The Not-So-Simple View of Writing in Struggling Readers/Writers

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Abstract

Research suggests that executive function, motivation, transcription, and composition processes are implicated in the writing quality and productivity of children with and without learning difficulties. However, numerous components embedded within these constructs create both conceptual and empirical challenges to the study of written expression. These challenges are reflected in the writing research by way of poor delineation of constructs and insufficient distinction among domain general resources (e.g., working memory) versus processes related to the academic domain of writing (e.g., pre-planning), as well as among lower- (e.g., handwriting) and higher-order (e.g., editing) writing-specific processes. The current study utilizes the Not-so-Simple View of Writing (NSVW) as an organizing framework for examining the relations among multiple components, correlates, and attributes of writing in a sample of struggling readers/writers ($n = 402$) in grades 3–5. Data were collected on measures of (a) handwriting, spelling, planning, revision, and editing, derived from the Test of Oral Written Language (TOWL-4), (b) executive function derived from the NIH Examiner, and (c) motivation/self-efficacy derived from the Student Contextual Learning Scale. Structural equation modeling was utilized to test direct and indirect relations in the NSVW model. Results showed generally moderate correlations among observed/latent variables and found support for relations among writing-specific processes. Domain-general resources (executive function and motivation/self-efficacy) were related to spelling directly and indirectly to writing. Domain-specific processes (handwriting, spelling, planning, editing, and revision) were related to writing. The results have implications for explicit instruction of writing processes and for future research on empirical models.

Reading and writing difficulties and disabilities, occurring separately or comorbidly, are major public health problems, affecting educational, vocational, and social outcomes (Cortiella & Horowitz, 2014; Fletcher et al., 2019). Even among students selected only for reading difficulties, deficits in written language are likely (Costa et al., 2016). These students are slower at re-reading text, poorer at spotting spelling errors, and are less engaged with the text they write (O’Rourke et al., 2018). Students with word-level reading
difficulties struggle with handwriting and spelling and produce narratives that include few ideas and little elaboration compared to good comprehenders, although writing productivity and number of revisions are similar (Carretti et al., 2016). In a recent meta-analysis of 111 studies, Graham et al. (2020) showed that children with reading difficulties scored lower than same-age typically developing students on spelling ($g = -1.42$), syntax ($g = -1.07$), writing quality ($g = -0.95$), sentence writing ($-0.78$), organization ($g = -0.72$), productivity ($g = -0.66$), and handwriting ($g = -0.64$). Comorbidity estimates of 30-75% have been reported (Costa et al., 2016; Mayes & Calhoun, 2007), with an increase in co-occurring reading and writing disabilities from 30% in Grade 1 to 47% in Grade 4. The reciprocal development of reading and writing has been hypothesized given common cognitive processes and activation of overlapping brain regions (Ahmed et al., 2014; Fitzgerald & Shanahan, 2000).

Over the past 30 years, considerable scientific knowledge has accrued regarding understanding and preventing reading and writing difficulties (Grigorenko et al., 2020), but there is a notable lack of empirical writing models in contrast to the reading and language domains (Miller & McCardle, 2011). For example, the Simple View of Reading (SVR; Hoover & Gough, 1990) and the Direct and Inferential Mediation model (DIME; Cromley & Azevedo, 2007) guide understanding of how component skills can be leveraged to improve performance in reading, but relatively little systematic research has been devoted to specifying and testing models of writing. Simple View models (for reading and writing) posit a lower-level component such as decoding or transcription, as well as a language component such as linguistic comprehension or idea generation, and these models have proven robust across orthographies, grade/age levels, and measures, though most work is in the domain of reading (Ahmed & Wagner, 2020; Florit & Cain, 2011; Juel et al., 1986; Hoover & Gough, 1990). However, reading/writing skills in children with or at-risk for learning difficulties (LD) become less driven by verbal knowledge (i.e. vocabulary) over time (Blachman et al., 2014). Compared to word-level reading/writing, there is a lack of knowledge and specificity of higher-order skills that underlie literacy. Cognitive frameworks present a more “complex view” of writing because they include executive function (e.g. working memory and attention) and higher-order writing processes such as planning, editing, and revising. However, a number of studies have found that domain-general cognitive processes do not make unique contributions or predict response to intervention after controlling for writing-specific components (Berninger et al., 1995; Hooper et al., 2006; Kellogg, 2008; Kuhrt & Farris, 1990). The goal of the current study is to examine a components-skills model derived from a well-known theoretical framework of writing (the Not-so-Simple View of Writing [NSVW], Figure 1; Berninger & Winn, 2006) in a sample of upper elementary students with learning difficulties, a critical period of not only reading to learn but also writing to learn marked by writing being utilized to boost knowledge acquisition and for students to demonstrate understanding of varied topics (e.g. writing notes during class lectures or while reading content-area source documents, and writing answers to subject-area exams; Berninger et al., 2009). Component-skills models can identify key areas of weaknesses (and strengths) and have important practical implications for struggling reader/writers in upper elementary grades because they help shift the focus of interventions...
from broad skills with far transfer (such as executive functions and oral language) to more fine-grained skills with near transfer (such as editing and revision).

The not-so-simple view of writing

The Simple View of Writing (Berninger et al., 2002) supports the notion that, during writing, lower-level skills such as spelling and handwriting fluency interact with high-order, executive and self-regulatory function to produce writing through its planning, reviewing, and revision phases. Later iterations specifically invoked higher-level demands placed on writers beyond the early grades, and expanded the role of executive function, ultimately leading to the NSVW (Berninger & Winn, 2006; see also Hayes & Berninger, 2014). The NSVW (Figure 1) posits that long-term memory is activated when a writer is engaged in planning, composing, reviewing, and revising, while short-term memory is activated during reviewing and revising of output. Thus, the NSVW postulates a number of lower and higher-level cognitive processes involved in the development of written expression (these are each described in detail next), but how different elements of models such as the NSVW interact is not yet specified in detail (O’Rourke et al., 2018), particularly for children with or at-risk for LD in upper elementary grades, a critical stage when writing instruction in key malleable skills needs to be explicit.

Executive function

Executive function (EF) refers to domain general control processes important for managing goal-directed behaviors (Cirino et al., 2018). There is debate about the number and types of EF factors, but there is general agreement on the tasks used to measure EF, including inhibition, shifting, updating/working memory (Miyake et al., 2001), as well as planning, generative fluency, behavioral regulation, meta-cognition, and motivation (e.g. Cirino et al., 2018). MacArthur and Graham (2016) noted the bevy of support from researchers for the notion that EF resources must be distributed between lower-level transcription processes and higher-level planning and evaluation processes (e.g. Bourdin & Fayol, 1994; McCutchen et al., 1994). The cognitive burden of writing is greater for children with reading or writing disabilities, and greatest for students with disabilities in both domains (Costa et al., 2016) because students with LD have difficulties inhibiting prepotent responses, switching attention, and integrating multiple processes (Hebert et al., 2018).

Working memory serves to provide maintenance of multiple ideas, retrieval of structural and mechanical rules, and the control process for self-monitoring and self-evaluation (Kellogg, 1996; McCutchen, 1996; Swanson & Berninger, 1996). The role of working memory during written expression has been documented widely over the last two decades (e.g. Olive, 2004) with clear evidence of the importance of working memory in supporting higher-level strategic processes and in composition quality, beyond transcription processes (Kim & Schatschneider, 2017). Reviews by McCutchen (1996, 2000) highlight the role that working memory can play, when not constrained by transcription skills, in both writing fluency and quality. In general, research supports that working memory is more strongly related to higher-level processes such as editing and revision. Beyond working memory, Hooper et al. (2002) found that measures of inhibition and shifting differentiated between good
vs. poor writers in late elementary on a narrative writing task. Additionally, Altemeier et al. (2008) demonstrated that EF (measured as inhibition, rapid automatic switching and combined inhibition/switching) explained variance in written expression performance in typically developing readers across grades 1 through 6, but not for children with dyslexia.

In the NSVW framework, Berninger and Winn (2006) describe EF as supervisory attention, goal setting, self-monitoring and self-regulation strategies, along with planning, reviewing, and revisions. Thus, the NSVW model seems to conflate domain-general EF with domain-specific writing strategies that also invoke higher-order linguistic skills (i.e. planning, reviewing, and revising) unlike recent component-based writing models that conceptualize EF as exogenous to writing (Drijbooms et al., 2015; Kim & Park, 2019).

As mentioned above, some frameworks of EF include self-regulatory processes of learning and motivation (Cirino et al., 2018), whereas others view motivation and self-regulation as separate from EF. One distinction between these frameworks is how measurement occurs, with ‘EF’ measured via neuropsychological performance measures, self-regulatory strategic writing skills such as editing assessed via academic performance measures or experimental writing tasks, and motivation and self-efficacy assessed via self, teacher, or parent report (Hofmann et al., 2012). In the present study, we distinguish between EF measured via neuropsychological assessments, writing measures, and self-report although we show elsewhere that “self” constructs such as self-monitoring and self-efficacy and motivation can contribute to both specific and general aspects of EF (Cirino et al., 2018). Self-regulated learning, motivation, and positive disposition toward writing have all been linked to writing achievement (Graham et al., 2007; Limpo & Alves, 2013a; Pajares, 2003), and have received strong support from experimental research on the evidence-based SRSD (Self-Regulated Strategies Development) intervention of writing (Graham & Perin, 2007), although children with LD are known to overestimate their self-efficacy (Klassen, 2002). Self-efficacy and motivation have also been linked to both lower-level writing skills (transcription) and composition processes (planning and revision; Limpo & Alves, 2014).

Transcription

Individuals produce text by translating sounds to written symbols via handwriting (and/or keyboarding) and spelling, which are discrete mechanical skills that operate together in order to produce written language (Connelly et al., 2012; Sumner et al., 2014). Research has shown that spelling exerts an influence on the handwriting of children with and without LD (Dockrell et al., 2019; Gosse & Reybroeck, 2020; Sumner et al., 2014). Transcription skills are also related to EF and to writing-specific processes. First, EF such as working memory, inhibition and updating predict both handwriting fluency and spelling because difficulties with any of these processes may constrain transcription (Drijbooms et al., 2015).

More specifically, in early writing, the act of spelling and handwriting alone requires EF, leaving little for higher-level composing. The NSVW holds that as transcription becomes more fluent, EF are freed to support higher-level components1. Second, difficulty with transcription can constrain a writer’s access to self-regulatory writing skills (Bourdin &

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1This is reflected in the empirical NSVW model (Figure 2) as both direct and indirect effects of EF on writing composition processes and outcomes mediated via transcription skills.
Fayol, 2000; Graham & Weintraub, 1996; Juel et al., 1986). Particularly, mechanical difficulties with transcription may constrain text-production by interfering with skills like planning and content generation. Third, fluency with handwriting is significantly related to writing in the earliest grades and beyond (Graham et al., 1997). Problems with handwriting are characteristic of children, adolescents and adults with LD and have been shown to negatively impact productivity, ideation, and overall quality (e.g. Berninger et al., 2008; Hatcher et al., 2002). Spelling has likewise been shown to be problematic for young children and individuals with LD and dyslexia (Juel, 1988; Tops et al., 2013). Recent meta-analyses noted a moderate correlation between spelling skills and both writing quality and production (Ahmed & Wagner, 2020; Kent & Wanzek, 2016). The instructional research provides further support for the influence of transcription skills on written expression, with findings noting that explicit instruction in handwriting and/or spelling can significantly enhance quality of writing (Graham et al., 2012).

**Linguistic composition processes**

Both work addressing individual differences in writing and intervention research have examined the role of strategies such as planning, translating, and reviewing on writing outcomes. Early research (i.e. Whitaker et al., 1994; Berninger et al., 1996) supported the notion that processes such as translating and revising develop independently, but recent work has demonstrated the relationship between these components and support for a linear process to writing (Koutsoftas & Gray, 2013). In addition, planning time and complexity of planning predicts quality of older student’s written products (Beauvais et al., 2011; Limpo et al., 2014).

Self-regulatory processes that are specific to composition processes such as editing and revision have also received strong support from research on SRSD (Graham & Perin, 2007). Revision and editing require higher-order cognitive processing: editing requires detecting and diagnosing problems (Alamargot & Chanquoy, 2001) and revision is a problem-solving process focused on evaluating discrepancies between the author’s intention and the actual text (Berninger, 2012). While it is difficult to measure online processes of editing and revision using paper and pencil measures, most tests require students to edit or revise texts or short sentences embedded with errors. Editing requires knowledge of mechanics such as capitalization and punctuation, while revision taps content, organization, tone, syntax, and word choice. In the present study, we derived editing and revision from similar items (see methods section), although these measures do not tap the self-regulatory processes of editing and revision derived from comparing multiple drafts (e.g. Koutsoftas & Gray, 2013). Of note, evidence for the relationship with lower level writing skills also exists. For example, Limpo et al. (2017) showed that better transcription skills were associated with increased planning and translating skill. Finally, Graham and colleagues (Graham et al., 2012; Santangelo et al., 2016) highlight that instruction/intervention that includes goal-setting, cognitive strategy instruction (i.e. for planning, drafting, etc.), and/or self-regulation has a strong, positive impact on writing quality (e.g. effect sizes ~0.50).
Present study

This study integrates findings from previous research on components of the NSVW into a single components-based empirical model. In doing so, we extend the approaches used in the reading literature that have used structural equation modeling and cross-sectional mediation to test cognitive frameworks such as the SVR (e.g. Tunmer & Chapman, 2012). In the writing literature, cross-sectional mediation analyses have included some, but not all, aspects of the NSVW model (namely, EF, motivation/self-efficacy, transcription and linguistic composition processes; e.g. Childress, 2011; Dockrell et al., 2019; Drijbooms et al., 2015; Kim & Schatschneider, 2017; Kim & Park, 2019; Limpo & Alves, 2013a; Poch, 2016; Salas & Silvente, 2019; Troia et al., 2020). Notably, Poch (2016) included all key constructs, but like the NSVW, their model confounded domain-general EF (meta-cognition) with a writing-specific composition process (planning), resulting in non-convergence (the standardized loadings of EF and writing-specific planning measures on a common factor were 0.09 and 0.96, respectively, indicating that self-regulation and planning did not adequately represent a unitary factor).

A new empirical model of writing known as the Direct and Indirect Effects Model of Writing (DIEW; Kim & Schatschneider, 2017) specifies relations among language and cognitive skills and shows support for a complete mediation model in which foundational oral language, working memory and higher-order cognitive skills make indirect (but not direct) contributions to writing through discourse-level oral language, spelling and handwriting fluency. The DIEW also incorporates variables that are commonly linked to reading (e.g. inferencing, comprehension monitoring, background knowledge). We do not evaluate the DIEW in the present study because oral language skills were not exhaustively measured, and because componential models of writing focused on oral language may be more influential for samples such as English Language Learners (e.g. Schoonen et al., 2002), than for the struggling readers/writers of the present study. Likewise, we do not evaluate Kellogg’s (1999) model of the role of working memory in writing because we did not measures specific components of working memory (viz., spatial, central executive, and verbal) or some basic writing processes (e.g. programming and executing). We did not evaluate the Hayes and Flower (1980) or Hayes and Berninger (2014) frameworks of writing because we did not measure the task environment or long-term memory, but we note that the NSVW builds on and/or overlaps with aspects of all of these models.

Previous NSVW studies vary in the number and types of components included, and little is known about the writing of children with LD within this framework. Figure 2 depicts the schematic of the NSVW as an empirical model and contains two main panels which distinguish between domain-general resources (executive function, and motivation/self-efficacy) and domain-specific processes (i.e. specific to the academic domain of writing). Three additional panels depict latent (ovals) or observed (rectangles) variables for writing processes: (a) transcription (handwriting and spelling), (b) composition processes (planning, editing and revision), and (c) writing outcomes or products (hereafter “writing” or “written expression”; measured in the present study as writing quality and quantity). Relations within and across panels were evaluated based on prior literature reviewed above. For example, writing was regressed on all other constructs; constructs in panel IIc were
regressed on constructs in panels IIb and IIa. The full model in Figure 2 shows lower- and higher order domain-specific processes mediating the relations among EF and motivation, and writing. We did not examine domain-general language (i.e. receptive and expressive vocabulary and language) because the NSVW does not include these as explicit constructs, and because oral language is often not a significant predictor of writing when other domain-specific variables are controlled for (e.g. Puranik & Al Otaiba, 2012). Three main research questions guided our analyses.

RQ1 – domain-general resources

What are the relations of domain general resources with writing-specific composition processes, and with writing?—In the domain-general resources panel of Figure 2, EF and motivation were modeled as correlated exogenous factors because these constructs are domain-general correlates rather than components of writing. As an example, Drijbooms et al. (2015) and Kim and Schatschneider (2017) modeled the direct effect of working memory, inhibition and/or updating on writing, as well as mediated relations through handwriting and spelling rather than modeling the effect of handwriting or spelling mediated by working memory as depicted in the NSVW schematic in Berninger and Winn (2006; see Figure 1). Thus, we did not expect domain-specific resources to precede domain-general processes in a mediation model. We expected writing processes to make larger contributions to writing than domain-general resources.

RQ2 – transcription

What are the relations of transcription processes with composition processes and with writing?—In panel IIa of Figure 2, handwriting and spelling were modeled as separate constructs because prior research has found that spelling is a predictor of handwriting quality (e.g. Abbott et al., 2010; Dockrell et al., 2019; Gosse & Reybroeck, 2020; Sumner et al., 2014), even though these constructs can represent a single higher-order transcription factor, both theoretically (Berninger & Winn, 2006) and empirically (Limpo & Alves, 2013). In the present study, we do not test the (bi)directionality of effects among spelling and handwriting (e.g. alternative models with a path from handwriting to spelling) because such tests would result in equivalent models and studies designed to test directionality of effects require longitudinal data (e.g. see Wagner et al., 2015). We expected that both handwriting and spelling would be related to writing, whereas only handwriting would be related to planning, and spelling would be related to both editing and reviewing.

RQ 3 – linguistic composition processes

What are the relations among composition processes and writing?—In panel IIb of Figure 2, editing and revision were regressed on planning, and planning had an indirect effect on revision through editing. Furthermore, planning, editing and revising have direct effects on writing because we hypothesized the three composition processes will be significantly related to writing in our sample of upper elementary students with LD.
Methods

Participants

This study was approved by the institutional review boards of the University of Houston and the University of Texas at Austin. The sample consisted of \( n = 402 \) students with or at risk for LD in grades 3-5 who were identified using the 25th percentile cutoff on the Test of Reading Efficiency and Comprehension (TOSREC; Wagner et al., 2010) as part of a larger RCT\(^2\) (Roberts et al., 2018; see also Ahmed et al., 2021). The students also struggled with writing compared to national norms for typically developing students. The mean aggregated score from writing samples using the 6 Trait rubrics (e.g. Organization, Ideas, Sentence Structure; Northwest Regional Educational Laboratory, 2011) was 15.37 out of a total possible score of 36 (i.e. 6 rubrics scored 1–6 rating); that is, an approximate score of 2.5 per trait scored. This performance reflects a lack of proficiency, placing students somewhere between “emerging” and “developing”. Furthermore, given the amount of time allotted to plan and compose, writing production was also an area of weakness (Overall \( M = 96.75 \) words). Scores in spelling and domain-specific writing processes were similarly depressed.

The sample was balanced in terms of gender (54% female) and was ethnically representative of the school districts from which data were collected (57% Caucasian, 43% African American, 41% Hispanic, 3% American Indian or Alaska Native, 2% Asian, and/or <1% Native Hawaiian and other Pacific Islander), with some students identifying with more than one race. Most students came from low socio-economic status (69% received free or reduced lunch), and a small portion were either ELLs (20%) and/or were in special education (20%).

Instruction

Following the Texas Essential Knowledge and Skills (TEKS) state standards, students were required to take the State of Texas Assessments of Academic Readiness (STAAR) Reading in grades 3-5, and STAAR Writing in grade 4. Accordingly, writing instruction in the Houston and Hutto independent school districts, where this study was conducted, used commercially available writing curricula in grades 3-5 such as the ‘Literacy by 3’ which focus on transcription and text generation (Houston Independent School District, 2021). In the school years 2015-2016 when the data were collected, students were expected to know about writing processes (e.g. planning, drafting, revising, editing and publishing) to compose texts on the STAAR Writing test (Texas Education Agency, 2019). Specifically, students were expected to: (a) plan a first draft by selecting a genre appropriate for conveying the intended meaning to an audience and generating ideas through a range of strategies (e.g. brainstorming, graphic organizers, logs, journals); (b) develop drafts by categorizing ideas and organizing them into paragraphs; (c) revise drafts for coherence, organization, use of simple and compound sentences, and audience; (d) edit drafts for grammar, mechanics, and spelling using a teacher-developed rubric; and (e) publish written work for a specific audience. For this study, a lead teacher at each participating school also completed a survey

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\(^2\)The present study reports on data collected at baseline because measures of writing, EF, and motivation were not collected as part of the post-test battery.
on the frequency and duration of school-based reading interventions each student received, indicating that the core reading curriculum targeted phonics, fluency, vocabulary and reading comprehension (see Roberts et al., 2018), and some reading curricula also included spelling and writing instruction. Specific components, duration, and intensity of writing instruction were not recorded because the parent RCT focused on reading and not writing.

**Measures**

Assessments took place in schools as part of an after-school program and were conducted by trained administrators. We derived measures of handwriting, spelling, and planning, from secondary coding of the Test of Written Language writing samples (TOWL-4; Hammill & Larsen, 2009) and measures of editing and revision from TOWL items as described below. The writing samples were first typed “as is” (i.e. retaining spelling, punctuation and grammatical errors; Koutsoftas & Gray, 2013; Puranik et al., 2012), and then the typed samples were separately scored by two graduate students with extensive experience in coding written samples. This approach prevented ratings of writing quality to be influenced by handwriting quality (Graham et al., 2011). The spelling subtest of the Woodcock Johnson III (WJ-III; Woodcock et al., 2001) was used as an additional measure of spelling. Motivation/self-efficacy measures were derived from the Contextual Learning Scale (Cirino et al., 2018), and all EF measures were assessed with the NIH EXAMINER (Kramer et al., 2014).

**Writing quality – standardized test**

The Test of Written Language – 4th Edition (TOWL; Hammill & Larsen, 2009) is norm-referenced standardized test designed as a diagnostic measure of writing for students ages 9–17. The Story Composition subtest requires 5 minutes to plan a story and then 15 minutes to write in response to a stimulus picture. The writing sample is then scored on items such as vocabulary, writing style and whether the writing sample includes a story sequence, plot, and story action, in addition to whether the characters show emotion. The technical adequacy of the TOWL-4 ranges from 0.74 to 0.92 for internal consistency. In addition, interrater reliability specifically for the Story Composition subtest was .80 and higher (Castro-Villarreal & Ponce, 2017), and in the present study internal-consistency of the Story Composition subtest ranged from .86 to .90. The samples were also scored for the dimensions of the 6+1 Trait Rubric (Northwest Regional Educational Laboratory, 2011), and the total number of words written (TWW) were recorded. The 6+1 Trait Rubric was designed for use across genres of writing and across grades. Scoring of the rubric requires consideration of seven different elements associated with writing including ideas, organization, voice, word choice, sentence fluency, and conventions.

The definitions of the domains on the 6+1 trait rubric are largely self-explanatory: (1) Ideas domain is related to whether the writing sample is focused on a specific topic that is clearly communicated with accurate details; (2) the Organization domain requires rating whether the passage has a logical structure that makes the ideas easy to follow; (3) the Voice domain is a rating of whether the author writes in an engaging manner that communicates with the reader; (4) Word Choice is the vocabulary selected by the student and how that vocabulary creates a clear vision for the reader while (5) the Sentence Fluency domain
quantifies how the author uses sentences and phrases to communicate; (6) the Conventions domain is focused on attributes of a sample such as punctuation, spelling, and capitalization and is the only trait on the rubric where grade should be considered when judging student performance. The last trait on the rubric is (7) Presentation and requires a judgment about the aesthetics of the passage such as format, handwriting, and general neatness. Each domain is scored on a six-point scale ranging from 1 (Beginning) to 6 (Exceptional). Broadly, scores of 1, 2, and 3 are considered not proficient while 4, 5, and 6 are judged to be proficient. Composite scores of the 6-traits can be derived, ranging from 6 to 36. The 6+1 Trait rubric (http://educationnorthwest.org) is widely accepted and promoted by organizations such as the National Education Association (http://www.nea.org/tools/lessons/59760.htm) as a valuable approach to assessing student writing quality. In the present study, reliability among raters was established using 15% of the samples, ranging from $\kappa = 0.80$ on ideas to $\kappa = 0.91$ on word choice (Pearson correlations ranged from $r = 0.90$ to $r = 0.97$).

**Handwriting**

Student handwriting was scored using the Story Composition subtest of the TOWL. Specifically, the presentation domain of the 6+1 Trait Rubric was used to score the degree to which the handwriting was legible and neatly presented. The presentation domain includes rubrics for font style/size, white space, text features, visuals and graphics and handwriting. Only the handwriting rubric was used in the current study. The dimensions for consideration when scoring handwriting include whether letters are written consistently and correctly formed such that the passage is legible as well as whether there is appropriate spacing between letters and words. Handwriting is considered exceptional when it is pleasing to the eye (i.e. facilitates readability) and uses uniform spacing and lettering. On the other hand, beginning handwriting is characterized by inconsistent and incorrect letter formations and spacing between letters and words. Inter-rater reliability was high ($\kappa = 0.91$).

**Spelling**

The Woodcock Johnson III (WJ-III; Woodcock et al., 2001) is generally regarded as a technically adequate individual test of achievement. The WJ-III is individually administered, and the Spelling subtest involves having students spell phonetically regular (i.e. words that are spelled how they sound) and irregular words (i.e. words that are not spelled how they sound) of increasing difficulty. Estimates of internal consistency reliability are adequate (0.93) for Grades 3 to 5. The writing samples generated in response to the TOWL picture prompt were also scored for the percentage of words spelled correctly (%WSC; the number of words spelled correctly, divided by the total number of words written, and then multiplied by 100). Discrepancies in tallying the words spelled correctly were resolved by an additional rater. There was near perfect inter-rater reliability for %WSC (.98), consistent with prior research (e.g., Gansle et al., 2002).

**Planning**

During the 5 min of planning time allowed as part of the standardized TOWL administration, students were given paper to use and the evidence produced was reviewed using an advanced planning rubric adapted from Olinghouse and Graham (2009). The rubric allowed for scores ranging from 1 to 5. Low scores reflect little or no planning, and consist
of writing only words or phrases that are verbatim (2), or are not related to the story (1).
Planning involving listing of questions or actions elaborated upon in the story received a
score of 3, with scores of 4 and 5 indicating that the student clearly planned prior to writing.
The evidence of planning in the high scores includes the organization of the writing through
use of support such as story maps or other visual organizing strategies. Inter-rater reliability
was $\kappa = 0.75$.

**Editing and revision**

The Contextual Conventions subscale of the TOWL contains 21 items which evaluate the
student’s written essay for orthographic (e.g. punctuation and spelling) and grammatic
conventions (e.g. sentence-construction, noun-verb agreement). In the present study, items
were coded as either focusing on Editing or Revision. Editing items required knowledge
of writing mechanics (such as use of capitalizations and punctuation), and Revision items
tapped sentence structure and complexity, content, and organization. Estimates of internal
consistency were 0.62 for Editing and 0.72 for Revision in the current sample.

**Executive function**

Working memory, fluency and cognitive control were assessed via the Executive Abilities:
Measures and Instruments for Neurobehavioral Evaluation and Research (NIH EXAMINER;
Kramer et al., 2014). The NIH EXAMINER is a battery of tasks often used to examine
executive function and cognitive processing skills in children (e.g. Schreiber et al., 2013).
Working memory was measured using the dot-counting subtest of the NIH EXAMINER, a
measure of verbal working memory which requires the examinee to view multiple screens
(ranging from 2 to 7 screens) with blue dots as well as distractor shapes, and recall the
number of blue dots presented in each screen. The examinee is instructed to count all of the
blue circles on the screen one at a time and remember the total. The examiner then moves to
another screen with the same shapes and directs the examinee to again count the blue dots.
At the end of a trial, the examinee must recall the number of blue circles in each display
presented in order.

Fluency skills were measured using the phonemic fluency subtest, which requires
participants to say as many words as possible that begin with a particular letter of the
alphabet, and the category fluency subtest, which requires examinees to name as many items
within a specified category (e.g. animals and vegetables) as possible within 1 min. Finally,
the domain of Cognitive Control was assessed using the (a) set shifting and (b) anti-saccades
subtests. Set-shifting taps into metal flexibility by comparing performance on tasks when
attention must shift and when attention must not shift. The set-shifting subtest requires
examinees to view an image at the top of a computer screen and match it to one of two other
options presented, in a task-homogeneous block and a task-heterogeneous block. Each block
involves two tasks. Task A requires the examinee to classify shapes and Task B involves
classifying colors. When completing the task-homogeneous block, only Task A or Task B
are presented while for the task-heterogeneous block, the two tasks alternate in presentation.

The anti-saccades subtest measures typical and atypical eye movements when the eyes must
move toward the stimulus and away from the stimulus. Completion of the anti-saccades task
requires participants to look at a point in the center of a computer screen and move their eyes to follow the stimulus. There are two types of trials. During the pro-trials, participants are instructed to move their eyes in the direction of the presented stimulus while during the anti-trials, participants are instructed to move their eyes in the opposite direction of the stimulus.

Internal consistency is high for the dot-counting task (0.69), phonemic fluency (0.88), category fluency (0.78), anti-saccades (0.92), and set-shifting (0.86–0.97) for individuals under 18 years of age.

Motivation/Self-efficacy

Beliefs and behaviors consistent with student learning skills were examined using several subscales of the Student Contextual Learning Scale (SCL; Cirino, 2012), a self-report measure. The SCL scale contains original items as well as items adapted from other motivation and learning strategies scales (e.g., Pintrich & DeGroot, 1990; Stroud & Reynolds, 2006; Wigfield & Guthrie, 1997; Cleary, 2006; Midgley et al., 1996). The subscales of interest included Effort, Self-Efficacy, and Strategies. Students responded to a range of items by indicating whether a statement is “Not at all like me (0), Just a little like me (1), Pretty much (2), or Definitely (3)”. Items in the Effort domain include “Even though I don’t like homework, I can make myself get it done, and do it well.” and “I take my time to do my best on school-related tasks.” The Self-Efficacy scale includes items such as “I am confident that I can succeed in learning tasks or activities.” and “Even if school work is hard, I know I can learn it.” The Strategies subscale includes items such as “I ask myself questions to make sure I know the material I’ve been studying” and “I tell myself exactly what I want to accomplish during studying.” The SCL has been used in other studies examining self-efficacy and motivation in elementary aged children (Cirino et al., 2018) and demonstrated adequate reliability (α = 0.84) in the current sample.

Analytic approach

All models were fit using M-Plus 8.1 (Muthén & Muthén, 1998–2017). The full structural equation model depicted in Figure 2 was fit with 95% bootstrapped confidence intervals estimated for all parameters from 1,000 replications for testing mediation effects (for space considerations, reduced models with omitted paths are not presented). Additionally, all demographic variables (grade, gender, race, English Proficiency status, SES, and special education status) were regressed on writing in the full model. Data were missing completely at random (MCAR), and missingness was handled using full information maximum likelihood (FIML) in M-Plus. Multi-group models by grade level are reported in the Supplemental Table, but are not reported in detail because (a) we did not have strong hypotheses regarding the nature of covariance structure in grades 3, 4, and 5, and (b) sample sizes were not practicably large enough to power robust multi-group analyses (e.g. the grade 3 sample had only 1.71 cases per parameter estimated in an unconstrained model).

The model (Figure 2) consisted of 26 direct effects (single-headed arrows in the structural model), and 19 total indirect effects. In a linear model, the indirect effect is the product of the direct effects of: (a) a variable X (e.g. spelling) on the mediator M (e.g. handwriting) and
(b) the mediator (M) on a variable Y (e.g. writing). When multiple mediators are involved, the total indirect effect is the product of all direct paths involving the mediator (M; i.e. single-headed structural arrows coming into or out of M). Thus, in the full model some total effects involved a single specific indirect effect whereas other total effects involved multiple specific indirect effects. For example, the total effect of spelling to writing consisted of several specific indirect effects, including: (1) spelling → handwriting → editing → writing; (2) spelling → handwriting → editing → revision → writing; and (3) spelling → handwriting → planning → editing → revision → writing.

Results

Table 1 contains descriptive statistics by grade and for the whole sample. For all measures, values of skewness and kurtosis fell within acceptable ranges (<3 for skew index and <10 for kurtosis index; Kline, 2015). Correlations among observed measures are presented in the Appendix Table A1. As expected, the strongest correlations were among the two measures of spelling ($r = 0.72$) and among the three measures of motivation/self-efficacy ($r = 0.66-0.72$) because of the shared variance among measures of the same latent constructs (Fornell & Larcker, 1981). Moderate significant correlations were also found among measures derived from the TOWL ($r = 0.24-0.51$) because of the common measurement variance. Smaller significant correlations were found among the NIH EXAMINER measures of working memory (with handwriting [$r = 0.28$] and total words written [$r = 0.28$]), and cognitive control (with % words spelled correctly [$r = 0.19$]). The standardized measure of spelling from the Woodcock-Johnson III was significantly correlated with several TOWL measures ($r = 0.21-0.55$). The model (Figure 3) provided a good fit to the data ($\chi^2 (53) = 86.60, p < 0.00$, RMSEA [90% CI] = 0.04 [0.02, 0.05], SRMR = 0.03, CFI = 0.98, TLI = 0.97), and explained 82% of the variance in writing, and 51%, 40%, and 32% in editing, spelling, and, revision, respectively. The model also explained a small amount of variance in handwriting (15%), and planning (11%).

Domain-general resources

As Figure 3 shows, EF had a direct effect on spelling ($\beta = 0.57, \text{S.E.} = 0.09, p < 0.001$), but not handwriting. Motivation was also not related to handwriting quality but had a small direct effect on spelling ($\beta = 0.20, \text{S.E.} = 0.07, p < 0.05$). EF and motivation were not significantly correlated in the model. Note that although the loadings of the NIH EXAMINER variables on EF were small (ranging from $\lambda = 0.37$ to $\lambda = 0.52$), the magnitude of the loadings are consistent with prior studies using measures of EF to estimate latent variables (e.g. Cirino et al., 2018). Both EF and motivation had indirect effects on editing via spelling (see Table 2 for indirect effects). Both exogenous factors also had significant total indirect effects on revision (EF: $\beta = 0.27, \text{S.E.} = 0.07, p < 0.001$; motivation: $\beta = 0.11, \text{S.E.} = 0.04, p < 0.05$), although no specific indirect effects were significant. Finally, EF did not have a significant direct or indirect effect on writing, but the total effect of EF on writing was significant ($\beta = 0.71, \text{S.E.} = 0.09, p < 0.001$).
Transcription

Spelling significantly predicted handwriting ($\beta = 0.27$, S.E. = 0.11, $p < 0.05$). While spelling had a direct effect on editing ($\beta = 0.57$, S.E. = 0.09, $p < 0.001$), and revision ($\beta = 0.20$, S.E. = 0.10, $p < 0.05$), it was not directly related to writing. Thus, spelling only had an indirect effect on writing ($\beta = 0.30$, S.E. = 0.10, $p < 0.05$), particularly via editing and revision (see Table 2). Handwriting predicted planning ($\beta = 0.20$, S.E. = 0.06, $p < 0.05$), editing ($\beta = 0.17$, S.E. = 0.03, $p < 0.05$) and writing ($\beta = 0.30$, S.E. = 0.07, $p < 0.001$), but not revision ($\beta = 0.05$, S.E. = 0.05, $p > 0.05$). Finally, both handwriting ($\beta = 0.08$, S.E. = 0.02, $p < 0.05$) and spelling ($\beta = 0.21$, S.E. = 0.06, $p < 0.05$) had indirect effects on revision, particularly via editing.

Composition

Planning was related to revision ($\beta = 0.13$, S.E. = 0.05, $p < 0.05$), but not editing ($\beta = 0.09$, S.E. = 0.05, $p > 0.05$), and had a direct effect on writing ($\beta = 0.18$, S.E. = 0.07, $p < 0.05$). Editing was not directly related to writing ($\beta = 0.10$, S.E. = 0.09, $p > 0.05$), but predicted revision ($\beta = 0.29$, S.E. = 0.07, $p < 0.001$), which in turn was directly related to writing ($\beta = 0.30$, S.E. = 0.07, $p < 0.001$). Thus, revision also mediated the effect of editing on writing ($\beta = 0.09$, S.E. = 0.03, $p < 0.05$).

Factor correlations from the full model are provided in the Appendix Table A2. Writing was highly correlated with EF, revision, spelling, handwriting, and editing. Writing had a moderate correlation with planning and a small correlation with motivation. Other moderate correlations included spelling with editing and EF, as well as revision with editing. Finally, in the model with demographic characteristics, gender, ELL status, race, and SES were not significantly related to writing. This model showed significant effects of grade ($\beta = 0.16$, S.E. = 0.07, $p < 0.05$) and special education status ($\beta = 0.12$, S.E. = 0.06, $p < 0.05$), such that students in higher grades and who were not in special education produced longer and better texts. We note that the results of the demographic covariates are provided for descriptive purposes. We are not suggesting that the abilities and needs of students in special education are clearly understood or that the label represents the students’ true ability or potential for growth. The overall pattern of results was not substantively different between the two models.

Discussion

The influential work of Berninger and colleagues on the NSVW paved the way for the discussion of the higher-order processes and EF involved in written expression, a notable movement away from focusing only on products and transcription skills. Much like the SVR/SVW frameworks, however, the NSVW is more a conceptual model than an empirical model (Francis et al., 2018), does not specify important direct and mediated relations among components, and conflates EF with self-efficacy and composition processes. Given the complexity of the writing process and product it is important that empirical models distinguish between: (1) domain-specific components such as handwriting, spelling, revision and editing; (2) domain-general correlates such as working memory, attention, motivation and learning; and (3) attributes of the writing product (e.g., quality and productivity). The
present study investigated various structural relations among correlates, components, and attributes from the writing literature using the NSVW as an organizational framework, with the ultimate goal of developing a deeper, more nuanced conceptualization of the NSVW for upper elementary students with LD. Strong evidence suggests that explicit teaching of writing strategies to students with LD has moderate to strong positive effects (e.g. Graham et al., 2012). Thus, a better understanding of development and connections among writing components for this group has the potential to inform pedagogical practices and improve achievement. In general, our results support previous research demonstrating that the compositions of students with LD are shorter in length, lack organization and detail, and are marked by grammatical, spelling, and mechanical errors (Hooper et al., 2002), and is not driven by EF or motivation (Troia, Graham, & Harris, 2017). Specific findings regarding the NSVW are discussed next.

**Domain-general resources**

**Executive function**—Our hypothesis of a direct effect from EF (and motivation) to lower-level skills such as spelling was largely confirmed, supporting previous research (e.g. Bourdin & Fayol, 1994; Salas & Silvente, 2019). However, we did not find a direct effect on handwriting, likely because we used a measure of accuracy rather than speed or fluency. Much of the work on the relationship between EF and transcription have examined the role of working memory, whereas we defined EF as representing a constellation of processes (e.g. Cirino et al., 2018). Although the model resulted in indirect effects of EF on both editing and revision via spelling, there were no direct effects on these writing processes or on the outcome itself in our LD sample. This conflicts with previous findings of the direct and indirect impact of EF, including working memory, on writing quality in typically developing elementary age children although these studies did not control for proximal measures of writing such as revision (Altemeier, 2006; Hooper et al., 2002; Kim & Schatschneider, 2017; Salas & Silvente, 2019). In the current study, planning, editing, and revision were derived from the same measure as the writing outcome, potentially lessening the amount of variance left over for EF to account for. However, the estimated correlation among the EF and writing latent factors was high (0.71) and the magnitude of the EF-to-writing path was larger than any other direct effect on writing, although this path was not significant. These results provide support for the idea that EF can be conceptualized as a correlate of writing, rather than an essential component. As highlighted in a review by Titz and Karbach (2014), there has been mixed support for the direct training of EF on academic achievement for students with academic and cognitive deficits, with the most pronounced benefit in language and reading. Garcia-Madruga et al. (2016) noted that training of EF are likely insufficient, arguing the need for inclusion of specific competencies (e.g. in writing, process such as planning, editing, revising). Rather than benefitting from EF training per se, children could benefit from strategies to reduce working memory and attention load by bolstering and automatizing spelling, handwriting, editing, revision and planning (O’Rourke et al., 2018). However, given the dearth of research explicitly addressing training of EF specific to writing, this remains an area ripe for further exploration.

**Motivation/Self-efficacy**—Prior research has confirmed the relationship between motivation/self-efficacy and writing outcomes (Page-Voth & Graham, 1999; Pajares, 2003).
Beyond its effect on transcription, motivation was not related to composition skills, likely because we used self-report measures of general efficacy, effort, and strategy use. Although there is support for the role of self-constructs on student achievement (e.g. Zimmerman & Martinez-Pons, 1990), the findings may represent the fact that in this study, self-constructs were not specific to writing. Thus, future work on the NSVW is needed to test this conjecture in the context of motivation for writing, and in the context of targeted writing interventions (see below).

**Transcription**

The strong direct effects of transcription skills on planning and editing further support the notion that fluency in spelling and handwriting can “free” cognitive resources to allow an individual to engage in higher-order writing processes. Conversely, lack of automaticity with handwriting and spelling serve to constrain students’ use of higher-level processes. In this study, editing reflected knowledge of general mechanics of writing, including capitalization and punctuation usage. Thus, difficulty at the orthographic-motor and orthographic-linguistic level may lead to less attention and focus on these mechanics during the process of composing. The relationship between transcription and quality/quantity of student’s writing has been shown for typically and atypically developing students, as well as for older students (Graham et al., 1997; Ahmed & Wagner, 2020). Our findings confirmed this for handwriting, but not spelling; handwriting had both direct and indirect effects on the writing outcome, which supports recent work from Limpo and Alves (2013). In relation to this finding, it is important to note that we eliminated potential scoring bias associated with poor handwriting presentation by typing compositions prior to scoring for writing quality. This sample demonstrated poor handwriting, consistent with orthographic-motor difficulties, which likely interfered with the quality of their written work (Bourdin & Fayol, 1994; Olive & Kellogg, 2002). It is also possible that inability to spell words correctly from dictation and in composition detracted attentional and other EF resources from handwriting. Although such a bottleneck would constrain handwriting fluency more so than handwriting quality, it appears that transcription processes may compete with each other for EF resources even when these processes do not reflect automatization/fluency.

**Composition processes**

Planning and revision demonstrated direct effects, while editing had an indirect effect on writing, a finding that supports both instructional research on the impact of student’s use of writing strategies when composing (e.g. Graham et al., 2013) and studies with older students showing the specific effects of planning on writing quality (Beauvais et al., 2011; Limpo & Alves, 2013a; Limpo et al., 2014). However, our findings are in contrast with the work of Olinghouse and Graham (2009) and Whitaker et al. (1994), both of which found no relationship between preplanning and writing quality in elementary-age students. Although lack of planning prior to writing is a common finding in the writing literature (see Torrance et al., 2007), that planning was significantly related to quality of student’s writing should not be understated given the relative dearth of quality preplanning by students in this study. An important implication is that increasing the amount and sophistication of planning, through tools such as outlines and graphic organizers, will serve to increase the quality of student writing for students deemed as low performing or at-risk.
Implications for explicit instruction

As opposed to reading and math difficulties, writing deficits often encompass a broad category because what constitutes difficulties of written expression is not well established (Fletcher et al., 2019). For example, reading difficulties occur in the areas of word-recognition and spelling, and/or comprehension. Math difficulties occur in the areas of computations and/or problem solving. The distinction between lower- and higher-order writing skills deficits is important because these processes are separable in students with and without LD, and it is important to identify and treat deficits in written expression that have independence from domain-general language or learning skills. The findings from the present study have important implications for independently characterizing writing deficits of children with LD as lower-level (difficulty with spelling and/or handwriting accuracy or fluency) and/or higher-level (difficulty with specific composition processes) in order to provide targeted interventions.

In the present study, a large portion of the variance (82%) in writing performance was accounted for by the model, supporting the importance of the proposed components and correlates in contributing to writing outcomes. Overall, our evaluation of the NSVW model revealed mixed support for its implementation, with the most support for (a) the direct effect of writing-specific processes, but not domain-general resources, and (b) multiple indirect effects of domain-general and specific skills, which have important implications for explicit and implicit instruction. Similar to prior mediation models of writing, our findings highlight, first, the direct relation of handwriting to writing quality and quantity (Drijbooms et al., 2015; Kim & Park, 2019; Kim & Schatschneider, 2017; Limpo & Alves, 2013a); second, the near-transfer of lower-order transcription processes on higher-order composition processes such as planning and revision (Limpo & Alves, 2013a); and third, the importance of EF and motivation/self-efficacy for lower-order processes (e.g. spelling) rather than far-transfer to written expression (Kim & Schatschneider, 2017; Kim & Park, 2019), a finding that is surprising given the strong support for motivation and self-efficacy in writing, but that is not surprising considering that children in our sample did not receive explicit or implicit instruction in EF or motivation/self-efficacy. Our recent work with this sample shows that covariances (i.e. direct and indirect effects) among academic skills can be disrupted based on the focus of the intervention (Ahmed et al., 2021). It is possible that in the context of targeted instruction motivation/self-efficacy may play a significant role in predicting writing processes and outcomes, particularly when self-efficacy is taught in conjunction with composition processes and EF demands of the writing task are diminished (e.g. by providing additional writing time). Indeed, our supplementary analyses showed a different pattern of results in grade 4 (when students were expected to take the state writing exam and presumably received more writing instruction), suggesting the potential for interventions to support differential relations among writing skills. However, this is an empirical question that necessitates further research.

Given research demonstrating teachers’ infrequent use of evidence-based practices in writing (Brindley et al., 2015) and perceived lack of adequate teacher preparation (Gillespie & Graham, 2014), the implications for direct and/or computer assisted instruction is that children with LD require explicit instruction in handwriting and also higher-order skills.
(e.g. planning and revision) rather than just mechanics, grammar, and the production of
greater texts because the expectation that they may incidentally pick up composition skills
is wrong (Graham & Perin, 2007; Troia et al., 2017). Children with LDs tend to (a) rely
on knowledge-telling tactics rather than pre-planning; (b) do not appear to consider the
rhetorical or personal goal of the writing task, or take the reader’s perspective, (c) spend
more time editing mechanical errors than inconsistencies between what was intended and
what they wrote, and (d) over-estimate their capabilities and underestimate the need for
strategic effort (Troia et al., 2017).

Since writing skills are critical for managing content mastery and self-expression, it is
essential that instructors are thoroughly trained in robust writing interventions. Essential
principles for teaching written expression include explicit instruction as part of a
comprehensive writing program with opportunities for frequent and personally relevant
writing tasks; fostering motivation and strategic behavior by directly linking strategy use
with improved performance; and providing individualized instruction according to specific
needs (Troia et al., 2017). Relying on proven methods/models of instruction such as SRSD
has great potential for improving the writing skills of all developing writers, including those
with LD (Graham et al., 2012), but currently such interventions are still mainly the domain
of few practitioners and reading researchers (Graham, 2020).

**Limitations and future directions**

In our attempts to specify and validate the NSVW, several limitations must be noted. A
primary limitation of the present study was the sample was limited to atypically developing
students in the upper elementary. The present study did not target students with disorders
of written expression or specific writing skills deficits but rather targeted struggling readers
using a cutoff on a standardized reading test, and not behavioral observations (Roberts et
al., 2018). Nonetheless, the findings have important implications for all students with/at
risk for writing difficulties. Further research to validate the NSVW should include early
writers (K-2) and/or secondary grades, and a full range of learners. There were also
limitations in the type and number of measures included in the parent study. For example,
writing quality was based on a single composition in one genre. It is also unknown if
different operationalization of domain general or specific skills would result in stronger
or weaker models (e.g. handwriting assessed as an explicit fluency measure rather than
as quality of writing). Prior work has included a timed, handwriting fluency measure,
and such measures have demonstrated moderate relationships to writing. It is possible
that handwriting, revising and editing could be assessed in real-time using transcribing
technology. Thus, the development of future empirical models of writing should include
multiple sources of variation in the writer, the task, and the written product and process,
including genre, prompt, raters, time on task, and drafts. Another limitation is related
to the use of cross-sectional mediation. In the absence of longitudinal data, the use
of cross-sectional mediation analyses is common practice in social sciences (Hayes &
Preacher, 2014), and particularly educational sciences (cf. SVR). However, like the SVR,
the validation of any theoretical model of writing will require corroboration from future
experimental and/or longitudinal mediation analyses which control for previous time points
and additional confounding factors. Finally, the parent RCT study was not designed

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to exhaustively evaluate developmental differences across grades. Supplemental analyses showed that estimates of smaller magnitude (≈0.15) did not reach statistical significance for grades 3, 4, or 5, but were significant in the full model (see Supplementary Table). Future research should use longitudinal data to evaluate the (bi)directionality of effects, and/or RCTs targeting multiple writing processes to confirm the pattern of interrelations. Related to study design, future empirical models should consider alternative linear and non-linear specifications and frameworks. For example, Kellogg’s 1996 model is a self-regulatory model wherein written expression proceeds through phases of planning first, then translating, programming, executing, reviewing, and editing, while in the functional dynamic approach composition processes have distinct temporal distributions (Rijlaarsdam & van den Bergh, 2006).

Conclusions

This study focused on core processes of writing from the perspective of a theoretically meaningful model, the Not-so-Simple View of Writing (NSVW). We showed that the NSVW can be deconstructed into domain-general resources (executive function and motivation), and domain-specific processes such as transcription (handwriting and spelling), and composition processes (planning, editing and revision), with multiple relations within and across portions of the model. The findings imply that for struggling readers and writers in upper elementary grades, domain-general EF resources are related to transcription but not higher-order writing processes, or written expression. Written expression of children with LD is related to specific writing processes such as handwriting, spelling, planning, editing and revision. The present study provides guidance for future theoretical, pedagogical and empirical work to further specify and validate a robust empirical model of writing.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix

Table A1. Correlations among observed measures.

| Variable     | 1    | 2    | 3    | 4    | 5    | 6    | 7    | 8    | 9    | 10   | 11   | 12   | 13   | 14   |
|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1. TOWL handwriting | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |      |
| 2. TOWL %WSC   | 0.14 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |      |
| 3. WJ III Spelling | 0.11 | 0.72 | 1.00 |      |      |      |      |      |      |      |      |      |      |      |
| Variable                  | 1     | 2     | 3     | 4     | 5     | 6     | 7     | 8     | 9     | 10 | 11 | 12 | 13 | 14 |
|--------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-----|-----|-----|-----|-----|
| 4. NIH – Working Memory  | 0.28  | 0.13  | 0.13  | 1.00  |       |       |       |       |       |     |     |     |     |     |
| 5. NIH – Fluency         | −0.10 | 0.00  | 0.10  | −0.01 | 1.00  |       |       |       |       |     |     |     |     |     |
| 6. NIH – Cognitive Control| −0.07 | 0.19  | 0.16  | 0.02  | 0.18  | 1.00  |       |       |       |     |     |     |     |     |
| 7. SCLS – Self-Efficacy  | 0.10  | 0.17  | 0.16  | −0.02 | −0.06 | 0.02  | 1.00  |       |       |     |     |     |     |     |
| 8. SCLS – Strategies     | 0.04  | −0.02 | 0.01  | −0.02 | −0.16 | −0.08 | 0.72  | 1.00  |       |     |     |     |     |     |
| 9. SCLS – Effort         | 0.10  | 0.17  | 0.14  | 0.12  | −0.13 | −0.04 | 0.72  | 0.66  | 1.00  |     |     |     |     |     |
| 10. TOWL Planning        | 0.17  | 0.06  | 0.21  | 0.14  | 0.06  | −0.05 | 0.15  | 0.02  | 0.09  | 1.00 |     |     |     |     |
| 11. TOWL Editing         | 0.30  | 0.51  | 0.55  | 0.02  | 0.05  | 0.17  | 0.20  | −0.05 | 0.14  | 0.27 | 1.00 |     |     |     |
| 12. TOWL Revision        | 0.11  | 0.34  | 0.43  | 0.13  | 0.03  | 0.08  | 0.11  | −0.08 | 0.08  | 0.19 | 0.43 | 1.00 |     |     |
| 13. TOWL # words written | 0.25  | 0.06  | 0.12  | 0.28  | 0.09  | 0.00  | −0.04 | −0.08 | −0.05 | 0.26 | 0.18 | 0.24 | 1.00 |     |
| 14. TOWL 6-traits total  | 0.36  | 0.29  | 0.36  | 0.18  | 0.15  | 0.15  | 0.12  | −0.10 | 0.09  | 0.27 | 0.38 | 0.41 | 0.44 | 1.00 |

Note: Correlations in bold were significant at p < 0.05. %WSC: percent of words spelled correctly; NIH: NIH Examiner; SCLS: Student Contextual Learning Scale; TOWL: Test of Written Language.

Table A2.

Correlations among latent/observed variables from the NSVW model.

| Variable  | 1     | 2     | 3     | 4     | 5     | 6     | 7     |
|-----------|-------|-------|-------|-------|-------|-------|-------|
| 1. Handwriting | 1     |       |       |       |       |       |       |
| 2. Spelling    | 0.37  | 1     |       |       |       |       |       |
| 3. Executive function | 0.31  | 0.60  | 1     |       |       |       |       |
| 4. Motivation/self-efficacy | 0.14  | 0.28  | 0.14  | 1     |       |       |       |
| 5. Planning    | 0.27  | 0.25  | 0.23  | 0.13  | 1     |       |       |
| 6. Editing     | 0.42  | 0.68  | 0.44  | 0.25  | 0.28  | 1     |       |
| 7. Revision    | 0.30  | 0.47  | 0.37  | 0.14  | 0.29  | 0.51  | 1     |
| 8. Writing     | 0.61  | 0.62  | 0.71  | 0.12  | 0.47  | 0.61  | 0.65  |

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Figure 1.
Schematic of the Not-so-Simple View of Writing as a theoretical model. From Berninger and Winn (2006, p. 97). Copyright © 2006 The Guilford Press. Reprinted by permission.

aActivates long-term memory during planning, composing, reviewing, revising, and short-term memory during reviewing and revising output. bComponents include (1) orthographic, phonological, and morphological storage units for verbal information, (2) a phonological loop for learning words and maintaining verbal information actively in working memory, and (3) executive supports that link verbal working memory with the general executive system (a distributed network of many executive functions) and with nonverbal working memory (which stores information in a visual-spatial sketchpad). cA complex system that regulates focused attention – selecting what is relevant and inhibiting what is not relevant, switching attention between mental sets, attention maintenance (staying on task), conscious attention, (metalinguistic and metacognitive awareness), cognitive presence, and cognitive engagement.
Figure 2.
Schematic of the Not-so-Simple View of Writing (NSVW) as an empirical model. Note.
%WSC: % words spelled correctly; CC: cognitive control; FL: fluency; Strat: learning strategies; TOWL: Test of Written Language; WJ-III: Woodcock Johnson-III; WM: working memory.
Figure 3.
Standardized results for the full model. *Note.* %WSC: words spelled correctly; CC: cognitive control; FL: fluency; Strat: learning strategies; TOWL: Test of Written Language; WJ-III: Woodcock Johnson-III; WM: working memory. aHandwriting to planning; bhandwriting to editing; cplanning to editing; dspelling to planning; eplanning to revision; fspelling to revision. Solid lines represent significant direct effects or correlations; dashed lines represent non-significant direct effects or correlations. Parameter estimates are shown for direct effects only.
Table 1.
Descriptive statistics by grade and for the overall sample.

| Measure                          | Narrow construct        | Reliability | G3 (n = 113) | G4 (n = 152) | G5 (n = 137) | Total (n = 402) |
|----------------------------------|-------------------------|-------------|--------------|--------------|--------------|-----------------|
| **Domain-general resources**     |                         |             | M            | SD           | M            | SD             |
| **Executive function**           |                         |             |              |              |              |                 |
| NIH – Working memory<sup>c</sup> | Dot-counting            | 0.69<sup>a</sup> | −0.28        | 0.52         | −0.10        | 0.57           | −0.03          | 0.53           | −0.13          | 0.55           |
| NIH – Fluency<sup>c</sup>        | Phonemic/category       | 0.78–0.88<sup>a</sup> | −1.14        | 0.48         | −0.99        | 0.48           | −0.84          | 0.46           | −0.98          | 0.48           |
| NIH – Cognitive control<sup>c</sup> | Shifting/anti-saccade   | 0.86–0.97<sup>a</sup> | −0.30        | 0.51         | −0.06        | 0.50           | 0.10           | 0.48           | −0.07          | 0.52           |
| **Motivation/Self-efficacy**     |                         |             |              |              |              |                 |
| SCLS – Self-efficacy<sup>d</sup> | Confidence in ability   | 0.84<sup>a</sup> | 15.35        | 4.31         | 16.62        | 3.48           | 16.23          | 4.20           | 16.12          | 4.00           |
| SCLS – Strategies<sup>d</sup>    | Learning strategies     | 0.84<sup>a</sup> | 17.28        | 5.26         | 17.64        | 5.07           | 17.19          | 4.97           | 17.39          | 5.08           |
| SCLS – Effort<sup>d</sup>        | Motivation to work      | 0.84<sup>a</sup> | 12.39        | 3.74         | 12.84        | 3.31           | 12.44          | 3.73           | 12.58          | 3.58           |
| **Transcription**                |                         |             |              |              |              |                 |
| TOWL handwriting<sup>e</sup>     | Handwriting accuracy    | 0.91<sup>b</sup> | 2.28         | 0.97         | 3.04         | 1.13           | 3.13           | 1.10           | 2.85           | 1.13           |
| TOWL %WSC                        |                         | 0.98<sup>a</sup> | 77.55        | 12.50        | 85.75        | 10.60          | 87.76          | 7.44           | 84.12          | 11.06          |
| WJ III spelling<sup>f</sup>      |                         | 0.93<sup>b</sup> | 85.86        | 14.75        | 95.49        | 12.41          | 91.69          | 11.46          | 91.48          | 13.36          |
| **Composition processes**        |                         |             |              |              |              |                 |
| TOWL planning<sup>g</sup>        | 5 Min. pre-planning     | 0.75<sup>b</sup> | 1.29         | 0.53         | 1.65         | 0.86           | 1.70           | 0.85           | 1.57           | 0.79           |
| TOWL editing<sup>h</sup>         | Mechanics               | 0.62<sup>a</sup> | 3.64         | 2.06         | 6.26         | 2.92           | 6.36           | 2.78           | 5.56           | 2.91           |
| TOWL revision<sup>h</sup>        | Content/organization    | 0.72<sup>a</sup> | 2.05         | 1.53         | 3.99         | 2.77           | 4.15           | 2.84           | 3.50           | 2.66           |
| **Writing outcomes**             |                         |             |              |              |              |                 |
| TOWL #words written              | Writing fluency         | 1.00<sup>a</sup> | 71.27        | 35.11        | 103.38       | 40.38          | 110.37         | 44.09          | 96.75          | 43.35          |
| TOWL 6-traits total<sup>i</sup>  | Writing quality         | 0.80–0.91<sup>b</sup> | 11.40        | 3.85         | 16.17        | 5.39           | 17.80          | 4.67           | 15.37          | 5.40           |

Note. Standard scores were available only for WJ Spelling. %WSC: percent of words spelled correctly; NIH: NIH Examiner; SCLS: Student Contextual Learning Scale.

<sup>a</sup>Cronbach’s alpha

<sup>b</sup>Cohen’s kappa.

<sup>c</sup>Factor scores

<sup>d</sup>Sub-scale scores (max = 21 for Self-Efficacy, max = 27 for Strategies, max = 28 for Effort)

<sup>e</sup>1–6 point rubric

<sup>f</sup>Grade-based standard scores

<sup>g</sup>1–5 point rubric

<sup>h</sup>Sub-scale scores (max = 13 for Editing, max = 14 for Revising)

<sup>i</sup>Maximum possible score = 36.
Table 2.
Standardized solution for total, total indirect and specific indirect effects from the full model.

| Path               | Total |      |      |      | Total indirect |      |      |      |      | Statistically significant specific indirect effects |
|--------------------|-------|------|------|------|---------------|------|------|------|------|-----------------------------------------------------|
|                    | Estimate | S.E. | 95% CI |      | Estimated | S.E. | 95% CI |      | Estimated | Paths | Estimate | S.E. | 95% CI |
| Editing            |       |      |      |      |       |      |      |      |      | β_{EF}→EDIT | 0.42** | 0.08 | [0.18, 0.59] |       | 0.39** | 0.10 | [0.20, 0.75] |       | β_{EF}→SPELL→EDIT | 0.32** | 0.09 | [0.13, 0.63] |
|                    |       |      |      |      |       |      |      |      |      | β_{MO}→EDIT | 0.19* | 0.06 | [0.01, 0.34] |       | 0.14* | 0.05 | [0.02, 0.30] |       | β_{MO}→SPELL→EDIT | 0.11* | 0.05 | [0.01, 0.27] |
|                    |       |      |      |      |       |      |      |      |      | β_{SPELL}→EDIT | 0.63** | 0.09 | [0.43, 0.94] |       | 0.06* | 0.03 | [−0.02, 0.13] |       | β_{SPELL}→HW→EDIT | 0.05* | 0.02 | [−0.01, 0.11] |
| Revision           |       |      |      |      |       |      |      |      |      | β_{EF}→REV | 0.35** | 0.08 | [0.12, 0.55] |       | 0.27** | 0.07 | [0.13, 0.53] |       | n/a | n/a | n/a |
|                    |       |      |      |      |       |      |      |      |      | β_{MO}→REV | 0.09ns | 0.07 | [−0.08, 0.26] |       | 0.11* | 0.04 | [0.01, 0.22] |       | n/a | n/a | n/a |
|                    |       |      |      |      |       |      |      |      |      | β_{SPELL}→REV | 0.41** | 0.09 | [0.16, 0.65] |       | 0.21* | 0.06 | [0.08, 0.39] |       | β_{SPELL}→EDIT→REV | 0.16* | 0.06 | [0.05, 0.35] |
|                    |       |      |      |      |       |      |      |      |      | β_{HW}→REV | 0.13* | 0.05 | [0.00, 0.26] |       | 0.08* | 0.02 | [0.02, 0.15] |       | β_{HW}→EDIT→REV | 0.05* | 0.02 | [0.01, 0.11] |
| Writing            |       |      |      |      |       |      |      |      |      | β_{EF}→W | 0.71** | 0.09 | [0.45, 0.94] |       | 0.29* | 0.16 | [−0.49, 0.43] |       | n/a | n/a | n/a |
|                    |       |      |      |      |       |      |      |      |      | β_{HW}→W | 0.39** | 0.07 | [0.20, 0.57] |       | 0.09* | 0.03 | [0.02, 0.20] |       | β_{HW}→EDIT→REV→W | 0.01* | 0.01 | [0.00, 0.04] |
|                    |       |      |      |      |       |      |      |      |      | β_{SPELL}→W | 0.32* | 0.16 | [−0.56, 0.57] |       | 0.30* | 0.10 | [0.11, 0.67] |       | β_{SPELL}→EDIT→REV→W | 0.05* | 0.01 | [0.01, 0.12] |
|                    |       |      |      |      |       |      |      |      |      | β_{PLAN}→W | 0.24** | 0.07 | [0.07, 0.39] |       | 0.05* | 0.02 | [0.00, 0.14] |       | β_{PLAN}→REV→W | 0.04* | 0.02 | [−0.01, 0.10] |
|                    |       |      |      |      |       |      |      |      |      | β_{EDIT}→W | 0.18* | 0.09 | [−0.05, 0.48] |       | 0.09* | 0.03 | [0.02, 0.18] |       | β_{EDIT}→REV→W | 0.09* | 0.03 | [0.02, 0.18] |

Note.

ns: Not significant
*

p < 0.05

**: p < 0.001. Direct effects are presented in Figure 2. n/a: total or total indirect effect was significant, but no specific indirect effects were statistically significant. Estimates with zero included in the confidence intervals were not considered to be significant. EDIT: editing; EF: Executive function; HW: handwriting; MO: motivation/self-efficacy; PLAN: planning; SPELL: spelling; REV: revision; W: writing.