THE ASSESSMENT OF WRITING, SELF-MONITORING, AND READING (AWSM READER) AND RELATIONS WITH EXECUTIVE FUNCTIONING

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Abstract

Extant literature measuring academic outcomes in school-aged children indicates a significant overlap in the domains of writing and reading. Cognitive predictors, such as executive function (EF), have been implicated for both domains, though less is known regarding its joint relation to reading and writing. In this study, we focus on evaluating the psychometric properties of a novel measure that directly evaluates both reading comprehension and writing, as well as the contribution of EF to these domains. Participants consisted of 377 3^{rd}, 4^{th}, and 5^{th} grade struggling readers. The Assessment of Writing, Self-Monitoring, and Reading (AWSM Reader) was created to measure reading comprehension and writing (Key Words and Ideas Expressed) within the same topic. Reliability was $\alpha = .58$ for the AWSM Reader reading comprehension, $\alpha = .80$ for Key Words, and $\alpha = .75$ for Ideas Expressed. The AWSM Reader validity for reading was $r = .50$, for Key Words was $r = .50$, and Ideas Expressed was $r = .47$, (all *p*s < .001). Correlations between the AWSM Reader reading and writing portions were $r = .56$ and $r = .51$ (both *p*s < .001), respectively. EF was a unique predictor of AWSM Reader reading comprehension ($\eta_p^2 = .016$, $p = .005$) and Key Words ($\eta_p^2 = .014$, $p = .010$), and was approaching significance for Ideas Expressed ($\eta_p^2 = .008$, $p = .065$), over demographic and language covariates. However, partialing both language and EF, the reading portion of the AWSM Reader continued to have significant correlations with Key Words and Ideas Expressed, $r = .50$ and $r = .46$ (both $p < .001$), respectively. Overall, the results stress the difficulty in constructing combined reading and writing measures, but give direction for how this might be accomplished. Further, these results highlight the contribution of EF to reading and writing, though EF (and language) did not fully account for the relation between the domains.

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Introduction

Extant literature measuring academic outcomes in school-aged children shows significant overlap in the domains of writing and reading (Allen, Snow, Crossley, Jackson, & McNamara, 2014). A variety of studies have examined the relation between reading and writing at multiple levels, but most study designs include separate tasks to measure these two domains (Abbott, Berninger, & Fayol, 2010). An alternative design where the two are combined might facilitate a more direct comparison as the content would be similar, and could minimize "noise" related to how predictors influence two separate tasks. Furthermore, combining the two could be more cost- and time- efficient. Given that the development of reading and writing are intertwined, a measure that directly evaluates both might also be more strongly tied to curricula, as a number of tasks require both reading and writing in elementary school (Fitzgerald & Shanahan, 2000).

Considering the similarities and differences in underlying cognitive processes necessary to develop skills in reading comprehension versus written expression is also important because the extent that they overlap can ultimately aid in identifying or modifying intervention targets. Language is one obvious candidate for a shared cognitive predictor of these domains, as it has been clearly linked to both reading and writing (Berninger & Abbott, 2010; Dockrell, Lindsey, & Connelly, 2009; Gough & Tunmer, 1986; Hoover & Gough, 1990; Kim, 2015; Kim, Al Otaiba, Puranik, Folsom, Greulich, & Wagner, 2011; Kim, Al Otaiba, Folsom, Greulich, & Puranik, 2014; Olinghouse, 2008; Schatschneider, Carlson, Francis, Foorman, & Fletcher, 2002). Beyond language though, executive function (EF) has been repeatedly implicated for reading (decoding, fluency, and reading comprehension) at both empirical and theoretical levels (Butterfuss & Kendeou, 2018; Cirino, Ahmed, Miciak, Taylor, Gerst, & Barnes, 2018; Follmer, 2018; Gerst, Cirino, Fletcher, & Yoshida, 2015; Toplak, West, & Stanovich, 2013). The role of EF for writing is less well-defined generally, and although it has been evaluated in early elementary aged students (e.g., Hooper, Costa, McBee, Anderson, Yerby, Knuth, & Childress, 2011), fewer studies focus on later elementary students, when the emphasis switches to written expression.

Given the above, the present study has two key goals. First, we evaluate the properties of a measure that assesses both reading comprehension and written expression. Second, we evaluate the similarities and differences in cognitive predictors of these two domains with a focus on EF. The present study focuses exclusively on struggling readers, for whom reading and writing are difficult, and where it is particularly relevant to identify their cognitive concomitants.

Reading

Research investigating the development of reading has been discussed at the theoretical and empirical level for the past half-century. Below, we briefly review research pertaining to struggling readers, such as prevalence, components of reading, and theoretical and empirical support regarding predictors of reading, to contextualize the current study that relies on this foundation.

Prevalence. Rates of reading difficulty vary widely depending on the source and definition of difficulty. For example, the National Center for Educational Statistics (2019) reported that only 35% of children in fourth grade read at the proficient or advanced level, and 65% read at or below basic levels. Additionally, dyslexia, the most common type of learning disability in children, has a prevalence rate ranging from 5 to 10% to 17.5% (Shaywitz et al., 1998).

Reading Components. Three primary components of reading are decoding, fluency, and comprehension. For the purpose of this study, decoding is defined as the process of identifying and recognizing printed words accurately (Cirino et al., 2018; Garcia & Cain, 2014; Hoover & Tunmer, 2018; Oakhill, Cain, & Bryant, 2003). Decoding is the focus of most research because it is the first instructed skill. Even though the focus of this study is on reading comprehension, decoding is relevant given that it makes distinct contributions to reading comprehension after controlling for numerous factors (Oakhill et al., 2003), and a recent meta-analysis showed a strong relation between decoding and reading comprehension (Garcia & Cain, 2014). Reading fluency can be defined as the measurement of the rate of accurate reading and prosody (Hasbrouck & Glaser, 2012), and is typically measured via isolated word reading (Fuchs, Fuchs, Hosp, & Jenkins, 2009). Reading fluency enhances decoding skill by effectively and accurately combining text, and is a reflection of automatized word reading skill; so it makes sense that there is a strong correlation between the two (Petscher & Kim, 2011). Reading fluency explains variance in reading comprehension, even beyond decoding (Kim, Wagner, & Lopez, 2012), and text reading fluency becomes a key contributor to reading comprehension by fourth grade (Kim & Wagner, 2015). Reading comprehension can be defined as understanding and integrating printed text into meaning. Traditionally and most frequently, reading comprehension is measured by answering multiple choice questions about a passage that was just read or orally filling in a word to complete a sentence/paragraph (Fletcher, 2006). Students who struggle with reading often have difficulty across reading outcomes. For example, in a large sample of middle schoolers oversampled for reading difficulties on the basis of their state test, Cirino, Romain, Barth, Tolar, Fletcher, and Vaughn (2013) found that 47% had decoding deficits, 46% had fluency deficits, and 84% had comprehension deficits; of this latter group, only 12% had neither decoding or fluency deficits. This study also found that the structure of reading components (how they relate to one another) was partially dependent on whether students were struggling readers or not.

Reading Predictors: Language. Language is a crucial predictor of reading throughout development since reading is a language-based task. Specifically, phonological awareness and rapid naming are important in the early development of reading (Schatschneider et al., 2002). In addition, both decoding and language comprehension contribute unique variance to reading comprehension (Simple View of Reading model; Gough & Tunmer, 1986; Hoover & Gough, 1990); however, decoding contributes significantly more variance in the early elementary years, whereas the unique contribution of language comprehension grows throughout childhood (Foorman, Petscher, & Herrera, 2018). Vocabulary knowledge is also a significant predictor in the development of reading comprehension, especially as children progress from earlier elementary to later elementary years where decoding and reading fluency become more automatic (Kim, 2015). Other models of reading comprehension (e.g., the Reading Systems Framework; Perfetti, 1999; Perfetti & Stafura, 2014) also include language factors such as word knowledge within a cognitive system.

Reading Predictors: Beyond Language. A variety of non-language cognitive processes contribute to reading comprehension in children, and the empirical evidence to support these findings is robust. A recent meta-analysis (Kudo, Lussier, & Swanson, 2015) found that numerous cognitive domains accounted for variance in the difference between children with and without reading disabilities, including vocabulary, verbal and visual-spatial working memory, short-term memory, processing speed, attention, and executive functioning (EF). Processing speed deficits are also documented in struggling readers, but this deficit is investigated more with regard to reading fluency than to reading comprehension (Catts, Gillispie, Leonard, Kail, & Miller, 2002; Pennington, 2006; Shanahan, Pennington, Yerys, Scott, Boada, Willcutt, Olson, & DeFries, 2006). Sustained attention and visual attention have also been associated with decoding and reading comprehension (Arrington, Kulesz, Francis, Fletcher, & Barnes, 2014; Macdonald, Barnes, Miciak, Roberts, Halverson, Vaughn, & Cirino, 2020; Savage, Cornish, Manly, & Hollis, 2006; Vidyasagar & Pammer, 2010); however, working memory and related executive processes contribute to reading comprehension moreso than word recognition, decoding, and fluency (Cirino, Miciak, Ahmed, Barnes, Taylor, & Gerst, 2018), even when controlling for these attentional processes (Sesma, Mahone, Levine, Eason, & Cutting, 2009).

Although processing speed and attention contribute to reading, recent research has clearly established EF as having a substantial and crucial role in reading comprehension at theoretical and empirical levels. Butterfuss and Kendeou (2018) reviewed three subdomains of EF, arguing for a theoretical role of updating, inhibiting, and shifting for reading comprehension. Updating helps with holding relevant information from the text (working memory), inhibition filters out irrelevant information that was not necessary for comprehending text, and shifting helps switch attention between phonological and semantic aspects of text. Empirically, EF is a unique predictor for decoding, fluency, and reading comprehension (Cirino et al., 2018). Additionally, Follmer (2018) conducted a meta-analysis on the role of EF in reading comprehension specifically, finding moderate significant relations (overall $r = .36$) across child and adolescent age ranges, including measures of working memory, shifting, inhibition, and planning. Thus, there is ample evidence that EF is robustly related to reading comprehension; however, much less is known how this compares to the relation between EF and written expression.

Writing

Prevalence. Writing difficulties are common. Hooper, Swartz, Montgomery, Reed, Brown, Wasileski, and Levine (1993) found that 6% to 22% of children in three middle school samples across the US (southeastern, midwestern, and western) had writing deficits. Similarly, Katusic, Colligan, Weaver, and Barbaresi (2009) conducted a population-based birth cohort study and found that 6.9% to 14.7% exhibited a writing deficit depending on the formulas being calculated. Furthermore, the National Center for Education Statistics (NCES, 2003) stated that 16% of fourth graders wrote below the basic level.

Writing Components. Major components of writing include transcription, writing fluency, and written expression. This is consistent with the levels of language framework (Abbott, Berninger, & Fayol, 2010; Berninger & Garvey, 1982) that discusses writing ability at the word, sentence, and discourse level. The most basic writing level is transcription, defined as the transformation of spoken words into written text (Graham & Harris, 2000). A variety of studies have found a relation between transcription skills and written expression quality; for example, a number of studies find that transcription skills have a direct contribution to writing quality in the early grades (1 to 3), whereas this effect was indirect at later grades (4 to 9; Abbott et al., 2010; Graham, Berninger, Abbott, & Whitaker, 1997; Limpo & Alves, 2013). In addition, writing fluency, another vital component and the next developmental level of writing, defined as writing with speed and accuracy (Johnson & Street, 2013), also improves written expression performance over time (Graham, Harris, &

Fink, 2000; Graham, McKeown, Kiuhara, & Harris, 2012). Moreover, transcription and writing fluency, considered together, were found to each contribute unique variance to written expression (Puranik & Al O'taiba, 2012). Written expression can be defined as organizing ideas and expressing them on paper; however, there are several ways to measure written expression, especially in children (Cameron, Hunt, & Linton, 1996), and it can be viewed along a spectrum. Specifically, writing can be measured at both the sentence and discourse level. Further, different discourse levels of writing include summary writing, narrative writing, and persuasive writing, with the latter taken to be the highest level of writing composition (Burkhalter, 1993). However, even if it appears that students use more mental operations for persuasive than summary writing, research has found that the writing products (e.g., hierarchical organization of content, cohesive conjunctions) between the two are not significantly different (Durst, 1989).

Writing Predictors: Language. Because writing, like reading, is a language-based task, it makes sense that language skill is strongly related to written work. For example, phonological awareness is significantly related to spelling in 1st grade (Kim, Apel, & Al Otaiba, 2013), and is a significant predictor of written expression in children in grades 2-5 (How & Larkin, 2013). Oral language, specifically vocabulary and listening comprehension, significantly contribute to writing quality starting in kindergarten, throughout the elementary years, and continuing into adolescence (Berninger & Abbott, 2010; Dockrell et al., 2009; Kim et al., 2011; Kim et al., 2014; Olinghouse, 2008).

Writing Predictors: Beyond Language. Multiple cognitive domains such as short-term memory, long-term memory, and attention appear in models of writing (Flower & Hayes, 1981; Hayes, 1996; Hooper et al., 2011; Repovs & Baddeley, 2006), indicating that written expression is more than just a language-based or graphomotor construct. The Cognitive Process Model of Writing (Flower & Hayes, 1981) specifically discusses planning, translating, and revising, and in this way includes self-regulatory processes that other writing researchers have since echoed including the planning of written work, compiling information for writing, self-monitoring throughout writing to decide whether a goal has been completed, and revising or modifying a text (Graham & Harris, 1994; Graham & Harris, 2000; Zimmerman & Risemberg, 1997). These self-regulation processes are also important for writing coherence, which is critical for writing quality (Limpo & Alves, 2013). Importantly, self-regulation has been implicated within executive functioning frameworks, and otherwise has been shown to have parallels to EF (Blair & Ursache, 2011; Cirino et al., 2018; Hofmann, Schmeichel, & Baddeley, 2012). Thus, theoretical models have implicated EF for the planning, review, and revision of written output (the Not-So-Simple View of Writing, Berninger & Winn, 2006).

Task initiation and task set-shifting are two EF related tasks that are related to written expression in elementary school children (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002; Hooper et al., 2011), and are also significant predictors of tasks involving writing reports from notes (Altemeier, Jones, Abbott, & Berninger, 2006). Additionally, working memory, which is perhaps the strongest EF-relevant skill, has been implicated in helping store information during the writing process, specifically storing syntactic and semantic information (Olive, 2004; Olive, 2011) as well as accessing information in short-term and long-term memory necessary for writing (Berninger & Amtmann, 2003; Kim & Schatschneider, 2017). Inhibition has also been implicated in the writing process to help filter information that would and would not be relevant for the writing task, specifically note-taking (Altemeier et al., 2006). Thus, EF is related to written expression and also essential to the development of writing in children, though not yet studied to the same level as reading.

Reading and Writing

Although much research has investigated the cognitive concomitants of reading and writing individually, a much smaller pool of research has evaluated these two academic domains together. This gap is relevant because of the high conceptual and empirical overlap of reading and writing, as children develop these skills in tandem. For example, in grades 1 and 2, children use knowledge about universal text attributes that rely on a grapheme-phoneme system to help read and write at the lower levels of decoding and word writing (Ahmed, Wagner, & Lopez, 2014; Fitzgerald & Shanahan, 2000). Meta-knowledge is used increasingly to monitor for meaning and word making, and later, transition to meta-comprehension (Fitzgerald & Shanahan, 2000). Furthermore, for higher-order reading and writing skills such as reading comprehension and written expression, the functional view of reading-writing connections contends that writing about text that was read can help facilitate reading comprehension (Fitzgerald & Shanahan, 2000). Additionally, the interactive and dynamic literacy model (Kim, Petscher, Wanzek, & Al Otaiba, 2018) proposes that reading and writing are interrelated based on grain size, specifically, that they are more related at the lexical level (word reading and spelling) than the discourse level (reading comprehension and writing composition).

There are also strong empirical relations between reading and writing. For example, comorbidity rates between reading and writing learning disabilities range from 30% (Mayes & Calhoun, 2007) to 70% (Berninger, Yates, Cartwright, Rutberg, Remy, & Abbott, 1992;

Landerl & Moll, 2010), and shared variance of reading and writing has been documented to be as high as 50% (Fitzgerald & Shanahan, 2000), and this is true of their subcomponents as well. For example, decoding and spelling correlate *r* = .72 in 1st grade (Ahmed et al., 2014). For reading fluency and writing fluency, correlations range from .45 to .67 (Kang, McKenna, Arden, & Ciullo, 2016; Kim et al., 2014). Additionally, reading comprehension and written expression correlate .49 in first grade students (Ahmed et al., 2014). Moreover, Kent and Wanzek (2016) conducted a meta-analysis on reading and writing and found that reading achievement, operationalized as phonological awareness, decoding and reading comprehension, was strongly correlated to writing quality (average *r* across all grades, .48). Furthermore, empirical findings show support for an interactive model of reading and writing (Abbott et al., 2010; Ahmed et al., 2014). Specifically, at the text level, Abbott et al. (2010) found that reading comprehension significantly predicted written expression in grades 2 through 6 (partial path coefficients range from .13-.22), but also that written expression significantly predicted reading comprehension in grades 3 through 5 (path coefficients .18 to .20).

A fair amount of work has focused on the directionality of the reading and writing relation. For example, some models emphasize reading to writing (Kim et al., 2011), others writing to reading (Chomsky, 1976; Fitzgerald & Shanahan, 2000; Graves, 1978; Tierney & Shanahan, 1991), and still others in an interactive model (Freedman & Calfee, 1984; Shanahan & Lomax, 1986). However, results are mixed. In early elementary years, studies suggest that word spelling contributes significantly to word reading in grades 1 and 2, whereas another study found that word reading significantly predicted spelling in grade 3 (Caravolas, Hulme, & Snowling, 2001; Cataldo & Ellis, 1988; Ellis & Cataldo, 1990;

Graham & Hebert, 2010; Kim et al., 2018). Additionally, a meta-analysis on writing interventions and their influence on reading comprehension found that 94% of studies showed improvements in reading comprehension after the writing intervention indicating that writing almost always enhanced reading comprehension (Graham & Hebert, 2011). Although no consensus on directionality has thus far been determined, this empirical evidence does clearly support a link between reading and writing throughout development. In addition to reading and writing being related throughout development, they can also be measured together in different ways, particularly since, as noted, writing can be viewed across a spectrum. One way of combining reading and writing tasks is writing about what was read. Such “summary writing” can aid in reading comprehension but the task itself is still a writing task since a person needs to articulate and organize coherent thoughts on paper (Mokeddem & Houcine, 2016). In the context of reading and writing, Hayes’ (1996) updated cognitive-affective model of writing places reading comprehension as a fundamental feature of writing and summary writing helps access topic knowledge, understand the task, and revise the written outcome (Delaney, 2008). Furthermore, the constructivist model of reading and writing (Spivey, 1987; Spivey, 1990; Tierney & Pearson, 1983) emphasizes that both reading and writing are ways of expanding meaning and knowledge. Specifically, reading comprehension establishes new meaning while writing articulates and expresses this meaning on paper (Kucer, 1985; Nelson & Calfee, 1998). Thus, both are still separate academic tasks but are used together to integrate the information presented.

The above sections evaluate the way that reading and writing relate to one another, but few studies evaluate cognitive predictors of reading and writing in the same sample. This is relevant because the extent to which these are shared could provide insight into the mechanisms of the relation of reading comprehension and written expression. Language is an obvious candidate for a shared predictor of reading and writing at multiple levels. For example, studies have found that phonological awareness, alphabet knowledge fluency, and vocabulary knowledge are unique predictors of word reading and spelling starting in kindergarten and first grade continuing into adulthood (Allen et al., 2014; Kim et al., 2013; Kim et al., 2014). In the Allen et al. (2014) study, vocabulary knowledge was found to be the most significant shared cognitive predictor between reading comprehension and written expression in college students. Based on research investigating reading and writing separately, domain cognitive processes such as attention, processing speed, and EF are contributory, with EF among the most prominent. EF processes such as inhibition, set-shifting, and working memory help create a mental model for both reading comprehension and written expression (Altemeier et al., 2006; Berninger & Winn, 2006; Butterfuss & Kendeou, 2017; Cirino et al., 2018; Dedeyan et al., 2006; Follmer et al., 2018; Hooper et al., 2002; Hooper et al., 2011). For reading comprehension, EF helps filter irrelevant information, monitor the level of understanding, and connect different pieces of relevant information in the text (van den Broek, 2010). For written expression, these same EF processes are used to help generate relevant information while excluding irrelevant information, express ideas in writing, and connect multiple ideas in a written composition (Berninger & Swanson, 1994; Cornoldi, Del Prete, Gallani, Sella, & Re, 2010; Swanson & Berninger, 1996).

Only a handful of studies explicitly address EF, reading, and writing altogether in the same sample. A few relate EF and language to lower-level areas of reading and writing such as word reading and spelling (Chung, Lam, & Cheung, 2018; Zhang. Bingham, & Quinn, 2017); however, higher-order reading skills are not included in these studies. Other articles discuss EF, reading at multiple levels, and spelling, but not written expression (Alloway & Alloway, 2010; Fischbach, Konen, Rietz, & Hasselhorn, 2014; Monette, Bigras, & Guay, 2011; Walda, van Weerdenburg, Wijnants, & Bosman, 2014; Willoughby, Kupersmidt, & Voegler-Lee, 2012). Moreover, one study assessed multiple aspects of EF and its relation to teacher ratings of reading and writing performance in children rather than performance-based measures (Tsubomi & Watanabe, 2017).

There are only four known studies that have explicitly addressed EF, reading comprehension, and written expression altogether. Berninger, Abbott, Cook, and Nagy (2017) found that attention and executive functioning predicted both writing and reading. However, only composites of reading and writing were utilized, and no demographics or other covariates were considered. Another study examined the contribution of verbal comprehension and verbal comprehension and verbal working memory to academic outcomes (Jones, Abbott, & Berninger, 2014). In these models, working memory was a unique contributor over verbal comprehension. However, only one aspect of EF was evaluated, the study did not directly compare reading comprehension to written expression, and the study did not focus on struggling readers. Altemeier, Abbott, and Berninger (2008) found that EF measured as inhibition and set-shifting were each uniquely predictive of reading and writing. Similar to some of the studies above, language skills were not assessed, and the contribution of EF to reading comprehension and written expression were not directly compared. Finally, Carretti, Motta, and Re (2016) assessed writing quality in poor and good reading comprehenders and included working memory, inhibition, language, and comprehension group status to measure the unique predictive value in four areas of writing.

Results indicated that working memory, specifically intrusion errors in a working memory task, significantly contributed to the participants' writing quality; however, once the comprehension group status was added into the model, working memory was no longer significantly predictive of writing quality. Additionally, vocabulary did not significantly contribute to writing quality in this study. Although Carretti et al. (2016) evaluated components relevant to the present study, their sample size was quite small (12 per group) and the writing outcomes were based on qualitative reports from raters. Finally, this study was in Italian, and therefore results could be different in English, whose orthography is more opaque than Italian (Brunswick, McDougall, & de Mornay Davies, 2010).

In sum, there is research that assesses both reading and writing levels, along with EF (and sometimes with language). However, these studies vary in their comprehensiveness, sample size, and extent to which they utilize strong covariates, and none explicitly compare the contribution of EF to both outcomes in struggling readers. Thus, this study can help investigate and define these relations in struggling readers, and particularly at the developmental stage of transition from more basic skills to the emphasis on reading comprehension and written expression.

Measurement

In evaluating the cognitive contributions to both reading and writing, a complicating factor is the way these skills are measured, which could moderate study results. This is especially true for the most complex versions of each skill, reading comprehension and written expression (Francis, Fletcher, Catts, & Tomblin, 2005; Francis et al., 2006). Although there are a myriad of reading and writing measures used for clinical and research purposes that include separate reading and writing subtests (Kaufman & Kaufman, 2014; Schrank, Mather, McGrew, 2014), we know of no clinically validated measures that address reading comprehension and written expression together within the same subtest using the same passages. However, a small amount of research has used experimental measures assessing the two (Spivey, 1990; Spivey & King, 1994) as well as state assessments that combine the two domains (e.g., Ozuru, Briner, Kurby, & McNamara, 2013). These measures typically frame the writing portion as open-ended reading comprehension tasks given that the content is directly related to a passage individuals have read rather than distinguishing the open-ended task as a separate writing task where the content is generated from the individuals. Although summary writing can be conceptualized as an open-ended reading comprehension task, writing is still undeniably considered to be a major part of the task, albeit a lower-level written expression task, particularly for children who are still developing writing skills. Additionally, previous research has investigated the comparison of summary writing and multiple choice questions as tasks measuring reading comprehension and found only a moderate correlation between the two tasks, and beyond that, found general writing ability to be significantly associated with summary writing suggesting that summary writing is indeed a writing task (Head, Readence, & Buss, 1989). Further, the relation between reading comprehension and written expression has been established by using separate measures of these two constructs. Evaluating the degree of overlap in cognitive processes for reading and writing in a singular measure in part controls for the topic being read/written, which is likely to minimize measurement “noise” created by two separate measures. Separate measures are also less cost- and time-efficient (for both students and examiners). Finally, given that cognitive predictors such as decoding and language comprehension vary across measures of reading comprehension (Cutting & Scarborough, 2006; Keenan, Betjemann, & Olson, 2008), such differences are likely to be even more variable when reading comprehension and written expression vary in their operationalization, or have different comparison bases (e.g., normative samples). Although the present study expects clear benefits to combining reading and writing by implementing both simultaneously to measure the same topic, it is possible that this could lead to an inflated relation between the two. However, what is more relevant is the extent to which students do or do not perform systematically higher versus lower on the reading and writing portions.

In addition to measurement issues with reading and writing, executive functioning has been discussed in the literature for over forty years, but measuring EF in children is still relatively new (Zelazo, Blair, & Willoughby, 2016). Although many performance-based measures of EF have been developed for children, creating valid tasks that measure specific EF processes has been a major difficulty (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000; Miyake & Friedman, 2012). Specifically, a barrier for measuring EF in the past has been the difficulty with evaluating the specific EF subdomain without measuring other cognitive domains in the same task which is a major psychometric issue (Hughes & Graham, 2002; Miyake et al., 2000). Stemming from this, there also is no agreement on the core executive functions to use in a standard battery, and some have advocated for the use of a composite EF score to encompass multiple aspects of EF in one score as well as reduce the Type I error rate with less outcome measures (Crane et al., 2008; Riordan, 2017). Additionally, digital assessments of EF can be more efficient providing valid and reliable data in a short time-span (Adams, 1986; Adams & Brown, 1986). One measure that meets most of the above criteria is the NIH Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (EXAMINER). The EXAMINER uses Miyake et al.'s (2000) model of executive function as the core conceptual structure, which found three critical subcomponents of EF: information updating, set shifting, and inhibiting. Although these are three separable constructs, they can also be combined to form a unitary structure of EF (Miyake et al., 2000).

Present Study

As part of the Texas Center for Learning Disabilities (TCLD) program, measures of reading and writing were collected in 3rd, 4th, and 5th graders in the Houston and Austin independent school districts, particularly those relating to text generation due to the age of the cohort. The context of the overall project is to study reading and reading-related processes for struggling readers. There are a number of studies from our group because of the large scope of the study, but only five studies have used the same sample as the current study, and none have used the same measures. The first is a reading intervention study (Miciak et al., 2018); however, the current study is only using pre-test data and does not use the primary measures of interest presented in the intervention paper. The second study (Halverson et al., under review) uses the same sample as well as the same EF measure; however, that study focused on the utility of EF for different types of reading, did not include the combined reading and writing measure used here or address writing at all, and evaluated additional measures (e.g., inferencing). The third is a study on the "not so simple view of writing" analyzing writing measures other than the AWSM Reader (Ahmed et al., under review). The fourth study (Reid, 2020) evaluated the contribution of inattention/hyperactivity and impulsivity in a sub-sample of students for whom data were available on a state-wide assessment of writing at post-test. Finally, the fifth study evaluated the "direct and inferential mediation" model of reading comprehension (Ahmed, Miciak, Taylor, & Francis, under review). Thus, the goals and frameworks for these studies and their contributions are all separable.

The broad goals of the present study are to evaluate the relationship between reading comprehension and writing, and to evaluate their potential shared cognitive processes which could lead to more effective intervention targets. A singular measure of reading comprehension and writing called the Assessment of Writing, Self-Monitoring, and Reading (AWSM Reader) was developed for the larger parent project and is examined specifically here. Our hope is for this measure to be a more precise way of discerning the extent of the relationship between reading comprehension and writing content in the same session and the same instrument. Using such a measure also allows us to compare the contribution of EF to these academic skills in a comparable fashion.

The first specific aim of this project is to examine the psychometric properties of the AWSM Reader, as well as to observe the relationship between reading comprehension and writing outcomes. We hypothesize that the AWSM Reader will have high internal consistency within the reading and writing items (Hypothesis 1a). In reliability analysis, an accepted alpha level is greater than or equal to .7 for tests of ability (Kline, 2013). Additionally, the reading and writing items will be highly correlated with other well-validated reading comprehension measures and writing measures, respectively (Hypothesis 1b). We expect both of these correlations to be robust and that the reading comprehension correlation will range from $.65 < r < .81$, since these were the range of correlations for the reading comprehension measures between the Kaufmann Test of Educational Achievement, Third Edition (KTEA-3; Kaufman & Kaufman, 2014), Woodcock-Johnson, Fourth Edition (WJ-IV; Schrank, et al., 2014), and Wechsler Individual Achievement Test, Third Edition

(WIAT-III; Wechsler, 2009). We expect the writing measures to have a correlation of $.59 < r < .78$ since this was the range of correlations between written expression measures in the KTEA-3, WJ-IV, and WIAT-III (Kaufman & Kaufman, 2014; Schrank, Mather, McGrew, 2014; Wechsler, 2009). In addition, we postulate that performance on the writing portion of the AWSM Reader and performance on the reading comprehension portion of the measure will be significantly related to one another (Hypothesis 1c), at $r \sim .5$ to be consistent with other measures of reading comprehension and written expression (Ahmed et al., 2014; Kent & Wanzek, 2016). This will be directly evaluated in the present study, by comparing the AWSM Reader correlations, against the correlation of standardized reading comprehension and written expression tasks with one another. Although writing about a topic that was just read might potentially increase the expected correlation of the two tasks, to the extent that the demands of reading and writing are different, the correlation is expected to be far less than unity.

The second specific aim is to analyze the association between written expression and EF and how this differs from the relation between reading comprehension and EF in this sample of elementary school aged children. Using data collected from this project, we hypothesize that EF, measured by a composite score encompassing several EF domains, will be predictive of both reading comprehension and writing portions of the AWSM Reader even after controlling for language, but that the contribution of EF will be stronger for writing than for reading comprehension, specifically EF will contribute more to the ideas expressed accurately total score than the key words total score since the former deals with higher-order processes more closely related to EF (Hypothesis 2a).

In corollary with the above aims, we further hypothesize that language and EF will contribute to explaining the relation between reading comprehension and written expression. However, we expect that both would be needed to completely explain the relation (Hypothesis 2b).

Methods

Participants

Participants were recruited from elementary schools in Houston and Austin and informed consent forms were signed by the parents of the students participating in the study. The IRB at the University of Houston approved this study. This study stems from a larger study, using pre-test data from struggling readers who participated in a reading intervention based off of low scores on the Test of Silent Reading Efficiency and Comprehension (TOSREC; Wagner, Torgesen, Rashotte, & Pearson, 2010). Although these students received a reading intervention, the data used for this study would not be impacted by this since data were collected before the intervention began. The final sample consisted of 419 3rd, 4th, and 5th graders from 3 sites in the southeastern US who enrolled on the larger study who qualified for and were randomized to the treatment or control group due to having a TOSREC average score below 90. However, cases were removed if students did not partially complete the primary outcome measure, the AWSM Reader (n = 377). Of note, there was no significant difference in TOSREC scores ($F = 0.41$, $p = .524$) between the original sample (n = 419) and the sample used for this study (n = 377). Demographic data is provided in Table 1. All 377 students completed the reading comprehension portion of the AWSM Reader. Of the writing portion, 371 students gave a response for Passage 1, 365 gave a response for Passage 2, and 355 gave a response for Passage 3, though these specific scores were entered as 0s rather than missing data since portions of the measure were completed and no examiner concerns were noted. Regarding Aim 2, students with missing demographic data (i.e., gender, race/ethnicity, SES, age) were removed (n=20) since all were evaluated as covariates for the regression model.

Measures

Reading and Writing: The Assessment of Writing, Self-Monitoring, and Reading (AWSM Reader) was created for this study to more efficiently measure reading comprehension and writing in the same measure using the same topic. Three separate passages were read on the topics of sand dunes, Yellowstone National Park, and barefoot running. Students read the short passage and then were instructed to answer five multiple-choice comprehension questions for the passage. This process was repeated for the remaining two passages. The reading comprehension score was the total number of correct multiple-choice answers across all three passages (maximum = 15). Since evaluating psychometrics for this measure is part of the aims of this study, reliability and validity will be presented in the Results section.

After students completed the reading comprehension questions, students were directed to the writing portion of the task. For the writing portion of the passage, students were instructed to write what they learned from the passage and then write a summary of the passage. Student responses were written on forms that could be optically scanned, such that after the written student work from the writing portion of the AWSM Reader were captured electronically, they were subsequently verified by a member of the research team member. Of note, students could review the passages while completing the reading comprehension and writing portions of the AWSM Reader.

Two scores were generated from the writing portion of the measure: one was the number of "Key Words" and the other was the number of "Ideas Expressed". Within each passage, the Key Words score generated a raw score ranging from zero to eight consisting of relevant words pertaining to the passage. Similarly, within each passage, the Ideas Expressed score generated a raw score of zero to seven consisting of relevant and accurate ideas from the passage. Each of the Key Words and Ideas Expressed scores were summed across the three passages for a total maximum score of 24 for Key Words and 21 for Ideas Expressed. Following a training set of 10 responses, 90 of the 372 AWSM Reader writing responses were double-coded to ensure inter-rater reliability. All correlations for the six scores between raters were above .95 indicating high inter-rater reliability. Furthermore, weighted kappa coefficients were calculated for each of the six scores and ranged from .92 to .97 indicating an almost perfect agreement in scores between raters. Because the evaluation of more formal psychometrics for this measure is part of the aims of this study, reliability and validity will be presented in the Results section.

Executive Functioning: The NIH Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (NIH Examiner; Kramer et al., 2014) was used to measure executive functioning, specifically working memory, inhibition, set-shifting, and verbal fluency. The Verbal Fluency task consists of participants naming as many words that start with a certain letter of the alphabet (phonemic fluency) and naming as many objects in a certain category (category fluency) in 60 seconds. The coefficient alpha for category fluency is .78 and for phonemic fluency is .88. The total correct score is used for this task. The Set-shifting task consists of participants matching a stimulus presented with one of two stimuli at the bottom of the screen, the stimulus items are either shape or color, and are alternated throughout the task. This trial captures reaction time (RT) and accuracy. Internal consistency was separated based on color, shape, and shifting trials. The coefficient alpha for participants under age 18 was .95 for the color trials RT, .86 for the color trials accuracy, .94 for the shape trials RT, .93 for the shape trials accuracy, .97 for the set shift trials RT, and .88 for the set shift trial accuracy. The sum of the accuracy and total time scores is the score used for this task. The Dot Counting task is a verbal working memory task where participants see blue circles, green circles, and blue squares. The participants are told to count the blue circles and remember the total. Once the participant says the total number, another screen with blue circles, green circles, and blue squares is presented and the participants are told to once again count the blue circles and remember the total. The number of screens increases from two screens (one trial) to seven incrementally and at the end of each trial, the participants are told to state the total number of blue circles on each screen in order. This score is reported based on accuracy. The internal consistency coefficient alpha for this task for ages under eighteen is .69. The total score (sum of all six trials) is used in this task. The Anti-saccades task is an inhibitory task where participants are told to focus their eyes in the center of the screen. Subsequently, a stimulus is presented to the left or right and participants are either prompted to move their eyes in the direction of the stimulus or away from the stimulus. The internal consistency reliability for this task is .92. The total number of correct responses in both trials is the score used for this task.

For analyses, we used the EF composite score which is derived from item response theory and includes performance across the Verbal Fluency, Set Shifting, Dot Counting, and Antisaccade tasks. Validity for the NIH Examiner was determined through the Executive Composite score via relations with the Frontal Systems Behavior Scale (FrSBe; Gracy &

Malloy, 2001) total raw score, $r = -.57$, $p < .001$, and the Behavior Rating Inventory of Executive Function (BRIEF; Gioia, Isquith, Guy, & Kenworthy, 2000) total raw score, $r = -.21$, $p < .001$.

Reading Comprehension: The Gates-MacGinitie Reading Test (GMRT; MacGinitie, MacGinitie, Maria, & Dreyer, 2007) Form S Reading Comprehension subtest is a measure where participants are given 35 minutes to read passages and answer questions related to the text to measure an individual's understanding and comprehension of the passage. Raw scores are calculated and transformed into standard scores based on age-related norms; however, we used the total raw score when comparing these scores to the AWSM Reader reading comprehension total score. Reliability data were collected and the coefficient alpha for internal consistency in Grade 3 and Grade 4 is .96. The coefficient alpha for test-retest reliability in Grade 3 ranges from .85 to .90 and in Grade 4 ranges from .88 to .92. Criterion validity comparing the GMRT 4th Edition with the 3rd Edition reported a validity coefficient (correlation) of .92 for both Grades 3 and 4.

Writing: The Test of Writing Language, Fourth Edition (TOWL-4; Hammill & Larsen, 2009) Contextual Conventions and Story Composition subtest measures written expression constructed from a story that the individual creates from a stimulus picture. Participants are shown a sample stimulus picture with a story and then are presented the test stimulus picture with five minutes to plan writing. The participants are then given fifteen minutes to write a story related to the stimulus picture. Age-based standard scores are calculated from the total score; however, the total raw score was used for this study. Internal consistency for all subtests and ages had a coefficient alpha ranging from .74 to .92 (Hammill & Larsen, 2011). Test-retest reliability for 93% of subtests exceeded .80. Although no specific validity statistics were reported, criterion validity evaluated by measuring the correlation between the TOWL-4 and another writing measure found no significant differences in scores (Hammill & Larsen, 2011).

Language: The Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman & Kaufman, 2004) Verbal Knowledge subtest measures receptive vocabulary and general information by having participants listen to a word and choosing the picture that describes the word. We used the total correct raw score in our analyses. The KBIT-2 Verbal Knowledge subtest had an internal consistency alpha coefficient ranging from .74 to .84 for ages 7-11 (Kaufman & Kaufman, 2004). The test-retest reliability coefficients for the verbal subtests ranged from .88 to .93 (Bain & Jaspers, 2010).

Analyses

All statistical analyses were conducted using SAS computer software. To address the first aim, we analyzed the psychometric properties of the AWSM Reader. Specifically, we measured the internal consistency of the 15 reading comprehension items, the 3 key words passage scores, and the 3 main ideas passage scores, using Cronbach's alpha. We then assessed the correlation between the AWSM Reader reading comprehension items to the GMRT to test the validity of the reading comprehension items since the GMRT is a well-validated psychometrically-sound measure. Similarly, we assessed the correlation of the AWSM Reader Key Words and the Ideas Expressed scores with the TOWL-4 since this is a psychometrically sound measure of written expression. Next, we analyzed the correlation between reading comprehension and the two writing scores within the AWSM Reader. Lastly, we measured the correlation between the GMRT reading comprehension score and TOWL-4 writing score to compare the correlations between these standardized, well-validated reading and writing tasks with the reading and writing tasks from the AWSM Reader. We also compared these relations to those established in the literature (i.e., .50).

In order to address the second aim, we conducted multiple multivariate regression analyses. Five assumptions of multivariate regression include homoscedasticity, normality, linearity, multicollinearity, and independence (Kleinbaum, Kupper, Muller, & Nizam, 2007). To confirm the existence of outliers, the Cook's D statistic calculated whether individual observations had an influence on the data. The observation was removed from the data if the Cook's D statistic was greater than 1.0 (Stevens, 1984). To check for normality, we examined the skewness and kurtosis plots of the residuals (Osborne & Waters, 2002). We then computed the variance inflation factor (VIF) to ensure multiple predictor values were not too highly correlated with each other. If the VIF exceeded a value of ten, then multicollinearity was violated (Belsley, Kuh, & Welsch, 1980). To check for homogeneity of variance, we ran the White, Pagan, and Lagrange multiplier test (Godfrey, McAleer, & McKenzie, 1988). If $p > .05$ then the assumption of homoscedasticity, equal variance in the residual plot, was met. In order to check these assumptions, we employed residual analyses, which showed: (a) a normal distribution of residuals; (b) no significant variation in the plot (homoscedasticity); (c) no significant residual outliers; and (d) the outcome variables (reading and writing) having a constant standard deviation (Alexopoulos, 2010).

Assessing potential covariates is necessary to clearly determine the unique relation that the predictor variables (EF) have on the outcome variables (reading comprehension and written expression). We determined which covariates to include by measuring the relation between these potential variables and the outcome variables (reading comprehension and written expression). Potential covariates we considered were age (Crone & Whitehurst, 1999), sex (Mullis, Martin, Gonzalez, & Kennedy, 2003; Reynolds, Scheiber, Hajovsky, Schwartz, & Kaufman, 2015), race (Becares & Priest, 2015; Riegle-Crumb & Grodsky, 2010), and SES (Lee & Burkam, 2002) since previous research shows differences in academic outcomes on each of these variables. The variables that show significant correlations ($p < .05$) with the outcome variables were further evaluated together as covariates in the regression models, with consistent unique predictors remaining (to account for overlap in covariates). Significant predictors for the AWSM Reader reading comprehension portion were grade ($r = .42$, $p < .001$), age ($r = .30$, $p < .001$), and SES ($r = -.15$, $p = .003$). Significant predictors for the AWSM Reader writing key words portion were grade ($r = .29$, $p < .001$), age ($r = .16$, $p = .003$), and gender ($r = -.17$, $p = .001$). Significant predictors for the AWSM Reader writing ideas expressed portion were grade ($r = .21$, $p < .001$) and gender ($r = -.14$, $p = .009$). Due to all covariates being significant for at least one of the three outcome variables, all were included in the multivariate model. Step one of the primary analyses included these identified covariates, step two included the Verbal Knowledge score from the KBIT-2 (to represent language), and step three included the composite EF score from the NIH Examiner. The three outcome measures are the reading comprehension total score, writing Key Words total score, and writing Ideas Expressed total score from the AWSM Reader, which helped investigate the unique contributions of EF and language in reading and writing development. We ran a multivariate regression analysis to examine whether the predictor variable (EF) contributed significantly more to the reading comprehension portion than the writing portion of the AWSM Reader. An F-test evaluated the different contributions of EF with the three outcome variables and a significance test determined whether the unique contribution of EF is significantly different in the two academic domains.

In order to address the hypotheses regarding the ability of language and EF to explain the relation between reading comprehension and written expression, we utilized partial correlations. These evaluated the extent to which EF and language, separately and together, accounted for this relationship. The extent to which the correlation of reading and writing remains significant after inclusion of these factors will answer this question.

Results

Psychometric properties were analyzed for the AWSM Reader in order to determine the reliability and validity of the measure. Descriptive statistics for the AWSM Reader are provided in Table 2. Hypothesis 1a was that internal consistency measured by Cronbach's alpha for the reading comprehension and writing portions of the AWSM Reader would be greater than or equal to .7. Reliability was $\alpha = .58$ for the reading comprehension portion, which is lower than expected, and which is inconsistent with our hypothesis. Prior to coming to the conclusion that the reading comprehension items had insufficient internal consistency, we implemented alternative post-hoc analyses such as calculating Cronbach's alpha after removing items that had a % correct rate at less than chance (25%), clustering the items by story (n=3), calculating McDonald's omega, and test-retest reliability; however, all post-hoc analyses continued to indicate reliability coefficients at a similar level. For the writing portion of the AWSM Reader, reliability was $\alpha = .80$ for the Key Words scores and $\alpha = .75$ for the Ideas Expressed scores, which are both acceptable scores and confirmed our hypotheses.

Subsequently, Hypothesis 1b regarding validity for the AWSM Reader stated that the correlations between reading comprehension measures and writing measures would be consistent with previous findings. The validity for the reading comprehension portion of the AWSM Reader measured by the correlation with the GMRT was $r = .50$ ($p < .001$), which was lower than what we hypothesized. We implemented the Fisher's z transformation to test whether our results were consistent with standardized, well-validated reading comprehension measures ($.65 < r < .81$) in the literature and found that it significantly differed ($p < .001$, *CI*: .39-.55). We measured the correlation of both writing composite scores with the TOWL. The correlation for the AWSM Reader Key Words and the TOWL was $r = .50$ ($p < .001$), which is slightly lower and significantly different than previous literature reporting correlations between writing measures ($.59 < r < .78$). Additionally, the correlation for the AWSM Reader Ideas Expressed score and the TOWL was also $r = .47$ ($p < .001$) and also slightly significantly different from previous correlations. Furthermore, the correlation between reading comprehension and both writing scores (Key Words and Ideas Expressed) was $r = .56$ ($p < .001$) and $r = .51$ ($p < .001$), respectively, which are both consistent with previous correlations of reading comprehension and writing measures ($.48 < r < .72$). Moreover, regarding Hypothesis 1c, the correlation between the GMRT reading comprehension score and the TOWL-4 writing score was $r = .42$ ($p < .001$), which is also consistent with the AWSM Reader reading comprehension to writing correlation. Correlations between all measures included in this study are presented in Table 2.

Hypotheses for Aim 2 stated that EF would significantly contribute more to the writing portion, particularly the Ideas Expressed score, of the AWSM Reader than the reading comprehension portion (Hypothesis 2a). When adding the previously stated covariates and language to the multiple regression model for the AWSM Reader reading comprehension, the overall R^2 was .299 with language being significant and uniquely accounting for $\eta_p^2 = .061$ of the variance ($p < .001$). For the AWSM Reader Key Words model, the overall R^2 was .263 with language being significant and uniquely accounting for $\eta_p^2 = .026$ of the variance ($p = .001$). For the AWSM Reader Ideas Expressed model, the overall R^2 was .196 with language being significant and uniquely accounting for $\eta_p^2 = .023$ of the variance ($p = .002$). When adding executive functioning to the model, the overall R^2 was .316 with EF significantly contributing to the AWSM Reader reading comprehension and uniquely accounting for $\eta_p^2 = .016$ of the variance in the model ($p = .005$). Additionally, EF was a significant predictor of the AWSM Reader Key Words (overall $R^2 = .277$) and uniquely accounted for $\eta_p^2 = .014$ of the variance ($p = .010$). Furthermore, EF was approaching significance for the AWSM Reader Ideas Expressed and uniquely accounted for $\eta_p^2 = .008$ of the variance ($p = .065$). The full models are presented in Tables 3, 4, and 5. Moreover, EF contributed significantly more to AWSM Reader Key Words than AWSM Reader Ideas Expressed ($F = 5.63$, $p = .018$). EF's contribution did not significantly differ between the ASWM Reader reading comprehension and either of the AWSM Reader writing variables.

As mentioned above, the AWSM Reader reading comprehension had significant zero-order correlations with AWSM Reader Key Words ($r = .56$, $p < .001$) and AWSM Reader Ideas Expressed ($r = .51$, $p < .001$). When partialing for language (Hypothesis 2b), the AWSM Reader reading comprehension still had significant correlations with the AWSM Reader Key Words ($r = .52$, $p < .001$) and the AWSM Reader Ideas Expressed ($r = .47$, $p < .001$). When partialing for EF, the AWSM Reader reading comprehension still had significant correlations with the AWSM Reader Key Words (*r* = .52, $p < .001$) and the AWSM Reader Ideas Expressed (*r* = .48, $p < .001$). Moreover, when partialing for both language and EF, the AWSM Reader reading comprehension still had significant correlations with the AWSM Reader Key Words (*r* = .50, $p < .001$) and the AWSM Reader Ideas Expressed (*r* = .46, $p < .001$), which did not support our hypothesis that language and EF account for the total relation between the AWSM Reader reading comprehension and writing tasks.

Discussion

Our goals were to evaluate the psychometric properties of a combined reading and writing measure, the AWSM Reader, and to evaluate its cognitive predictors, focusing on EF. Hypotheses received mixed support. Reliability for the reading comprehension portion was below expectations, but were good for writing portions. Also, relations of the AWSM Reader components with external measures of reading and writing were comparable with prior work. EF significantly contributed to two of three components (reading comprehension and Key Words), but even EF combined with language did not account for the relation between reading and writing. Results highlight directions for how reading and writing might be more fruitfully combined, and highlight the need to consider additional sources for the overlap among reading and writing.

Psychometrics of the AWSM Reader

Reading. Reliability metrics of the reading comprehension portion were lower than anticipated, and also lower than the writing portions. It might be plausible that because our sample was of struggling readers, that restriction of range may have been an issue. However, this does not seem to be the case, as variability on the reading and writing portions of the

AWSM Reader were similar, and post-hoc analyses on the GMRT also revealed high internal consistency. The design of the AWSM Reader is a second alternative explanation for the lower than expected reliability values of the reading portion. For example, all three passages are expository, which presents greater difficulties for comprehension relative to narrative texts (Best, Floyd, & McNamara, 2008; Kraal, van den Broek, Koornneef, Ganushchak, & Saab, 2019), particularly for struggling readers (Williams et al., 2004). Coh-metrix analyses were computed for the texts, revealing a Flesch-Kinkaid grade level for Passage 1 (Sand Dunes) was 4.5, for Passage 2 (Yellowstone) was 6.0, and for Passage 3 (Barefoot Running) was 6.3; thus, it is possible that the passages were too difficult for this sample. However, this if anything would have been an additional contributor to a restriction of range or floor effects, which as noted did not appear to be an issue. Of note, the reading comprehension total score for 3rd graders ($M = 4.92$, $SD = 2.01$) was significantly lower ($F = 46.27$, $p < .001$) than the 4th ($M = 7.27$, $SD = 2.50$) and 5th graders ($M = 7.83$, $SD = 2.64$) indicating that the passages were more difficult for our 3rd grade students. Further, the five questions for each passage had a mix of literal and inferential questions, to which a struggling reader sample may have responded differentially. Increased guessing is a further possible since the questions were multiple-choice; this was less an issue for the writing task, and guessing has been shown to affect reliability of a reading comprehension task particularly for struggling elementary-aged readers (Baldauf, 1982). Thus, the implication may be that these passages as well as the items are too complex for elementary school students, particularly 3rd graders since research shows that the switch from “learning to read” to “reading to learn” occurs in late elementary and early middle school (4th grade and beyond; Chall, 1983; Harlaar, Dale, & Plomin, 2007). Unfortunately, we are unable to definitively pinpoint the reason that reliability was lower than expected, but did not appear to be due to obvious factors, particularly in ways that would not have also affected the writing portion. Fortunately, as explicated below, this did not appear to have any downstream effects on our aims.

The size of the relation of the AWSM Reader reading comprehension portion to a standard reading measure (the GRMT) was lower than hypothesized, but still moderate, $r = .50$. In developing our hypotheses, we relied on data from normative samples most of which were included in assessment manuals (KTEA-3, WJ-IV, WIAT-III) comparing other normative samples, relative to the focus of the present study which is limited to struggling readers. There in fact does appear to be evidence for lower, and more variable, relations amongst reading comprehension measures in struggling readers ($.19 < r < .79$; Berninger, Abbott, Vermeulen, & Fulton, 2006; Kang & Shin, 2019) as well as in other samples ($.24 < r < .70$; Francis et al., 2006; Keenan, Betjemann, & Olson, 2008). Specific to the age of our sample and measures used, Kang & Shin (2019) found GRMT correlations of .35 with the TOSREC, and .23 with the Woodcock-Johnson III Passage Comprehension measure. Thus, our hypothesized expectation between reading comprehension measures was in retrospect perhaps too high.

Writing. In contrast to the mixed results for the reading comprehension portion of the AWSM Reader, the writing portion exhibited good psychometric properties. Both Key Words and Ideas Expressed showed good internal consistency, and correlated at an expected level with performance on established writing measures.

Implications for the Relation of Reading and Writing

Overall, the study supports previous findings that reading and writing are significantly related to one another, particularly during the late-elementary ages (Abbott et al., 2010; Ahmed et al., 2014; Fitzgerald & Shanahan, 2000; Kent & Wanzek, 2016; Kim et al., 2018). That these were similar in size to the relation of normative measures of reading and writing to one another, yet produced by an integrated measure is promising. Further, as noted above, the relations of each individual component of the AWSM Reader were consistent with their respective domains. Moreover, a key point that this study conveys is that utilizing the same topic content for both the reading and writing sections helps to show a more direct comparison of the relation between reading and writing. In contrast, other comparisons of reading and writing in the literature have been conducted within separate measures where an unknown variable could have influenced the observed correlation. On the other hand, it is possible that utilizing the same content could have artificially increased the correlation we observed. However, we do not believe this to be the case, as reading and writing had a similar relationship with this measure as compared to previous literature (Ahmed et al., 2014; Kent & Wanzek, 2016).

The Role of Language and EF in Reading and Writing

Consistent with Aim 2 hypotheses, both language and executive function significantly predicted reading comprehension, and significantly predicted at least one of the writing portions of the AWSM Reader. This is consistent with previous research supporting the contribution of executive functioning in reading (Cirino et al., 2018; Follmer 2018) and writing (Altemeier et al., 2006; Hooper et al., 2011; Olive, 2004; Olive, 2011), albeit separately in those studies. Again, it is reassuring to find similar sized relations in the same sample, with a novel measure of EF, and with a combined measure of reading and writing, and suggests good generalizability to these findings. Further, this study also confirms that using a composite measure of EF from the NIH Examiner is a useful tool to include when measuring a general EF factor. Additionally, significant correlations were found with EF and reading ($r = .34$, $p < .001$) and writing ($r = .28$, $p < .001$; $r = .22$, $p < .001$). These findings are novel in finding this unique and similar contribution of EF with a combined measure of reading and writing in a struggling reader elementary-aged sample.

One interesting yet unexpected finding was that EF contributed differentially to the two writing scores, though this was not the case at the zero-order level since the correlations between EF and the two AWSM Reader writing portions were not significantly different. We believe this difference is due to the inclusion of demographic covariates as well as language in the multivariate model. One explanation of our regression models showing findings where EF has a greater relation to Key Words than Ideas Expressed may be due to low scores on Ideas Expressed comparatively which is reflected in the total mean and standard deviation across the sample. Since Key Words has a wider range in scores, it may potentially be a more fitting indicator of writing in late-elementary school, and, thus, explain why EF skills contribute more to Key Words than Ideas Expressed.

Language was also significantly associated with the AWSM Reader; however, language and EF each correlated with all portions of the AWSM Reader to similar degrees suggesting that both may be equally contributory to reading comprehension and writing in late-elementary-aged struggling readers. It further supports the roles of EF and language separately for both reading and writing outcomes, suggesting the potential to leverage this information in reading and writing interventions for struggling readers. Specifically, during reading comprehension and summary writing, students could receive strategies to hold relevant information and filter irrelevant information, such as taking notes, and also bolster vocabulary by identifying and defining difficult vocabulary terms in passages. Within the literature, aspects of language have successfully been incorporated into lessons and recommendations for teachers (Cavanaugh, Kim, Wanzek, & Vaughn, 2004; Fletcher, Lyons, Fuchs, & Barnes, 2018; Kamil et al., 2008), whereas the inclusion of EF strategies efficiently is less utilized (Cirino et al., 2016). Thus, it may require further study to develop effective ways to utilize both language and EF strategies in reading and writing interventions.

Our partial correlation analyses found that EF and language together did not account for the entire relation between reading comprehension and writing in our sample, and in fact they accounted for quite little of this relation. Previous studies have also investigated the overlap of reading and writing and found that linguistic knowledge (vocabulary, grammatical, orthographic), rating-based metacognitive knowledge, and fluency could not explain all shared variance (Schoonen, 2018), which is consistent with our findings. Further, three points seem relevant. First, although not a hypothesis of the present study, we evaluated correlations between the GMRT and TOWL, again partialing both EF and language, and there too, those cognitive factors accounted for very little of the overlap. This suggests that the finding is not specific to measurement issues associated with the AWSM Reader per se. Second, the correlations of our EF measure with reading and writing were: (a) similar whether they were evaluated with the AWSM Reader, GMRT, or TOWL; and (b) similar to those described in the literature and in the normative samples, with regard to reading (Berninger et al., 2017; Best, Miller, & Naglieri, 2011; Cirino et al., 2016; Follmer, 2017; Stringer, Toplak, & Stanovich, 2004), or to writing (Berninger et al., 2017; Hooper et al., 2011; Pazeto et al., 2014). Thus, it is not likely that the aberrant finding was due to the specific measure of EF chosen (or to the specific properties of the AWSM Reader). Third, more atypical were the relations found between our language measure and writing (regardless of how those were measured). That is, prior work has found language and writing correlations that range from $.40 < r < .50$; Karakoc & Kose, 2017; Kilic, 2019); however, our sample reported $r = .26$ and $r = .23$ for the AWSM Reader writing portions, which is lower than most previous research findings.

There are at least three potential explanations for these unexpected results. First, it may be argued that our language measure of receptive vocabulary had a restricted range due to the struggling reader sample. However, this is unlikely since univariate analyses were measured for concerns with normality, skewness, and kurtosis, and all were acceptable. Second, it could be argued that our receptive vocabulary/verbal knowledge measure does not map onto the way language is being used in the AWSM Reader writing portion since this study only utilized one aspect of language. Other aspects that comprise language such as expressive vocabulary or phonological awareness skills may help account for the relation between reading and writing. Furthermore, previous studies reviewed above utilized measures of expressive vocabulary or a composite of language measures (Kim, 2015). It is also possible the nature of our sample is relevant. For example, many studies that have evaluated language in relation to both reading and writing (again, using separate measures) used a typically-developing sample (Berninger & Abbott, 2010; Foorman et al., 2018). It is interesting that some prior studies, also with elementary aged struggling readers, have found similar results. For example, Carretti et al. (2016), discussed above, found a weak relation between vocabulary and writing.

Limitations

The study team noted a few limitations to the current study. One major limitation was that reliability was weaker than expected in the reading comprehension portion of the

AWSM Reader; however, there were no other major concerns with our results. Moreover, there are a number of ways that such a component can be improved, such as increasing length or more systematically assessing both literal and inferential items. Second, this study could have measured EF and/or language differently (e.g., phonological awareness, expressive vocabulary) or could have used different statistical analyses such as latent variables, but the EF relations were as expected, and in many ways, the AWSM Reader measure performed similarly as the more established GMRT and TOWL measures. It could be argued that a third limitation is the restriction of the present study to struggling readers. Such a design decision could potentially lead to a restriction of range, but as noted, this did not seem to be the case, and did not appear to drive the weaker relations found. Even if the struggling reader sample is less generalizable to the population as a whole, understanding relations in this context is important, given that such students are those most likely to require additional assistance, and/or to experience cognitive barriers in their academic performance.

Summary

Although the reading comprehension portion reported reliability levels slightly lower than expected, there were no downstream implications of this isolated finding and we successfully achieved our goal in creating a measure that includes both reading comprehension and writing with numerous benefits. While more work is needed to elaborate upon the specific items of the reading comprehension portion of the measure, most other findings were positive and acceptable. We learned that a measure similar to the AWSM Reader that incorporates both reading and writing within the same topic is feasible and can aid in measuring the direct relation between reading and writing by utilizing the same topic content which we consider a strength rather than a risk of conflation in scores. Further, with a few minor logistical changes an adapted AWSM Reader might be used as an efficient, time- and cost-effective measure in the assessment of reading and writing. Overall, assessing struggling readers with a measure that assess both domains within the same topic content could potentially be helpful in identifying areas of strengths and weaknesses within these academic domains. This study builds upon prior work by measuring shared cognitive predictors of reading and writing within the same measure. Furthermore, our findings support literature in that EF is a significant predictor of reading and writing after accounting for language and other covariates, but that language and EF do not account for the entire relation between reading and writing within the AWSM Reader; however, this may be due to our language measure rather than the EF measure or AWSM Reader. Overall, our study supports the combination of reading and writing in one measure as well as the significant contribution of EF and language to reading and writing development in elementary school-aged struggling readers.

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Tables and Figures

Table 1. *Summary of Sample Demographic Characteristics (n=377)*

Demographics	N	%
Gender[a]		
Female	190	50.4
Male	167	44.3
Grade		
3rd	106	28.1
4th	143	37.9
5th	128	34.0
Race/Ethnicity[a]		
Caucasian	55	14.6
Hispanic	143	37.9
African American	144	38.2
Other	15	4.0
Free/Reduced Lunch Status[a]		
Not Disadvantaged	102	27.1
Free/Reduced Lunch	255	67.6
Limited English Proficiency[b]		
Yes	54	14.3
No	243	64.5
Special Education[c]		
Yes	63	16.7
No	238	63.1

Note. Percentages do not add up to 100% due to missingness.
[a]Missing n = 20 [b]Missing n = 80 [c]Missing n = 76.

Table 2. *Correlation Matrix and Means and Standard Deviations for All Variables*

	Mean	*SD*	*Range*	1	2	3	4	5	6
1. AWSM Reader Reading Comprehension	6.80	2.70	1-13	--					
2. AWSM Reader Key Words	6.26	3.97	0-19	.56**	--				
3. AWSM Reader Ideas Expressed	2.26	2.52	0-14	.51**	.87**	--			
4. NIH Examiner Composite	-0.76	0.45	-2.57-0.30	.34**	.28**	.22**	--		
5. KBIT-2 Verbal Knowledge	49.41	11.26	7-77	.39**	.26**	.23**	.43**	--	
6. GMRT Reading Comprehension	17.96	6.84	3-44	.50**	.41**	.41**	.24**	.33**	--
7. TOWL Story Composition	6.58	3.80	0-16	.45**	.50**	.47**	.31**	.35**	.44**

Note. ***p*<.001. AWSM Reader = Assessment of Writing, Self-Monitoring and Reading. NIH Examiner Composite = National Institutes of Health NIH Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research Composite. KBIT = Kaufman Brief Intelligence Test, Second Edition. GMRT = Gates-MacGinitie Reading Test. TOWL = Test of Written Language.

Table 3. *Summary of Regression Analyses for Variables Predicting AWSM Reader Reading Comprehension*

	β	*B*	*SE b*	*t*	*p*	η_p^2
Gender						.014
Female [a]	.12	0.66	0.25	2.67	.008	
Grade						.040
Grade 4[b]	.30	1.67	0.39	4.28	<.001	
Grade 5[b]	.42	2.33	0.58	4.04	<.001	
Race/Ethnicity						.031
Hispanic[c]	.17	0.91	0.39	2.35	.019	
African American[c]	-.02	-.10	0.39	-0.26	.795	
Other[c]	.05	0.66	0.67	0.99	.321	
Free/Reduced Lunch[d]	.09	0.52	0.30	1.75	.081	.006
Age	-.08	-0.21	0.23	-0.92	.356	.002
Language	.22	0.05	0.01	4.21	<.001	.035
Executive Function	.15	0.89	0.31	2.84	.005	.016
Adjusted R^2	0.30					

Note:
[a]Reference = Male
[b]Reference = Grade 3
[c]Reference = Caucasian (Non-Hispanic)
[d]Reference = Economically Disadvantaged (based on lunch status)

Table 4. *Summary of Regression Analyses for Variables Predicting AWSM Reader Writing Key Words*

	β	*B*	*SE b*	*t*	*p*	η_p^2
Gender						.029
Female[a]	.17	1.38	0.37	3.68	<.001	
Grade						.098
Grade 4[b]	.49	4.01	0.60	6.73	<.001	
Grade 5[b]	.46	3.86	0.88	4.39	<.001	
Race/Ethnicity						.026
Hispanic[c]	.09	0.74	0.59	1.25	.214	
African American[c]	-.05	-0.42	0.60	-0.70	.483	
Other[c]	.17	2.00	1.01	1.97	.049	
Free/Reduced Lunch[d]	-.02	-0.22	0.45	-0.48	.630	.001
Age	-.20	-0.84	.35	-2.39	.017	.012
Language	.13	0.05	0.02	2.38	.018	.012
Executive Function	.14	1.24	0.48	2.59	.010	.014
Adjusted R^2	0.26					

Note:
[a]Reference = Male
[b]Reference = Grade 3
[c]Reference = Caucasian (Non-Hispanic)
[d]Reference = Economically Disadvantaged (based on lunch status)

Table 5. *Summary of Regression Analyses for Variables Predicting AWSM Reader Writing Ideas Expressed*

	β	*B*	*SE b*	*t*	*p*	η_p^2
Gender						.019
Female [a]	.14	0.72	0.25	2.85	.005	
Grade						.076
Grade 4[b]	.42	2.26	0.40	5.65	<.001	
Grade 5[b]	.41	2.21	0.59	3.73	<.001	
Race/Ethnicity						.023
Hispanic[c]	.02	0.10	0.40	0.25	.801	
African American[c]	-.11	-0.57	0.40	-1.41	.159	
Other[c]	.08	0.99	0.68	1.45	.147	
Free/Reduced Lunch[d]	<-.01	<-.01	0.30	-0.01	.993	<.001
Age	-.25	-0.66	0.24	-2.80	.005	.018
Language	.13	0.03	0.01	2.34	.020	.013
Executive Function	.10	0.03	0.32	1.85	.065	.008
Adjusted R^2	0.18					

Note:
[a]Reference = Male
[b]Reference = Grade 3
[c]Reference = Caucasian (Non-Hispanic)
[d]Reference = Economically Disadvantaged (based on lunch status)