Writing Abilities of Adolescents with and without ADHD and the Role of Inattention

by

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Abstract

Adolescents with ADHD are at risk for academic and future occupational difficulties. Despite the importance of strong writing skills for educational and occupational success, the writing abilities of adolescents with ADHD are not well understood. I examined group differences in writing ability between adolescents with and without a parent-reported ADHD diagnosis and the extent to which inattention symptoms uniquely predicted writing ability independent of variables related to written expression such as handwriting fluency and reading. Findings indicated that adolescents with ADHD performed significantly lower than their same-age peers on the writing outcomes of text length, sentence-writing, and vocabulary sophistication, although once handwriting fluency was controlled for in the analyses, statistically significant group differences remained only for vocabulary sophistication. Analyzing the sample using a dimensional approach, inattention symptoms only uniquely predicted sentence-writing ability independent of writing-related variables. Instead, handwriting fluency appears to be a vital transcription skill to higher-level writing abilities.
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Introduction

1.0 Background on ADHD

1.1 Prevalence and Diagnostic Criteria

Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder occurring in approximately 5% of children and 2.5% of adults (American Psychological Association, 2013). ADHD is comprised of two symptom dimensions: inattention and hyperactivity-impulsivity, and individuals can be diagnosed as one of three subtypes: predominately inattentive presentation, predominantly hyperactive-impulsive presentation, or combined presentation. Individuals must show a minimum of six symptoms of inattention and/or hyperactivity, before the age of 12, in two or more settings, and those symptoms must be impairing to the individual’s functioning in the social, academic, or occupational domains (American Psychological Association, 2013).

The symptoms of ADHD occur at varying levels throughout the population, and once they reach the clinical level and become impairing to everyday functioning across settings, a child or adolescent can be diagnosed with ADHD. However, genetic research exploring individual variation in ADHD symptoms within community-based samples shows that ADHD is best conceptualized as the far end of the ADHD-symptom spectrum, a spectrum everyone is on (e.g., Levy, Hay, McStephen, Wood, & Waldman, 1997). Thus, while the population is divided into groups of individuals diagnosed with ADHD and those who are not, ADHD symptoms occur genetically in the entire population at varying levels.

1.2 Impairments in Adolescents with ADHD

While ADHD symptoms must be present before the age of 12 for a diagnosis, symptoms of ADHD can persist well into adolescence and remain impairing across areas of functioning,
including academics (Bussing, Mason, Bell, Porter, & Garvan, 2010). Research on adolescents with ADHD has identified pervasive and persistent difficulty with academics across subject areas (Frazier, Youngstrom, Glutting, & Watkins, 2007; Rogers, Hwang, Toplak, Weiss, & Tannock, 2011), as well as lower expressive oral language abilities than adolescents without ADHD (Rucklidge & Tannock, 2001). Occupationally, adolescents with ADHD are less likely to gain future full-time employment and earn income as high as their typically functioning peers (Biederman & Faraone, 2006), resulting in greater financial dependence on family members or social assistance in adulthood (Altszuler et al., 2016).

Adolescents with ADHD are also more likely than their typically-functioning peers to experience difficulties in the cognitive domain. For example, adolescents with ADHD exhibit deficits in their executive functions (Martel, Nikolas, & Nigg, 2007), a set of cognitive processes that are necessary for goal-directed behaviour, such as shifting and response inhibition. One specific executive function of note is working memory, the ability to hold information in mind and manipulate it (Baddeley & Hitch, 1974). Working memory has been found to be associated with many domains of academic achievement (Alloway & Alloway, 2010; Gathercole, Pickering, Knight, & Stegmann, 2004), and is a deficit observed in children and adolescents with ADHD (Fried et al., 2016; Kofler et al., 2017).

1.3 What is missing in this research?

Difficulties with decoding, reading comprehension, executive functions, and oral language are all associated with ADHD (Martel et al., 2007; Rucklidge & Tannock, 2001) as well as with written expression (DeBono et al., 2012). As a result, impairments in written expression are also likely experienced by adolescents with ADHD. Despite this likelihood, few studies have explored writing proficiency and the correlates of written expression skills in youth with ADHD.
Thus, this thesis focuses on examining group differences in two different assessments of writing ability between adolescents with and without ADHD. I also examine the role of behavioral inattention symptoms in uniquely predicting youths’ performance on various indicators of writing proficiency independent of variables that are believed to be important to writing such as handwriting fluency and decoding ability. In the next section, I highlight why writing is an important domain to study in ADHD, particularly in adolescents with ADHD.

2.0 The Importance of Writing

The ability to generate well-written text has important implications for everyday life. Not only is writing a primary method of communication and connection between people, it is a foundational literacy skill that is essential for school, employment, and daily living (Graham & Perin, 2007). One of the most commonly used models to study writing is the Simple View of Writing (Berninger & Graham, 1998). According to the Simple View of Writing, writing ability can be thought of as a triangle of three components. Transcription, encompassing skills such as handwriting and spelling, allows the writer to create the orthographic representation of their ideas. Text generation is the active process of constructing the written content, referring to composing words, sentences, and passages. Lastly, executive functions, such as attention, planning, and reviewing are necessary processes to complete this goal-directed behaviour.

Writing is a cornerstone academic skill, as secondary and post-secondary students generate text to demonstrate their knowledge in the classroom. Writing gives students a process to explore, organize, and interpret information on their own (Durst & Newell, 1989). Adolescents who are weak writers are likely to have lower grades as a result, particularly when writing is used in course assessments (Graham, 2006), this then reduces future academic opportunities
dependent on strong grades. Additionally, writing itself serves as a learning tool (Bangert-drowns et al., 2016; Graham, Gillespie, & McKeown, 2013). Some scholars interpret writing so similarly to thinking and learning that they theorize writing as a physical manifestation of these latent processes (e.g., Emig, 1977). Unfortunately there is a gap in the research on the relation between writing and learning, although there is some evidence that writing can improve school achievement (Bangert-drowns et al., 2016), and students’ learning of the material they are writing about (Graham & Perin, 2007). Writing ability is also linked to reading, and teaching writing has been found to improve word-reading, reading comprehension, and reading fluency abilities (Graham & Hebert, 2011), which indicates that students gain reading skills through the process of writing.

High school is an especially important time for the development of proficient writing skills. By the end of grade 12, students are expected to express and organize ideas in written form to effectively communicate those ideas to different audiences with correct grammar, spelling, and punctuation (Ministry of Education, 2007). For many individuals, the end of high school marks the end of formal education in writing, and they are expected to have gained the necessary skills for advancement in education or employment.

Once students graduate and begin employment, writing ability continues to be a vital skill. At the very least, most job applications require a written CV or resume, and a cover letter. The United States National Commission on Writing (2004) surveyed employers and found that writing is a “threshold skill” to gain both initial employment and subsequent advancement in one’s profession. Further, in the job sectors with the greatest employment growth, 80% or more of companies assess the writing ability of their job applicants, and half of all companies consider
writing ability when making decisions on promotions. Thus, the ability to write is a necessary skill for occupational success in many fields.

While there are many skills involved in producing a written text, one key skill is handwriting fluency. Although one might argue that in an increasingly technological age, handwriting is obsolete; it continues to be an important skill. Handwriting speed is highly correlated with typing speed (Connelly, Gee, & Walsh, 2007), which means that developing strong handwriting skills is important for optimal typing abilities. Additionally, the neural connection between sound and motor regions may be strong in those who are more proficient hand writers, which would also make them faster at typing. Moreover, the physical process of handwriting has been found to be related to better text generation (Berninger et al., 1997). Handwriting is also often used by adolescents and young adults to capture lecture notes in high school or college and evidence demonstrates that slow handwriting constrains note quantity and quality, which in turn negatively affects written test performance (Peverly et al., 2013). Lastly, and perhaps most importantly, handwriting itself, along with spelling, have been found to predict both writing fluency and writing quality in elementary school students (Graham, Berninger, Abbot, Abbot, & Whitaker, 1997). The mechanical aspects of handwriting appear to be an important factor in overall writing proficiency.

3.0 Writing and ADHD

3.1 Transcription Skills and ADHD

Less proficient writing is seen early in children with ADHD; in the area of transcription, handwriting deficits are noted as early as 6 years of age (Brossard-Racine, Majnemer, Shevell, Snider, & Bélanger, 2011). In a meta-analysis by Brossard-Racine et al. (2008) that examined 12 studies published between 1977 and 2006, the authors concluded that although there was little
research available on the handwriting of children with ADHD, preliminary evidence suggests that children with ADHD often experience impaired handwriting in comparison to children without ADHD. Among the available studies, less legible writing, including poor word and letter spacing, and slower handwriting speed were noted as specific impairments. However, several limitations from the available studies emphasized the need to extend research with greater sample sizes and control groups of children without ADHD.

Consistent with Brossard-Racine et al.’s meta-analysis, Graham et al.’s (2016) recent meta-analysis included 10 studies on handwriting abilities in students with ADHD ranging from elementary school to early high school, all of which found lower handwriting scores for students with ADHD, with an average weighted effect size of -0.62, indicating a moderate effect of ADHD on handwriting ability. When Graham et al. examined handwriting legibility separately from speed, they again found moderate effect sizes (legibility ES = -0.79 and fluency ES = -0.60).

In an article that was not included in either Brossard-Racine et al.’s (2008) or Graham et al.’s (2016) meta-analyses, Brossard-Racine, Majnemer, Shevell, Snider, and Bélanger (2011) examined handwriting in children newly diagnosed with ADHD who were medication naïve. Participants completed a battery of handwriting tasks including writing the alphabet in uppercase and lowercase, and sentence composition. The authors found that children with ADHD produced writing with poorer legibility of words, letters, and numbers compared to previously published results of normative samples, and that these handwriting difficulties were associated with motor skills such as visual-motor integration. They also found that the older children in their sample, 11-year olds, had better legibility and faster handwriting speed than the 6-year olds. However, the authors noted a significant limitation in the lack of a typically-functioning control group.
Beyond handwriting, transcription also encompasses spelling ability (Berninger, 2000), children with ADHD exhibit deficits in spelling as well (Graham et al., 2016). In their meta-analysis, Graham et al. (2016) found that in 24 studies on spelling in students with ADHD between grades 1 and 12, all studies indicated lower spelling scores in the students with ADHD versus their typically-functioning peers. However, only several of these studies controlled for comorbid reading abilities. The average weighted effect size was -0.80, indicating a large negative association between ADHD and spelling ability in childhood and adolescence.

Considering the transcription skills of adults with ADHD, one might predict that their handwriting does not significantly differ from adults without ADHD, given Brossard-Racine et al.’s (2011) finding that in children, older age is associated with better legibility and faster handwriting speed. Although research on the handwriting abilities of adults with ADHD is scarce, one study examined adults retrospectively diagnosed with ADHD and found no differences in their handwriting to a control group of adults on a fluency task (Tucha & Lange, 2004). Regarding spelling, little research has investigated spelling abilities of adults with ADHD, although one study reported that adults with ADHD performed lower on standardized spelling tasks than their peers (Frazier et al., 2007).

Thus, transcription skills appear to be impaired in children and adolescents with ADHD. In terms of handwriting, difficulties have been noted with poorer legibility, longer length of time to complete writing, and differences in handwriting speed (Brossard-Racine, Majnemer, Shevell, & Snider, 2008; Graham et al., 2016). Unfortunately, the handwriting abilities of older adolescents and young adults with ADHD have received very little attention in the literature, and although one study suggests that there are no differences in handwriting in adults with and without ADHD (Tucha & Lange, 2004), more research is needed. Regarding spelling, students with ADHD score
lower than their peers on spelling measures across childhood and adolescence and into adulthood (Graham et al., 2016; Frazier et al., 2007). However, it is not clear whether lower spelling proficiency occurs when reading proficiency is controlled for.

3.2 Text Generation and ADHD

Beyond transcription, deficits in text generation are also evident in children with ADHD (Graham et al., 2016). In Graham et al.’s (2016) recent meta-analysis of 45 studies published between 1986 and 2014, the authors examined group differences between children with and without ADHD between grades 1 to 12 on a variety of text generation outcomes. Lower performance was noted in all text generation areas by the majority of studies included in the meta-analysis. Further, all average weighted effect sizes fell within the moderate range and were statistically greater than no effect, indicating a moderate negative association of ADHD and each text generation outcome. Students with ADHD showed lower achievement in writing quality (ES = -0.78), writing output (text length; ES = -0.64), text elements (discourse structures; ES = -0.69), vocabulary (ES = -0.76), and sentence-writing (ES = -0.71).

The studies included in Graham et al.’s (2016) meta-analysis used a wide variety of tasks to measure writing, all with specific demands. Some tasks were time-limited, ranging from about 7 to 20 minutes, while many were untimed. Several studies did not specify whether the writing task was time-limited or not, which reduces the ability for the reader to fully understand the results and implications.

Within the existing studies for each text generation outcome, several controlled for demographic variables such as age, gender, socioeconomic status, and ethnicity. There was no mention of controlling for transcription skills such as handwriting, or other academic skills that are related to writing such as reading ability. Failing to control for handwriting fluency or other
variables that are linked to writing, such as reading and linguistic ability, is a significant limitation in the existing literature, because of the relations between writing and these variables (DeBono et al., 2012; Shanahan, MacArthur, & Fitzgerald, 2006) and the comorbidity between ADHD and reading and language difficulties (Frazier et al., 2007; Rucklidge & Tannock, 2001). Graham et al. were not able to test moderators between ADHD and writing ability due to a lack of sufficient studies.

A recent study published after Graham et al.’s (2016) meta-analysis (Rodriguez, Torrance, Betts, Cerezo, & Garcia, 2017) provides results that are consistent Graham et al.’s (2016) findings of less proficient writing in students with ADHD. Rodriguez et al. (2017) examined non-time limited essay-writing skills in students between grades 3 and 7. The essays of children with ADHD had lower scores on all three outcomes measured: structure, coherence, and holistic quality, when controlling for age, grade, and general ability. However, the authors did not control for reading or linguistic abilities, a limitation considering the aforementioned relations between these abilities.

In contrast with previous research (Graham et al., 2016), the students with ADHD did not write shorter texts. Rodriguez et al. (2017) also had students record a “writing process log” of what specific tasks they were doing at particular moments (e.g., reading reference materials, thinking about content, writing, etc.) and found that students with ADHD were significantly less likely to re-read and edit their written work. This provides interesting evidence as to what differences in writing process may underlie or relate to writing difficulties in children with ADHD.

Molitor et al. (2016) recently published a paper with a latent profile analysis of 326 children with ADHD between grades 6 and 8 to examine their writing abilities. Within the sample, they
found that 22% had impaired writing abilities on standardized writing tasks, controlling for estimated IQ, indicating that writing impairment is a “common phenomenon” amongst children with ADHD. Further, the authors found that writing ability was associated with both GPA and parent ratings of academic performance, independent of IQ. Thus, there is evidence that writing impairment may occur in roughly 1/5 of children with ADHD, and that those impairments are associated with general academic achievement (Molitor et al., 2016).

As text length was not assessed in the majority of studies examining youth in the older high school grades, I examined text length in available studies conducted with young adults with ADHD to determine whether text length differs in individuals with ADHD beyond early adolescence. Similar to studies conducted with younger students with ADHD, recent research highlights text generation impairments in young adults with either elevated ADHD symptoms (Kim, Lee, & Lee, 2015) or a childhood diagnosis of ADHD (Miranda, Baixauli, & Colomer, 2013). Kim et al. (2015) studied writing samples of undergraduate university students and found that those with high ADHD symptoms wrote fewer complex sentences within the 20-minute time limit. Instead, the students with higher ADHD symptoms wrote more sentences, but those sentences were simpler, with fewer clauses and morphemes. While this correlational study did not control for relevant covariates such as socioeconomic status, IQ, or reading, connections appear to occur between ADHD symptoms in young adults, and less sophisticated sentence-writing.

Similarly, Miranda et al. (2013) also found impaired writing structure in a sample of adults who had been diagnosed with ADHD-Combined subtype as children. In comparison to typical controls, adults with a childhood diagnosis of ADHD performed lower on several indices of microstructure and macrostructure than adults without a childhood ADHD diagnosis on a non-
time limited task in which they wrote a story to match a sequence of pictures. In particular, young adults with a childhood ADHD diagnosis wrote shorter texts with fewer unique words, made more morphosyntax errors, wrote shorter sentences, and included fewer subordinate clauses. Overall, this indicates poorer writing fluency and accuracy, and provides evidence that writing quantity continues to be impaired in individuals with ADHD past early adolescence.

In terms of the higher-level macrostructure, adults with a childhood ADHD diagnosis included significantly less information on vital story components such as characters, setting, and time (Miranda et al., 2013). Without this crucial information, Miranda et al. (2013) reported that their stories seemed incomplete and confusing to the reader. As well, just more than half of the adults with a childhood ADHD diagnosis, significantly fewer than the control group, produced stories with complete episodes (an event in the story that includes an initiating event, an attempt, and a direct consequence). The adults with a childhood ADHD diagnosis not only had lower fluency and accuracy, but their texts appeared to lack vital components indicating difficulty structuring and organizing longer passages into cohesive, complete written texts. Limitations from Miranda et al.’s (2013) study are consistent with limitations previously reported for papers on ADHD and writing, namely that the authors did not control for writing-relevant variables such as reading or linguistic ability. Additionally, the sample in this study was comprised of only males, so it is not generalizable to the entire ADHD population.

It appears as though many areas of text generation are impaired in individuals with ADHD ranging from the beginning of elementary school into young adulthood. Children and adolescents with ADHD show poorer performance on measures of writing quality, quantity, discourse structures, vocabulary, and sentence-writing (Graham et al., 2016). Recent research provides evidence that writing impairments continue after secondary school ends, as young
adults with either a childhood diagnosis of ADHD or current elevated-ADHD symptoms show less proficient sentence-writing (Kim et al., 2015) and narrative microstructure and macrostructure (Miranda et al., 2013). However, existing studies commonly fail to control for important variables such as reading and linguistic ability, and so the role of ADHD status independent of these abilities is not well understood.

3.3. Limitations of the Research

Broad limitations encompassing the existing research on writing and adolescents with ADHD highlight the need for more research to replicate and extend current findings. First, studies must consider the demands of their writing tasks and compare to real-life writing tasks that adolescents are expected to complete. For example, while some studies included in Graham et al.’s (2016) meta-analysis had time-limited writing tasks, many other studies allowed participants unlimited time to complete their writing. However, adolescents must work under time limits in school, while completing time-limited exams, and while note-taking in class, so a writing task with unlimited time may not yield results that are representative of adolescents’ performance at school. Considering timed tasks of text generation (e.g., writing an essay in 15 minutes), results are limited when handwriting fluency is not controlled for, as performance on a timed task may depend on how fast adolescents can write words on the page. This is an important consideration because the text generation papers included in Graham et al.’s (2016) meta-analysis did not report controlling for handwriting fluency, although handwriting fluency may play a key role in predicting text generation, particularly on timed tasks.

Failing to control for reading and language is another limitation in the existing literature, as it is important to acknowledge the connections between writing, reading and oral language when examining writing abilities. Problems with reading (McGrath et al., 2012; Rucklidge & Tannock,
2002), writing (Graham, Fishman, Reid, & Hebert, 2016), and oral language (Tirosh & Cohen, 1998; Wassenberg et al., 2010) often occur in children and adolescents with ADHD. In turn, problems with reading and oral language are interwoven with writing skills. A recent study identified reading efficiency as a significant predictor of writing abilities in adolescents with ADHD (DeBono et al., 2012), and while relations between oral language and writing are less understood, children with better oral language skills tend to be better writers (Shanahan, MacArthur, & Fitzgerald, 2006). Thus, reading and oral language abilities are important covariates in the study of written expression.

A common limitation reported in the ADHD and writing literature is the lack of research available. Graham et al. (2016) noted that the limited number of studies for certain writing outcomes (i.e. only 6 available studies for text elements) created average weighted effect sizes that are less reliable. Thus, more research on writing outcomes for adolescents with ADHD are needed to further support these findings.

In research on ADHD, researchers often categorically assess group differences in individuals who have ADHD and those who do not. Another approach is to examine ADHD symptoms as they exist dimensionally to examine the role of ADHD symptoms on particular outcomes. Categorical research yields important group-specific results that help shape assessment and intervention for those diagnosed with ADHD, while dimensional research can reveal more subtle effects of inattention and hyperactivity-impulsivity symptoms as they exist at mild, moderate, or severe levels. In the existing literature on ADHD and writing, the majority of studies have used a categorical approach, unlike the literature on ADHD and math (e.g., Gray, Rogers, Martinussen, & Tannock, 2015) and reading (e.g., Rogers et al., 2011).
In the present study, I decided to use a combination of categorical and dimensional methods to study: a) how adolescents with ADHD differ in their writing abilities from those without an ADHD diagnosis, and b) whether inattention symptom severity uniquely predicts one or more indices of writing ability. The dimensional component to the present study is important because inclusion into our ADHD group depended on a past ADHD diagnosis and current clinical symptoms, but not necessarily clinical levels of inattentive symptoms. Thus, a dimensional approach allows for an examination of whether inattention symptom severity uniquely predicts writing ability, independent of important writing-related variables.

Thus, the present study will use both the categorical and dimensional approach. The writing tasks include both an untimed task (Writing Samples subtest of the *Woodcock Johnson Tests of Achievement – Third Edition* (WJ-III ACH; Woodcock, McGrew, & Maher, 2001), and a timed 5-minute persuasive essay-writing task. I will control for the role of handwriting fluency on timed and untimed task performance. I will also control for reading, working memory, and oral language abilities in my analyses to examine the role of ADHD status and symptoms on writing abilities independent of these relevant variables.

**4.0 Rationale and Hypotheses**

There does appear to be a relationship between ADHD symptoms and writing ability, as children and adolescents with ADHD achieve lower in writing than their typically-functioning peers, in both transcription skills and text generation outcomes (Graham et al., 2016). Students with ADHD across elementary and secondary school tend to produce less written text with less accuracy, use a simpler vocabulary, and struggle with organizing sentences and larger discourse structures (Graham et al., 2016).
Despite this research, writing is still relatively understudied in comparison with reading and math in individuals with ADHD (Molitor et al., 2016), and limitations within the existing literature indicate that replications and extensions are needed to better understand relations between ADHD and writing. Thus, the present study aims to replicate and extend past findings of the writing ability of adolescents with ADHD by investigating group differences in writing ability and role of ADHD symptoms in uniquely predicting writing ability independent of relevant variables. As such, our first research question examines the effect of ADHD status on writing ability. Based on past findings (Graham et al., 2016), we hypothesize that adolescents with ADHD will show deficits in writing quantity, quality, sentence-writing, discourse structures, and vocabulary.

Because handwriting fluency is a skill so closely related to writing ability (Graham et al., 1997), we will also investigate whether group differences in writing ability are evident once effects of handwriting fluency are controlled. Our second research question is therefore to what extent does ADHD status affect writing ability over and above the effects of handwriting fluency? To this end, I predict that once handwriting fluency is controlled for, group differences will be eliminated.

Lastly, we will investigate whether inattention, a dimensional ADHD symptom, accounts for unique variance in our writing outcomes independent of other factors that are important to writing. As previously discussed, handwriting fluency, working memory, language, and reading (decoding and text comprehension) have each been found to relate to writing ability, and have been found to be unique predictors in the writing ability of adolescents with ADHD and with subclinical ADHD (DeBono et al., 2012). However, previous research has frequently failed to control for these relevant variables, and so it is important to determine the role of inattention
independent of them. Previous research has found that behavioural ratings of inattention to not uniquely predict writing abilities in adolescents with ADHD (DeBono et al., 2012). Given these findings, and the fact that shared variance may occur between our set of predictors, we predict that inattention will no longer be a unique predictor of writing outcomes independent of these relevant variables.

5.0 Methods

5.1 Participants

A total of 94 14 to 17-year old participants (50% male) were included in the present study, which was part of a larger project examining reading and oral comprehension in adolescents with and without ADHD (e.g., Batho, Martinussen, & Wiener, 2015). Participants were recruited through newspaper and community advertisements, from local schoolboards, and through contacts with local organizations such as the Learning Disabilities Association of Ontario. Of the sample, 44 (28 males) were classified as having ADHD, and 50 (19 males) were classified as a typically functioning control group. Inclusion criteria for participants with ADHD were the following: (a) a previous diagnosis of ADHD, as reported by parents/guardians, (b) evidence for ongoing ADHD symptoms measured by clinically significant scores (T-scores ≥70) on at least one of the three ADHD subtypes of the DSM-4 (Hyperactive Impulsive, Inattentive, or Global) measured on the Conners’ 3 Parent Rating Scale, Long Form (Conners 3-P; Conners, 2008), (c) Full-Scale IQ of 70 or higher on the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999); (d) fluent English language abilities as reported by parents, and (e) no evidence of significant neurological, psychiatric, sensory, or physical disability.

Corresponding inclusion criteria for the control group were: (a) no previous diagnosis of ADHD or behavioural disorder, (b) scores in the normal functioning range (T-score ≤65) on the
Conners 3-P indices of ADHD, (c) a Full-Scale IQ of 70 or above on the WASI, (d) fluency in English, and (e) absence of significant neurological, psychiatric, sensory, or physical disability.

A total of 109 participants originally consented to participate in the study, but 15 were excluded from the overall sample. Participants with ADHD were excluded for one of the following reasons: (a) Parent Conners rating scale was not available (n = 2), (b) they no longer met criteria for a diagnosis of ADHD on the Parent Conners (n = 2), (c) parents were not sure whether there was a confirmed ADHD diagnosis (n = 3), (d) their IQ was below 70 on the WASI (n = 2). For the present study, we also excluded the 3 participants in the sample who scored below 85 on the WJ-III ACH Letter-Word Id subtest (n=3) resulting in a sample of youth with ADHD without comorbid word-level reading difficulties. Participants without ADHD were excluded in the overall study due to a clinically significant rating of ADHD symptoms on the Parent Conners (n = 2). One additional participant in the control group as excluded from the present study because they did not complete one of the writing measures (n=1). Thus, the final sample included 44 adolescents with ADHD (64% male) and 50 adolescents (38% male) without ADHD, between the ages of 14 and 17.

A review of the sample characteristics indicated that, 76% of the total sample was born in Canada (91% of the participants with ADHD, 64% of the comparison group), and 60% reported that they spoke English at home (80% of the participants with ADHD, 42% of the comparison group). The remaining 40% reported that they also spoke at least one other language at home. Of the adolescents with ADHD, 75% were on medication for their ADHD, although parents were asked to withhold any stimulant medication on the day of the assessment. 80% of the adolescents with ADHD were on an Individual Education Plan at school, compared with only 4% of the adolescents without ADHD.
5.2 Materials

Child participants, their parents, and teachers completed a battery of cognitive and academic measures and questionnaires for the larger project upon which this study is based. The measures described below are the selected subset that are relevant to the present study.

5.2.1 Cognitive functioning.

Intellectual ability, including an estimated Full-Scale IQ, was obtained from the Vocabulary and Matrix Reasoning subtests of the Wechsler Abbreviated Scale of Intelligence (WASI), a standardized measure of intellectual ability. The two subtests yield a Full-Scale IQ score represented by a T-score with a mean of 100 and a standard deviation of 15. The WASI has been found to have high reliability and concurrent validity (Saklofske, Caravan, & Schwartz, 2000). Expressive oral language in the present study was measured by the WASI Vocabulary subtest.

Each participant was asked to complete measures of verbal short-term and working memory. Participants completed the Digits Forward and Digits Backward subtest from the Test of Memory and Learning (TOMAL; Reynolds & Bigler, 1994) which provide a measure of verbal short-term memory and verbal working memory respectively. These subtests show evidence of strong reliability in both typical students and students with learning disabilities, $\alpha = .95-.98$ (Reynolds, 1998), and both concurrent and construct validity in a sample of adolescents (Russo et al., 1995). Working memory was also assessed through the listening recall subtest of the Working Memory Test Battery for Children (WMTB-C; Pickering & Gathercole, 2001), in which participants listen to a series of short sentences, respond “true” or “false” to the statement,
and then recall the final word of the sentence. The number of sentences in each item increases over time. The Listening Recall subtest of the WMTB-C has good test-retest reliability with younger children ($\alpha = .83$), but poor reliability with students in grades 5 and 6 ($\alpha = .53$; Pickering and Gathercole, 2001). Despite the poor reliability, the Listening Recall subtest both correlated significantly with the TOMAL Digits Backwards subtest ($r = .370$), and has been used in past research.

Results on the cognitive measures were converted into age-based standardized scores for analyses. Standardized scores of the TOMAL digits backwards and WMTB-C Listening Recall task were transformed into z-scores and then averaged to create a single working memory composite score.

5.2.2 Writing ability.

Following the Simple View of Writing (Berninger & Graham, 1998), several measures of text generation were selected as well as one transcription measure as indices of writing ability. The measure of transcription was a handwriting fluency task based on a task developed by Peverly et al. (2007). Participants were asked to print the alphabet in order, first in lowercase, then uppercase, as many times as possible in 30 seconds. The number of letters written correctly within the 30 seconds is the raw score used in analyses.

Text generation outcomes included: sentence writing, text length, writing accuracy, number and quality of discourse structures, and vocabulary sophistication. To assess sentence writing, participants completed the Writing Samples subtest from the Woodcock Johnson Tests of Achievement – Third Edition (WJ-III ACH; Woodcock, McGrew, & Maher, 2001). On the WJ-III Writing Samples subtest, participants write sentences in response to prompts and are scored for quality of their written expression. Participants are not penalized for spelling or grammar
errors. The WJ-III ACH Writing Samples subtest has reliability of .84 (Mather & Woodcock, 2001). Raw scores for all subtests on the WJ-III ACH were converted into age-based standardized scores for analyses.

The second writing assessment was a non-standardized persuasive essay. Participants were informed that they had 2-minutes to plan their response to the persuasive essay prompt and then 5-minutes to write a persuasive essay in response to the prompt “Should students be allowed to carry cell phones at school?” This component of the larger study also required the youth to complete the essay writing task within one of three noise conditions: no noise, white noise, or irrelevant speech. Analysis of the noise effects on the writing outcomes were reported by Batho et al. (2015). They reported that the white noise group wrote longer essays, but the accuracy of the writing did not differ between groups. In the present study, noise condition was dummy-coded as noise or silence, but was not correlated with any of our dependent variables, and so it was excluded from further analyses.

The essay was scored in several ways. First, text length was assessed by total words written (TWW) within the 5-minute span. Accuracy of writing mechanics, such as spelling, grammar, and punctuation was measured by the percentage of correct writing sequences out of the total number of writing sequences (PCWS). A correct writing sequence occurs when there is a two-word segment, or a word-punctuation segment that has accurate spelling, punctuation, capitalization, and grammar. For example, the sentence “The girl ran.” has three correct writing sequences: “The girl”, “girl ran” and “ran.”.

Using TWW and PCWS as indicators of writing fluency and accuracy has been found to be a valid and reliable assessment of writing ability in previous research with adolescents (Espin, Shin, Deno, Skare, Robinson, & Benner, 2000). The TWW and PCWS were double-scored by
two different raters. In the ADHD sample, the interrater reliability of the TWW, measured by the intraclass correlation coefficient, was extremely high (ICC = .99), as was the interrater reliability for the PCWS for both raters (ICC = .93, ICC = .90).

For the present study, the essays were scored for discourse structures and vocabulary sophistication by the first author and one undergraduate research assistant. The number of discourse structures was examined to capture participants’ ability to write cohesive discourse structures. Discourse structures link together written units into broader topics and expand on those topics (Berninger & Graham, 1998), and are thus important for producing strong works of writing. Following the scoring guidelines of Jacobson and Reid (2010), raters scored each essay for containing the following: a topic sentence, supporting ideas (out of 3), the rejection of at least one argument for the other side to support their opinion, and a conclusion. Participants received a score out of 6, with one point awarded for each essay part. Deviating from Jacobson and Reid’s scoring guidelines, we also gave participants a score out of 12, in which each essay part was scored as high quality (2 points) or low quality (1 point). This was done to give a more thorough view on the ability to write strong essay parts, such as well-written and coherent topic sentences and high-quality supporting ideas. The raters scored the first 29 essays together, to reach a consensus on scoring guidelines for high- and low-quality essay parts. They scored the remaining 65 essays independently. Inter-rater reliability of the independently-scored essays was very high for both the score out of 6 (ICC = .94) and the score out of 12 (ICC = .97). Differing scores were analyzed by both raters together and a consensus was reached to use for analyses, following the essay scoring protocol of Troia, Graham, and Harris (1999). Lastly, vocabulary sophistication was measured by the number of words with seven letters or more, including repetitions, following the scoring procedures of Houck and Billingsley (1989).
Correlations between each of our writing measures were analyzed for validity before analyses. The persuasive essay discourse structure score out of 6 only correlated with only one other measure of writing ability, text length (TWW), so it was removed from subsequent analyses. Thus, the final outcomes of writing ability were sentence-writing (as measured by the WJ-III ACH Writing Samples subtest), text length (TWW), writing accuracy (PCWS), discourse structures score (out of 12), and vocabulary sophistication.

5.2.3 **Reading ability.**

Decoding skills were assessed using the Letter-Word Identification and Word Attack subtests of the WJ-III ACH. In these tasks, participants read aloud lists of both real words (Letter-Word Identification) and pseudowords (Word Attack). The median reliability of Letter-Word Identification is .91, while Word Attack has a median reliability is .87 (Mather & Woodcock, 2001). Reading comprehension was assessed using the Passage Comprehension subtest of the WJ-III ACH, in which participants read a brief passage with one word missing and provided the missing word. The median reliability of Passage Comprehension is .83 (Mather & Woodcock. Standardized scores of each reading subtest significantly correlated with each other. The standardized scores were then transformed into z-scores and then averaged to create a single reading ability composite score.

5.2.4 **Parent measures.**

Parents completed a short battery of questionnaires designed to collect information about their child’s social-emotional functioning and life at home. Demographic information was collected from a survey including marital status, languages spoken at home, whether their child was born in Canada, and highest level of education completed. Parents also completed the Conners’ 3 Parent Rating Scale, Long Form (Conners 3-P; Conners, 2008), to examine their
child’s inattention and hyperactivity-impulsivity symptoms. Parents rated their child on a 4-point Likert-type scale, with higher scores associated with higher frequency of concerns.

5.3 Procedure

Consent to assess participants was granted by parents/guardians prior to testing. All participants were tested individually by a trained graduate student in a single 5-6 hour session, completing the larger battery of cognitive and academic tasks, and questionnaires. Parent and teacher questionnaires were distributed and collected once completed.

6.0 Results

6.1 Data Analysis Plan

To address my first research question, I conducted multivariate analysis of variance (MANOVA) to investigate differences in writing outcomes between participants with and without ADHD, controlling for age and gender. For my second research question, I ran the MANOVA with the addition of handwriting fluency as a covariate, to see to what extent writing outcomes in adolescents with and without ADHD differed after controlling for the speed with which youth could produce their essays. For the MANOVAs, post-hoc pairwise comparisons of the outcomes associated with the persuasive essay (4) were examined using Bonferroni correction of \( p = .01 \) (\( p = .05/4 \)) to assess specific differences between groups. Finally, to examine whether inattention accounts for unique variance in writing outcomes independent of the cognitive, language, or reading predictors, we ran five multiple linear regressions with DSM-IV Inattention symptoms entered in the final block of the regressions. Preliminary analyses with both inattention and hyperactivity indicated that when hyperactivity was added as a variable into the regression analyses after inattention, it did not add any significant unique variance and given that inattention is typically more related to academic achievement outcomes than hyperactivity
(Rodriguez et al., 2007), inattention was the symptom dimension used in the analyses. The exact predictors in each block differed per regression depending on the correlations. Given the relatively small sample size for the regressions, variables which did not show a significant bivariate correlation with the outcome were not included in the regressions. Key covariates included gender, age, and handwriting fluency. Writing-related variables were handwriting fluency, working memory, language, and reading ability. Inattention was measured by the Conners 3 DSM-IV Inattention Symptoms T-score, as the regressions were investigating the extent to which inattention predicted the writing outcomes over and above writing-relevant factors.

6.2 Preliminary Analyses

6.2.1 Normality and linearity.

For all variables, skewness and kurtosis were found to be in the satisfactory range of -2 to 2. Visual inspection of histograms and normal probability plots for each variable support normality, only one outlier fell past 3 standard deviations of the mean across variables, on the writing accuracy score. This outlier was winsorized to three standard deviations below the mean. Winsorizing outliers following this method has previously been used in studies on children with ADHD (e.g., Arnett, Macdonald, & Pennington, 2013). Scatterplots were generated for each predictor and dependent variable to assess linearity, and visual inspection confirms linear relationships.

6.2.2 Correlations among variables of interest.

Prior to regression analyses, we examined whether correlations among our variables of interest differed between our ADHD and control groups. The difference in $r$ values between each writing outcome measure and each predictor was tested for significance using the Fisher $r$-to-$z$
transformation. There was only one significant difference in the magnitude of the correlations between groups, the correlation between inattention symptoms and essay length was significantly different between the ADHD group \((r = .135)\) and the control group \((r = -.283)\), \(p = .046\). Neither correlation was statistically significant, and the difference is likely due to little variation in symptom severity occurring in the ADHD group in comparison to the control group. Because there was only one significant difference in correlation magnitude between groups, the regression analyses used the complete sample.

Correlations were also examined between each of our dependent variables to assess validity of the tasks (see Table 3). Almost all our writing outcomes were moderately correlated with one another, with the exception of the WJ-III ACH Writing Samples subtest, and the discourse structures score on the persuasive essay, which were not correlated. This is not surprising given the differences between these two tasks and the skills necessary to complete them. The ability to write accurate and cohesive sentences may draw from similar word-level skills as writing fluency, mechanical accuracy, and vocabulary sophistication, but likely differs from the ability to organize and execute all required discourse structures of a thought-provoking persuasive essay. Because the sentence writing task was structured and untimed, while the persuasive essay task was unstructured but time-limited, the tasks themselves pull from different skillsets. Thus, given tasks differences, and the fact that the remaining writing outcomes are significantly correlated with each other, these correlations support validity of our writing measures.

6.2.3 Gender differences in writing accuracy.

Gender differences were found on the writing accuracy outcome, such that girls had a higher PCWS score than males, \(t(92) = -3.53, p = .001\). Follow-up analyses were conducted to better understand where these gender differences occurred in relation to our ADHD and control groups.
Examining girls and boys in the ADHD group versus the control group, we found that the gender difference only occurred in the control group, where girls had a higher PCWS ($M = .94$, $SD = .06$), than boys ($M = .89$, $SD = .08$), $t(48) = -2.38$, $p = .022$. There were no significant gender differences in the ADHD group.

6.3 Between-Groups Effects

A one-way MANOVA was conducted to determine the effect of ADHD status on writing outcomes. Control variables were age and gender. The assumptions for a MANOVA were tested and all confirmed. Homogeneity of covariance was confirmed using Box’s Test ($p = .389$), while the univariate homogeneity of variance was confirmed using Levene’s Test, in which all variables were nonsignificant.

Significant differences on the writing outcomes were found between the ADHD and non-ADHD groups, Wilk’s $\Lambda = .71$, $F(5, 86) = 7.14$, $p < .001$ with partial $\eta^2=.29$, indicating a large effect. See Table 2 for results of univariate ANOVAs for each writing outcome. As the between-subjects variable only had two levels, pairwise comparisons were examined for specific group differences and follow-up analyses revealed significant differences for essay length, sentence writing, and vocabulary sophistication. Participants with ADHD wrote fewer words on the essay than their typically-functioning peers, and their essays included fewer words with seven letters or more, indicating lower vocabulary sophistication. Participants with ADHD also had poorer sentence writing ability, in comparison to the control group, as indexed by their scores on the WJ-III ACH Writing Samples subtest.

6.4 Between-Group Effects controlling for Handwriting Fluency

A second MANOVA was conducted to investigate our second research question: to what extent does ADHD status affect writing ability over and above the effects of handwriting
fluency? Preliminary analyses revealed that the ADHD group had significantly slower handwriting fluency, measured by the number of correct letters written in 30 seconds ($M = 30.45$, $SD = 10.45$) than the control group ($M = 41.38$, $SD = 9.90$), $t(92) = 5.20$, $p < .001$ (See Table 1). In this analysis, handwriting fluency was added as a covariate to the MANOVA. Homogeneity of covariance was confirmed with Box’s Test, which was nonsignificant at $p = .389$, and homogeneity of variance across our dependent variables was confirmed with nonsignificant Levene’s tests.

Significant differences on the writing outcomes were found between the ADHD and non-ADHD groups, Wilk’s $\Lambda = .87$, $F(5, 85) = 2.45$, $p = .040$ with partial $\eta^2 = .126$, indicating a moderate effect. An inspection of the univariate ANOVAs revealed that once controlling for handwriting, group differences remain only for vocabulary sophistication. Participants with ADHD produced significantly fewer sophisticated vocabulary words controlling for the effect of handwriting fluency. See Table 2 for results of univariate ANOVAs for each writing outcome.

6.5 Exploring the extent to which inattention accounts for unique variance in writing once controlling for writing-related variables.

To investigate whether inattention symptom severity accounts for unique variance in writing outcomes once writing-relevant variables have been considered, five multiple linear regression were conducted. The initial data analysis plan was to run all of the regression analyses with the same writing-relevant variables, but the writing outcomes were each correlated with different variables, so each regression was modelled independently. First, I examined the correlations between each writing outcome and the set of hypothesized predictors to determine which ones were significantly correlated. Next, these were added into each model to determine which variables uniquely predict each writing outcome.
6.5.1 Assumptions.

Before interpreting results of the regression, several assumptions were tested: linearity, normality, independence of errors, and homoscedasticity. Diagnostic checks were also conducted to examine the existence of outliers and multicollinearity.

Across all regressions, scatterplots between each predictor and writing outcome indicate linear relationships. Visual examination of the histograms and normal probability plots support the assumption of normality and the residual scatterplots support the assumption of homoscedasticity and independence of errors. The assumption of independent errors is supported by a Durbin-Watson value between 1 and 3 for all dependent variables. The VIF for each predictor across all regressions was less than 10 and therefore multicollinearity was not a concern. Outlier analysis using standardized predicted values, Cook’s distance, and Mahalanobis distance revealed two influential data points with a standardized predicted value of above 3: one participant on the WJ-III ACH Writing Samples subtest, and one participant on the discourse structure score.

Each of these regressions was run with and without the outlier. While the results were similar in nature, in each case the β coefficients were stronger without the outlier. Thus, it appeared as though in both cases, the outlier was a case that differed from the patterns seen in the rest of the sample, and due to its influence demonstrated in the elevated standardized residual, the outliers were removed from each regression.

The Mahalanobis distance was slightly above the ideal range on the vocabulary sophistication regression, at 15.14. The outlier was removed but the subsequent analyses revealed that the Mahalanobis distance remained at 15.14. Additionally, both the standardized
predicted values and Cook’s distance were well within the acceptable range in both analyses, and so the regression was carried out with removing any outliers.

For each regression using a writing outcome from the persuasive essay, a Bonferroni correction at $p = .0125$ was used in examining the significance of individual predictors to control for the four separate multiple linear regressions. The regression using the WJ-III ACH Writing Samples subtest was examined with $p = .05$ as only one regression was conducted using this subtest.

6.5.2 Regression analysis of sentence writing on the WJ-III.

In examining the predictors of sentence writing ability, variables entered into this regression were inattention symptoms, handwriting fluency, the working memory composite, the WASI Vocabulary T-score, and the reading composite. All five predictors account for 46.2% of the variance in sentence writing ability, $F(5, 84) = 14.45, p < .001$. Once all variables were entered in the model, inattention symptoms ($\beta = -.270, p = .004$), working memory ($\beta = .213, p = .039$) and the reading composite ($\beta = .286, p = .007$) significantly predict sentence writing ability, and the reading composite was the strongest predictor. In this analysis, inattention was a significant unique predictor and the partial correlation indicates it accounts for 3% of the total variance. The negative beta value for the inattention symptoms predictor indicates that higher inattention scores are associated with lower scores on the WJ-III Writing Samples subtest.

6.5.3 Regression analysis of length of essay.

For length of writing on the essay task, the variables entered were inattention symptoms, handwriting fluency, the working memory composite, the WASI Vocabulary T-score and the WJ-III ACH Passage Comprehension Standard Score. The Passage Comprehension was used
instead of the reading composite that includes decoding because decoding was not significantly correlated with essay length.

Results of the regression indicate that all five predictors accounted for 39% of the variance in essay length, $F(5, 87) = 11.11, p < .001$. However, not all variables were significant predictors. Once accounting for all other variables, only handwriting fluency ($\beta = .439, p < .001$) was a unique predictor of essay length.

6.5.4 **Regression analysis of writing accuracy.**

The variables for examining writing accuracy were inattention symptoms, age, gender, handwriting fluency, the working memory composite, and the reading composite. All six predictors accounted for 43.4% of the variance in writing accuracy, $F(6, 84) = 10.76, p < .001$. Once all predictors are included in the model, handwriting fluency ($\beta = .317, p = .012$) and the reading composite ($\beta = .342, p = .001$) were significant predictors.

6.5.5 **Regression analysis of discourse structure score.**

The predictors for the number and quality of discourse structures in the persuasive essay were entered as inattention symptoms, gender, and handwriting fluency. These three predictors accounted for 13% of the variance in the discourse structures score, $F(3, 89) = 4.44, p = .006$. However, once all three predictors were entered into the model, none significantly predicted the discourse structures score.

6.5.6 **Regression analysis of vocabulary sophistication.**

Lastly, factors predicting vocabulary sophistication were examined. These variables were inattention symptoms, age, handwriting fluency, the working memory composite, WASI Vocabulary T-score and the reading composite. All six predictors account for 52.9% of the variance in vocabulary sophistication $F(6, 84) = 15.73, p < .001$. Once all predictors were
included in the model, age ($\beta = .245, p = .004$) and handwriting fluency ($\beta = .494, p < .001$) were the significant predictors of vocabulary sophistication.

6.5.7 **Summary of regression results.**

The purpose of the regression analyses was to determine whether inattention symptoms uniquely predict writing outcomes. While our MANOVA analyses indicated that group differences occurred between adolescents with ADHD and controls on three writing outcomes (essay length, sentence writing, and vocabulary sophistication), and group differences in vocabulary sophistication were apparent even after controlling for handwriting fluency, inattention symptoms only uniquely predicted sentence-writing ability over and above the effects of relevant variables. This finding will be further discussed below.

Note: the question of whether another language was spoken at home was not related to lower performance in our sample, in fact it was related to higher performance, so it was not included in analyses.

7.0 **Discussion**

Adolescents with ADHD are at-risk for academic difficulties across subjects (Frazier et al., 2007), and despite the importance that writing has to success in both the classroom and future workplace (Graham, 2006), the writing abilities of adolescents with ADHD have received less attention in the literature than reading or math (Molitor et al., 2016). Impairments in text generation, more specifically in the areas of writing quantity, quality, vocabulary, sentence-writing, and discourse structures, as well as transcription skills such as handwriting, have all been identified in children and adolescents with ADHD (Graham et al., 2016). However, the lack of research on writing and ADHD and limitations in the literature have left the need for replication and extension of previous findings. Specifically, there is a lack of research that incorporates both a categorical and dimensional view of ADHD and ADHD symptoms, and
research that controls for important writing-related factors such as reading, language, and handwriting fluency.

Thus, this study served to investigate group differences between adolescents with ADHD and their typically-functioning peers on several indices of text generation, and also examined group differences once controlling for handwriting fluency. The second focus of this study was to examine whether inattention symptoms uniquely predict writing ability independent of writing-related factors such as handwriting fluency, working memory, and reading ability. This latter question was examined using the full sample of participants and the continuous scores on all of the measures.

7.1 Evaluation of Main Objectives

7.1.1 Group differences in writing ability.

As illustrated in Table 2, the results show that adolescents with ADHD performed lower than their typically-functioning peers on a standardized sentence-writing task, and on a non-standardized essay-writing task, in which they wrote fewer words and had less sophisticated vocabulary. Effect sizes for these significant group differences were in the moderate range. These results are consistent with previous research that has identified deficits in text length, sentence composition, and vocabulary in adolescents with ADHD (Graham et al., 2016).

Interestingly, our results did not indicate that adolescents with ADHD had poorer writing accuracy, or fewer or lower-quality discourse structures on the persuasive essay task, despite previous research identifying deficits in both areas in adolescents with ADHD (Graham et al., 2016). Our finding that adolescents with ADHD did not differ from the typically-functioning control group on writing accuracy or discourse structures could be due to several different reasons. It could be due to the relatively small sample, and a subsequent lack of power, or it
could be due to the nature of the essay-writing task, that 5-minutes was not enough time for adolescents to write an essay that is fully representative of their capabilities. On the other hand, it could be that our sample of adolescents who did not exhibit concurrent word reading problems, truly do not have lower writing accuracy or difficulty producing sufficient and good-quality discourse structures in comparison to the control group.

Our second research question examined the extent to which ADHD status predicted writing ability when controlling for effects of handwriting fluency. Given that students with ADHD have been found to make more handwriting errors, such as illegible words (Casas, Ferrer, & Fortea, 2013), which contributes to academic difficulties (Barkley, 2006), we hypothesized that handwriting fluency may be a major process behind the group differences, and may eliminate group differences once included in the analysis. As expected, handwriting fluency was significantly lower in the ADHD group. Indeed, once controlling for handwriting fluency, group differences in essay length and sentence-writing ability were eliminated and group differences remained only for vocabulary sophistication, though the effect size was small.

Previous research on text generation outcomes of adolescents with ADHD, while consistently finding less proficiency than same-age peers (Graham et al., 2016), has failed to control for the role of handwriting fluency. So while it is possible that this result could be due to a relatively small sample or the essay task demands, as previously discussed, it is also possible that some group differences in our sample of adolescents who do not have concurrent reading problems are primarily due to underlying group differences in handwriting fluency. In this case, this finding is very interesting as it indicates that two primary reasons why adolescents may be struggling with text length, writing accuracy, sentence-writing, and discourse structures are reading-related issues (e.g., spelling) and handwriting fluency. For example, youth who are less
efficient at producing written text may focus more attention on transcription and thus lose track of their key points or relevant discourse structures (Cahill, 2009). It would be interesting to see if bypassing handwriting fluency through the use of speech-to-text or training of typing skills would similarly eliminate group differences in many measures of writing ability between adolescents with and without ADHD.

Consistent with this finding is previous research that has explained that difficulties with handwriting constrain students’ ability to attend to their writing and subsequently compromises the length and quality of their writing (Cahill, 2009). Even in high school, when one might not consider handwriting to be as important, adolescents are expected to produce written work within specific time-limits (e.g., written exams, note-taking in class), and slow handwriting negatively affects their ability to do so.

To extend these categorical findings, I next conducted explored the role of inattention, a core ADHD symptom, in uniquely predicting writing ability, independent of relevant variables including handwriting fluency and reading ability.

7.1.2 Relationships between our variables of interest.

Our variables of interest were related in ways that are consistent with both past research and what would be expected based on the Simple View of Writing model (Berninger & Graham, 1998). In accordance with this view, handwriting fluency (a transcription skill) was correlated with all other variables of interest, such as inattention, reading, language and all five text generation outcomes. This is also consistent with past research linking handwriting fluency to not only writing, but to memory, language, and reading (Medwell & Wray, 2008).

Regarding executive functions, working memory was correlated with all variables of interest with the exception of the discourse structures score, and inattention symptoms were correlated
with working memory, oral language, and all writing outcomes, consistent with previous research (DeBono et al., 2012). Inattention symptoms were not correlated with reading ability, likely due to the lack of variation in the reading ability of our sample, as participants did not fall beyond one standard deviation below the mean on decoding ability. Thus, all adolescents in this study had age appropriate decoding or word identification skills, whether they were diagnosed with ADHD or not.

7.1.3 Inattention as a unique predictor of writing ability.

Beyond investigating categorical group differences in adolescents with and without ADHD, we were also interested in the role that inattention symptoms play in writing abilities when examined dimensionally. As such, our final research question pertained to whether individual differences in inattention symptoms uniquely predict writing ability, independent of relevant variables. To this end, we ran five multiple linear regressions modelled independently using writing-related variables that correlated with each writing outcome. Given recent research that has identified handwriting fluency, working memory, language, and reading ability as unique predictors of writing ability in adolescents with ADHD (DeBono et al., 2012), these were particularly of interest.

We hypothesized that once writing-related variables are controlled for, inattention symptoms would no longer uniquely predict writing outcomes, given the shared variance between the predictors. Our results indicate that inattention symptoms only uniquely predicted sentence-writing performance on the WJ-III ACH Writing Samples subtest; inattention symptoms did not predict any outcomes on the persuasive essay task. These results may be a result of different task demands on the Writing Samples subtest versus the persuasive essay. The Writing Samples subtest provides students with the topic to write a sentence about, but not any indication for how
to structure that writing. In comparison to this, the persuasive essay by nature indicates how to structure the writing, as well as provides a topic. Being told to answer a question, as well as provide reasons for their opinion, evokes writing schemas and helps students structure their writing. This finding is consistent with previous research indicating that adolescents with ADHD are more likely to have difficulty planning and organizing their ideas in written form than their typically-functioning peers (Molitor et al., 2016). Inattention appears to play an important role in writing outcomes when the task itself does not provide structure on organization.

Additionally, the regression analyses yielded several more interesting results. Of particular interest is the finding that there was no defined pattern of which variables predicted which writing outcomes. Each writing outcome had a unique set of significant predictors. This indicates that different writing outcomes are truly driven by different combinations of processes and depending on how we measure writing ability, different processes come into play. This indicates that future research must be designed to include variables relevant to the specific type of writing ability measured.

In examining individual writing-related variables and the outcomes they predicted, several results confirm past research. Handwriting fluency uniquely predicted essay length, writing accuracy, and vocabulary sophistication on the timed essay task, which is consistent with previous literature linking handwriting fluency to writing quality and length (Baker, Gersten, & Graham, 2003). The relationship between vocabulary sophistication and handwriting fluency has received less attention in the literature, although this finding is consistent with the idea that students who struggle with their handwriting have to devote large amounts of cognitive processing to it, and subsequently have less mental resources for higher-level writing processes.
such as vocabulary (Medwell & Wray, 2007). It is also possible that since writing is laborious and difficult for slow writers, they choose the shortest words they know for ease.

Consistent with previous literature (Shanahan, 1984), reading ability predicted writing accuracy, likely because reading is related to better spelling and good spelling contributes to higher accuracy as measured by correct word sequences (Espin et al., 2008). Reading ability also predicted sentence-writing, which is consistent with Shanahan’s (1984) view that strong readers have more sophisticated writing structure, including cohesive sentence writing.

Working memory was a significant predictor for sentence-writing ability on the WJ-III ACH. Executive functions such as working memory are frequently implicated in the writing process, and are even a major part of theoretical models of writing such as the Simple View of Writing (Berninger & Graham, 1998). Thus, it is interesting that our working memory composite only predicted sentence-writing, and none of the outcomes from the persuasive essay, despite the fact that working memory was correlated with every writing outcome with the exception of the discourse structures score. There are several possible reasons for this. Firstly, since working memory was correlated with all writing outcomes except for the discourse structures score, but only significantly predicted sentence-writing, it could be that working memory is just not as important for these outcomes. Secondly, there could be a mediational affect where the influence of working memory is being carried out by another variable; however, our small sample size precludes us from investigating these possible relations. Lastly, our working memory measure may not be the best way of capturing working memory when examining writing. Our working memory composite was comprised of a digits backwards task and a listening recall task, and the listening recall task have tapped more into language ability than verbal working memory.
Age was found to be a unique predictor of vocabulary sophistication, which is to be expected since older high school students have been exposed to a richer vocabulary in the more difficult texts that they are expected to read. While adolescents may not experience growth in basic writing skills such as spelling and grammar over the high school years, as those skills have already been established, vocabulary continues to grow with exposure to new texts.

None of our predictors significantly predicted the discourse parts score on the essay. It could be that we did not have the appropriate underlying predictor variables included in this study, or it could be that the discourse structures score is not a good representation of writing ability. A primary limitation of the study, as will be discussed further below, is the specific characteristics of the persuasive essay task, particularly the time limit. An essay written in 5-minutes may not be representative of the writing that adolescents typically complete, and as a result may not have yielded valid indications of their full writing abilities.

Interestingly, oral language ability was not a unique predictors of any writing outcome. There are several reasons why this might be. First, oral language may not be as important to these specific writing outcomes. Secondly, the effect of language could have been carried out by another variable with which it is correlated such as working memory or reading ability, or lastly, our measure of expressive oral language may not be ideal for a study on writing outcomes.

7.2 Limitations and Considerations

There are several limitations and considerations that are important when interpreting these results. First of all, it is important to keep in mind the specific characteristics of our sample. While our ADHD sample was comprised of adolescents who still exhibit clinically significant symptoms, all of our participants have average or better word reading proficiency, and none fell beyond one standard deviation below the mean for decoding skills. Since children and
adolescents with ADHD often exhibit reading difficulties, including learning disabilities in the area of reading (Deshazo Barry, Lyman, & Klinger, 2002), our sample of adolescents with ADHD is not necessarily a typical sample. While this allows us to examine writing abilities that are not constrained by basic reading deficits, it nonetheless limits our generalizability to the greater population. Additionally, participants in our study chose to volunteer their time to participate. Because of this, they might not necessarily be representative of all the adolescents in Ontario. Lastly, while the participants with ADHD were asked to refrain from taking their methylphenidate medication on the date of testing, it is possible that they were taking other long-term medications and were not able to omit from taking those on the testing day.

Regarding participants’ writing abilities, one limitation is that there is no control for the quality of instruction that participants have received in school. Persuasive essay writing is taught in Ontario from the early grades, so participants should have had substantial practice, but there is no way to determine whether all our participants have received sufficient instruction.

Lastly, the essay task itself may not be representative of the work that adolescents do on a daily basis. The 5-minute time limit is much shorter than time-limits that adolescents are used to working under, and may have constrained their ability to write high-quality persuasive essays with organized discourse structures. However, research on curriculum-based measurement of writing supports the validity of brief, 3-5 minute writing tasks to measure writing variables such as percentage of correct word sequences (McMaster & Espin, 2007). While a longer time limit would be best to capture more generalizable and naturalistic writing abilities, a 5-minute time limit can still produce valid results. Further, the time limit on the persuasive essay is an advantage when considering that high school students are expected to produce written work under time constraints in exams and while note-taking. Under a strict time constraint, results
indicated the importance of handwriting fluency in predicting writing ability, a factor that previous research may not have considered to be important to high school students.

7.3 Implications for Practice and Future Research

The results of this study have implications for both writing instruction and intervention of adolescents with and without ADHD, as well as future research directions. One result with great practical implications is the role of handwriting fluency. Handwriting fluency was a unique predictor for several writing outcomes: essay length, writing accuracy, and vocabulary sophistication, consistent with previous literature (Baker et al., 2003) that supports handwriting fluency as a cornerstone writing skill. In comparison, inattention symptoms only uniquely predicted one writing outcome, vocabulary sophistication, indicating the greater importance of handwriting fluency than inattention symptoms.

Relating this to the practice of education, there needs to be an emphasis on handwriting instruction in the classroom and intervention settings. Currently in Ontario, elementary school writing curriculum for students in grades 1 to 8 does not outline goals for handwriting clarity or fluency (Ministry of Education, 2006), which likely translates into a lack of explicit handwriting instruction in the early grades, when students are beginning to develop their writing skills. This is problematic because in order for students to develop their writing skills, they must first have this baseline transcription skill. Even once adolescents move onto post-secondary education, handwriting fluency affects written exam quality and subsequent marks (Connelly, Dockrell, & Barnett, 2005). The importance of handwriting fluency for writing ability has implications for the use of assistive technology as well. Given the correlation between handwriting and typing fluency identified in the literature, (Connelly et al., 2005), it is likely not sufficient to provide a student with a computer without also providing keyboarding training to promote fluency.
Beyond difficulties with handwriting, another challenge for adolescents with ADHD is the organization of their writing, possibly due to underlying deficits with executive functions such as planning and reviewing (Altemeier, Jones, Abbott, & Berninger, 2006). Consistent with this is our result that inattention symptoms only uniquely predicted performance on the WJ-III ACH Writing Samples subtest, which is structured in terms of what adolescents are told to write about, but not in terms of how adolescents are told to convey that information. Inattention did not uniquely predict performance on the persuasive essay task, which inherently provides more scaffolding for organization. This has implications for future research, such that researchers must consider the specific task demands of their writing measures regarding organization and executive functions demands.

This result also indicates that support with organizing writing should be incorporated into writing instruction for adolescents with ADHD. This is consistent with research on adolescents with ADHD and self-regulated strategy development, a method of instruction that teaches both the necessary strategies to complete a task, as well as self-regulatory skills, while also aiming to improve self-efficacy and motivation in students (Graham & Harris, 1996). Limited research on adolescents with ADHD has found that SRSD improves the essay length, accuracy, and discourse structures while supporting organization and idea-generation (Jacobson & Reid, 2010).

Considering future research directions, a key theme in the existing research on writing abilities in adolescents with ADHD is the need for more research to replicate and extend current findings. Research is needed with large samples that compares adolescents with ADHD to a typically-functioning control group, includes a wider range of writing outcomes, and investigates possible moderators between ADHD status and symptoms, and writing. Our results highlighting the importance of handwriting fluency in text generation outcomes emphasizes that future
research should account for individual and group differences in handwriting fluency, as differences in text generation may be more strongly predicted by this transcription skill than ADHD symptoms. Regarding intervention research, it would be interesting to examine the effects of handwriting intervention on adolescents with ADHD to determine whether improving this skill has broader effects on their writing, improving areas in which they show less proficiency such as vocabulary, text length, and sentence structure. Similarly, examining writing quality and quantity in adolescents with ADHD who use or do not use assistive technology such as speech-to-text would allow for a comparison into how writing may improve when it is no longer constrained by handwriting abilities.

Future research should also examine the more complex relationships between our variables of interest to better understand how the relationship between ADHD status and inattention interact may be moderated by other variables. For example, does handwriting fluency moderate the relationship between inattention symptoms and certain writing outcomes such as length and accuracy? Research conducted with a larger sample will be able to better investigate these interconnections and yield more information on how ADHD status and symptoms are related to writing.

7.4 Conclusion

The writing abilities of adolescents with ADHD and the unique role inattention plays in predicting writing abilities are not well understood, so this study serves to broaden our knowledge of group differences in writing abilities between adolescents with and without ADHD, as well as investigate the extent to which inattention symptoms predict writing outcomes independent of relevant factors. Adolescents with ADHD wrote shorter essays with less sophisticated vocabulary, and performed lower on a sentence-writing task than their typically-
functioning peers. However, once handwriting fluency was controlled for, adolescents with ADHD differed only on vocabulary sophistication, indicating the importance of handwriting fluency for writing, over and above ADHD status when completing time limited writing tasks.

In examining whether inattention symptoms account for unique variance in writing outcomes independent of writing-related factors, results indicate that inattention symptoms only account for unique variance in performance on the sentence-writing task. Because the sentence-writing task did not provide support for how to structure the written responses, in contrast to the persuasive essay from which the other four writing outcomes were measured, this suggests that adolescents with higher levels of inattention have greater difficulty organizing their writing. Additionally, the fact that inattention only uniquely predicted the sentence-writing outcome also indicates that other writing-related factors, such as handwriting fluency and reading, are more important for predicting most of our writing outcomes.

These results have important implications in considering the planning of writing instruction and intervention for adolescents both with and without ADHD, indicating two areas of focus should be handwriting fluency and organization of writing. Future research should further examine the complex connections between inattention, writing ability, and writing-related factors such as handwriting fluency, working memory and reading, to investigate possible paths of effect and better understand how ADHD status and symptoms and writing are related.
References


employment and household income. *Medscape General Medicine, 8*(3), 12.


Miranda, A., Baixauli, I., & Colomer, C. (2013). Narrative writing competence and internal state


Table 1

Demographic, Cognitive, and Academic Characteristics of the ADHD and Control Groups

<table>
<thead>
<tr>
<th></th>
<th>ADHD n = 44</th>
<th>Control n = 50</th>
<th>Difference Statistic</th>
<th>Significance Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N(%)</td>
<td>N(%)</td>
<td>t</td>
<td>p</td>
</tr>
<tr>
<td>Gender (% male)</td>
<td>28 (64%)</td>
<td>19 (38%)</td>
<td>2.54</td>
<td>.013</td>
</tr>
<tr>
<td>Has an IEP (% yes)</td>
<td>35 (80%)</td>
<td>2 (4%)</td>
<td>-9.64</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Speaks language other than English at home (% yes)</td>
<td>9 (21%)</td>
<td>25 (50%)</td>
<td>3.50</td>
<td>.001</td>
</tr>
<tr>
<td>Born in Canada (% yes)</td>
<td>40 (91%)</td>
<td>32 (64%)</td>
<td>-2.60</td>
<td>.011</td>
</tr>
<tr>
<td>Age</td>
<td>15.63(1.03)</td>
<td>15.43(.87)</td>
<td>-1.03</td>
<td>.308</td>
</tr>
<tr>
<td>SES</td>
<td>8.14(2.2)</td>
<td>8.04(2.18)</td>
<td>-.2</td>
<td>.841</td>
</tr>
<tr>
<td>Parent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conners 3-DSM-IV-TR inattention symptoms</td>
<td>82.36(8.48)</td>
<td>51.04(6.2)</td>
<td>-20.61</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Conners 3-DSM-IV-TR H/I symptoms</td>
<td>83.09(9.7)</td>
<td>50.02(7.38)</td>
<td>-18.73</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Estimated IQ (WASI)</td>
<td>106.52(11.95)</td>
<td>111.26(9.07)</td>
<td>2.18</td>
<td>.032</td>
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<tr>
<td>Working Memory – Digits Backwardsa</td>
<td>9.48(2.55)</td>
<td>10.46(2.69)</td>
<td>1.81</td>
<td>.073</td>
</tr>
<tr>
<td>Working Memory – Listening Recallb</td>
<td>108.32(21.60)</td>
<td>114.62(16.01)</td>
<td>1.62</td>
<td>.109</td>
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<tr>
<td>Expressive Oral Languagec</td>
<td>54.41(8.98)</td>
<td>58.02(6.54)</td>
<td>2.25</td>
<td>.027</td>
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<tr>
<td>Decoding Ability – Word Readingd</td>
<td>103.68(8.95)</td>
<td>103.40(6.88)</td>
<td>-.17</td>
<td>.864</td>
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<tr>
<td>Decoding Ability – Pseudoword Decodinge</td>
<td>100.28(9.16)</td>
<td>103.76(9.08)</td>
<td>1.82</td>
<td>.071</td>
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<tr>
<td>Reading Comprehensionf</td>
<td>45.74(22.32)</td>
<td>50.57(25.89)</td>
<td>.77</td>
<td>.445</td>
</tr>
<tr>
<td>Handwriting Fluency</td>
<td>30.45(10.45)</td>
<td>41.38(9.90)</td>
<td>5.18</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note. IEP = Individual Education Plan; SES = socioeconomic status; WASI = Wechsler Abbreviated Scale of Intelligence; TOMAL = Test of Memory and Learning; WMTB-C = Working Memory Test Battery for Children; WJ-III ACH = Woodcock Johnson Test of Individual Achievement, Third Edition.

a = Digits Backwards subtest from the TOMAL.
b = Listening Recall subtest from the WMTB-C.
c = Vocabulary from the WASI.
d = Letter Word Identification subtest from the WJ-III ACH.
e = Word Attack subtest from the WJ-III ACH.
f = Passage Comprehension subtest from the WJ-III ACH.
g = number of letters correctly written in 30 seconds.
### Table 2

**Means and Standard Deviations of Writing Scores of Adolescents with and without ADHD**

<table>
<thead>
<tr>
<th>Measures</th>
<th>ADHD</th>
<th>Control</th>
<th>Without controlling for handwriting fluency</th>
<th>Controlling for handwriting fluency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
<td>F</td>
<td>p</td>
</tr>
<tr>
<td>WJ-III Writing Samples Subtest</td>
<td>102.25(12.42)</td>
<td>111.04(10.87)</td>
<td>11.87</td>
<td>.001</td>
</tr>
<tr>
<td>Essay Length&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.95 (25.61)</td>
<td>104.48 (23.58)</td>
<td>19.39</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Writing Accuracy&lt;sup&gt;b&lt;/sup&gt;</td>
<td>.87(.08)</td>
<td>.92(.07)</td>
<td>6.52</td>
<td>.012</td>
</tr>
<tr>
<td>Discourse Structures&lt;sup&gt;c&lt;/sup&gt;</td>
<td>4.86(1.81)</td>
<td>5.92(1.97)</td>
<td>5.85</td>
<td>.018</td>
</tr>
<tr>
<td>Vocabulary Sophistication&lt;sup&gt;d&lt;/sup&gt;</td>
<td>14.50(5.93)</td>
<td>20.36(5.84)</td>
<td>27.90</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

<sup>a</sup> = total words written in the persuasive essay.  
<sup>b</sup> = percentage of correct word sequences in the persuasive essay.  
<sup>c</sup> = number and quality of discourse structures in the persuasive essay.  
<sup>d</sup> = number of seven letter words, including repetitions, in the persuasive essay.
Table 3

Zero-order Correlations for the Full Sample

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Age</td>
<td>1.0</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Gender</td>
<td>-0.95</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Handwriting Fluency</td>
<td>0.203*</td>
<td>0.397***</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Working Memory Composite</td>
<td>0.021</td>
<td>0.046</td>
<td>0.417***</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. WASI Vocabulary</td>
<td>-0.052</td>
<td>0.152</td>
<td>0.387***</td>
<td>0.508***</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Passage Comprehension</td>
<td>0.128</td>
<td>0.138</td>
<td>0.441***</td>
<td>0.366***</td>
<td>0.665***</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Reading Composite</td>
<td>0.009</td>
<td>0.306**</td>
<td>0.494***</td>
<td>0.408***</td>
<td>0.535***</td>
<td>0.787***</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Parent Conners 3-DSM-IV-TR inattention symptoms</td>
<td>0.185</td>
<td>-0.194</td>
<td>-0.224*</td>
<td>-0.210*</td>
<td>-0.053</td>
<td>-0.100</td>
<td>1.0</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Sentence Writing</td>
<td>0.048</td>
<td>0.144</td>
<td>0.448***</td>
<td>0.478***</td>
<td>0.480***</td>
<td>0.484***</td>
<td>0.494***</td>
<td>-0.339**</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Essay length</td>
<td>0.175</td>
<td>0.088</td>
<td>0.560***</td>
<td>0.243*</td>
<td>0.358***</td>
<td>0.362***</td>
<td>0.254*</td>
<td>-0.361***</td>
<td>0.330**</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Writing accuracy</td>
<td>0.208*</td>
<td>0.346**</td>
<td>0.553***</td>
<td>0.219*</td>
<td>0.165</td>
<td>0.380***</td>
<td>0.510***</td>
<td>-0.214*</td>
<td>0.355***</td>
<td>0.358***</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Discourse Structures</td>
<td>0.132</td>
<td>0.207*</td>
<td>0.223*</td>
<td>0.072</td>
<td>0.003</td>
<td>0.008</td>
<td>0.058</td>
<td>-0.224*</td>
<td>0.094</td>
<td>0.305**</td>
<td>0.326**</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>13. Vocabulary Sophistication</td>
<td>0.311**</td>
<td>0.150</td>
<td>0.679***</td>
<td>0.277**</td>
<td>0.341**</td>
<td>0.384***</td>
<td>0.327**</td>
<td>-0.346**</td>
<td>0.736***</td>
<td>0.454***</td>
<td>0.283**</td>
<td>1.0</td>
<td></td>
</tr>
</tbody>
</table>

Note. WASI = Wechsler Abbreviated Scale of Intelligence.
*<.05, **<.01, ***<.001
Table 4

Regression Analyses for Writing Outcomes

<table>
<thead>
<tr>
<th>WJ-III Writing Samples Subtest</th>
<th>B</th>
<th>SEB</th>
<th>β</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inattention Symptoms</td>
<td>-.193</td>
<td>.065</td>
<td>-.270</td>
<td>-2.96</td>
<td>.004</td>
</tr>
<tr>
<td>Handwriting Fluency</td>
<td>.055</td>
<td>.114</td>
<td>.051</td>
<td>.480</td>
<td>.632</td>
</tr>
<tr>
<td>Working Memory</td>
<td>3.17</td>
<td>1.51</td>
<td>.213</td>
<td>2.10</td>
<td>.039</td>
</tr>
<tr>
<td>Expressive Oral Language</td>
<td>.229</td>
<td>.160</td>
<td>.151</td>
<td>1.43</td>
<td>.156</td>
</tr>
<tr>
<td>Reading Ability</td>
<td>4.63</td>
<td>1.69</td>
<td>.286</td>
<td>2.74</td>
<td>.007</td>
</tr>
</tbody>
</table>

| Essay Length                  |      |      |     |      |      |
| Inattention Symptoms          | -2.86| .148 | -.186| -1.93| .057 |
| Handwriting Fluency           | 1.01 | .250 | .439| 4.05 | <.001|
| Working Memory                | -2.67| 3.24 | -.084| -1.825| .441 |
| Expressive Oral Language      | .412 | .410 | .124| 1.40 | .318 |
| Reading Comprehension         | .257 | .290 | .107| .887 | .378 |

| Writing Accuracy              |      |      |     |      |      |
| Inattention Symptoms          | .000 | .000 | -.091| -.94 | .350 |
| Age                           | .012 | .008 | .134| 1.47 | .145 |
| Gender                        | .024 | .015 | .149| 1.59 | .116 |
| Handwriting Fluency           | .002 | .001 | .317| 2.37 | .012 |
| Working Memory                | -.011| .010 | -.109| -1.12| .266 |
| Reading Comprehension         | .037 | .011 | .342| 3.4  | .001 |

| Discourse Structures          |      |      |     |      |      |
| Inattention Symptoms          | -.022| .012 | -.204| -1.86| .066 |
| Gender                        | .018 | .019 | .111| .951 | .344 |
| Handwriting Fluency           | .637 | .402 | .170| 1.58 | .117 |

| Vocabulary Sophistication     |      |      |     |      |      |
| Inattention Symptoms          | -.08 | .032 | -.218| -2.47| .016 |
| Age                           | 1.65 | .548 | .245| 3.002| .004 |
| Handwriting Fluency           | .272 | .058 | .494| 4.67 | <.001|
| Working Memory                | -.320| .727 | -.042| -1.440| .661 |
| Expressive Oral Language      | .099 | .077 | .126| 1.28 | .203 |
| Reading Ability               | .071 | .823 | .008| .086 | .931 |