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COGNITIVE COMPONENTS OF DEVELOPMENTAL WRITING SKILL

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A significant number of studies have examined the cognitive components of basic academic skills, which has led to major changes in both teaching and early identification assessment practices. However, the majority of previous research has focused solely on reading. This study examines the cognitive components of academic writing skills across early grade levels (1–4) while controlling for basic word identification skills. Results from this study suggest writing skill requires several cognitive skills of differing emphasis depending on the level of writing skill. Perceptual and rapid perceptual processing skills are important during the early acquisition of writing skills followed by a transition to language and language retrieval skills and later still to working memory skills. Applications for education and cognitive assessment are discussed.

Early identification of children who do not learn academic skills within expected developmental time frames is a major national concern for policymakers, educators, and parents alike (Cortiella & Horowitz, 2014; U.S. Department of Education, 2002). Once identified, understanding the causes and potential solutions can improve academic outcomes for children with academic skill deficits (O'Shaughnessy, Lane, Gresham, & Beebe-Frankenberger, 2003). Although the underlying academic and cognitive contributors to math (Floyd, McGrew, & Evans 2003; Proctor, Floyd, & Shaver, 2005) and reading (Decker, Roberts, & Englund, 2013; Evans, Floyd, McGrew & Leforgee, 2002) are better understood, less is known about the cognitive contributors to writing (Abbott, Berninger, & Fayol, 2010). Understanding the cognitive contributors to writing is important because proficiency levels for writing are lower than reading (U.S. Department of Education, National Center for Education Statistics, 2004), whereas prevalence rates for written-language disorders in school-aged children are higher (Katusic, Colligan, Weaver, & Barbaresi, 2009).

Cognitive predictors of academic skills vary depending upon the individual's level of skill development (Decker et al., 2013). For example, perceptual measures of learning are often more predictive of basic academic skills, whereas working memory measures are more predictive of advanced academic skills. This is important because targeted cognitive interventions have been demonstrated to improve academic skills in both reading and math (Iseman & Naglieri, 2011; Loosli, Buschkuehl, Perrig, & Jaeggi, 2012).

Early models of writing typically involved cognitive processes related to planning, translating, and revising (Hayes & Flower, 1980). Berninger and Swanson (1994) proposed a model for the development of these three skills over time, based on a cross-sectional study of students in grades 1–9. During elementary school, Berninger and Swanson proposed that skill in translating develops first, with basic transcription skills appearing before the ability to generate text. Additionally, the skill of planning typically appears before the ability to revise one's own work. During intermediate grades, simple transcription becomes automatic and more advanced text generation and planning abilities

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begin to develop. In adolescence, these skills continue to develop, becoming further influenced by the development of working memory and metacognitive abilities (Berninger, Fuller, & Whitaker, 1996).

Distinguishing basic from higher level writing has also been useful for distinguishing different sets of skills at different developmental periods. Basic writing skills such as spelling and handwriting require skills in phonological awareness and the rapid retrieval of letter forms as well as the processing of orthographic information and fine motor skills (Fletcher, Lyon, Fuchs, & Barnes, 2007). Higher level writing skills such as composition, on the other hand, involve more complex knowledge of verbal language skills, including knowledge of vocabulary and word retrieval (Gregg & Mather, 2002), as well as grammar and syntax (Lyon, 1996). Higher level writing also requires the efficient use of executive functions such as planning and working memory (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002), which are involved in the generation and transformation of ideas into words (Swanson & Berninger, 1996).

Distinguishing different cognitive contributors for different stages of writing development has been useful for describing the developmental trajectory of writing. According to Berninger and Richards (2002), writing begins with basic visual-motor integration at early ages that is characterized by scribbling but later progresses to letters and words over the course of approximately 6 years. Next, orthographic skills develop (approximately from kindergarten to first grade) that include whole words as well as smaller units of letters and letter pairs. Spelling and composition both follow predictable developmental sequences. Automaticity of basic writing skills is important at intermediate grades, which relies on fluent memory retrieval. Writing strategies and composition planning require working memory and students during third and fourth grade change from learning how to write to writing to learn. As a result, writing assignments become more complex and crucial for learning (Jones, Abbott, & Berninger, 2014).

Component-level descriptions of writing suggest different cognitive processes should be involved at different stages of writing. To date, two studies have been conducted examining the relationship between cognitive abilities and writing achievement. An early study by McGrew and Knopik (1993) investigated the relationship between broad cognitive abilities and writing achievement across the lifespan utilizing the Woodcock–Johnson Psycho-Educational Battery-Revised (WJ-R). Results of the study indicated that processing speed, comprehension-knowledge, auditory processing, and fluid reasoning were significant predictors of writing skill. The study found no relationship between writing achievement and visual processing, long-term retrieval, or short-term retrieval. More recently, Floyd, McGrew, and Evans (2008) replicated this study. They investigated the relative contributions of broad Cattell-Horn-Carroll (CHC) cognitive abilities in the prediction of writing achievement in individuals aged 6–18, using the Woodcock–Johnson III (WJ III) Tests of Cognitive Abilities and Achievement. The study examined the cognitive correlates of basic writing skills, such as spelling, punctuation, and capitalization, as well as written expression, which measures compositional fluency and accuracy. Results of this study again indicated that comprehension-knowledge, processing speed, and auditory processing were moderate to strong predictors of written expression skills across development. Additionally, they found a moderate relationship between written expression and short-term memory and long-term retrieval. Visual-spatial thinking again showed negligible relationships with written expression. However, Floyd et al. (2003) did not find a relationship between fluid reasoning and written expression, which is in contrast to the original study.

The current study provides a further examination of the cognitive contributors of writing but extends the research by examining cognitive predictors across a range of early developmental grades with differing levels of writing proficiency. As indicated, it is likely that language, working memory, perceptual organization, visual-motor, and other skills are important cognitive predictors of writing,

Table 1
Demographics by Grade Level

Variable	Grade 1 ($N = 158$)	Grade 2 ($N = 165$)	Grade 3 ($N = 173$)	Grade 4 ($N = 194$)
Sex				
Male	87	92	76	101
Female	71	73	97	93
Race				
Caucasian	117	124	124	142
African American	31	26	33	33
Indian	5	6	8	3
Asian/Pacific Islander	5	9	8	16

Note. N = 690.

but have differing emphasis at different stages of writing development. Because previous studies could not parse out the influence of academic skill as opposed to cognitive processes at different stages, a basic measure of letter and word identification was used as a covariate to control for academic learning. Based on previous studies with reading, it is predicted there will be a gradual transition from low-level perceptual features (e.g., phonological awareness and letter-word identification) for basic writing to higher level language and working memory skills for higher level writing, as evident across early grade levels (1–4).

Building on previous research, we postulate the following hypothetical model to guide the investigation of the cognitive predictors of writing skill across early development:

1. Cognitive tasks involving low-level perceptual and attention skills will be more predictive at early grade levels.
2. Language, including language association and language retrieval skills, will be more important during intermediate stages of writing development.
3. Working memory will be more important during later stages of writing development.

Method

Participants

Participants for this study were 690 individuals (334 females, 356 males, $M_{age} = 8.01$ (1.28), age range = 5–11 years) from the Normative Update of the standardization sample of the Woodcock–Johnson Tests, Third Edition (WJ III; Woodcock, McGrew, & Mather, 2001). Tables 1 and 2 provide sample demographics and descriptive statistics by grade level. Additional information regarding sampling is available in the *Technical Manual* (McGrew, Schrank, & Woodcock, 2007). From this dataset, subjects were selected on the basis of having completed both the writing samples and letter-word identification subtests of the WJ III Achievement test (WJ III ACH). Additionally, to examine a broad spectrum of cognitive abilities inherent in developmental writing ability, only those subjects with a complete profile consistent with the Extended Battery of cognitive tests (i.e., subtests 1–7, 11–14 of the WJ III COG) were included in the analyses.

Table 2
Descriptive Statistics by Grade Level

Variable	Grade 1 $N = 158$ M (SD)	Grade 2 $N = 165$ M (SD)	Grade 3 $N = 173$ M (SD)	Grade 4 $N = 194$ M (SD)
Writing samples	99.98 (14.19)	99.82 (15.56)	101.45 (12.92)	97.91 (13.14)
Letter-word identification	100.40 (14.04)	101.75 (15.09)	101.62 (13.80)	100.96 (15.18)
Verbal comprehension	99.92 (14.27)	99.39 (13.90)	99.48 (14.88)	98.63 (15.36)
Visual-auditory learning	103.11 (14.61)	103.04 (12.94)	99.77 (13.98)	99.44 (15.35)
Spatial relations	101.83 (13.17)	98.15 (13.21)	101.66 (14.96)	99.76 (15.00)
Sound blending	103.18 (14.52)	103.34 (16.39)	104.37 (13.89)	100.95 (14.79)
Concept formation	101.10 (15.71)	100.29 (16.10)	101.72 (16.40)	99.14 (15.83)
Visual matching	98.75 (12.92)	99.13 (15.61)	100.08 (14.65)	98.44 (14.35)
Numbers reversed	99.50 (13.86)	101.06 (15.30)	98.43 (14.86)	98.70 (17.63)
General information	101.26 (14.75)	101.98 (14.21)	100.71 (14.45)	99.01 (14.29)
Retrieval fluency	100.36 (14.47)	101.58 (14.18)	101.73 (15.43)	101.44 (14.56)
Picture recognition	100.61 (15.25)	101.12 (16.26)	102.71 (14.07)	100.34 (14.14)
Auditory attention	95.99 (14.02)	97.76 (14.57)	94.07 (14.71)	94.94 (14.21)
Analysis-synthesis	100.29 (14.80)	101.58 (15.72)	98.90 (17.60)	98.66 (15.23)
Decision speed	100.73 (13.68)	101.43 (16.03)	100.67 (14.62)	98.65 (15.01)
Memory for words	100.00 (13.93)	101.21 (16.29)	102.33 (14.43)	99.96 (14.91)

Measures

The WJ III was selected for this study because it includes a comprehensive battery of both cognitive and academic tests. As in previous studies (i.e., Decker et al., 2013, Decker & Roberts, 2015), the goal of the present study was to explore specific cognitive hypotheses; therefore, individual subtests were used in the analyses rather than broad factors or composites. The writing samples subtest, which requires participants to write meaningful sentences in response to a prompt, was used as the dependent variable. For elementary students, the prompts range from filling in a blank to

Table 3
Subtest Reliabilities for Grades 1–4

Subtest	Reliability Coefficient Range
Writing samples	r_{11} = .70–.89
Letter-word identification	r_{11} = .90–.99
Verbal comprehension	r_{11} = .88–.90
General information	r_{11} = .82–.88
Concept formation	r_{11} = .94–.96
Analysis synthesis	r_{11} = .88–.94
Visual-auditory learning	r_{11} = .84–.88
Retrieval fluency	r_{11} = .79–.81
Spatial relations	r_{11} = .75–.90
Picture recognition	r_{11} = .61–.78
Sound blending	r_{11} = .81–.90
Auditory attention	r_{11} = .86–.93
Visual matching	r_{11} = .87–.91
Decision speed	r_{11} = .86–.89
Numbers reversed	r_{11} = .84–.92
Memory for words	r_{11} = .72–.82

describing a picture. The task has been shown to have sufficient reliability across the developmental range of interest, with reliability coefficients ranging from r_{11} = .70–.89 for children in grades 1–4. The reliability coefficients, as well as the relevant CHC factors, and specific abilities for each of the subtests used in this study are included in Table 3.

Procedures

To explore the cognitive correlates of writing performance across an early developmental period, hierarchical linear regression analyses were used across each grade level (i.e., first, second, third, and fourth grade). In each analysis, the writing samples subtest was specified as the dependent variable. In the first block, letter-word identification was entered as a covariate, as we were interested in the cognitive predictors of writing performance that are independent of basic academic knowledge (i.e., word identification skills). Word reading and general word knowledge have been shown to be significant predictors of academic performance across disciplines (Ehri, 1998; Mani & Huettig, 2014; Townsend, Filippini, Collins, & Biancarosa, 2012). Thus, a task such as letter-word identification is an appropriate proxy for basic academic knowledge. In the second block, the 14 subtests of the WJ III COG Extended Battery were entered as the independent variables using a forward selection approach (Field, 2009; Stevens, 1996). For the sake of space, only significant predictors are included in the tables.

Results

Across the entire sample, writing samples was significantly correlated with every subtest. However, there were large differences in the range of correlations and the correlations changed by grade, ranging from .15 (spatial relations) to .59 (letter-word identification). As expected, letter-word identification had the highest correlation with writing samples for all four groups (r = .54–.66). Given

Table 4
Significant Predictors of Writing Samples by Grade Level

Variable	*B*	*SE B*
Grade 1		
Intercept	3.41	7.93
Letter-word identification	.45**	.07
Auditory attention	.20*	.06
Visual matching	.19*	.07
Retrieval fluency	.14*	.06
Grade 2		
Intercept	16.52*	7.49
Letter-word identification	.39**	.09
Verbal comprehension	.25*	.09
Visual matching	.19*	.07
Grade 3		
Intercept	33.95**	7.31
Letter-word identification	.40**	.07
Retrieval fluency	.14*	.06
Concept formation	.13*	.05
Grade 4		
Intercept	29.83**	6.36
Letter-word identification	.25**	.07
Numbers reversed	.16**	.05
General information	.15*	.07
Concept formation	.12*	.06

Note. $^{*}p \leq .05$, $^{**}p \leq .001$.

this measure was used as a covariate for the regression analyses, any cognitive measure identified in the regression analyses are likely to be strong contributors to writing.

As the goal of this study was to examine the development of writing skill, the analyses were run individually for each grade level, rather than as a whole. Results are listed in Table 4. For first grade, F (4, 153) = 42.68, $p \leq .001$, significant effects were found for letter-word identification, auditory attention, visual matching, and retrieval fluency. In second grade, F (3, 161) = 44.11, $p \leq .001$, letter-word identification and visual matching remained significant predictors of writing performance, with the addition of verbal comprehension. For the third grade sample, F (3, 169) = 30.20, $p \leq .001$, letter-word identification remained, and retrieval fluency was again a significant predictor, with the addition of concept formation. Finally, in fourth grade, F (4, 189) = 30.39, $p \leq .001$, retrieval fluency was no longer a significant predictor, though letter-word identification and concept formation remained, in addition to general information and numbers reversed.

These results demonstrate that there is no one or two specific cognitive processes that predict performance on the writing samples task, though some patterns are evident. For instance, letter-word identification was consistently a significant predictor of writing ability. Additionally, for the younger participants (i.e., grades 1 and 2), visual matching was an important predictor. This suggests that low-level perceptual skills and motor speed are important processes when students are first beginning to write. For older participants (i.e., grades 3 and 4), concept formation became an important predictor, suggesting that as students transition from the formation of letters to writing meaningful sentences, reasoning skills such as the determination of rules becomes more important. Retrieval fluency was a significant predictor for grades 1 and 3, but was not a significant predictor for grade 2. The emergence of language measures (i.e., verbal comprehension and general information) as significant predictors for grades 2 and 4 followed a similar pattern. This suggests that memory retrieval and general language skills are differentially important for the writing process. Finally, the emergence of numbers reversed in fourth grade suggests the increasing importance of working memory as students' writing demands increase.

Discussion

The purpose of the study was to examine the cognitive correlates of writing ability across an early developmental period. Previous research has demonstrated the importance of understanding the underlying cognitive abilities involved in academic tasks; however, there is little research on the specific cognitive abilities important to writing tasks. The current study included a hypothetical model, based on previous research and neuropsychological theory, specifying the cognitive processes involved in writing at different developmental levels. The model suggested a shift from low-level perceptual and attention skills in grades 1–2, to language skills in grade 3, and finally to the importance of working memory in grade 4. To test this model, the standardization sample of the WJ-III NU was used. The results of the study generally support previous research and the proposed model, with the addition of the emerging importance of fluid reasoning skills in later grades. Inductive reasoning skills may become a critical predictor of writing ability later on due to the complexities of English grammar and syntax.

One area in which the model was not fully supported was in the inconsistent prediction of long-term retrieval skills in grades 1–3. One hypothesis for this difference is that when students first learn to write, they are constantly retrieving letter formations from memory until this process becomes more automatized (i.e., from grade 1 to grade 2). It is possible that the resurgence of retrieval fluency as a significant predictor in third grade coincides with the teaching of cursive writing. Though now declining in schools across the country, the skill was still taught at the time the standardization data were collected. Cursive writing introduces a new system of letter formation. Thus, students may experience a return of dependence on retrieval until these new letterforms are similarly automatized. Additionally, once students have mastered the writing of individual letters, they shift focus to the creation of individual words, and then to sentences. This shift in focus is supported by the emergence of significant language measures in grades 2 and 4. In first grade, students are typically focused on writing individual words, or simple sentences, whereas in second grade they are expected to write longer, more complex sentences. The reemergence of significant language measures in fourth grade reinforces the importance of language skills as students are learning to construct short paragraphs and transitioning to essays and story development.

The current study may contribute to the literature by providing information on the cognitive abilities important for writing. The results of the study demonstrate that while there are specific cognitive variables crucial for writing across development, some cognitive abilities may vary based on the developmental level of writing skill required at different grade levels. Our model offers a framework for further investigations of writing development. Future studies may further this research by examining the specific changes in neurocognitive processes across development. In sum, a developmental neurocognitive model of writing, such as the model proposed in this study, may enhance understanding of the underlying component processes inherent in writing ability.

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