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First-Grade Cognitive Predictors of Writing Disabilities in Grades 2 Through 4 Elementary School Students

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Abstract

The primary aim of this study was determining Grade 1 cognitive predictors of students at risk for writing disabilities in Grades 2 through 4. Applying cognitive measures selected to align with theoretical and empirical models of writing, tasks were administered to Grade 1 students assessing fine-motor, linguistic, and executive functions: 84 at risk (bottom quartile for age-base expectations) and 54 typically developing. A model with individual predictors was compared to a previously developed latent trait model to determine the relative predictive worth of each approach. Data analysis primarily involved stepwise logistic regression. Results revealed that the individual measures of orthographic choice, working memory, inhibitory control, visual memory recognition, and planning all were significant predictors of at risk status in Grades 2 through 4. The latent trait model also fared well but did not account for the same amount of variance as any of the individual measurement models for any of the grades. The findings lay the foundation for an empirically based approach to cognitive assessment in Grade 1 for identifying potential at-risk students in later elementary grades and suggest potential underlying neurocognitive abilities that could be employed with educational interventions for students with later-emerging writing disabilities.

Keywords

elementary, age, written language

Writing is a critical skill that is necessary for success in school, in the workplace, and within society (Graham & Harris, 2005). Despite its apparent importance to a variety of settings, findings from the National Assessment of Educational Progress assessments have shown that students' writing proficiency has remained virtually unchanged during the past decade. The National Assessment of Educational Progress (U.S. Department of Education, 2011) findings showed that only 33% of Grade 8 students and 24% of Grade 12 students demonstrated proficient writing skills. This may not be surprising given the complexity of written expression, but we are only beginning to understand how best to assess younger students who may be at risk for a writing disability (WD) in later grades.

This observation becomes even more important with the implementation of the Common Core State Standards Initiative in 2010, wherein the demands of writing have been vastly increased, with expectations for students' writing skills explicitly outlined beginning in kindergarten. According to the Common Core, by the end of Grade 1 students are expected to write about experiences, stories, people, and events by generating texts with facts and details that are presented in sequential order (National Governors Association Center for Best Practices, 2010). As expected, the standards become more demanding as children develop—by Grade 3 children are expected to write opinion pieces as well as informative (i.e., explanatory) texts that are clearly explained and supported by facts. This is further compounded by the findings that students who have difficulty with writing in Grade 1 are highly likely to remain poor writers in Grade 4 (Juel, 1988). These changes in educational policy and associated empirical findings underscore the importance of being able to identify writing problems as soon as possible in the elementary grades and intervene early.

Predictors of Later Learning Problems

There is a rich history of identifying early predictors of later learning problems. Within the reading decoding domain, there are strong findings targeting early phonological awareness

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and phonological processing as being critical to the identification of later difficulties, with these skills being identified early during the preschool years (e.g., Storch & Whitehurst, 2002). In fact, prediction models for at-risk readers in Grade 1 even have advanced how such readers should be selected for early intervention (Compton, Fuchs, Fuchs, & Bryant, 2006). Similarly, kindergarten children have been identified as being at risk for reading comprehension deficits in Grades 2 and 3 via assessment of their phonological awareness, oral language, and language comprehension capabilities during kindergarten (Catts, Herrera, Nielsen, & Bridges, 2015; Kendeou, van den Broek, White, & Lynch, 2009). Similarly, within the math domain, early predictors of later math difficulties have included number sense, number knowledge, magnitude comparison, counting knowledge, number identification, and working memory tasks (Baker, Gersten, & Lee, 2002; Gersten, Jordan, & Flojo, 2005; Jordan, Kaplan, Locuniak, & Ramineni, 2007). Other cognitive functions in Grade 1, such as attention, nonverbal problem solving, working memory, and phonological processing, also have been shown to be early predictors of later math disabilities (Fuchs et al., 2005). Furthermore, even social-behavioral measures obtained in kindergarten, which included teacher ratings of attention, internalizing behaviors, and externalizing behaviors, have been used to successfully predict both reading and math skills up through Grades 8 and 9 (Hooper, Roberts, Sideris, Burchinal, & Zeisel, 2010).

Potential Cognitive Predictors of At-Risk Status for WD

Theoretical Contributions

In the past few decades, theoretical models on writing skills have focused on the cognitive developmental processes involved in learning to write. This instrumental shift to understanding the cognitive development of written expression has been applied to the development of writing skills in the early elementary school years (Edwards, 2003; Graham & Harris, 2005), with several earlier efforts being noteworthy. For example, approximately 30 years ago Juel, Griffith, and Gough (1986) proposed the Simple View of Writing model. This model suggested that the ability to write consisted of attaining lower level skills, such as transcription, while concurrently using higher level skills, such as ideation. Berninger and colleagues (Berninger & Amtmann, 2003; Berninger, Winn, MacArthur, Graham, & Fitzgerald, 2006) expanded on the Juel et al. conceptualization and proposed a contemporary model of written expression: the Not-So-Simple View of Writing. According to this model, several skills are grouped into three primary components: transcription (letter and word production), executive functions (planning, monitoring, revising), and text generation (the main writing goal of the beginning writer, which occurs at the word, sentence, and text levels). These two models of writing provide a framework in which to think about the developing writer and the cognitive abilities that may be required for proficient writing in later grades.

The structure and the elements within these theoretical models of writing can be used as starting points in understanding how a good writer is able to produce writing and explore where weaknesses in the structure or elements contribute to problems with writing. The Simple View of Writing suggests that transcription skills and executive functions support text generation in an environment of working memory (Berninger & Amtmann, 2003), whereas the Not-So-Simple View of Writing identifies attention regulation as a system that allow writers to stay on task and switch between mental states as they write. The latter model also includes the components of working memory, long-term memory, short-term memory, and planning. A number of studies have shown evidence for these component skills of writing in children from elementary through middle school grades (Abbott, Berninger, & Fayol, 2010; Graham, 2006; Hooper et al., 2011; Kent, Wanzek, Petscher, Al Otaiba, & Kim, 2013; Kim, Al Otaiba, Sidler, Greulich, & Puranik, 2014; Kim et al., 2011).

Empirical Contributions

In our previous work (Hooper et al., 2011), we established longitudinal measurement invariance for a latent factor model that included fine-motor, language, and executive functions. We also concluded that the model accounted for approximately 44% and 48% of the variance in written expression for Grades 1 and 2, respectively. Those results suggested that nearly half of the difference between students' written expression abilities can be explained by fine-motor, language, and executive functioning skills. As well, more than half of the difference between second graders' written expression abilities can be explained by their Grade 1 fine-motor, language, and executive functioning skills.

Fine-motor skills. Fine-motor speed and coordination reportedly are the first of the writing skills to emerge, and they are essential in showcasing other writing skills (Berninger, Abbott, Abbott, Graham, & Richards, 2002). These low-level motor skills contribute to letter and word production, handwriting fluency, and spelling. Without the development of these low-level motor skills, it is challenging to demonstrate the higher order skills of writing. There is considerable evidence that fine-motor speed and coordination are strong predictors of writing fluency as students learn to write in the primary grades (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Jones & Christensen, 1999; Juel, 1988; Juel et al., 1986). Puranik and Al Otaiba (2012) found that spelling and handwriting fluency in kindergarten added significant unique variance in predicting writing fluency after accounting for reading, linguistic skills, and IQ. Graham, McKeown, Kiuhara, and Harris (2012) reported that when explicitly taught transcription skills, elementary students performed, on average, about one half of a standard deviation higher on writing quality than comparison students without such training. Consequently, fine-motor speed and coordination are potential predictors of later writing problems in young elementary school students.

Linguistic skills. Other empirically based studies have demonstrated the importance of a number of skills, including linguistic skills (Wakely, Hooper, de Kruif, & Swartz, 2006), such as phonology, orthographic choice, semantics, and grammar. In general, these skills have a longer growth trajectory than fine-motor skills (Berninger, 2000). These linguistic skills, and the resulting abilities to read and spell words, develop throughout the school years; thus, they may have different predictive value at different developmental epochs. After accounting for other literacy skills, Kim et al. (2011) found that word and syntax-level language skills in kindergarten revealed distinctive concurrent relations to compositional fluency. Similarly, using an at-risk preschool sample, Hooper, Roberts, Nelson, Zeisel, and Kasambira Fannin (2010) found that core receptive and expressive language abilities and prereading skills significantly predicted the level and rate of narrative writing skills in Grades 3 through 5. Kim, Al Otaiba, and Wanzek (2015) also examined the relationship of kindergarten transcription, oral language, word reading, and attention skills to both narrative and expository writing skills in third grade. Structural equation modeling showed that kindergarten oral language and lexical literacy skills (i.e., word reading and spelling) were significantly related to narrative writing quality in Grade 3, and kindergarten literacy skills were significantly related to expository writing quality. This study did not show a significant relationship with early attention and letter writing automaticity to later writing quality in either genre.

Executive functions. A number of executive functions also have been implicated as potential predictors of later writing difficulties. For written language, executive functions manifest in the form of attention regulation, planning, working memory, and self-monitoring (Berninger & Winn, 2006). These cognitive components are the higher order skills that help a writer compose an organized, cohesive, and understandable written output (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002), and they serve as potential predictors in any cognitive assessment model for identifying early writing problems in young elementary school students. Few studies, though, have examined the predictive value of executive functions to later at-risk writing status in early elementary school students.

Current Study

The primary purpose of this study was to identify Grade 1 measures that would serve as predictors of elementary-age children who were ascertained as part of a larger writing intervention study and deemed at risk for later writing problems. Specifically, we examined which single cognitive measures of linguistic, executive function, and fine-motor skills administered at Grade 1 best predicted students to be at risk for a WD in Grades 2 through 4 (Research Question 1). Similarly, we examined the predictive value of Grade 1 latent traits of language, executive functions, and fine-motor abilities to at-risk writing status in the later elementary grades (Research Question 2). These latent traits were previously created with the same participants in a previous study (i.e., Hooper et al., 2011). Last, we aimed to compare the latent traits model with the individual measures model to determine which one accounted for the most variation in students (Research Question 3). This final comparison is important for understanding the clinically based model of individual measures in relation to the empirically based latent trait model (i.e., data-derived model). Findings from this study will serve to provide an empirical basis for selection of cognitive measures that will assist in the early identification of students at risk for a WD.

Method

Participants

All participants for this study were selected from a single suburban-rural public school district in the southeastern part of the United States. Participants were recruited as part of a larger writing intervention study based on their writing status: typically developing writer (TD) or writer at risk for developing a WD (AR). Students were considered AR if their scores were in the bottom quartile (i.e., standard score ≤ 90) on either the Written Expression subtest or the Written Language composite of the *Wechsler Individual Achievement Test*, second edition (WIAT-II; Wechsler, 2002). Inclusion criteria required each student to have a primary placement in the general education setting, to have attended and completed kindergarten, and to be proficient in English.

Each of the seven elementary school principals in the district agreed to participate in the study. Altogether 950 students in 54 Grade 1 classes, across two cohorts, were initially screened for potential participation using the WIAT-II Written Expression subtest. This assessment was used to determine TD and AR status. From this initial screening, 545 students were recruited to participate in the study, and 223 (41%) signed consent forms that were received. Due to scheduling conflicts, 17 students were unable to participate, and 1 student was dropped because the student did not meet the inclusion criteria (i.e., did not attend kindergarten). The AR students were randomly assigned to treatment or control conditions, but for this study the students who participated in the intervention were not included in the current analyses.

This selection process yielded 137 Grade 1 participating students for the current study: 53 TD and 84 AR. Of these, 76 (55.5%) were boys and 61 (44.5%) were girls. Their ages ranged from 6 years to 7 years 4 months at the time of recruitment. Almost three quarters (73%) of the students were of European American ethnicity, 22.6% African American, 3.7% multiracial, and less than 1% Native American. Socioeconomic status ranged widely, with 49% of the participants' mothers having some postsecondary education, 29% having a high school diploma or GED, and 7% not completing high school. The level of intellectual functioning, measured using the *Wechsler Abbreviated Scale of Intelligence* (Wechsler, 1999), also ranged widely, with about 14% of the participants having scores less than 85, about 74% in the average range, and about 12% in the above average range. Of the students, 17 received services as English language learners for at least 1 year of the study but showed clear English proficiency in order to participate in the study.

Measures

Each year, all participants received a battery of measures that was theoretically and empirically linked to written language, with a particular focus on selecting measures related to fine-motor, linguistic, and executive functions, given their importance to the development of writing skills in young children. The measures were divided into two administration blocks to minimize order effects, with the block order being randomized for the Grade 1 assessment and alternated for the following assessment time points. Standardized scores were used in analysis unless indicated otherwise. The annual assessment measures were administered each spring for Cohort 1 and each fall for Cohort 2. Each measure was administered, scored, and standardized according to the instructions in the published test manuals. All responses were scored by trained researchers and graduate students, then double-checked by a school psychology graduate student. We have also provided reliability coefficients for each measure. In line with the internal consistency reliability coefficients guidelines from Wasserman and Bracken (2003), we determined that all of the coefficient estimates were acceptable for our purposes; specifically, for programmatic decisions being at least $r = .60$ or greater.

Writing status. To determine the writing skills of the students in each grade, and ultimately TD and AR status, the WIAT-II (Wechsler, 2002) Written Expression and Spelling subtests were administered. The Written Expression subtest measured handwriting, timed alphabet writing, written word fluency, and sentence combining. At Grades 1 and 2, the participant was given 15 s to write the lowercase letters of the alphabet and 60 s to write words related to a topic. Finally, the participant was asked to combine two simple sentences into one well-written sentence with the same meaning. At Grades 3 and 4, the participant was asked to write a paragraph in accordance with a specific writing prompt, in addition to the written word fluency task and sentence combining task. The Spelling subtest required participants to demonstrate single-letter, multiple-letter, and single-word production. Reliability for these WIAT-II tasks is moderate to strong ($r = .87–.94$). The Written Language composite is derived from the Written Expression and Spelling subtests.

Fine-motor skills. The Finger Sense Succession Dominant and Nondominant tasks from the *Process Assessment of the Learner: Test Battery for Reading and Writing* (PAL; Berninger, 2001) were administered to assess the participant's fine-motor speed and coordination by requiring the child to touch his or her thumb to each finger in order five complete times. This timed task is assessed separately for both hands. The scores from this task are a strong predictor of writing skills for students in elementary school (Berninger et al., 1992). Reliability estimates for this task ranged from $r = .87$ to .89.

Linguistic skills. The PAL Rapid Automatized Naming Letters and Word Choice subtests were administered (Berninger, 2001). The Rapid Automatized Naming task measures orthographic-phonological coordination through asking the child to quickly and accurately name aloud familiar letters and letter groups. Reliability estimates for this task ranged from $r = .84$ to .92. In the Word Choice subtest, which assesses orthographic capabilities, the child is asked to read 15 sets of words and circle the word in each set that is spelled correctly. Each set includes one real word and two pseudoword distractors that have a pronunciation similar to the correctly spelled word. Reliability for this subtest is $\alpha = .66$.

Executive functions. The measures selected to assess executive functions targeted dimensions including planning, inhibitory control, and working memory. Planning was assessed through use of the Planning and Retrieval Fluency subtests of the *Woodcock-Johnson III Test of Cognitive Abilities* (WJ-III; Woodcock, McGrew, & Mather, 2001). The Planning subtest assesses the participant's problem-solving abilities. The participant is asked to completely trace increasingly more difficult drawings without lifting the pencil from the paper or retracing. The Retrieval Fluency subtest assesses the participant's long-term verbal retrieval and fluency by asking the participant to name as many words as possible in 1 min for three designated categories (eat and drink, first names, animals). Reliability coefficients for these tasks ranged from $r = .67$ to .80.

Inhibitory control was assessed using the *Vigil Continuous Performance Test* (Vigil CPT; Psychological Corporation, 1998). This task requires the child to watch a computer screen as a sequence of single letters appears and then to press the space bar immediately after seeing the letter *K* followed by the letter *A*. This task is about 8 min in duration and yields scores reflecting errors of omission and errors of commission. Errors of omission represent the frequency of targets missed (i.e., lower attention), while errors of commission represent the frequency of incorrect anticipations of targets presented such that the participant responded as if the target were present when in fact no target was present (i.e., higher scores on errors of commissions indicate lower inhibitory control). Reliability estimates ranged from $\alpha = .90$ to .96. Vigil CPT age-adjusted raw scores were used in data analyses because standardized scores are not available.

Working memory was assessed via the Spatial Span Forward and Backward subtests of the *Wechsler Intelligence Scale for Children IV Integrated* (WISC-IV-I; Wechsler et al., 2004). For the Spatial Span Forward component, the child is asked to repeat a sequence of tapped blocks in the same order as demonstrated by the examiner. For the Spatial Span Backward component, the examiner points to a series of blocks and then asks the child to point to the same blocks in reverse order. Internal consistency estimates have ranged from $r = .70$ to $r = .81$. The following subtests from the *Wide Range Assessment of Memory and Learning*, second edition (WRAML-2; Adams & Sheslow, 2003) also were used to assess working memory: Picture Memory, Picture Memory Recognition, Story Memory, and Story Memory Recognition. Picture Memory assesses the participant's visual short-term memory and includes four stimulus picture cards and a response book with picture scenes. Each picture card is presented to the participant for 10 s, after which the participant is presented with a similar picture scene with the need to identify items that have been moved, changed, or added. Picture Memory Recognition is administered approximately 25 min after Picture Memory to assess delayed visual memory. Story Memory measures verbal short-term memory. The examiner reads aloud two stories, and after each story the participant is asked to verbally recall the story. Story Memory Recognition is administered approximately 25 min after Story Memory to assess delayed verbal memory. Reliability for these subtests ranged from $r = .72$ to .91.

Latent trait factors. In our previous work (Hooper et al., 2011), we developed the latent constructs of fine-motor, language, and executive functions using the same sample analyzed in the current study. These latent constructs were established from the measures mentioned above and provided an opportunity to compare the clinically based model of individual measures to the empirically based latent trait model with respect to relative predictive value. In the previous study we established longitudinal measurement invariance for the latent trait model for fine-motor skills as measured by PAL Finger Sense Succession Dominant and Nondominant tasks, for language as measured by PAL Word Choice and PAL Letters tasks, and for executive functions as measured by WRAML-2 picture and story memory recognition, WISC-IV-I Spatial Span, Working Memory (i.e., *Comprehensive Test of Phonological Processing* Nonword Recognition and WISC-IV-I Digit Span), WJ-III Planning and Retrieval Fluency, and Vigil CPT Commissions and Omissions tasks. As noted above, our intent for including the latent trait model was not to examine this model per se but rather to use it as a comparison for our examination of potential single-measure predictors of later writing problems.

Data Analyses

To address the first two research questions, we utilized longitudinal stepwise logistic models. We conducted two series of models, one for each question, predicting AR status in Grades 2, 3, and 4 as a function of individual measures or latent factor scores at Grade 1. These were run as stepwise logistic regression models in which predictors were added into the model sequentially. The sequence is determined by effect size wherein the variable with the largest effect is added first, then the next largest effect, and so forth. The model is evaluated, and parameters are estimated at each step. The evaluation includes tests of model fit, which assess how the effects of variables entered in previous steps may change in the presence of new models. Changes in model fit are evaluated via chi-square tests. A minimum p value for change was set at .05, and change must be significant for a step to run (i.e., be included in the model). Parameter estimates and odds ratios for each variable at each step are provided. To address the third research question, the comparison between models was assessed using R^2 values from the Nagelkerke Max–Rescaled Values procedure (Nagelkerke, 1991). Any missing data were missing at random, and Spearman correlations between missing observations, at-risk status, and all potential predictors were nonsignificant ($r < .17$, $p > .05$).

Additionally, we considered including covariate measures of intellectual functioning, gender, age, ethnicity, and maternal education in our models but concluded that for these research questions, the inclusion of these variables was not appropriate. Specifically, the reason for our choice of a data-driven procedure, such as stepwise regression, over a theory-driven procedure was that our primary concern was prediction, not explanation. We did examine the

Table 1. Sample Size for At-Risk and Typically Developing Groups at Grades 1 Through 4.

	Grade 1			Grade 2			Grade 3			Grade 4		
Group	*n*	IM	FS	*n*	IM	FS	*n*	IM	FS	*n*	IM	FS
AR	84	73	84	73	62	73	58	45	58	52	41	52
TD	53	49	53	61	57	61	69	67	69	67	64	67
Total	137	122	137	134	119	134	127	112	127	119	105	119

Note. IM = number of participants with complete data on the individual measures; FS = number of participants' data that were used for the analysis; AR = writer at risk for developing a writing disability; TD = typically developing writer.

possibility of the demographic variables affecting our other predictors and found them to be minimally correlated with our targeted predictors (r = .05 to .33). Further, we explored using the demographic variables as potential covariates in the analyses, and none were selected for inclusion in any of the models. This suggested that regardless of which variables were entered, the demographic variables were never significant predictors of other variables, nor did they significantly affect the model such that they needed to be included in our final calculations. Thus, the covariates were not included in our models. SAS Version 9.4 was used to conduct all data analyses.

Results

Descriptive Statistics

Stepwise logistic analysis in SAS requires listwise deletion of cases that are missing data on one or more variables. Of the 137 cases, 18 cases were removed at Grade 1, 15 each at Grades 2 and 3, and 14 at Grade 4. Even though about 11% to 13% of the sample was lost, data imputation was not performed as there was sufficient power to address our research questions. It also is noted that a reversal in at-risk pattern is seen, such that at Grades 1 and 2 more participants are AR, while at Grades 3 and 4 fewer participants are AR. These numbers can be seen in Table 1. Means and standard deviations on the individual measures for the sample fell largely within the average range and can be seen in Table 2.

Table 2. Descriptive Statistics for Individual Measures at Grade 1.

Measure	*n*	*M*	*SD*
PAL Finger Sense Succession Nondominant Hand scaled score	130	9.03	2.51
PAL Finger Sense Succession Dominant Hand scaled score	133	8.96	2.70
PAL Rapid Automatized Naming Letters *Z* score	130	-0.04	1.03
PAL Word Choice Accuracy scaled score	136	8.51	3.69
WISC-IV-I Spatial Span Forward scaled score	137	9.78	3.03
WISC-IV-I Spatial Span Backward scaled score	137	9.13	3.45
WJ-III Planning age-based standard score	137	105.32	8.85
WJ-III Retrieval Fluency age-based standard score	137	95.50	16.16
WRAML-2 Story Memory Recognition standard score	137	11.04	3.06
WRAML-2 Picture Memory Recognition standard score	137	9.78	3.13
WRAML-2 Story Memory standard score	137	10.66	2.59
WRAML-2 Picture Memory standard score	137	8.49	3.19
Vigil CPT Errors of Omissions total score	135	63.05	31.84
Vigil CPT Errors of Commissions total score	135	78.63	60.85

Note. PAL = *Process Assessment of the Learner: Test Battery for Reading and Writing* (Berninger, 2001); WISC-IV-I = *Wechsler Intelligence Scale for Children IV Integrated* (Wechsler et al., 2004); WJ-III = *Woodcock-Johnson III Test of Cognitive Abilities* (Woodcock, McGrew, & Mather, 2001); WRAML-2 = *Wide Range Assessment of Memory and Learning*, second edition (Adams & Sheslow, 2003); Vigil CPT = *Vigil Continuous Performance Test* (Psychological Corporation, 1998).

Prediction of AR by Individual Measures

Grade 1 predicting Grade 2. As can be seen in Table 3, three measures were entered into the final model for Grade 1 individual measures predicting AR status at Grade 2. The first individual measure that was entered into the Grade 2 model was PAL Word Choice, a measure of linguistic ability. This was followed by two measures of executive function, WISC-IV-I Spatial Span Forward and Vigil CPT Errors of Commissions. Each of the models resulted in significant results (p < .001), and the chi-square tests of change were all significant (p < .05).

As can be seen in Table 4, the effects for each variable remained consistent as other variables were added. Participants in Grade 2 who had higher scores on PAL Word Choice and WISC-IV-I Spatial Span Forward were less likely to be AR than participants with lower scores, whereas higher scores on Vigil CPT Errors of Commissions (i.e., lower inhibitory control) increased the likelihood of being AR.

Grade 1 predicting Grade 3. Two measures were entered into the final model for Grade 1 individual measures predicting AR status at Grade 3. The first individual measure that was entered into the Grade 3 model was PAL Word Choice, a measure of orthographic choice, and then WRAML-2 Picture Memory Retrieval, a measure of visual working memory. As

Table 3. Full Predictive Model Results and Tests of Change for Grades 2 Through 4.

		Full model			Test of change		
Step	Measure	χ^2	*df*	*p*	χ^2	*df*	*p*
Grade 1 to Grade 2							
1	Word Choice	22.27	1	< .0001	22.27	1	< .0001
2	Spatial Span Forward	38.30	2	< .0001	16.02	1	< .0001
3	Commissions	45.63	3	< .0001	7.33	1	.0068
Grade 1 to Grade 3							
1	Word Choice	25.09	1	< .0001	25.09	1	< .0001
2	Picture Memory Retrieval	38.58	2	< .0001	13.49	1	.0002
Grade 1 to Grade 4							
1	Word Choice	28.72	1	< .0001	28.72	1	< .0001
2	Spatial Span Backward	38.03	2	< .0001	9.31	1	.0023
3	Planning	43.96	3	< .0001	5.93	1	.0015
4	Picture Memory Retrieval	49.38	4	< .0001	5.42	1	.0199

Table 4. Stepwise Logistic Regression Model Results for Grade 2.

Step	Measure	Estimate (*SE*)	Odds ratio (confidence interval)	χ^2	*p*
0	Intercept	0.08 (0.18)		0.21	.6468
1	Intercept	2.39 (0.57)		17.55	< .0001
1	Word Choice	−0.26 (0.06)	0.77 (0.69−0.87)	18.64	< .0001
2	Intercept	5.48 (1.14)		23.07	< .0001
2	Word Choice	−0.26 (0.06)	0.77 (0.68−0.87)	17.02	< .0001
2	Spatial Span Forward	−0.31 (0.09)	0.74 (0.62−0.87)	12.44	.0004
3	Intercept	3.86 (1.20)		10.31	.0013
3	Word Choice	−0.25 (0.07)	0.78 (0.68−0.88)	14.91	.0001
3	Spatial Span Forward	−0.23 (0.09)	0.79 (0.67−0.94)	7.28	.0070
3	Commissions	0.01 (0.00)	1.01 (1.00−1.02)	6.68	.0097

can be seen in Table 3, each of the models resulted in significant results ($p < .001$), and the chi-square tests of change were all significant ($p < .05$).

As can be seen in Table 5, the effects for each variable remained consistent as other variables were added. Participants in Grade 3 who had higher scores on PAL Word Choice and WRAML-2 Picture Memory Retrieval were less likely to be AR than participants with lower scores.

Grade 1 predicting Grade 4. Four measures were entered into the final model for Grade 1 individual measures predicting AR status at Grade 4. The first individual measure that was entered into the Grade 4 model was PAL Word Choice. This was followed by three measures of executive function: WISC-IV-I Spatial Span Backward, WJ-III Planning, and WRAML-2 Picture Memory Retrieval. As seen in Table 3, each of the models resulted in significant results ($p < .001$), and the chi-square tests of change were all significant ($p < .05$).

As can be seen in Table 6, the effects for each variable were consistent as other variables were added. Participants in Grade 4 who had higher scores on PAL Word Choice, WISC-IV-I Spatial Span Backward, WJ-III Planning, and WRAML-2 Picture Memory Retrieval were less likely to be AR than participants with lower scores. It is noted that the odds ratios are a bit larger for the Grade 4 model than in the models from the previous grade levels (i.e., 2 and 3), which suggests that the predictive power of each measure may be decreasing with advancing grades.

Prediction of AR Status by Latent Factor Scores

All of the models that included factor scores predicting writing status resulted in a similar set of findings. These models revealed that of the three latent factors (i.e., fine motor, language, executive function) derived from our previous study with the same sample, the executive function latent factor was the only one that was significantly predictive of writing status at Grade 2, $\chi^2(1) = 22.27$, $p < .0001$; Grade 3, $\chi^2(1) = 44.44$, $p < .0001$; and Grade 4, $\chi^2(1) = 32.77$, $p < .0001$. All of the chi-square tests of change were significant ($p < .0001$). In general, higher levels of executive functioning in Grade 1 significantly reduced the probability of being AR at each subsequent grade,

Table 5. Stepwise Regression Logistic Model Results for Grade 3.

Step	Measure	Estimate (*SE*)	Odds ratio (confidence interval)	χ^2	*p*
0	Intercept	−0.40 (0.19)		0.21	.6468
1	Intercept	2.23 (0.61)		17.55	< .0001
1	Word Choice	−0.31 (0.07)	0.74 (0.64−0.84)	18.64	< .0001
2	Intercept	5.37 (1.21)		23.07	< .0001
2	Word Choice	−0.32 (0.08)	0.73 (0.63−0.84)	17.02	< .0001
2	Picture Memory Retrieval	−0.31 (0.09)	0.73 (0.61−0.88)	12.44	.0004

Table 6. Stepwise Logistic Regression Model Results for Grade 4.

Step	Measure	Estimate (*SE*)	Odds ratio (confidence interval)	χ^2	*p*
0	Intercept	−0.45 (0.20)		4.96	.0260
1	Intercept	2.86 (0.76)		14.29	.0002
1	Word Choice	−0.37 (0.09)	0.69 (0.58−0.81)	19.02	< .0001
2	Intercept	4.54 (1.03)		19.42	< .0001
2	Word Choice	−0.21 (0.07)	0.81 (0.70−0.93)	8.42	.0037
2	Spatial Span Backward	−0.35 (0.09)	0.7 (0.59−0.83)	16.48	< .0001
3	Intercept	12.01 (3.52)		11.67	.0006
3	Word Choice	−0.21 (0.07)	0.81 (0.70−0.94)	7.81	.0052
3	Spatial Span Backward	−0.3 (0.09)	0.74 (0.63−0.88)	11.51	.0007
3	Planning	−0.08 (0.03)	0.93 (0.87−0.99)	5.44	.0197
4	Intercept	14.15 (3.93)		12.99	.0003
4	Word Choice	−0.20 (0.08)	0.82 (0.70−0.95)	6.91	.0086
4	Spatial Span Backward	−0.29 (0.09)	0.75 (0.63−0.89)	10.68	.0011
4	Planning	−0.08 (0.03)	0.93 (0.87−0.99)	4.87	.0274
4	Picture Memory Retrieval	−0.21 (0.10)	0.81 (0.67−0.98)	4.80	.0284

with this effect being strongest at Grade 2 (estimate = −1.83, odds ratio = .16, confidence interval = .08–.31).

Prediction of AR Status by Individual Measures Versus Latent Factors

For the final research question, the models with the individual measures were compared to the models with the latent trait factors using R^2 values. The Nagelkerke Max–Rescaled R^2 values showed that the individual measures performed slightly better than the latent trait factor scores. For the individual measures, the amount of variance accounted for was 42% for Grade 2 prediction of AR, 39% for Grade 3, and 51% for Grade 4. In contrast, for the latent trait factors, the amount was 38% for Grade 2 prediction of AR, 29% for Grade 3, and 32% for Grade 4.

Discussion

This study addresses an important need in the area of written expression, namely, identifying early cognitive predictors and associated measures of at-risk status in Grade 1 students for a WD in Grades 2 through 4. This study explored the potential of both individual cognitive measures and latent trait variables to predict at-risk status and compared the two models.

For the individual cognitive measures, the longitudinal logistic regression analyses revealed that measures of orthographic processing (i.e., PAL Word Choice), nonverbal working memory (i.e., WISC-IV-I Spatial Span Forward), and inhibitory control (i.e., Vigil CPT Errors of Commissions) were predictive of writing status in Grade 2. Specifically, Grade 1 students who exhibited better performance on these measures were less likely to be AR in Grade 2. When predicting Grade 3 writing status, orthographic processing (i.e., PAL Word Choice) continued to be the most predictive measure, and a measure of delayed visual retrieval (WRAML-2 Picture Memory Retrieval) was also predictive. Once again, in the Grade 4 model, orthographic processing (i.e., PAL Word Choice) was the most predictive measure of writing status. Nonverbal working memory (i.e., WISC-IV-I Spatial Span Backward), planning (WJ-III

Planning), and delayed visual retrieval (WRAML-2 Picture Memory Retrieval) were also significantly predictive of AR status. For all of the individual measures, Grade 1 students who exhibited better performance on these measures were less likely to be AR.

The predictability of orthographic processing was consistent with early literature noting the importance of this function to young elementary school students. Other investigators clearly have demonstrated the importance of orthographic functions to both reading and spelling (e.g., Kim, Apel, & Al Otaiba, 2013; Roman, Kirby, Parrila, Wade-Woolley, & Deacon, 2009; Walker & Hauerwas, 2006) as well as to written expression. Berninger and Fuller (1992) found that orthographic coding (i.e., whole word, letter, letter clusters) had a strong positive correlation with handwriting, spelling, and compositional skills. In addition, Abbott and Berninger (1993) found that orthographic coding made a statistically significant contribution to handwriting fluency and spelling in Grades 1 through 3 students. These investigators also demonstrated that intact rapid automatized naming and orthographic coding, both involving speeded output of orthographic input, had a significant positive correlation ($r = .21$) with writing in Grade 1 students, although it accounted for only about 4.4% of the variance (Berninger, Abbott, et al., 2006). Our findings would be supportive of these early efforts to predict writing difficulties in elementary school students.

What is a bit surprising is the lack of predictive power for fine-motor skills (i.e., speed and coordination) and other linguistic functions beyond orthographic processing. Based on the earlier findings from the preschool and kindergarten literature (e.g., Hooper et al., 2010), we would have expected to see more representation from these types of assessment tools in the predictive models. Furthermore, the dominance of a variety of executive functions at this developmental time period also was a bit unexpected, particularly in the context of little predictive power of single measures of fine-motor skills and phonological processing. This may have been related, in part, to the measures selected for this study, and perhaps a different pattern of results might be seen with a different battery of tasks.

Findings related to the latent traits also fared well with respect to the Grade 1 prediction of AR status in Grades 2 through 4, with a clear predictive pattern of variables emerging. Specifically, similar to the dominance of the individual measures of executive functions in predicting at-risk status in later grades, all of the predictive models using latent traits revealed the strength of the executive function factor in predicting at-risk writing status in Grades 2 through 4. Again, the lack of significance for the latent trait factors of fine-motor skills (i.e., speed and coordination) and language was notable, particularly given earlier findings indicating the importance of these factors in written expression. Furthermore, despite the relative strength of having an empirical basis to the latent factor model, it is important to note that this model did not account for as much variance as the individual measures model, with the individual measures models accounting for more of the predictive variance at each of the later grades examined.

Implications

Taken together, these findings are a little surprising. The most predictive measure of writing status is one of orthographic choice; however, the latent trait factor of language was not predictive of later writing status, perhaps because it included other measures of linguistic abilities (e.g., phonological processing). Also, the importance of executive functions to the writing process, even in Grade 2, where written expression and associated organizational structure are just beginning to emerge, clearly should not be underestimated with respect to its predictive power, and such measures could provide "value added" in any cognitive assessment of written expression. These findings provide support for current writing models that suggest orthographic processing and executive functions are essential skills for the writing process (Abbott & Berninger, 1993). As we have suggested previously (Hooper et al., 2010), fine-motor skills and phonological processing abilities are perhaps better predictors of later writing skills for children at early developmental epochs (i.e., preschool, kindergarten).

These findings provide evidence for the inclusion of several cognitive measures in a Grade 1 assessment battery for identifying students at risk for later writing problems. Specifically, in addition to direct measures of written expression, measures of orthographic processing (e.g., PAL Word Choice), visual working memory (e.g., WISC-IV-I Spatial Span), inhibitory control (e.g., Vigil CPT), planning and problem solving (e.g., WJ-III Planning), and visual retrieval (e.g., WRAML-2 Picture Memory Recognition) all were significant predictors of at-risk status in Grades 2 through 4. While these exact measures should be available to most educational diagnosticians, we would submit that the underlying constructs would be the important targeted areas for assessment consideration and that other measures may suffice. These measures are standardized, have good normative data for the early elementary school age range, and nicely complement other measures of a larger psychoeducational evaluation. Results from these measures also should assist general and special educators in providing AR students with targeted instructional needs so as to minimize the downstream effects on later writing skills. Last, using targeted measures such as the above also may serve to lessen the assessment time that school psychologists and other educational diagnosticians need to evaluate young elementary school students, perhaps precluding the need for extensive testing procedures, and they may assist with laying the foundation for an evidence-based intervention for WD.

Limitations

First, the present study used data that were collected as part of a larger longitudinal study of the development of writing skills. Students were identified as at risk and not at risk for inclusion in the study; consequently, a different sampling method may have produced a different set of findings. Second, although the measures were based on theoretical conceptualizations and empirical findings from the early writing literature, the measures were not selected with the primary intention of using stepwise logistic analyses to investigate our specific research questions, and as noted earlier, a different battery of tasks may produce a different set of findings (e.g., Kim et al., 2015). Third, the criterion for determining at-risk status (i.e., performance in the bottom quartile on the WIAT- II) is an absolute. This absoluteness of the criterion, however, does not reflect the variation that exists among the students' abilities. Even though this criterion has been successful in identifying children at risk for reading and math problems (Fuchs et al., 2008), it is doubtful that a student with a written expression score of 91 (i.e., TD status) is that much different than a student with a score of 90 (i.e., AR status). The cut point selected might have affected the findings of this study; indeed, a cut point using a lower score (e.g., bottom 10%) may have produced a different set of predictors. Finally, it is important to note that there likely are other contributors to writing skill development that were not addressed in these models. As noted earlier, we made a purposeful decision to not include sociodemographic covariates in our models, given that we were in pursuit of a predictive model rather than an explanatory one; however, we are aware that other environmental factors could have an impact on such prediction models. For example, research has shown that several environmental factors—such as teacher-student relationships (Burchinal, Peisner-Feinbert, Pianta, & Howes, 2002), limited instruction, limited cultural experiences, and poor motivation (Gregg & Mather, 2002)—have an effect on school achievement. None of these variables were examined in the current study, and the availability of these types of factors also could have changed the predictive patterns observed in this study.

Future Directions

Previous theoretical models and associated research has suggested that deficits in fine-motor skills constrain early writing, deficits in memory constrain writing in the intermediate years, and deficits in executive functions constrain later writing (Berninger & Rutberg, 1992); however, this study found that orthographic processing and executive functions significantly predicted at-risk writing status for students in Grades 2 through 4. Longitudinal studies of writing development that examine students beginning in the preschool years would add to this research and, perhaps, would reveal a different set of predictors (Hooper et al., 2010). A foundation of understanding the development of writing over time would help inform instruction and intervention in writing for children. In the meantime, the findings from this study begin to lay an empirical foundation for using specific cognitive measures for identifying Grade 1 students at risk for later writing problems. This is critical to the assessment process as the identified measures from this study go beyond typical psychoeducational assessment strategies that include IQ and achievement and begin to target underlying neurocognitive processes that are important to not only the writing process but also to the early identification of later writing problems in elementary school students.

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