two of our three teacher-based measures, working memory and response inhibition, correlated significantly with our lab-based measures of these skills. All three teacher-based measures correlated with at least one lab-based measure of EF, and one measure of academic achievement. This suggests that teachers can grasp the EF skills of their students simply by observing their behavior. The utilization of such behavioral insights can help teachers better understand the needs of each student, thus improving their ability to succeed academically.

Tables

Table 1.
Pearson intercorrelation for study variables

Variable	1	2	3	4	5	6	7	8
1. TQ_WM	-							
2. TQ_RI	**.770**	-						
3. TQ_A	**-.660**	**-.716**	-					
4. DS-F	-.117	.006	-.042	-				
5. DS-B	**-.320**	-.158	.039	**.357**	-			
6. HTKS.	**-.442**	**-.417**	**.260**	**.227**	**.415**	-		
7. PairCanc	**-.294**	**-.213**	.180	.137	**.323**	**.240**	-	
8. Math	**-.453**	**-.344**	**.285**	**.403**	**.493**	**.476**	**.306**	-
9. Literacy	**-.386**	**-.303**	.173	**.333**	**.452**	**.266**	**.388**	**.570**

p < .05 is **bold**

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