Joint Modeling of the Component Skills of Reading and Writing: A Meta-Analytic SEM Approach

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JOINT MODELING OF THE COMPONENT SKILLS OF READING AND WRITING: A META-ANALYTIC SEM APPROACH

By

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For my sister, Ridda,

and for Nayaab and Alisha.
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ABSTRACT

Introduction – The Simple View of Reading (SVR) and the Not-so-Simple View of Writing (NSVW) are well established models of reading and writing, respectively. This study combined and expanded upon these theoretical frameworks of component skills of reading and writing using data from a multivariate meta-analysis of the overlapping indicators and predictors of literacy skills. Method – Data for this study came from previously conducted meta-analyses of the correlations among component skills of reading and writing (Ahmed, 2013). A synthesized correlation matrix of 77 studies was fit to a joint model of reading and writing. The samples varied in age of participants, languages spoken, and other participant characteristics, but the majority of the samples included English speaking students in grades 1 through 7. The variables included rapid automatized naming (RAN), phonological awareness (PA), decoding/orthography (D/O), reading comprehension (RC), vocabulary/morphology (V/M), listening comprehension (LC), oral expression (OE), working memory (WM), non-verbal reasoning (NVR), spelling (SP) and handwriting (HW), writing quality (WQ), and Curriculum-based (or count-based) measures of writing (CBM). The first class of models replicated and extended the Simple View of Reading. The second class of models was based on components of the Not-so-Simple View of Writing, but did not replicate this model, as the meta-analysis did not identify a well-defined construct for executive functioning. Finally, the last class of models examined the contributions of component skills to both reading comprehension and text generation, and tested whether relations among component skills and writing are mediated through reading. Results – The results supported the validity of the Simple View of Reading as originally proposed by Gough & Tunmer, 1986, that reading comprehension equals the sum of two components (word reading and language comprehension). Results for the models of writing indicated that transcription emerged as an
important predictor of writing, and working memory did not explain variance in writing. The models of literacy supported the role of text reading in writing, over and above the role of language and decoding. The results have implications for studying the development of reading and writing in the context of literacy rather than in the context of language.
CHAPTER ONE

INTRODUCTION

Reading and writing are important aspects of literacy, and they are essential to educational, economic and social opportunities beyond school. Competent individuals are able to read about complex topics in order to understand a writer’s point of view. They’re also able to translate thoughts and ideas into written text to communicate to other readers. Readers apply a series of inferences and construct propositions based on the information provided by the text (Kintsch & Mangalath, 2011). Additionally, they form mental models of the text that represent the situation described in the text. Analogous to reading comprehension, composition is also a complex process, entailing translation of ideas and situations into writing as well as transcription skills (handwriting and spelling; Hayes & Berninger, 2010). However, the pattern of reasoning is different for each process: Whereas readers focus on gaining support for their interpretations, writers focus on strategies to create meaning (Langer, 1986).

Research and policy have largely focused on the reading aspect of literacy (e.g., the No Child Left Behind Act), and component skills of reading have been identified in order to provide interventions to students with poor reading achievement in the general education framework (e.g., Joshi and Aaron, 2000). In the special education framework, deficits in word and non-word decoding, as well phonological awareness, an essential sub-skill required for accurate decoding of words (Torgesen et al., 1997), are used for the identification of dyslexia. For example, the Department of Education recommends failure to respond to targeted interventions of phonological awareness and/or other relevant skills as one of the requirements to diagnose a student with a reading disability (Fletcher et al., 2006). The identification of key components of literacy outcomes plays an important role in the identification of specific learning disabilities as well as
interventions provided for inadequate achievement, especially for word-level reading disability. Although the component skills of lower level processes such as decoding and spelling have been identified, this strategy does not work well for discourse-level processes, because they depend on other word and sentence-level processes (Perfetti & Stafura, 2014). In addition to identification of key component skills, often a second goal is to specify direct and mediational structural relations among variables and discourse-level process (e.g., text reading or writing).

1.1 Component Skills of Reading Comprehension

The Simple View of Reading (SVR; Gough & Tunmer, 1986; Hoover & Gough, 1990) and the Not-so-Simple View of Writing (NSVW; Berninger & Winn, 2006) are examples of well-established frameworks of reading and writing, respectively. Both frameworks rest on the assumption that the sum and/or interaction of component skills lead to an outcome skill. For example, the SVR holds that D + LC = RC (Decoding + Listening Comprehension = Reading Comprehension), which are each necessary but not sufficient for predicting reading comprehension.

Decoding is defined as the ability to accurately read words or made-up words by breaking them down into syllables or by rapidly accessing the word in the metal lexicon. The original Simple View of Reading model included word reading accuracy under the construct of decoding, although additional specifications of the model have included word reading accuracy as well as fluency (e.g., Florit & Cain, 2011). Listening comprehension is defined as the ability to understand spoken language, mainly spoken words as well as sentences and passage-level oral language (Gough & Tunmer, 1986). Under this framework, deficits in reading comprehension are due to failure to achieve word decoding skills only (dyslexia), listening comprehension skills only (specific reading comprehension disability) or both (garden variety poor readers). In addition, other components of
reading have been identified such as phonological awareness, rapid naming speed, vocabulary, passage fluency, working memory and IQ (Adlof, Catts & Lee, 2010; Joshi, 2005; Joshi & Aaron, 2000; Kershaw & Schatschneider, 2012). The components of reading comprehension have been defined as processing systems that operate on internal representations of objects and symbols, and are independent of each other (Aaron et al., 2008), but additional terms that have been added to the SVR include the interaction of decoding and listening comprehension (D*LC). Other models of reading comprehension have specified direct and mediational paths from lower-level component skills such as phonological awareness, phonological decoding, word identification, spelling, and listening comprehension to reading comprehension (e.g., Convergent Skills Model of Reading Development; Vellutino, Tunmer, Jaccard & Chen, 2000). Research on older students has also identified higher-level components such as inference making, background knowledge and reading strategies which mediate the relations among lower-level processes such as word reading and vocabulary and reading comprehension (e.g., the Direct and Inferential Mediational (DIME) Model of Reading Comprehension; Cromley & Azevedo, 2011).

Several studies have replicated and expanded upon the reading components frameworks and have shown the importance of these and other broad components, (e.g., psychological processes such as motivation and ecological components such as home environment) in English (Aaron et al., 2008) as well as other orthographies (Joshi et al., 2012; Chiu, McBride-Chang & Lin, 2012). The current study also utilized several component skills of reading and writing as identified by an exploratory meta-analysis (Ahmed, 2013) to assess whether the component skills make unique contributions to reading over and above other relevant skills. Perfetti and Stafura (2014) best summarize it as:
“There is no theory of reading, because reading has too many components for a single theory. There are theories of word reading, theories of learning to read, theories of dyslexia, and theories of comprehension at various grain sizes (sentence comprehension, text comprehension), appropriately targeted to a manageable part of reading.” (p. 22).

Recently, the Reading Systems Framework has been proposed as a broad framework that is based on well-known theories of reading comprehension, and can be used to guide the formation of novel theories and hypotheses of reading problems (Perfetti and Stafura; 2014). These cognitive theories include the reader’s situation model (Van Dijk & Kintsch, 1983) and the construction-integration model (Kintsch, 1988). The framework claims that reading comprehension is dependent on: a) a procedural and semantic knowledge base (e.g., linguistic, orthographic and general/background knowledge), b) interactive processes of reading (e.g., decoding, word identification, meaning retrieval, sentence parsing, inferencing and comprehension monitoring), and c) a neuro-cognitive system that integrates pathways between long term and short-term memory and control processes.

In the Simple View of Reading, and other static models of reading comprehension (e.g., the DIME model), the focus is the nature of the relations among the interactive components of reading (e.g., decoding and vocabulary), as opposed to a process approach. However, although the Simple View of Reading is a parsimonious framework, it is based on the LaBerge and Samuels Theory (LaBerge & Samules, 1974), which is an interactive theory that includes a broad range of phenomena that accounts for decoding, rather than an automatized conceptualization of word reading attributed to the Simple View (Samuels, 2004). The paradigm of the Simple View has become important in the identification of individual and developmental differences in
learning to read, and has had robust theoretical, educational, as well as diagnostic implications (Florit & Cain, 2011).

Additional components that have been added to the Simple View of Reading framework include phonological awareness (e.g., Kendou, Savage & van den Broek, 2009; Hoien-Tengesdal, 2010; Kendou et al., 2013) and RAN (e.g., Aaron et al., 2008) in English and other orthographies, but most of the support for extensions of the SVR have focused on vocabulary (e.g., Joshi, 2005; Kendou et al., 2009; Ouellette & Beers, 2010; Protopapas et al., 2012; 2013). In addition, working memory has been found to account for individual differences in comprehension as reading comprehension processes compete for limited memory resources (Cain, Oakhill & Bryant, 2004; Kershaw & Schatschneider, 2011; Seigneuric et al., 2000, 2005; Swanson & Berninger, 1995; Swanson & O’Connor). Specifically, inference making and comprehension monitoring require readers to store information in memory (Cain & Oakhill, 2009). As the reading process unfolds, readers must also integrate information from the text and from background knowledge. Working memory capacity is associated with reading comprehension in adequate comprehenders, and deficits in working memory have been found for inadequate comprehenders.

The construct of comprehension has been additionally examined in the context of the simple view of reading using a latent variable for language comprehension. The construct of language comprehension differs from the linguistic comprehension component of the original simple view of reading in that the latent variable has been specified to include several indicators of language such as vocabulary (e.g., Tunmer & Chapman, 2012), listening comprehension at the word, sentence (Cutting & Scarborough, 2006) and text levels, oral expression, inference making, syntax (Kirby & Savage, 2008), among other constructs (e.g., Kendeou et al., 2009).
In addition to the replication of the SVR, the purpose of this study was to empirically incorporate the SVR in a model of literacy, and in the context of component skills that are associated with writing in order to test whether the SVR has implications for writing as well as reading.

1.2 Component Skills of Text Generation

The Simple View of Writing was modeled after the Simple View of Reading, based on the Hayes and Flower (1980) and Hayes (1996) cognitive processing theories of writing. The Hayes and Flower (1980) model, includes three main cognitive processes: planning, translating and reviewing, which later became reflection, text production and text interpretation (Hayes, 1996). This model also included working memory, long-term memory as well as motivation for writing (Hayes, 1996). The model is process-based, as it assumes a sequence of events with a temporal distribution that occur for the end goal of writing. Furthermore, the model focuses on adult expert writing, and can serve as a framework for developmental models of writing in younger children (Berninger & Winn, 2006). For example, the sub-components of the cognitive process section of the 1996 model included reading and listening comprehension (text interpretation), as well as problem solving and reasoning (reflection). Building on the ideation component of the Hayes and Flower (1980) and Hayes (1996) model, the Simple View of Writing (SVW) posits that lower level skills such as handwriting (Berninger et al., 2002) and spelling (Juel, Griffith and Gough, 1986; Berninger et al., 2002) as well as higher level skills such as ideation (which includes planning, revision and translation), account for most of the variation in writing skills (Juel, 1988; Juel, Griffith and Gough, 1986; Berninger et al., 2002; 2003). This model was later updated to the Not-so-Simple View of Writing (NSVW; Berninger & Winn, 2006) in order to reflect a deeper understanding of the relations between working memory and long-term memory as well as the
central role of attention to executive functioning. Thus, the model that was initially intended to simplify the processes related to written expression was later “not-so-simple” because it was a model which incorporated research from cognition, education, neuro-psychology, linguistics and development.

The Simple View of Writing and the Not-so-Simple View of Writing proposed by Berninger and colleagues are testable models that are less specific than the Simple View of Reading in terms of directional relations among components of writing skills. On the surface the models are equally parsimonious: individual differences in writing skills can be explained by Transcription (spelling and handwriting), Executive Functions, and Working Memory (Berninger et al., 2002). Empirically testing the nature of these relations has been employed via path-analytic models and structural equation models differentially. For example, Limpo and Alves (2013) specified direct as well as mediational paths among transcription, planning, revision, self-efficacy and text-generation, and Childress (2011) tested the model including fine motor skills, language, executive functions, working memory and text generation. The SVW and NSVW models intimate the complexity of the interrelations among cognitive processes related to writing, and these paradigms suggest key measurable components such as transcription, oral language and working memory, which can be used to specify a static model of written expression.

Expansions of the SVW and NSVW models or similar componential frameworks of text level writing include vocabulary (Shanahan, 1984) and listening comprehension (Berninger et al., 2010). Theoretical and empirical studies of text generation and writing quality, as well as the meta-analysis used in the present study (Ahmed, 2013) have also identified a large range of criterion variables that provide qualitative scores of writing. For example, writing fluency indices include Curriculum Based Measures (CBM) of writing such as Total Number of Words written (Gansle
et al., 2004) and Correct minus Incorrect Word Sequences (Espin et al., 2000), whereas writing quality indices range on a number of characteristics, including which aspects of written language are scored (ideas, macro-organization, punctuation, etc). The purpose of the present study was to evaluate the effect of transcription skills as well as working memory on several aspects of written expression such as writing quality, a combined construct including several curriculum based measures (e.g., correct word sequences) as well as count based measures (e.g. total number of sentences, clauses, t-units, etc.), and a total number of words written. Executive functioning, except for working memory, was excluded from the meta-analysis because the construct of executive functions is operationally defined in different ways (e.g., code switching/fluency, working memory, attention, inhibition, self-regulation, and writing specific processes such as planning, reviewing and revising) depending on the field of study. Because of the complexity and multi-faceted nature of the executive functions construct, it was difficult to combine measures from different studies under one umbrella (Ahmed, 2013). Thus, two out of three components of the Not-so-Simple View of Writing were evaluated in the present study (i.e., transcription and working memory components).

1.3 Component Skills of Literacy

Importantly, the first proponents of the Simple View of Writing, proposed a “Simple View of Reading and Writing” (Juel, Griffith and Gough, 1986), which could be teased apart to make predictions about individual differences in reading or writing. The model was a path analysis with the following relations among variables: a) spelling and ideas predicted writing, b) word recognition and listening comprehension predicted reading comprehension, c) lexical knowledge and cipher knowledge (spelling-sound knowledge) predicted spelling as well as word recognition, d) exposure to print predicted lexical knowledge and cipher knowledge, and e) IQ and oral
language predicted phonemic awareness. Paths a and b are representative of the Simple Views of writing and reading, respectively, and the additional factors were predictors of word level or sub-word level reading and writing. The results provided support for the Simple Views of writing and reading and indicated that word level reading and writing are dependent on the same sources of knowledge.

However, historically most research and pedagogy has separated reading and writing (Shanahan, 2006), and theoretical models of the literacy are limited to emergent literacy, or broader aspects of literacy such as ecological literacy based on home and school environments. Based on a literature on reading-writing connections, Deane, Sabatini and O’Reilly (2011) have proposed an English Language Arts (ELA) literacy framework which integrates interpretation (reading), expression (writing) and deliberation (critical thinking) for assessment design (Gorin et al., 2014). An important aspect of the model is that it reinforces the shared cognitive resources employed in literacy systems, irrespective of modality (reading, writing or reasoning; Gorin et al., 2014). The shared cognitive resources such as decoding, transcribing, and editing occur in different combinations and sequences of models and modalities. Although this model describes the interplay of literacy skills, it is a departure from the empirical models mentioned above (e.g., models that utilize observed or latent variables to specify relations among constructs) in that the framework has not been simultaneously tested across all modalities (reading and writing) and modes (e.g., print and discourse), although this framework has been applied to the empirical evaluation of component skills of reading (Sabatini et al., 2014).

Research on linguistics, psychology and educational sciences suggests there are common constructs underlying literacy development. These constructs include knowledge of phonological structures, knowledge of the alphabetic principle, and fluency in decoding and encoding,
comprehension of oral and written language, and wide reading and writing (Foorman et al., 2011). Furthermore, reading and writing depend on common knowledge of specific components of written language that can be subdivided into grapho-phonics, text attributes of syntax and text format (Fitzgerald & Shanahan, 2000). Most studies find that reading and writing are highly related (e.g., Jenkins et al., 2004; Berninger et al., 2002; Abbott & Berninger, 1993; Tierney & Shanahan, 1996; Juel et al., 1986; Juel, 1988; Shanahan, 1984), and have shown that the correlations between passage comprehension and text composition range from moderate to high for both children and adults (Berninger et al., 2002;). However, most studies on individual differences in reading or writing have proposed that one skill is a component of the other. For example, the development of writing has been studied in the context of reading comprehension (e.g., Foorman & Petscher, 2010; Jenkins, Johnson & Hileman, 2004; Vellutino, Tunmer, Jaccard & Chen, 2007), and reading has been studied in the context of writing (e.g., Abbott & Berninger, 1993; Kent et al., 2013; Kim et al., 2011).

A second question that is often explored in the literature is the directionality of effects between reading and writing (a question that was not initially posed by the “Simple View of Reading and Writing” Model). Although several studies show that relations between reading and writing appear to be bidirectional (Abbott et al., 2010; Lerkkanen et al., 2004; Shanahan & Lomax, 1986; Foorman et al., 1991), other studies suggest that the relation is largely unidirectional, with some studies reporting that writing influences reading (e.g., Groff, 2001; Foorman and Francis, 1994; Berninger et al., 2002; Caravolas et al., 2001, 2005; Cataldo et al., 1988; Shanahan & Lomax, 1988; Ehri, 1987), and other studies reporting that reading influences writing (Aarnoutse et al., 2005; Ahmed et al., 2014; Babagayigit & Stainthorp, 2011; Berninger et al., 2002; ; Leong et al., 2005; Shanahan & Lomax, 1986; Sprenger-Charolles et al., 2003). Part of the reasons for
the mixed findings from previous studies is that previous studies varied in a) the number and type of indicators used to represent constructs, b) several aspects of the text materials (e.g., reading and writing the same versus different words, topics, genres, etc.), and c) the instructional context, as some studies focus on intensive instruction whereas others focus on the natural development of these skills (Graham, 2000). The important conclusion from the reading-writing research is that although reading and writing are not inverse processes, they rely on similar cognitive mechanisms that allow for simultaneous growth as well as transfer of knowledge.

A third experimental question that is often explored in reading-writing studies, as well as the present study, concerns the nature of the contributions of linguistic and cognitive factors to reading as well as writing (e.g., Berninger et al., 1994; Nikolopoulos, Goulandris, Hulme & Snowling, 2006). Babayigit and Stainthorp (2011) extended the Simple View of Reading by modeling the effect of phonological awareness, RAN, IQ, and vocabulary on reading fluency and spelling, separately, in two longitudinal samples of Turkish students in grades 2-3 and 4-5. A second set of models included IQ, vocabulary, listening comprehension, working memory and reading fluency as component skills of reading comprehension or writing quality. The results of the four models indicated that RAN made contributions to reading fluency and spelling, and vocabulary and listening comprehension made contributions to reading comprehension, but none of the component skills contributed to writing quality after controlling for writing at the first time-point. Berninger, Abbott, Thomson and Raskind (2001) applied a similar framework in a sample of dyslexic probands and their relatives to separately model the relations among orthographic choice, phonological memory, RAN and IQ on the following outcome skills: reading accuracy, reading rate, reading comprehension, handwriting, spelling, and written composition, and found
that the competent skills were differentially related to reading and writing at different levels of language (i.e., word and text levels).

Other multivariate studies have jointly modeled both outcome processes in the same model in order to evaluate how the component skills are differentially related to reading and writing (Aarnouste van Leeuwe & Verhoeven, 2005; Al’Otaiba, Puranik, Folsom, & Gruelich, 2014; Caravolas, Hulme & Snowling, 2001; Cataldo & Ellis, 1988; Juel, 1986; Kim, Parodi, 2007). Multivariate studies have also utilized structural equation modeling (SEM) to form latent variables for reading, writing and component skills (e.g., Kim et al., 2014; Shanahan & Lomax, 1986, 1988;), but the outcome variables in these studies are word level decoding and spelling. For example, Kim, Al’Otaiba, Puranik, Folsom, & Gruelich (2014) examined the relation among component skills (vocabulary, phonological awareness, alphabet knowledge and handwriting) and reading measures (word and non-word reading), and writing measures (word and non-word spelling) in a sample of kindergarteners and found that vocabulary, phonological awareness and alphabet knowledge were uniquely related to word reading and spelling, but handwriting fluency was not related to word reading or spelling. Other studies of the joint modeling of reading-writing in younger children have similarly found that vocabulary, RAN, and phonological awareness are related to reading comprehension, but only RAN is related to spelling (Aarnoutse et al., 2005), and that phonological awareness makes differential contributions to reading and spelling (Cataldo & Ellis, 1988; Caravolas, Hulme & Snowling, 2001). Given that reading is a precursor of unassisted writing development at the word, sentence and text levels of written language (Ahmed, Wagner & Lopez, 2014), Guan, Ye, Wagner, Meng and Leong (2014) tested whether the relations among component skills (morphological awareness, syntactic processing and working memory) and Chinese writing quality are mediated by reading comprehension. The results favored mediated effects, rather than
direct effects of the component skills. The rationale of a mediated model is also in line with
cognitive theories of writing (e.g., Hayes, 1996), which suggest that the cognitive processes
associated with written expression rely on reading and listening comprehension. Thus, it’s possible
that some components are directly related to reading and writing, whereas other components are
related to writing via their effects on text-level reading. With the exception of Juel, Griffith and
Gough (1986), none of the previous studies have empirically tested the joint modeling of the
“Simple View of Reading and Writing”.

The purpose of the present study was to jointly model the component skills of literacy and
evaluate their contributions to text level reading and written expression.

The specific research questions were:

1. How well do the meta-analytic data replicate the Simple-View of Reading? The present
   study will replicate the model by including language comprehension as a latent variable
   comprised of listening comprehension, vocabulary and oral expression. The model will
   also be extended by including working memory as an additional predictor. It was
   hypothesized that working memory will account for independent variance in reading, but
   will account for less variance in reading comprehension than language and decoding.

2. How well do the meta-analytic data replicate the transcription factor of the Not-so-Simple-
   View of Writing, and what is the effect of transcription and working memory on writing?
   Are the results different for writing quality, a cumulative construct of curriculum based
   measures of writing, and total number of words written? As described above, the NSVW
   is less specific than the SVR, as structural relations among components sills have not been
   clearly specified in the literature. Thus, a simple model will be fit with transcription and
working memory making contributions to outcome variables of writing. It was hypothesized that working memory will be a more important predictor of writing than reading, and that transcription will make significant contributions to text level writing.

3. Do component skills of reading comprehension predict written expression when other relevant skills are being controlled, and does text reading mediate the relation between component skills and writing? It was hypothesized that the SVR will be relevant in the context of reading as well as writing, and that text reading will mediate the relations among component skills and writing.

1.4 Analytic Approach

Several component skills of reading and writing have been covered in the studies described above. Building on the existing literature, Ahmed (2013) quantitatively synthesized the literature on the component skills that overlap word- and text-level reading and writing, and identified the following variables: alphabet knowledge (AK), rapid automatized naming (RAN), phonological awareness (PA), decoding/orthography (D/O), reading comprehension (RC), vocabulary/morphology (V/M), listening comprehension (LC), oral expression (OE), working memory (WM), non-verbal reasoning (NVR), spelling (SP) and handwriting (HW), writing quality (WQ), Curriculum-based (or count-based) measures of writing (CBM), and writing knowledge (WK) (see Appendix A for the literature search criteria and Appendix B for the list of studies included in the meta-analysis). When both predictor and criterion variables are continuous, the correlation coefficient represents the estimate of effect sizes, and because correlation coefficients are standardized it is possible to compare them across studies. The results of the meta-analysis of 77 studies showed that Text Reading, Decoding, Alphabet Knowledge, CBM, and Spelling have the highest correlations with Writing Quality (range = .49-.60). Moderate correlations were found
between RAN, Phonological Awareness, Listening Comprehension, Non-Verbal reasoning, Handwriting and Writing Quality (range = .32-.39). Finally, low correlations were found between Vocabulary/Morphology, Oral Expression and Working Memory and Writing Quality (range = .27-.28). Because of the low incidence of studies reporting correlations with alphabet knowledge as well as with writing knowledge, these variables were excluded from the present analyses.

1.4.1 Pooled Correlation Matrix

Table 1 presents a 13x13 synthesized correlation matrix of seventy eight effect sizes, containing data from \( k = 104 \) independent samples, \( n = 15,442 \) subjects and 3,543 raw correlations. Each correlation in the matrix represents an individual meta-analysis. For each meta-analysis the effect sizes were aggregated to yield one effect size per study (or independent sample) whenever several forms of the same measure were administered, or several measures for the same variable were administered. The correlations were also corrected for reliability, as well as range of restriction, and a weighted average was computed based on the sample size. Appendix C provides a visual presentation of selected meta-analyses, with the synthesized effect at the top of the forest plot, as well as individual effects and confidence intervals for each study. The synthesized effect represents the estimate of the population correlation. Differences in correlations that are attributable to sampling variance alone are characteristic of homogeneous effect sizes, whereas heterogeneous effect sizes comprise additional sources of unexplained variability and are less representative of the population effect. The first forest plot (Decoding/Orthography and Spelling) depicts a homogeneous effect size, whereas the last forest plots (Phonological Awareness and Handwriting; Writing Quality and Text Reading; Decoding/Orthography and Text Reading) depict heterogeneous effect sizes. Note that in all of the forest plots, the effects are normally distributed around the overall effect size, with a minor skew for the heterogeneous effects. See Ahmed (2013)
for a discussion of the moderator analyses, including age/grade, language, participant characteristics (e.g., English Language Learner and low reading comprehension vs. typically developing students) as well as test-specific moderators (e.g., holistic vs. composite writing quality scores, and reading comprehension vs. passage level oral reading fluency). In addition to testing the homogeneity of each meta-analysis separately, the homogeneity of the synthesized correlation matrix was evaluated using the Bonferroni-adjusted at-least-one (BA1) approach described in Cheung and Chan (2005). By jointly modeling the components of literacy skills using meta-analytic SEM, the present study adds to the literature by extending the number and types of component skills associated with reading and writing outcomes, as well as jointly modeling word and text level processes.
Table 1. Synthesized correlation matrix (mean $n = 139$, harmonic mean $n = 67$, total $n = 15,442$).

<table>
<thead>
<tr>
<th></th>
<th>CBM</th>
<th>CBM (NW)</th>
<th>WQ</th>
<th>RAN</th>
<th>PA</th>
<th>D/O</th>
<th>TR</th>
<th>V/M</th>
<th>LC</th>
<th>OE</th>
<th>WM</th>
<th>NV</th>
<th>SP</th>
<th>HW</th>
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Note. Correlations in bold represent heterogeneous effect sizes; all other effects are homogeneous. WQ = writing quality, CBM = Curriculum Based Measures, NW = Number of Words Written, RAN = rapid automatized naming, PA = phonological awareness, D/O = decoding/orthography, TR = text reading, V/M = vocabulary/morphology, LC = listening comprehension, OE = oral expression, WM = working memory, NVR = non-verbal reasoning, SP = spelling, HW = handwriting.
CHAPTER TWO

METHODS

The pooled correlation matrix was fit to path-analytic and structural equation models to evaluate relations among component skills using Mplus 7 (Muthen & Muthen, 2014). A series of observed and latent variable models were fit to the synthesized data matrix presented in Table 1, and direct and indirect effect sizes, standard errors, confidence intervals and \( p \)-values can be interpreted as in traditional SEM models (Becker, 2009). The present study utilized a synthesized correlation matrix in a traditional SEM framework, with mostly homogeneous effect sizes \( n = 100 \) but also some heterogeneous effects \( n = 3 \). Structural equation modeling with meta-analytic data differs from traditional model fitting in the following ways: (a) in a Meta-SEM, latent variables reflect common variance across related constructs (e.g., spelling and handwriting), whereas in SEM latent variables reflect common variance across measures of the same construct; (b) residual variances in SEM models are associated with errors of the observed measures (e.g., measurement error), whereas in the Meta-SEM framework, the residuals represent unique aspects of the construct which are not shared with other constructs (e.g., the word recognition aspect of spelling is not shared with handwriting, but alphabet knowledge and motor-skills are associated with both). This is because the meta-analytic procedure corrects for unreliability of the measures at the level of the study (but see Ahn, 2008, for a psycho-metric application of meta-SEM). Furthermore, the concept of validity is relevant in the present context because validity of a construct is not ascribed to tests or test scores, but rather to the pattern of relations among criterion measures found in different samples and contexts, given that differences are expected due to variations in participant and study characteristics (Messick, 1995).
The sample size was based on the harmonic mean \( n = 67 \) instead of a) the mean \( n = 139 \) because the harmonic mean does not give more weight to larger samples, or b) the total number of participants included in the synthesized correlation matrix \( n = 15,442 \) because model fit indices are sensitive to extremely large sample sizes. Traditional model fit indices (i.e., chi square and chi-square difference for nested models) can be utilized to assess model fit. Note that when the models are fit using different sample sizes (e.g., 67 vs 15,442) the unstandardized and standardized parameter estimates are expected to remain the same, but a drop in model fit indices is associated with larger sample sizes. The AIC and BIC values were be used in order to make comparisons within the three classes of models: (a) Simple View of Reading, (b) Simple View of Writing, and (c) Joint model of reading and writing.

### 2.1 Variables and Measures included in the Meta-Analysis

Appendix D provides a list of measures included in the meta-analysis by construct. In this section, a brief description of the tests and measures for each construct is provided.

#### 2.1.1 Text Reading

Text reading included measures which require children to read connected words in the context of a short story or passage. Reading comprehension tests such as the Gates MacGinitie require children to answer questions about the passage read. Oral reading fluency tests require children to read a passage and are scored based on the number of words read correctly. Finally, scores based on reading rate refer to the time taken to read a passage.

#### 2.1.2 Writing Quality

Several standardized measures of writing were used, including the Test of Written Language-3 (TOWL-3; Hammill & Larsen, 1996), the Woodcock Johnson-Revised Broad Written
Language Cluster (WJ-R; Woodcock & Johnson, 1990) and the Wechsler Individual Achievement Test (WIAT-II; The Psychological Corporation, 2002). Writing quality assessments also included experimental writing prompts and were coded based on the rubrics and scoring systems used in the studies. Qualitative rubrics included published rubrics such as the Tindal and Hasbrouck Analytic Scoring System (THASS; Tindal and Hasbrouck, 1991), standardized tests of writing such as the WIAT II Written Expression, and experimental rubrics. The qualitative scores of writing were coded as holistic, componential, and composite rubrics and quantitative scores included readability, Curriculum Based Measures (CBM) and computational indices. Holistic scores of writing were based on a global assessment of the text, where samples were given one numeric value. Although raters considered specific aspects of writing, such as grammar or structure, they assigned one score per sample. The scales ranged from a 4-point scale (Espin, 2001) to 14-point scale (Ritchey et al., 2010). Componential scores were classified as scores that are based on specific rubrics for different aspect of written language. For example, each sample received a separate score for a specific aspect of written language, such as accuracy, main idea, content, coherence, etc. Finally, composite scores included rubrics that evaluate separate aspects of writing (same as the componential scores) but added or averaged the component scores to come up with one final score. In addition, composite scores included standardized measures of writing which tested word and sentence level writing in addition to writing text (e.g., the Written Expression sub-test of the WIAT-II which measures spelling, sentence construction as well as paragraph writing). Characteristics of the writing quality assessments are listed in Appendix B by study. For the writing prompts students were asked to write on a free topic or a topic provided by the tester. With the exception of two studies that required students to type (Espin, 2001 and Bird et al., 2008) all of the writing prompts were paper and pencil based. Students were allowed to write
for a minimum of 3 minutes (e.g., Gansle et al., 2004) to a maximum of 175 minutes (Nathan, 2009), and 9 studies allowed students to write for as long as they needed. Sixty one percent of the studies ($n = 46$) did not provide information about the amount of time students were allowed to write.

2.1.3 Curriculum (and count) based Measures of Writing (CBM)

Curriculum Based Measures (CBM) or count-based measures of writing are quantitative indices which denote productivity. CBM measures are based on the amount of writing that was done, or the count of a specific element of writing. For example, common CBM measures include number of words, t-units, punctuation errors, number of correct words written, and words spelled correctly. CBM measures also include transformations of the count based measures such as percent of words spelled correctly and percent of correct word sequences, and type-token ratio which is the ratio of different words to total words written. Importantly, correct counts were included in the meta-analysis and incorrect counts were excluded. Incorrect counts included number of errors (such as grammatical and punctuation errors) as well as incorrect clauses. A complete list of the variables coded can be found in Ahmed (2013), but the following count variables were included as CBM measures of writing in the meta-analytic SEM: correct clauses, correct capitalizations, correct minus number of incorrect word sequence, correct letter sequence, number of adjectives, adverbs, connectives, nouns or pronouns, correct punctuation marks, correct words, clauses, different words, ideas, sentences, non-simple sentences, syllables, T-units, words, type-token ratio, T-unit (mean length), and words per sentence.

2.1.4 Handwriting

Handwriting measures included letter or alphabet writing, name writing, and handwriting fluency tests. For letter and alphabet writing, children were asked to write specific letters from
dictation, copy letters, or write all the letters of the alphabet. For name writing, children were asked to write their own names. Finally, for handwriting fluency, children were asked to write a sentence or the alphabet as many times as they can in a specified time period. Handwriting tasks are scored based on individual letter formations (for example, a lowercase “b” must be transcribed as a “stick” followed by a “ball” with no space in between), as well as correct sequence of letters (e.g., “b” must come after “a” and before “c” and “d”). Handwriting measures included measures that are specific to handwriting (such as the Expressive Orthographic Coding Task, Berninger 1993) but also included RAN tests as well as spelling tests that are scored for handwriting.

2.1.5 Spelling

Spelling measures required students to spell words with increasing difficulty from dictation. Standardized tests of spelling included the Test of Written Spelling (TWS-4; Larsen et al., 1999), The Vernon Graded Word Spelling Test (1977) and the Spelling subtest of the Wechsler Individual Achievement Test (The Psychological Corporation) and the Woodcock Language Proficiency Battery-Revised (Woodcock, 1991). Spelling scores that were assigned to writing prompts (such as percentage of words spelled correctly in the passage) were also included under spelling.

2.1.6 Vocabulary/Morphology

Standardized tests of vocabulary measures required children to define words presented orally or in a picture. Data from the following tests were included in the synthesis: Comprehensive Receptive and Expressive Vocabulary Test-Second Edition (CREVT-2; Wallace & Hammill, 2002), Expressive Vocabulary Test (EVT-2; Williams, 1997), Hundred Picture Naming Test (HPNT; Fisher & Glenister, 1992), Peabody Picture Vocabulary Test (PPVT-IV; Dunn & Dunn, 2007), Stanford-Binet Intelligence Scale (Thorndike, Hagen, & Sattler, 1986) and Wechsler
Individual Achievement Test (WIAT II, The Psychological Corporation, 2002). In addition, qualitative and quantitative indices of vocabulary (e.g., vocabulary in a written paragraph or sentence) and morphology (e.g., verb forms and noun inflections in a written passage) were also included under vocabulary/morphology because they provide an index of a child’s vocabulary knowledge.

2.1.7 Listening Comprehension

Most listening comprehension measures, such as the Test of Language Development (TOLD) and the Test of Reception of Grammar (TROG), required children to answer questions about passages that were read out loud to them, or to point to a picture that best describes the passage read. Some measures required children to listen to a sentence out loud and determine if it’s grammatically correct or incorrect. For younger children, sentences were read aloud and children were required to provide a word to finish a sentence. Finally, for one of the measures (Direction Following Task) participants were asked to carry out oral instruction involving placing shapes of different colors and sizes on colored spaces that varied in terms of color and size.

2.1.8 Oral Expression

Most oral expression tasks required children to orally generate a short story about a topic provided by the tester, a topic chosen by the student, or a picture that was presented by the tester. Oral expression also included story retelling where students were asked to retell a story read to them by the testers. The Delis-Kaplan Executive Function System (D-KEFS) Verbal Fluency Tests were also included in the synthesis. These tests required students to generate letters and exemplars from one or more categories in 60 seconds. The Oral Expression subtest of the Wechsler Individual Achievement Test (WIAT-II) included sentence repetition, giving directions for executing real-world tasks, verbal fluency, and visual passage retell items. The Descriptive Pragmatic Profile of
the Clinical Evaluation of Language Fundamentals (CELF-PK) was used to obtain teacher’s ratings of children’s conversational routines and skills as well as asking for, giving and responding to information were used. Finally, some studies tape recorded oral expression “passages” and scored them similar to written passages using indicators such as Total Number of Words and T-Units and Average Sentence Length.

2.1.9 Non-Verbal Reasoning

Non-verbal reasoning included Raven’s Colored Progressive Matrices (RAVEN’S) and the Block Design subtest of the WISC-R, which require analysis of visual part-whole relationships. Experimental measures included visual matrix, where children were asked to copy an increasingly difficult routine of tapping plastic chips in the correct order, and spatial organization, where children were asked to remember the order of small objects in an array and reproduce the sequence.

2.1.10 Working Memory

Working memory refers to the ability to process information while simultaneously processing unrelated information. Standardized tests of working memory, such as the Wide Range Assessment of Memory and Learning (WRMAL-2) were included in the synthesis. Several studies also adapted tests of phonological ability and rapid automatized naming, such that students were asked to recall a list of letters, words or non-words from these tests. The computer based Self-Ordered Pointing Task required students to update visual information and inhibit previous responses (see Aitken, 2011 for additional details). Importantly, several experimental working memory assessments included in this synthesis were categorized under different variables depending on the nature of the measure. For example, the story retelling measure included in Hoskyn & Tzoneva (2008) required students to retell an orally presented passage. This measure
was coded as oral expression rather than working memory in the present study, because the measure is more theoretically related to oral expression than to working memory.

2.1.11 Rapid Automatized Naming

RAN tasks require children to name words, colors or objects as soon as they see them. To keep consistency among studies, only studies that scored RAN as time to name a series of letters, pictures, objects or numbers were included. Thus, two studies providing correlations with RAN (Babayigit and Staintorp, 2010 & 2011) were not included because they scored RAN as correct number of items instead of the time to name items. Standardized measures of RAN included the Digits and Letters subtests of the Comprehensive Test of Phonological Processing.

2.1.12 Phonological Awareness

Phonological awareness refers to the knowledge of letter-sound correspondences. Several standardized tests of phonological awareness were included in the studies, as presented in Appendix C. Phonological tasks require children to know and manipulate the sound structures in words by completing words or by breaking down complete words. For example, the Incomplete Words subtest of the Woodcock Johnson Test of Cognitive Abilities (WJ-R) requires the child to identify a complete word after hearing a tape-recorded word with one or more phonemes missing, and the Begging Sound subtest of the Canadian Readiness Test, required the child to circle a picture whose name begins with the same initial phoneme as another word printed separately.

2.1.13 Decoding and Orthography

Decoding refers to the ability to read individual words or made-up words by breaking them into syllables. Orthography refers to the ability to represent sounds of language using letters. Standardized tests of decoding included the Word Identification and Word Attack subtests of the
Woodcock Johnson Tests of Achievement (WJ-III) and the Phonemic Decoding Efficiency and Sight Word Efficiency subtests of the Test of Word Reading Efficiency (TOWRE) which require children to read a list of increasingly complex words and non-words. Other standardized tests are listed in Appendix C. Orthography tests included the Expressive Orthographic Coding Task (EOCT) which required children to decide if a cluster of letters was found in a previously viewed word and the Homophone Choice Task (HCT) which required children to discriminate between words that are pronounced identically but spelled differently (e.g., rose vs. rows) and match them to pictures.
CHAPTER THREE

RESULTS

3.1 Replication of the Simple View of Reading

The first set of models replicated (Model 1a) and extended (Models 1b) the Simple View of Reading, by modeling linguistic comprehension as a latent variable comprised of listening comprehension, vocabulary/morphology and oral expression because recent evaluations of the Simple View of Reading have incorporated listening comprehension as well as oral vocabulary as indicators of language comprehensions (e.g., Tunmer & Chapman, 2012; Ouellette and Beers, 2010; Protopapas et al., 2012). Model 1a was similar to the Gough & Tunmer (1986) and Hoover & Gough (1990) additive model with structural paths from decoding to text reading as well as language comprehension to text reading (see Figure 1). However, because the present study utilized summary data, only the sum of decoding and listening comprehension (D + LC) can be evaluated, as multiplicative models with interactions (D x LC) cannot be evaluated. As presented in Table 2, the model provided an excellent fit to the data ($\chi^2 = 1.62, df = 4, AIC = 839.98, BIC = 864.14, RMSEA = 0.00, CFI = 1.00, TLI = 1.05, SRMR = 0.02$). The model results indicated that the language factor adequately captured the common variance between the listening comprehension ($\lambda = .72, p < 0.001$), vocabulary ($\lambda = .82, p < 0.001$), and to a lesser extent oral expression ($\lambda = .44, p < 0.001$). The results indicated that the model accounted for 73% of the variance in reading comprehension, with a significant effect of decoding on text reading ($\beta = .54, p < 0.001$) as well as language comprehension on text reading ($\beta = .47, p < 0.001$), and a significant correlation between decoding and the language comprehension factor ($r = .47, p < 0.001$). Note that Tunmer, one of the original proponents of the simple view of reading, and Chapman (2012) specified a directional path from language comprehension to decoding, because one of the
components of linguistic comprehension (vocabulary) was theorized to make a direct contribution to decoding. More recently, however, Wagner et al., (in press) presented a modeling exercise which demonstrates that a model with a directional path and a model with a correlation among exogenous variables are equivalent, because both models produce the same implied covariance matrix, as well as the same directional/correlational coefficient, and adequate evaluations of this causal relation necessitates longitudinal data. Thus, a directional path between decoding and linguistic comprehension was not specified in the replication of the simple view of reading.

In order to evaluate the Simple View of Reading with additional component skills a structural path from working memory was also added to the model. Similar to the previous model, the results for the second model showed that decoding ($\beta = .53, p < 0.001$) and linguistic comprehension ($\beta = .46, p < 0.001$) made contributions to text reading, but working memory did not make a significant contribution to text reading ($\beta = -02, p < 0.001$). The correlation between working memory and decoding ($r = .25, p < 0.005$) remained the same as in the synthesized correlation matrix because these variables were modeled as manifest variables, and the correlation between decoding and language ($r = .43, p < 0.001$) remained similar to the previous model. Model 1b also accounted for 73% of the variance in text reading.

Note that when additional covariates were added to the simple view of writing model, the model provided an adequate fit to the data ($\chi^2 = 10.58, df = 16$, AIC = 2184.15, BIC = 2301.34, RMSEA = 0.00, SRMR = 0.03, CFI = 1.00, TLI = 1.07), but none of the covariates made significant contributions to text reading, over and above the effect of decoding and linguistic comprehension to text reading. The covariates included phonological awareness, RAN, non-verbal reasoning, spelling and handwriting.
3.2 Component Skills of Writing

The next class of models evaluated the component skills of writing by modeling the effect of handwriting, spelling, working memory, and reasoning on writing (see Figure 2). Model 2a included working memory, as well as a latent variable for Transcription (comprised of spelling, $\lambda = .80$, $p < 0.001$, and handwriting, $\lambda = .54$, $p < 0.001$). Similar to the models of reading, this model provided an excellent fit to the data ($\chi^2 = 0.001$, $df = 1$, AIC = 724.72, BIC = 744.56, RMSEA = 0.00, SRMR = 0.00, CFI = 1.00, TLI = 1.14). The transcription factor made a significant contribution to writing quality ($\beta = .71$, $p < 0.001$), whereas working memory ($\beta = -.02$, $p > 0.05$) did not, and the model accounted for 50% of the variance in writing quality.

The structural portion of Model 2b and 2c were identical to Model 2a, but included curriculum based measures of writing and total number of words written, respectively, as outcome variables. Model 2b introduced a lack of model fit in comparison with the previous model, but provided an adequate fit to the data ($\chi^2 = 1.12$, $df = 1$, AIC = 735.44, BIC = 735.44, RMSEA = 0.00, SRMR = 0.00, CFI = 1.00, TLI = 0.98). Similar to the previous model, working memory ($\beta = -.02$, $p > 0.05$) did not make contributions to writing, whereas the effect of transcription was significant ($\beta = .71$, $p < 0.001$). As with the models of reading, a directional path was not specified between working memory and transcription as this would have resulted in an equivalent model.

The total number of words outcome variable was obtained by excluding all other count variables from the thirteen meta-analyses involving CBM measures of writing. Thus, an alternative correlation matrix was fit to the data which included the effect sizes for total number of words instead of curriculum based measures of writing. These values are presented in parenthesis in the first column of Table 1. Model 2c provided an adequate fit to the data based on some fit indices ($\chi^2 = 2.68$, $df = 1$, AIC = 737.23, BIC = 757.07, SRMR = 0.05, CFI = 0.95), and a poor fit to the
data based on other indices (RMSEA = 0.16 and TLI = 0.70). Note, however, that the TLI index depends on the magnitude of the correlation among the variables in the model, and if the correlations are not high, the TLI value will not be high. Similarly, RMSEA is dependent on sampling error, which tends to be higher for models with small degrees of freedom, and with smaller sample sizes. Thus TLI and RMSEA indices are generally not reported for meta-analytic SEM models (Becker, 2009). For example, also note the unusually high TLI value (1.14) for Model 2a, which provided an excellent fit to the data. Similar to Models 2a and 2b, the effect of transcription was significant (β = .61, p < 0.001), whereas the effect of working memory was not significant (β = -.04, p > 0.05), although the magnitude of the effects were smaller.

3.3 Joint Models of Literacy

In order to model both reading and writing processes, the component skills of the simple view of reading were specified as predictors of reading and writing. The mediation of component skills through text reading was also tested in Model 3a, in order to test direct and indirect relations among component skills and writing, and the extent to which text reading accounts for the relationship between language comprehension and writing, as well as decoding and writing. As Figure 3 shows, paths a and b are the direct effect of the independent variable on the mediator, and paths a’ and b’ are the direct effects of the independent variables on writing. Additionally, path c represents the direct effect of text reading on writing. Tracing the effects from writing to decoding, or language comprehension via text reading results in the indirect effect, which is also represented by a’ and b’. Because working memory did not make contributions to reading or writing in previous model, this variable was not included in the joint modeling of literacy skills.

As a first step all the variables were regressed on writing and the paths to reading were fixed to zero. Only text reading (β = .45, p < 0.001) made significant contribution to writing quality in
this model, whereas the effect of language (β = -0.07, p > 0.05), decoding (β = -0.03, p > 0.05) and transcription (β = 0.38, p > 0.05) were not significant. Because of the lack of a significant effect between language comprehension and writing, and decoding and writing, subsequent models did not include mediation (i.e., paths a’ and b’ were not tested). Model 3a (see Figure 4) provided an excellent fit to the data (χ² = 15.77, df = 16, AIC = 1330.58, BIC = 1374.67, RMSEA = 0.00, SRMR = 0.05, CFI = 1.00, TLI = 1.00). Decoding (β = 0.52, p < 0.001) and language comprehension (β = 0.50, p < 0.001) made significant contributions to text reading, which in turn made a significant contribution to writing quality (β = 0.38, p < 0.001). In addition, the effect transcription on writing quality was significant (β = 0.32, p > 0.05). The model accounted for 75% of the variance in text reading and 41% percent of the variance in writing quality. Subsequent models included CBM measures of writing (Model 3b) and number of words written (Model 3c) as the outcome variables. The model explained 42% of the variance in CBM writing, and the results indicated that the effect of transcription (β = 0.34, p < 0.001) was significant, but the effect of text reading was not significant (β = 0.12, p > 0.05). Finally, Model 3c only explained 12% of the variance in total number of words written, and neither transcription (β = 0.34, p > 0.05), nor text reading (β = 0.02, p > 0.05) were significant predictors.
a) Simple View of Reading with language as a latent variable.

b) Simple View of Reading with working memory as a covariate.

**Figure 1. Model 1a and 1b: Replication of the Simple View of Reading**

Note. LC = listening comprehension, V/M = vocabulary/morphology, OE = oral expression.
a) Writing model with writing quality as an outcome variable.

b) Writing model with curriculum (count) based measures of writing as an outcome variable.

Figure 2. Model 2a-2c: Writing model with different aspects of writing as an outcome variable.

Note. Dashed lines = non-significant paths, solid lines = significant paths. Spell = Spelling, HW = Handwriting, CBM = curriculum based writing, WQ = writing quality.
c) Writing model with total number of words written as an outcome variable.

**Figure 2 continued.**
Figure 3. Model of literacy with text reading as a mediator of the effects of decoding and language on writing. a and b = direct effects of the independent variables on the mediator; a’ and b’ = direct and indirect effects of the independent variables on the dependent variable; c = direct effect of the mediator variable on the dependent variable.
a) Joint model of reading and writing with writing quality as an outcome variable.

**Figure 4. Models 3a-3c: Joint models of reading and writing skills.**

*Note.* Dashed lines = non-significant paths, solid lines = significant paths. LC = listening comprehension, V/M = vocabulary/morphology, OE = oral expression, SPELL = spelling, HW = handwriting.
b) Joint model of reading and writing with curriculum based measures of writing as an outcome variable.

Figure 4 continued.
c) Joint model of reading and writing with total number of words written as an outcome variable.

**Figure 4 continued.**
Table 2. Model fit indices

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<th>RMSEA (RMSEA ≤ .05)</th>
<th>P</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
<th>R$^2$ Reading</th>
<th>R$^2$ Writing</th>
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<td><strong>Component Skills of Reading</strong></td>
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<td>839.98</td>
<td>864.14</td>
<td>829.51</td>
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<td><strong>Component Skills of Writing</strong></td>
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<td>0.33</td>
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<td>0.95</td>
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*Note.* *$p < 0.05$
CHAPTER FOUR

DISCUSSION

Meta-analytic structural equation modeling (SEM) was employed in the present study to determine the generalizability of the Simple View of Reading and Not-so-Simple View of Writing, as well as the joint modeling of these frameworks. Differences across studies may lead to heterogeneous conclusions about interrelations among component skills due to (a) differences in the unit of analysis at the sub-word, word, sentence or text levels, and (b) differences in the number and types of component skills included (e.g., linguistic variables such as vocabulary versus cognitive functioning variables such as working memory), (c) differences in qualitative versus quantitative aspects of the outcome skills, and (d) differences in modality of the measures used (for example, picture vs. verbal tests of vocabulary). Thus, meta-analytic procedures provide a useful tool for determining the heterogeneity in the effect sizes based on study-specific characteristics. Despite variations in sample characteristics as well as the characteristics of the measures, the exploratory meta-analysis of 77 studies yielded mostly homogeneous population correlations, and structural equation modeling was applied to the synthesized data (Becker, 1992). The first purpose of the study was to evaluate the Simple View of Reading as well as two components of the Not-so-Simple View of Writing. A second purpose was to expand these frameworks by adding working memory to the SVR, and linguistic comprehension as well as decoding to the NSVW in a joint model. A third purpose was to investigate differences in writing outcome variables by comparing qualitative writing scores and curriculum based measures of writing.
4.1 Simple View of Reading

Despite efforts to identify additional independent components of the SVR in previous research, the present study found evidence for the robustness and generalizability of the SVR because only decoding and language made contributions to reading, over and above working memory, as well as other covariates which have been previously examined in the context of the SVR (e.g., phonological awareness, RAN, and non-verbal reasoning). This study corroborates the finding that the language comprehension component of the SVR is a unitary construct which incorporates listening comprehension, and vocabulary (e.g., Tunmer & Chapman, 2012), but also oral expression. Few studies have evaluated the role of oral expression in the context of reading comprehension, as this construct occurs more frequently in the writing literature. Although most of the studies included in the meta-analysis defined oral expression as telling or retelling a story, some studies also defined this construct at the word and sentence levels. Hence, future studies are required to determine the role of oral expression at different levels of language (Santoro, 2012).

In addition, several studies have investigated the differences in accuracy and fluency of word reading skills (e.g., Silverman et al., 2013). The meta-analysis reported in the present study found that a construct which encompasses both word reading accuracy and speed behaves similarly to the word reading component proposed in the original model, although it is important to note that this effect size was one of the few heterogeneous effects. Florit and Cain (2011) conducted a fixed effects meta-analysis of 33 studies which examined the components of the SVR in English as well as transparent orthographies, and reported the correlations based on schooling years (i.e., students having spent more, or less time in school), as well as age. The results indicated that for English, decoding was more influential than linguistic comprehension in younger students, and for transparent orthographies linguistic comprehension was a stronger predictor of reading
comprehension. Specifically, the correlations for the younger cohort were .79, .84 and .89 for reading comprehension and non-word reading accuracy, word reading accuracy, and word reading fluency, respectively, whereas in the present study the correlation between word and non-word reading accuracy and fluency, and reading comprehension was .74. Similarly, they reported a correlation of .38 for linguistic comprehension, whereas the present meta-analysis found a correlation of .32 for listening comprehension. This similarity in the results of the meta-analyses is reassuring, given the small overlap in the studies included in both meta-analyses, as the present analysis focused on studies including component skills of reading as well as writing. However, the findings differ in that the application of SEM to meta-analytic data is better suited for making conclusions about the strength of the relationship among component skill of the SVR.

Contrary to studies which find that working memory plays an important role in reading comprehension (Seigneuric et al., 2000; 2005; Cain, Oakhill & Bryant, 2004), the present study did not find evidence for working memory as an independent predictor. It’s possible that the effects of working memory from previous studies of SVR are inflated because measures of working memory required reading words, in which case common method variance of the predictor and criterion skills necessarily confounds the results. In the present study the use of meta-analytic data yielded information about multi-modal working memory, which allowed us to investigate the construct of working memory outside of the context of reading. This approach allowed us to test whether working memory – the capacity to hold information in memory – is related to reading or writing, and that the effect is not significant because both reading comprehension and the working memory test required reading words. A meta-analysis provided one way to compare measures of the same construct in multiple domains (e.g., vocabulary skills as well as it’s usage in written and oral expression). However, the issue of common method variance remains an empirical question,
and studies that examine both reading and writing from a multi-trait multi-method (MTMM) approach might provide more insight.

4.2 Not-so-Simple View of Writing

Empirical evaluations of the NSVW in the SEM and path-analytic framework are difficult because the model includes several component skills, and does not clearly delineate structural paths among each of its components and sub-components. Despite this limitation, the present study supported components of the Not-so-Simple View of writing because our results indicate that transcription is a latent factor that is comprised of handwriting and spelling skills (Limpo & Alves, 2013), and is uniquely related to writing skills, both when writing is defined as the quality of written text, as well as the productivity of writing. It is likely that other components specified by the NSVW (i.e., executive functions such as switching/fluency and inhibition) are important predictors of written expression. As the model posits, these higher-order skills draw upon working memory capacity, but the present study showed that working memory was not causally related to writing when transcription and text reading are also in the model. Further research is necessary to empirically test the NSVW in a structural equation modeling framework to determine specific direct and mediational relations among constructs.

Although we found support for a unitary construct of transcription, the results indicated separable dimensions of written expression, as the components skills of writing were differentially related to writing quality, cumulative curriculum based measures of writing, as well as total number of words written. Although transcription skills were related to all aspects of writing, text reading was related to writing quality, but not writing productivity. These results are in line with research that shows that these constructs represent separable aspects of writing. For example,
Wagner et al. (2011) have found that productivity represents one dimension of written expression, whereas macro-organization and complexity represent additional dimensions.

### 4.3 Joint Model of Literacy

The joint models of literacy showed that reading exerts an influence on writing, over and above language, and word decoding. Importantly, the components of the SVR made direct contributions to text reading, and were not related to writing. Although it was hypothesized that decoding and language would be implicated in writing because of their relation with text reading, the components of the SVR were not related to writing. This finding is contrary to research which shows that language plays an important role in written expression, even after controlling reading comprehension (Berninger & Abbott, 2010).

Language skills are possibly related to reading because reading is highly dependent on another person’s language skills (i.e., the text’s author). Because readers are expected to understand another person’s vocabulary as well as syntactic and grammatical usage, it is likely that a person’s own linguistic skills aid the understanding of text. On the other hand, writing requires creating text using all the linguistic skills that individuals have at their disposition. It’s possible that developing writers produce quality texts (i.e., error-free texts) despite individual differences in depth and breadth of linguistic knowledge.

The finding that writing is more related to reading than to language is important because it suggests that writing should be studied in the context of literacy, in addition to the context of language. The implications are that reading and writing are highly related, and the shared variance is not due to language, but rather literacy factors that go beyond word level skills (decoding and spelling). Thus, it’s possible that factors that are specific to a reader’s interaction with written text
might play an important role. For example, the role of inference making and reading strategies for the purpose of understanding text has been widely explored (e.g., Cain, Bryant & Oakhill, 2004; Cromley & Azevedo, 2007). Information in the text is integrated with a reader’s background knowledge, and the “situation model” described in the text is constantly updated as the reading process unfolds. By comparison, it’s possible that adequate readers also understand how to construct a “situation model” in writing, and this skill might be more related to the reader’s knowledge and experience with text than their language skills.

4.4 Limitations

The results from the present study need to be interpreted in the context of several limitations. Firstly, the random effects, exploratory meta-analysis did not include the original Gough & Tunmer (1986), and Hoover and Gough (1990) studies, but did include the Juel, Griffith and Gough (1986) study, because the purpose of the meta-analysis was to identify studies which are related to both reading as well as writing. It is thus possible that results would vary if studies which explicitly test the SVR are included in the analysis and if specific aspects of the components are tested (e.g., word reading accuracy and fluency). However, note that the overlap in the Florit and Cain (2011) meta-analysis and the present study suggest that the correlations were similar in these sets of studies. Furthermore, the present meta-analysis included measures of reading comprehension as well as passage-level reading fluency for the construct of text reading. Although these variables are highly correlated, they represent distinct aspects of reading. This was also the case for oral expression as expressive language was defined in the meta-analysis as producing narratives, sentences or words, and no clear distinction was made based on levels of language. Secondly, the current study only examined two components of the NSVW, and the meta-analysis
identified the need for more extensive future work that specifically targets the components of the NSVW.

A third limitation involves the analysis of meta-SEM models using a univariate approach. Alternative approaches such as generalized least squares (GLM; Becker, 1992, 1995), two-step SEM (TSSEM; Cheung, 2013) as well as bootstrap and Bayesian analyses (Prevost et al., 2007) can be applied to fully account for the multivariate nature of the synthesized matrix, as sensitivity analyses have determined that multivariate approaches are less biased and more precise than univariate approaches (Cheung & Chan, 2005).

4.5 Conclusions

The strength of the present study is that we have included several measures of reading as well as writing, and have explored two main aspects of writing: a) quality of writing and b) amount of writing, or productivity. Our results indicated that the Simple View of Reading was generalizable using meta-analytic data from 77 studies, and the SVR was not extended to writing, but text reading was an important predictor of writing along with transcriptions skills. An important implication is that when the entire distribution of bottleneck variables such as decoding and spelling are investigated, then the SVR and NSVW are generalizable. However, an important question that remains unanswered is which component skills would be relevant for children who struggle with reading comprehension or text composition despite adequate word and/or spelling skills? Importantly, the results from the present study also suggested that additional component skills (such as working memory) are, in fact, correlated with reading as well as writing but future studies should examine the nature of reading and writing skills in the context of literacy rather than language-specific and cognitive-specific contexts.
APPENDIX A

LITERATURE SEARCH

An initial search was carried out using the following databases: ProQuest (PsychInfo), ProQuest (Dissertations and Theses, PQTD), ERIC, and Google Scholar. As a first search criterion, studies had to include the word "write" or variations thereof in the title. An asterisk after a word, or the root of a word (eg., writ*) was used in order to retrieve all related terms to that word, such as written expression, writing development, writers, etc. As a second criterion, the abstracts had to include the words predict*or develop* to assure retrieval of empirical studies. Finally, studies had to have one of the following keywords: writ*, spell*, handwriting, language*, literacy, short term memory, or working memory. Qualitative studies, case studies, interviews, focus groups and literature reviews were excluded from the search. The age-group was specified to be childhood (birth-12 years), and only studies published in English were searched. The search was conducted on March 6th, 2012, and yielded 580 studies. A second wave of literature search was conducted in order to find estimates for effect sizes that had not returned results in the first wave of data search. Several combinations of keywords were used in the same databases as before. The specific literature search criteria entered in ProQuest (PsychInfo) is provided below. Literature searches on other engines were similar:

(ti(writ*) AND ab(predict* OR develop*) AND su((writ* OR spell* OR handwriting OR listening* OR language* OR short term memory OR working memory OR literacy)))

Narrowed by

- **Source type:** NOT Books
- **Age Group:** Childhood (birth-12 Yrs)
- **Methodology:** NOT (Qualitative Study AND Nonclinical Case Study AND Interview AND Literature Review AND Clinical Case Study AND Focus Group)
- **Language:** English.
## APPENDIX B

### STUDIES INCLUDED IN THE META-ANALYSIS

Table 3. Studies ($n = 77$) and independent samples ($k = 108$) included in meta-analysis.

<table>
<thead>
<tr>
<th>Study</th>
<th>Grades</th>
<th>Independent Samples N (% female)</th>
<th>Typically Developing vs. Other Participant Characteristics</th>
<th>English vs. Other Languages</th>
<th>Peer Reviewed Journal vs. Dissertation</th>
<th>Writing Prompts vs. Other Measures</th>
<th>Narrative, Expository and Other Genres</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Abbott &amp; Berninger, 1993</td>
<td>1</td>
<td>100 (50)</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>WP</td>
<td>N &amp; E</td>
<td>story starter</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>100 (50)</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>100 (50)</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>100 (50)</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
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<td>E</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>6</td>
<td>100 (50)</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Abbott et al., 2010</td>
<td>4</td>
<td>241 (53)</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>WIAT Written Expression</td>
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<td>n/a</td>
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<td></td>
<td>4 &amp; 5</td>
<td>45</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td>story starter</td>
</tr>
<tr>
<td>3) Aitken, 2011</td>
<td>4</td>
<td>45</td>
<td>TD</td>
<td>E</td>
<td>D</td>
<td>WP</td>
<td>N</td>
<td>story starter</td>
</tr>
<tr>
<td>4) Albuquerque, 2012</td>
<td>1</td>
<td>70 (46)</td>
<td>Portuguese</td>
<td>PRJ</td>
<td>TOWL</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td></td>
<td>1</td>
<td>120</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>4</td>
<td>120</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>5</td>
<td>122 (34)</td>
<td>dyslexia</td>
<td>E</td>
<td></td>
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<td>n/a</td>
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</table>

Note. 1 These studies provided an intervention on writing or writing related skills; they were included in the meta-analysis because they reported pre-test correlations on typically developing children. *grade levels were estimated from ages. DCD = Developmental Coordination Disorder, ELL = English Language Learner, ESL = English as Second Language, ERRNI = Expression, Reception, and Recall of Narrative Instrument, LD = learning disability, LEP = Limited English Proficient, MAEP = Michigan Educational Assessment Program, MAP = Missouri Assessment Program, MZ = monozygotic, SHELL = School-Home Early Language and Literacy Assessment, SLI = Speech and Language Impairment, SPEP = State Proficiency Examination Program, TOWL = Test of Written Language, WASL = Washington Assessment of Student Learning, WIAT II = Wechsler Individual Achievement Test, WJ-R BWLC= The Woodcock Johnson-Revised Broad Written Language Cluster.
<table>
<thead>
<tr>
<th>Study</th>
<th>Grades</th>
<th>Independent Samples N (% female)</th>
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<th>Narrative, Expository and Other Genres</th>
<th>Task</th>
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</thead>
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<tr>
<td>6) Apel et al., 2010</td>
<td>2 &amp; 3</td>
<td>56</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>7) Apel, 2010</td>
<td>K</td>
<td>41 (59)</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>8) Aram &amp; Levin, 2004\textsuperscript{1}</td>
<td>K</td>
<td>38 (53)</td>
<td>TD</td>
<td>Hebrew</td>
<td>PRJ</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td>9) Babayigit &amp; Staintrop, 2010</td>
<td>1</td>
<td>57 (47)</td>
<td>TD</td>
<td>Turkish</td>
<td>PRJ</td>
<td>WP</td>
<td>N</td>
<td>picture prompt</td>
</tr>
<tr>
<td>10) Babayigit &amp; Staintrop, 2011</td>
<td>2 &amp; 4</td>
<td>103 (52)</td>
<td>TD</td>
<td>Turkish</td>
<td>PRJ</td>
<td>WP</td>
<td>N</td>
<td>picture prompt</td>
</tr>
<tr>
<td>11) Bae, 2007</td>
<td>1 &amp; 2</td>
<td>192</td>
<td>TD &amp; ELL</td>
<td>E</td>
<td>PRJ</td>
<td>WP</td>
<td>N</td>
<td>picture prompt</td>
</tr>
<tr>
<td>12) Balloussis, 2010</td>
<td>3, 5 &amp; 8</td>
<td>105 (72)</td>
<td>TD</td>
<td>E</td>
<td>D</td>
<td>WP</td>
<td>N &amp; persuasive</td>
<td>scenario</td>
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<td>13) Ball, 2003</td>
<td>3</td>
<td>56</td>
<td>TD</td>
<td>E</td>
<td>D</td>
<td>TOWL-III</td>
<td>expressive, descriptive</td>
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<td></td>
<td>3</td>
<td>62</td>
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<td>E</td>
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<td></td>
<td>5 &amp; 6</td>
<td>48</td>
<td>ESL</td>
<td>E</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14) Berninger &amp; Abbott, 2010</td>
<td>1</td>
<td>122 (56)</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>WIAT-II Paragraph Writing</td>
<td>n/a</td>
<td>n/a</td>
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<tr>
<td></td>
<td>5</td>
<td>106 (51)</td>
<td>TD</td>
<td>E</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15) Berninger et al., 1992</td>
<td>1-3</td>
<td>300 (50)</td>
<td>TD; rural, suburban &amp; urban</td>
<td>E</td>
<td>PRJ</td>
<td>WP</td>
<td>N &amp; persuasive</td>
<td>story starter</td>
</tr>
<tr>
<td>16) Berninger et al., 2006</td>
<td>1</td>
<td>128 (55)</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>WIAT-II Written Expression</td>
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<td>n/a</td>
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<td></td>
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<td>TD</td>
<td>E</td>
<td></td>
<td></td>
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<tr>
<td>17) Berninger et al., 2011</td>
<td>1</td>
<td>128</td>
<td>TD</td>
<td>E</td>
<td>PRJ</td>
<td>n/a</td>
<td>n/a</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>113</td>
<td>TD</td>
<td>E</td>
<td></td>
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<td>Task</td>
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<td>75) Vellutino et al., 2004</td>
<td>2 &amp; 3</td>
<td>297 TD E</td>
<td>PRJ</td>
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<td>76) Wagner et al., 2011</td>
<td>1</td>
<td>98 TD E</td>
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<td>77) Welsh et al., 2003</td>
<td>PK*</td>
<td>3546 (50) TD E</td>
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APPENDIX C

FOREST PLOTS FOR SELECTED META-ANALYSES

a) Forest plot for decoding/orthography & spelling (homogeneous effect size).

**Figure 5. Forest plots for selected meta-analyses.**

*Note.* Effect sizes were corrected for reliability as well as range restriction. The summary (overall) statistic appears at the top of the graph and the vertical line references the distance between a study specific effect size and the overall effect size.
b) Forest plot for phonological awareness & handwriting (heterogeneous effect size).

Figure 5 continued.
c) Forest plot for writing quality & reading comprehension (heterogeneous effect size).

Figure 5 continued.
d) Forest plot for decoding/orthography & reading comprehension (heterogeneous effect size).

Figure 5 continued.
APPENDIX D

LIST OF TESTS AND SUB-TESTS CODED BY CONSTRUCT

*Note.* Test authors and publication year are provided along with the tests, but citations were taken from the original studies and are not included in the references for this study.

**Decoding/Orthography**

1. ALA = *McGuffey Reading Center’s Assessment of Literacy Acquisition* (Invernizzi & Bloodgood, 1991).

2. BRT = *Beginner’s Reading Test* (Airo, Roman & Tuononen, 1985).

3. BRYANT = *Bryant Test of Basic Decoding Skills* (Bryant, 1975).

4. EOCT = *The Expressive Orthographic Coding Task* (Berninger, 1993).

5. GRADE = *Group Reading and Diagnostic Evaluation test* (GRADE; Williams, 2001).


7. HPCT (adapted) = *The Homophone/Pseudohomophone Choice Task* (Olson, Kliegl, Davidson, & Foltz, 1985; Olson et al., 1989).


9. TOWRE = Test of Word Reading Efficiency (Torgesen, Wagner & Rashotte, 1999).
   a. SWE = Sight Word Efficiency.
   b. PDE = Phonemic Decoding Efficiency.


   a. WID = Word Identification
   b. WA = Word Attack.


15. WRMT-R = Woodcock Reading Mastery Test (Woodcock, 1987).
   a. WID = Word Identification
   b. WA = Word Attack.

**Handwriting**

1. ALA = *McGuffey Reading Center’s Assessment of Literacy* (Invernizzi & Bloodgood, 1991).


3. GDRA = *Group Diagnostic Reading Aptitude and Achievement Tests* (Monroe & Sherman, 1966).

4. NWS = *Name Writing Scale* (Haney, 2003).

   a. AW = Alphabet Writing.
   b. D = Digits.
   c. L = Letter.

   a. WWF = Written Word Fluency.
   a. C = Coding.

   a. S = Spelling.

**Non-verbal Reasoning**


2. WASI = *Wechsler Abbreviated Scale of Intelligence* (Wechsler, 1999).
   a. BD = Block Design.
   b. MR = Matrix Reasoning.

**Listening Comprehension**


   a. SS = Sentence Structure.
   b. WS = Word Structure.


4. DFT = *Direction Following Task* (in Balioussis, 2010, pg. 78; Agostino et al., 2010)

5. IOWA = *IOWA Test of Basic Skills* (Hieronymous, Lindquist & Hoover, 1980).


8. LC = Listening Comprehension.
   a. LC = Language Comprehension.
    a. SI = Sentence Imitation.
    b. GC = Grammatic Completion.
11. TROG = The Test for Reception of Grammar (Bishop, 1989).
12. WIAT II = Wechsler Individual Achievement Test, 2 (The Psychological Corporation, 2002).
13. SEN COMP = Sentence Comprehension.
15. WIS-R = Wechsler Intelligence Scale- Revised (Wechsler, 1974).
   a. LC = Listening Comprehension.

Oral Expression

   a. DPP = Descriptive Pragmatic Profile.
   a. LF = Letter Fluency.
   b. CF = Category Fluency.
c. CS = Category Switching.


   a. GD = Giving Directions.
   b. OES = Oral Expression.
   c. OWF = Oral Word Fluency.
   d. VPR = Visual Passage Retell.

**Phonological Awareness**


2. BANC = *Neuropsychological Assessment Battery of Coimbra* (BANC; Simoes et al., 2008).

3. CRT(2) = *Canadian Readiness Test* (CRT; 1975).
   a. BS = Beginning Sounds.

4. CTOPP = *Comprehensive Test of Phonological Processing* (Wagner, Torgesen, & Rashotte, 1999)
   a. E = Elision.
   b. B = Blending.

5. DIBELS = *Dynamic Indicators of Basic Early Literacy Skills* (5th ed.; Good, Kaminski, Smith, Laimon, & Dill, 2001)
   a. LNF = Letter Name Fluency.
   b. LSF = Letter Sound Fluency.
c. **PSF** = Phoneme Segmentation Fluency.

6. **GFW** = *GFW Sound Symbol Test* (Goldman, Fristoe, & Woodcock, 1974).

7. **HKT** = *Hong Kong Test of Specific Learning Difficulties in Reading and Writing* (Ho et al., 2000).

8. **PAT** = *Phonological Awareness Test* (Robertson & Salter, 1997).
   a. **A** = Alphabet.


10. **SDRT** = *Stanford Diagnostic Reading Tests* (Karlsen, Madden, & Gardner, 1976).


   a. **IW** = Incomplete Words.

**RAN**

1. **CTOPP** = *Comprehensive Test of Phonological Processing* (Wagner, Torgesen, & Rashotte, 1999)
   a. **D** = Digits.
   b. **L** = Letters.

2. **RAN** = *Rapid Automatized Naming* (Denckla & Rudel, 1974, 976).
**Reading Comprehension**

1. **ALA** = *McGuffey Reading Center’s Assessment of Literacy Acquisition* (Invernizzi & Bloodgood, 1991).
   a. **FR** = Finger-point Reading.
2. **CRT** = *Criterion Referenced Test-Reading* (State Department of Education, 2007).
3. **CRT [2]** = *Canadian Readiness Test* (Canadian Readiness Test; 1975).
   a. **DRP** = Degrees of Reading Power.
5. **GM** = *Gates–MacGinitie* (MacGinitie, MacGinitie, Maria, & Dreyer, 2000).
7. **GRADE** = *Group Reading and Diagnostic Evaluation test* (GRADE; Williams, 2001).
8. **IOWA** = *IOWA Test of Basic Skills* (Hieronymous, Lindquist & Hoover, 1980; The University of Iowa College of Education, 2007).
11. **NARA-II** = *Nealy Analysis of Reading Ability* (Neale, 1997).
12. **RPT** = *Reading Performance Test* (Aunola et al., 2002).
15. **WIAT II** = *Wechsler Individual Achievement Test, 2* (The Psychological Corporation, 2002).
16. **RC** = Reading Comprehension.

18. WRMT-R = Woodcock Reading Mastery Test (Woodcock, 1987).

**Spelling**

1. DTRS = *Diagnostic Tests of Reading and Spelling* (Poskiparta, Niemi & Lepola, 1994).


   a. S = Spelling


   a. S = Spelling Subscale.


   a. D = Dictation.

**Vocabulary**


3. HPNT = *Hundred Picture Naming Test* (HPNT; Fisher &Glenister, 1992).

4. PPVT = *Peabody Picture Vocabulary Test-IV* (Dunn & Dunn, 2007).

5. SB = *Stanford-Binet Intelligence Scale-IV Edition* (Thorndike, Hagen, & Sattler, 1986)
6. SDRT= *Stanford Diagnostic Reading Tests* (Karlsen, Madden, & Gardner, 1976).

7. WIAT II = *Wechsler Individual Achievement Test, 2* (The Psychological Corporation, 2002).
   
a. EV = Expressive Vocabulary.

   b. RV = Receptive Vocabulary.

**Working Memory**

1. CTOPP = *Comprehensive Test of Phonological Processing* (Wagner, Torgesen, & Rashotte, 1999).
   
a. NW = Non-word Repetition.

   b. EL = Elision.


3. SOPT = *Self-Ordered Pointing Task* (Petrides & Milner, 1982).

4. WISC = *Wechsler Intelligence Scale for Children-IV-Integrated*
   
a. DS = Digit Span.

   b. SS = Spatial Span.

   
a. PM = Picture Memory.

   b. SM = Story Memory.

   c. VL = Verbal Learning.

   
a. NR = Numbers Reversed.
**Writing**

1. ERRNI (adapted) = *Expression, Reception, and Recall of Narrative Instrument* (Bishop, 2004).

2. MAEP = *Michigan Educational Assessment Program*.


   
   i. WC = Writing Concepts.

5. SPEP = *State Proficiency Examination Program Fifth-Grade Writing Assessment* (State Department of Education: *Writing Assessment*).

6. STEP-W = Sequential Test of Educational Progress - Writing (ETS, 1979).


   
   a. SC = Story Construction.


10. WESSE-E = *the Writing Essential Skill Screener - Elementary Version* (in Erford et al., 2001)

11. WIAT II = *Wechsler Individual Achievement Test, 2* (The Psychological Corporation, 2002).
   
   a. WE = Written Expression.
   
   b. WWF = Written Word Fluency.
c. PW = Paragraph Writing.


   a. WE = Written Expression.
   b. WS = Writing Samples.


   a. BWL = Broad Written Language.
   b. WS = Writing Samples.
REFERENCES


Yusra Ahmed completed her Associate of Arts degree from Florida State University, Republic of Panama, in December 2005. She pursued and completed a Bachelors degree in Psychology from Florida State University, Tallahassee, in August 2008. She worked at Florida State University as a Research Assistant with Dr. Rick Wagner and Dr. Ralph Radach. As the Bess H. Ward scholar she also completed an honors thesis in Clinical Psychology with Dr. Joyce Carbonelle, Dr. Doris Gray and Dr. Ashby Plant.

Yusra completed her MS degree in Fall 2011, and as the Eugenia and Russell Morcom Fellow, she completed her PhD degree in Developmental Psychology also from Florida State University in the Summer of 2014. In the Fall of 2012, she started working at the Texas Institute for Measurement, Evaluation and Statistics at the University of Houston, where she currently holds a postdoctoral position. Her research interests include the development of reading comprehension in young and older students, co-development of reading and writing skills, language proficiency of Spanish-speaking English Language Learners and identification and classification of learning disabilities.