

Evaluating Working Memory Deficits on Writing in Youth with Autism Spectrum Disorder
(ASD)

by

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H.B.A, The University of Western Ontario, 2009
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Supervisory Committee

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Abstract

Few studies have researched writing difficulties in individuals with Autism Spectrum Disorder (ASD) and the factors responsible for such difficulties. The current study sought to examine writing difficulties in individuals with ASD and the contribution of working memory (WM) difficulties. The investigation consisted of five youth formally diagnosed with ASD (under DSM-IV-TR, higher functioning Autistic Disorder or Asperger's Disorder), and five youth with no formal diagnosis. Participants completed a counterbalanced battery of tests that assessed their written expression and WM abilities. Due to challenges in recruiting enough participants for purposes of quantitative research, the study mainly used a case-study analysis. The study showed that participants with ASD (group with ASD) had more difficulty with writing and WM tasks than participants without ASD (traditionally developing [TD] group). Nonparametric analyses revealed that writing and WM were not related; however, these findings are cautionary due to very low participation numbers in the investigation. Case-study analysis showed that the group with ASD had underdeveloped writing skills notably in the areas of word count, vocabulary, spelling and grammar. Regarding WM abilities, the group with ASD showed variable patterns of difficulty; some had strengths in verbal WM while others did not. Unfortunately, the study could not determine if writing difficulties were specific due to WM or other causes, although it does provide useful information for further investigation. Additional studies investigating the relationship between writing and WM, particularly in individuals with ASD, are encouraged.

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List of Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
ADI-R	Autism Diagnostic Interview, Revised
APA	American Psychiatric Association
ASD	Autism Spectrum Disorder
Beery VMI 6	Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition
CTOPP-2	Comprehensive Test of Phonological Processing, Second Edition
DSM-IV-TR	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision
DSM-V	Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
EF	Executive Functions
FSIQ	Full Scale Intelligence Quotient
FWS	The Functional Writing System
GARS-2	Gilliam Autism Rating Scale, Second Edition
IQ	Intelligence Quotient
KBIT-2	Kaufman Brief Intelligence Test, Second Edition
M	Mean
P1	Participant 1 from the group with ASD
P2	Participant 2 from the group with ASD
P3	Participant 3 from the group with ASD
P4	Participant 4 from the group with ASD

P5	Participant 5 from the group with ASD
PIQ	Performance Intelligence Quotient
R	Range
SD	Standard Deviation
SS	Standard Score
TD	Typically Developing
VIQ	Verbal Intelligence Quotient
WM	Working Memory
WMTB-C	Working Memory Test Battery for Children
WIAT-II	Wechsler Individual Achievement Test, Second Edition

Chapter 1: Introduction

Rationale

The purpose of this study was to examine how Executive Functioning (EF), specifically working memory (WM), in individuals with Autism Spectrum Disorder (ASD) influences writing to better understand the cause of writing difficulties in this population. Executive functioning has been defined as different control processes that are instrumental for goal-directed behaviour, including planning, WM, mental flexibility, response inhibition, impulse control, and monitoring of actions (Bishop & Norbury, 2005; Pennington & Ozonoff, 1996), all of which are important for writing. Writing is a complex mental task that integrates transcription (e.g., orthographic demands), WM, reader and content, and EF demands, all to produce text. Writing is an important task for success in schools and beyond, The British Columbia Ministry of Education views literacy (e.g., written language) as fundamental to “thinking, learning, and communicating in all cultures” (British Columbia Ministry of Education, 2007, p. 3). Furthermore, teaching youth to use written language is one of the main goals of the school curriculum. According to Berninger’s research utilizing her Functional Writing System (FWS) (Berninger & Amtmann, 2003), WM is core to the writing process in that it is the coordinating cognitive process that controls and manages the different components of text generation. Working memory deficits greatly impact text generation (Berninger & Amtmann, 2003).

Due to the unique cognitive profile in individuals with ASD, a myriad of problems in writing would be anticipated. First, writing includes a social component in that we are often writing for an audience. Difficulties with social perspective taking in individuals with ASD would be expected to hinder this aspect of writing (Brown & Klein, 2011; Mayes & Calhoun, 2003, 2005, 2007, 2008; Myles, Huggins, Rome-Lake, Hagiwara, Barnhill, & Griswold, 2003).

Second, students with ASD would be expected to struggle in other aspects of writing, including planning, handwriting, organization, and addressing abstract concepts, due to cognitive deficits in attention, flexibility, EF, and graphomotor output (Myles et al., 2003). Finally, there are many connections between oral language development, written language development and communication deficits and delayed or atypical language development seen in individuals with ASD that would be expected to impede writing in this population (Shanahan, 2006). While investigation of all of the different cognitive processes that may contribute to problems with writing in individuals with ASD is beyond the scope of this research project, WM was chosen as the focus due to its centrality in Berninger and Amtmann's FWS (2003).

Statement of the Problem

To date, there have been very few studies that have investigated writing in school-aged children with ASD. Of the research investigating writing in individuals with ASD that exists, most studies have focused on adults (Brown & Klein, 2011). Some studies of writing in adults with ASD have focused on the impact of theory of mind difficulties (i.e., problems with social perspective taking) on written expression (Brown & Klein, 2011). Alternately, other studies have documented difficulties with written expression without addressing the underlying cognitive causes of these difficulties (Mayes & Calhoun, 2003, 2005, 2007, 2008). In fact, little research has been undertaken to investigate the impact of ASD-associated cognitive difficulties (e.g., EF problems, WM deficits) on writing, either in adult or child populations. Given that individuals with ASD are known to have deficits in aspects of EF, such as WM, and given the important role of WM in written language, a better understanding of how WM deficits might contribute to writing problems in youth with ASD is crucial. In addition to academic success, learning to write fluently extends beyond the classroom in that writing has become a major form of social

communication. For example, writing emails, texting, and web-based messaging are common modes of communication in youth that can facilitate social belonging for students with ASD (Wainer & Ingersoll, 2011). The present study was designed to explore the relationship between WM deficits and writing in youth with mild ASD. Berninger and Amtmann's (2003) FWS, and Baddeley and Hitch's models of WM (1974) were the theoretical frameworks through which WM and writing, and the link between the two, were explored.

Chapter 2: Exploration of Theories and Current Research

Overview

This chapter defines essential concepts such as EF and WM. Working memory is divided into the theoretical components initially proposed by Baddeley and Hitch (1974) and subsequently revised by Baddeley (2000). The chapter also presents the history of cognitive writing models and introduces a current model, Berninger and Amtmann's FWS (2003). The critical roles of EF and WM in the writing process are explained. Next, ASD and the three most prominent cognitive theories of ASD are discussed. The chapter then links the difficulties faced by the population diagnosed with ASD in written tasks to EF and, in relation to, WM difficulties, culminating in a description of the current study.

Theories of Executive Functions

There are many different definitions of EF and researchers have tried to define this elusive construct in various ways. Some recent conceptualizations of EF have shifted away from defining EF as a unitary construct (e.g., “supervisory attention system” [Norman & Shallice, 1986]) towards recognizing EF as a diverse construct comprised of a constellation of diverse functions that underlie self-regulation and goal-directed behavior (Altemeier, Abbott, & Berninger, 2008; Lyon & Krasnegor, 1996). Overall, whether defined as a unitary or diverse construct, there is agreement that EFs are higher-order control processes necessary to guide goal-directed behaviour in a constantly changing environment (Jurado & Rosselli, 2007; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009). Executive functions are also seen as being strongly linked to academic success and literacy development (Altemeier et al., 2008; Best, Miller, & Naglieri, 2011). With respect to diverse ‘functions’ that might make up an overall construct of EF, specific abilities such as planning, WM, mental flexibility, response initiation,

response inhibition, impulse control and monitoring of action have been conceptualized as key constructs (Altemeier et al., 2008; Roberts, Robbins, & Weiskrantz, 1998; Stuss & Knight, 2002).

One of the challenges in generating a cohesive definition of EF has been identifying appropriate tasks to measure it. The tasks used in initial EF studies were imprecise, measuring several aspects of EF at the same time with no method to examine variance among operations (Ozonoff, 1997). Current EF measures continue to prove problematic regarding how to define and capture these cognitive processes. Cognitive measures of EF are often administered in very structured settings, which differ distinctly from the EF demands required in everyday life, making it very difficult to measure the construct adequately. Although different neurodevelopmental disorders are associated with different profiles of strengths and weaknesses in EF (Ozonoff & Strayer, 1997), even studies into EF in the same clinical populations sometimes yield varying results (Ozonoff & Jensen, 1999). This may be due to different ‘definitions’ for, and ways of, conceptualizing EF, and the use of different clinical measures to assess EF (Ozonoff & Jensen, 1999). The current study considers EF as a multidimensional construct (Friedman & Miyake, 2017) and focuses particularly on the WM sub-component of EF (Baddeley & Hitch, 1974).

Working memory is a complicated variable to define and whether it is an aspect of attention (Baddeley & Hitch, 1974; Vandierendonck, 2014) or EF (Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000) is up for debate. Regardless of whether one views WM as an EF or not, it is a central component of cognition that is necessary for goal-directed behaviour (Ozonoff & Strayer, 2001) and for completing academic tasks (Best et al., 2011). Working memory tasks require the ability to process and store information simultaneously (Ozonoff &

Strayer, 2001). One prominent model of WM is that proposed by Baddeley and Hitch (Baddeley & Hitch, 1974), as seen in Figure 1 below. In Baddeley and Hitch's model (Baddeley & Hitch, 1974), WM is divided into four components: the central executive, the visuospatial sketchpad (i.e., storage unit), the phonological loop (i.e., used for maintaining information in the temporary storage unit) and the episodic buffer (Baddeley, 2000; Berninger, Abbott, Thomson, Swanson, Wijsman, & Raskind, 2006). The central executive is responsible for the control and regulation of cognitive processes and is driven by two subordinate systems; the visuospatial sketchpad and the phonological loop, which are specialized for temporary storage and manipulation of visual and verbal material, respectively (Alloway, Gathercole, Willis, & Adams, 2004). The episodic buffer is a multimodal coding system that serves as an interface between different kinds of codes and works closely with the central executive (Baddeley, 2000). The phonological loop holds and integrates auditory information in the episodic buffer (Alloway et al., 2004). The phonological loop plays a key role in the development of language and vocabulary and is often assessed by using serial verbal recall tasks involving either non-words or digits (Alloway et al., 2004). The phonological loop plays a key role in the development of language and vocabulary, which is crucial for the development of writing (Alloway et al., 2004). The phonological loop has been reported to be integral in literacy development for reading and writing (Swanson & Berninger, 1996). Reading and writing skills are closely related and are part of the same language systems with research revealing that the phonological loop might serve as a "language learning device" and may help develop spoken and written language (Baddeley, Gathercole, & Papagno, 1998). Impairments in the phonological loop are likely to result in reading and spelling difficulties due to the high level of processing required (Berninger, Vaughan, Abbott, Begay, Coleman, Curtin, & Graham, 2002). The visuospatial sketchpad is responsible for the processing and maintenance

of material that can be described in terms of its visual or spatial characteristics (Alloway et al., 2004). Visuospatial skills have been found to contribute to one's ability to translate sounds into shapes; this translation process is termed the orthographic loop (Berninger et al., 2002). The central executive is a limited resource that can be flexibly allocated to support either processing or storage (Alloway et al., 2004). Working memory is a crucial component to academic success; Gathercole, Brown, and Pickering (2003) found that measures of WM at school entry have been found to predict children's academic success up to three years later. Hooper, Costa, McBee, Anderson, Yerby, Knuth, and Childress (2011) proposed verbal and visuospatial WM, in addition to other linguistic and attention/EF, are highly associated with written expression.

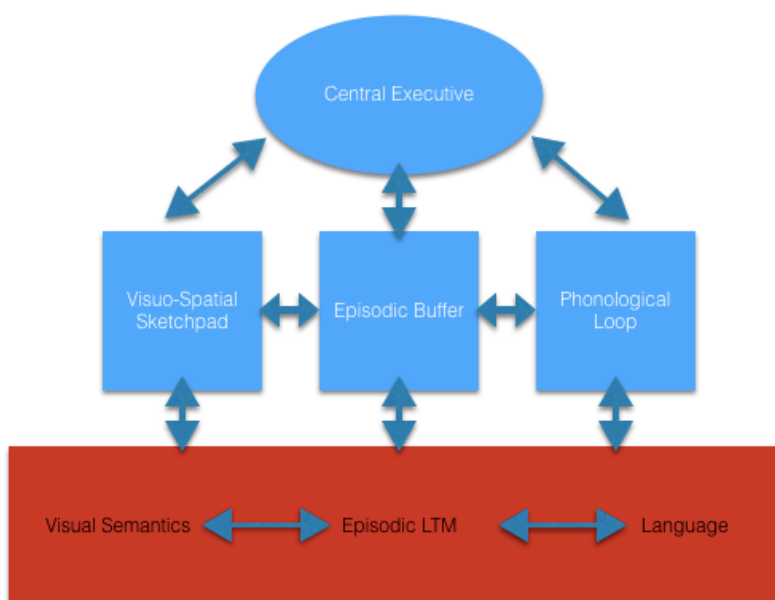


Figure 1. The current model of WM, revised (Baddeley, 2000).

Theories of Writing

Writing is a complex form of communication requiring the coordination of a number of component cognitive abilities. In producing a written composition, an individual must

simultaneously attend to the subject, the text, and the reader (Fletcher, Lyon, Fuchs, & Barnes, 2007). A skilled writer can be confronted with a variety of tasks to coordinate, including how to generate and organize ideas, phrase grammatically correct sentences, use correct punctuation and spelling, and tailor ideas, tone, and wording to the desired audience (Deane, Odendahl, Quinlan, Fowles, Welsh, & Bivens-Tatum, 2008).

There are several major theories of writing with cognitive models at the forefront. Cognitive models of writing have tended to define writing in terms of problem-solving ability (McCutchen, Teske, & Bankston, 2008). In these models, writing is viewed as a highly complex task involving strategic planning of text, motor skills, idea generation, organizational skills, and the ability to use correct grammar, spelling and vocabulary (Deane et al., 2008).

Bereiter and Scardamalia (1987) propose a model of writing that is dependent on two key types of knowledge: content knowledge, which is specific knowledge about the topic of the written text, and discourse knowledge, which relates to the understanding of genre and the writing process. Bereiter and Scardamalia's (1987) research lies in the area of expert writing, problem-solving, and goal setting. Bereiter and Scardamalia (1987) propose that skilled writers often "problematize" a writing task, adopting a strategy they called *knowledge transforming*. Expert writers often develop elaborate goals, particularly content and rhetorical goals, which require sophisticated problem-solving. In contrast, novice writers take a simpler, more natural approach to composing, adopting a knowledge-telling approach in which composition is generated by association, with one idea prompting the next (Bereiter & Scardamalia, 1987). Whereas the inefficient skills of novices may restrict them to a knowledge-telling approach, skilled writers can move freely between knowledge telling and knowledge transforming (Bereiter & Scardamalia, 1987).

John R. Hayes and Linda S. Flower (1980) developed the Cognitive Process Model for writing. These authors argue that writing is a set of hierarchically organized thinking processes rather than a series of linear steps or discrete stages. Hayes and Flower's (1980) model deconstructs writing into three parts: the task environment, the writer's long-term memory and the writing process (Deane et al., 2008; Hayes & Flower, 1981). Hayes and Flower (1981) posit that the writer's long-term memory has various types of knowledge, including knowledge of the topic, knowledge of the audience, and stored writing plans. The writer's long-term memory includes everything the writer stores about the topic, including useful knowledge about the task and audience, and the writer's plans or goals in writing. Hayes and Flower (1981) outline four major writing processes: planning, translating, reviewing, and monitoring (Deane et al., 2008; Hayes & Flower, 1981). Particularly relevant here is that Hayes (1996) revised their original model to take into consideration different aspects of WM and its role in the cognitive process of writing (Deane et al., 2008).

Within Berninger and Amtmann's (2003) cognitive model of writing, the FWS (i.e., termed the Simple View of Writing), the writer is seen as "coordinating lower level text generation and executive control processes within a limited capacity WM framework". Therefore, lower level skills, such as fluent text generation and encoding (e.g., spelling) must be automatized to free up valuable cognitive resources needed to translate ideas into quality text (Berninger & Amtmann, 2003). Berninger (2003) posits that there are three main components of writing: Text Generation (higher level), Transcription (lower-level), and EF, with all three of these components coordinated by WM to produce written text. Working memory, therefore, plays a key role in coordinating all the different processes (e.g., setting goals; generating ideas; planning words, sentences, and text structures; monitoring; and revising) that interact recursively

during text generation. Writing is extremely interactive; the different components involved in writing “continually interrupt each other”, and need a WM “architecture” to coordinate these processes (Berninger, 2003). See Figure 2.

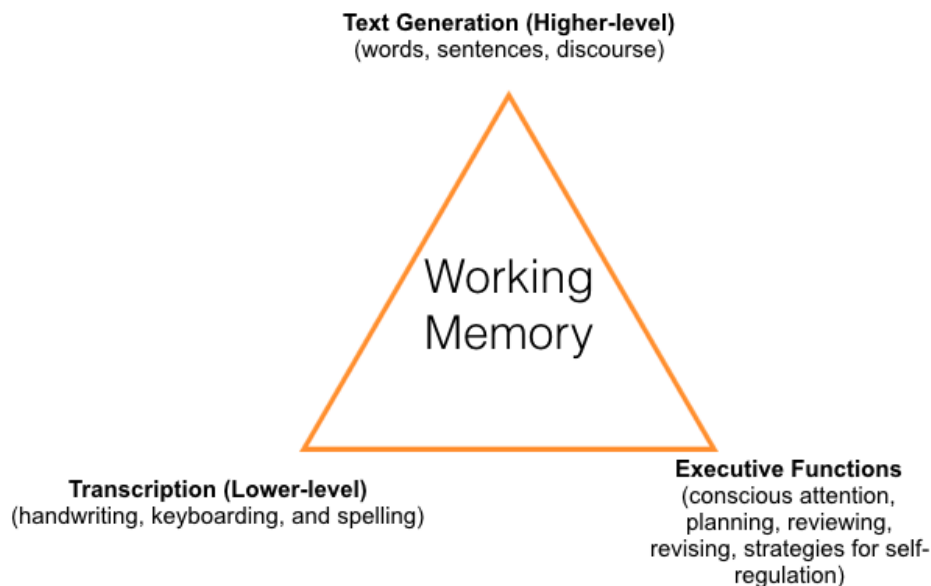


Figure 2. The Functional Writing System (Berninger & Amtmann, 2003).

However conceptualized, all writing models specify that writing processes compete for limited cognitive resources, particularly limited WM systems (Berninger & Amtmann, 2003; Deane et al., 2008; McCutchen, 1996).

Berninger and Amtmann’s (2003) FWS was chosen as the cognitive model of writing and theoretical framework through which the relation between WM and writing in individuals with ASD was analyzed in this present study. The FWS (Berninger & Amtmann, 2003) was selected, as it is a relatively straightforward model, has been used as a framework for writing research in

many other clinical populations, and because of its emphasis on WM, which is of direct relevance in this study.

Executive Functioning, Working Memory and Writing

From the perspective of those studying writing, EF has generally been defined as control processes that influence written output (Hooper, Swartz, Wakely, de Kruif, & Montgomery, 2002). Executive functions are correlated with writing skills in typically developing populations (Hooper et al., 2002), including handwriting (Berninger et al., 2006) and overall written output (Hooper et al., 2002), and are seen as adding variance to models of integrated reading–writing tasks such as note-taking and report writing (Altemeier, Jones, Abbott, & Berninger, 2006). When writing, a series of attention/EF skills are involved, including focusing attention, sustaining WM, planning, organizing the text, and continually monitoring performance (Casas, Ferrer, & Fortea, 2013).

From Berninger’s perspective, EF is involved in the following ways in the writing process: focusing attention, WM, planning and organizing text according to a purpose, continuous monitoring of performance, reviewing, revising, and applying strategies for self-regulation. When engaged in writing, writers need to continuously coordinate between lower level text generation skills (e.g., transcription and spelling) and higher-level skills (e.g., planning and organizing), within a limited capacity WM framework (Berninger & Amtmann, 2003). As such, EF and WM is central to this model and the writing process.

Executive functions monitor recursive planning, translating, and reviewing/revising processes in the problem-solving process of writing (Hayes & Flower, 1980). Executive functions are intimately linked to many aspects of writing, and deficits in this area impact writing composition dramatically. There is evidence that EF contribute unfalteringly to the development

of writing skills in elementary school students as seen in many research studies (Altemeier et al., 2006; Casas et al., 2013). In addition, individual differences in EF have been shown to affect both high-level composing processes in writing (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997; Singer & Bashir, 2004) and lower level handwriting and spelling processes (Berninger & Amtmann, 2003). For example, performance on lower level writing process tasks, such as automatic letter writing, is predicted by EF (Berninger, Nielsen, Abbott, Wijsman, & Raskind, 2008), as are high-level composition tasks such as planning and organizing (Berninger & Amtmann, 2003). Even a core writing skill such as handwriting automaticity requires EF for the integration of multiple processes, including motor planning, orthography, orthographic-motor integration via the orthographic loop of WM, and processing speed (Berninger, Nielson, Abbott, Wijsman, & Raskind, 2008).

Within the FWS (Berninger & Amtmann, 2003), WM is the central component through which all other writing components are relayed. As stated above, lower level writing skills, such as handwriting and spelling, must be automatized to free up WM space for higher order text generation skills (Berninger et al., 2006). Specifically, WM capacity allows one to simultaneously manage a series of processes, such as keeping various ideas alive, recovering morphosyntactic clues from long-term memory and continuous revision, all of which result in a coherent and cohesive text (Kellogg, 1996, 1999; Swanson & Berninger, 1996).

Other models of writing also place EF and WM at the forefront. Kellogg's (1996) model of writing theorizes that the planning component of the writing process relies on the central executive and the visuospatial sketchpad through choosing a tone, creating ideas for the text, and organizing those ideas. When a writer creates a mental visualization of the form of the paper, organizing the ideas and supporting details, the visuospatial sketchpad is activated. Finally, the

phonological loop and the central executive are taxed by the demands of the translating subprocess. During text generation, writers create internal discourse about the specific diction and the order of that diction. This discourse creates phonological representations of the words that are syntactically framed and placed in the loop. In addition, the writer must choose which text generated by inner speech will be stored in the loop, placing demands on the central executive. Storing these words enables the writer to create phrases and clauses in pretext. Planning also uses the central executive when it prepares the motor systems for writing, typing, or dictating. However, all three outputs minimally consume central executive capacity.

Berninger has utilized the FWS (Berninger & Amtmann, 2003) to explore writing (i.e., spelling skills) in at-risk learners (Berninger et al., 2002), struggling writers with Attention Deficit Hyperactivity Disorder (ADHD; Richards, Abbott, & Berninger, 2016), and students with dyslexia (Berninger et al., 2006; Berninger et al., 2008). Altemeier et al. (2008) investigated the association between three EF (i.e., inhibition, shifting, and updating/monitoring) and writing in students with typical literacy development and dyslexia. The results demonstrated that EF does explain some of the variances in writing skills, although the results were not entirely straightforward (Altemeier et al., 2008). The FWS (Berninger & Amtmann, 2003) has not yet been utilized to explore the writing skills of students with ASD, many of who have EF impairments similar to that seen in individuals with ADHD and other neurodevelopmental disorders.

Some of the research concerning EF and writing in youth has focused on individuals with ADHD and how attention and EF difficulties in this population influence specific aspects of the writing process. Research has shown that individuals with ADHD have problems with prerequisite writing skills, including transcription (De La Paz, 2001) and spelling (Berninger,

2004), difficulties in using language to express thoughts or producing a coherent narrative, and the planning and organizing of written compositions (De La Paz, 2001). A direct link has been made between EF impairments in ADHD and written expression, documenting the importance of EF in the writing process (Barkley, 1997). Problems with EF are very common in individuals with ADHD, including having difficulties with organizing tasks and activities, (Lienemann & Reid, 2008), inhibition (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), WM (Kempton, Vance, Maruff, Luk, Costin, & Pantelis, 1999; Rhodes et al., 2005), planning (Casas et al., 2013; Kempton et al., 1999; Rhodes et al., 2005), and flexibility (Vance et al., 2003). Padron and Cornoldi (2007) specifically investigated the link between planning skills and writing in youth with ADHD. They found that these students wrote poorly articulated compositions, without following a logical thread in their narrative. Rodriguez and Garcia (2008) found that students with ADHD made little use of composition processes such as thinking about the composition, making an outline, or correcting their work, leading to lower quality, coherence, and structure in their written work. Students with ADHD also struggle with the mechanics of writing, making more spelling errors and grammatical errors in addition to displaying graphomotor problems that render their writing difficult to read (Adi-japha, Landau, Frenkel, Teicher, Grosstsur, & Shalev, 2007; Casas et al., 2013). Casas et al. (2013) examined writing in youth with ADHD, seeking to create a collection of all the tasks that youth with ADHD did poorly on related to writing. This study did not research the link between EF and writing, but their results revealed that EF plays a role in the deficits that youth with ADHD are experiencing when writing. These authors found that youth with ADHD were less proficient writers, scoring significantly lower on the majority of variables evaluated (e.g., number of words, number of sentences, mean length of utterance in words, cohesiveness, syntactic complexity, morphosyntactic errors, etc.). Notably, youth with

ADHD scored significantly lower in text structure, had difficulty articulating an organizational plan for their writing, and showed deficits in the central executive (Casas et al., 2013). This study also demonstrated that youth with ADHD had difficulties in the main processes of written composition: planning, translation, and revision (Casas et al., 2013). This finding suggests that youth with ADHD have considerable difficulties on tasks that require organizing and structuring information, which are processes controlled by EF; these could be related to deficits in EF (Barkley, 2003; Casas et al., 2013).

Given that EF deficits are common in individuals with ADHD and that EF is a major component of the writing process, researchers have proposed that individuals with ADHD would be expected to have problems with “retaining ideas in their minds, acting upon and organizing ideas, quickly retrieving grammar, spelling and punctuation rules from long-term memory, manipulating all this information, remembering ideas to write down, organizing the material in a logical sequence, and then reviewing and correcting errors” (Casas et al., 2013, p. 444) . These types of difficulties with written language have been observed in individuals with ADHD (Casas et al., 2013; Padron & Cornoldi, 2007; Rodriguez & Garcia, 2008). Clearly there is evidence of the impact of EF difficulties on the writing process in youth with ADHD, which may hold direct relevance to individuals with ASD who also often experience attention and EF problems.

Autism Spectrum Disorder: Diagnosis and Clinical Features

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder with a wide range of clinical features and characteristics that vary in severity (American Psychiatric Association [APA], 2000). Some individuals are mildly impaired by their symptoms, whereas others have severe disabilities (APA, 2000). Autism Spectrum Disorder is a lifelong neurodevelopmental disorder affecting social, communication, and behavioural function (APA, 2000). The criteria for

the diagnosis of ASD changed in 2013 with the shift from “The Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision” (DSM-IV-TR) to “The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition” (DSM-V). The DSM-IV-TR described core deficits across three separate areas: qualitative impairment in social interaction, qualitative impairment in communication, and restricted or repetitive stereotyped patterns of behaviour (APA, 2000). Also, the DSM-IV-TR provided categorized different subtypes of ASD, including Autistic Disorder, Asperger’s Disorder, Childhood Disintegrative Disorder, and Pervasive Developmental Disorder Not Otherwise Specified (PDD-NOS). Within the DSM-V, the core deficits in ASD have been collapsed from three to two primary domains: persistent deficits in social communication/social interaction and repetitive behaviours (APA, 2013). Further, the DSM-V no longer refers to separate disorders along the Autism Spectrum (i.e., Autistic Disorder, Asperger Syndrome, and PDD–NOS (APA, 2000), referring to all of these disorders as Autism Spectrum Disorder (ASD) with the specifiers of Mild, Moderate, or Severe with or without an accompanying intellectual or language impairment (APA, 2013). In addition to core differences in social, communication and behavioural functions, many youth with ASD also experience deficits with EF and with writing (Corbett, Constantine, Hendren, Roche, & Ozonoff, 2009; Goldberg, Mostofsky, Cutting, Mahone, Denckla, & Landa, 2005; Happé, Booth, Charlton, & Hughes, 2006; Shuh & Eigisti, 2012), which will be the focus of the current study.

Cognitive Models of Autism Spectrum Disorder: The Executive Deficit Theory

Different cognitive theories have been proposed to explain the spectrum of impairments observed in individuals with ASD (Bishop & Norbury, 2005; Pellicano, 2010; Volkmar & Pauls, 2003). Three major theoretical perspectives have surfaced; the Theory of Mind Model (Happé, 1994), Central Coherence Model (Frith, 1989, 2003), and Executive Functioning Model

(Hughes, Russell, & Robbins, 1994; Ozonoff, Pennington, & Rogers, 1991; Hill, 2004). Each cognitive model has strengths and weaknesses, and no one model has been able to account for the full spectrum of difficulties seen in ASD. However, there has been some convincing research regarding the primacy of EF deficits and support for the Executive Function Theory of ASD (Bishop & Norbury, 2005; Hughes et al., 1994; Mayes & Calhoun, 2003, 2005, 2007, 2008; Nyden, Gillberg, Hjelmquist, & Heiman, 1999; Nyden, Billstedt, Hjelmquist, & Gillberg, 2001; Wechsler, 1991, 2003).

There have been a number of proponents of idea that the fundamental impairment in ASD may be due to EF deficits (Bishop & Norbury, 2005; Hill, 2005). The Executive Function Theory has attracted particular attention because it could account for restricted interests and repetitive, stereotyped behaviours, as well as some of the social and communicative impairments associated with ASD (Hughes, 2001; Ozonoff, 1997). Many studies indicate that youth with ASD perform poorly on measures of attention and EF (Bishop & Norbury, 2005; Hughes et al., 1994; Mayes & Calhoun, 2003, 2005, 2007, 2008; Nyden et al., 1999, Nyden et al., 2001; Wechsler, 1991, 2003), including information processing speed (Mayes & Calhoun, 2003, 2005, 2007, 2008), vigilance, response inhibition, cognitive flexibility/switching, and WM (Corbett et al., 2009; Russell, Jarrold, & Henry, 1996; Steele, Minshew, Luna, & Sweeney, 20017; Schuh & Eigsti, 2012). Clinically, the symptoms of ASD have also been associated with EF deficits, mirroring that seen in individuals with documented frontal lobe lesions, including a need for sameness and repetitive behaviours, lack of impulse control, difficulty initiating new non-routine actions, difficulties with generating new ideas, and difficulty flexibly switching between activities (Hill, 2004; Rajendran & Mitchell, 2007). Further, youth with ASD display attention and EF problems similar to youth with other neurodevelopmental disorders (e.g., ADHD, as described above). In

addition, ASD and ADHD are commonly comorbid (Corbett & Constantine, 2006; Goldberg et al., 2005; Goldstein and Schwebach, 2004; Verte, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006), with up to 95% of youth with ASD showing clinically significant attention problems (Sokolova et al., 2017). Although some have proposed that attention and EF problems are core cognitive features of ASD (Mayes & Calhoun, 2003, 2005, 2007, 2008), others have proposed that attention and EF problems in individuals with ASD are primarily resulting from comorbid ADHD (Pennington & Ozonoff, 1996; Corbett et al., 2009). Regardless of whether attention/EF difficulties are primary or secondary in ASD, deficits in attention and EF are common in youth with ASD and influence function (Happé et al., 2006; Shuh & Eigisti 2012; Corbett et al., 2009; Goldberg et al., 2005).

The studies that have investigated EF in individuals with ASD from a neuropsychological perspective have revealed variable results (Shuh & Eigisti 2012; Corbett et al., 2009; Goldberg et al., 2005). Some of this variability is likely due to differences in diagnostic criteria for ASD, the specific populations diagnosed with ASD sampled, and the use of different EF measures (Corbett et al., 2009). Some studies have demonstrated core deficits in EF in ASD (Corbett et al., 2009), whereas other studies have not supported this theory (Happé et al., 2006). Happé et al. (2006) compared individuals with ASD, ADHD and typically developing individuals on EF tasks and concluded that individuals with ASD have less severe and persistent EF deficits than youth with ADHD (Happé et al., 2006). On the other hand, Corbett et al. (2009) documented that youth with ASD performed more poorly than IQ matched typically developing youth and youth with ADHD, in aspects of EF such as inhibition, WM, and flexibility.

Concerning specific areas of EF that tend to be impacted in individuals with ASD, poor mental flexibility has been consistently documented as an area of concern (Hill, 2004; Corbett et

al., 2009; Ozonoff & Jensen, 1999). Poor mental flexibility leads to difficulty with shifting thoughts and actions (Hill, 2004), as clinically illustrated by perseverative, stereotyped behaviour and difficulties in the regulation and modulation of behaviour.

In addition, inhibition deficits have been documented in some studies with ASD, although not consistently across studies. Inhibition can be defined as delaying an automatic response to achieve a goal and protection of that delay even in the face of interference (Altemeier et al., 2008; Barkley, 2003). Inhibition is thought to be a lower level aspect of EF that supports higher order EF such as mental set shifting and can be measured in different ways (i.e., stopping an action before it has occurred or stopping an action when it is already in progress; Blair, Zelazo, & Greenberg, 2005; Hughes, 1998; Miyake et al., 2000; Pennington, 1997). Research regarding inhibition deficits in youth with ASD has been inconclusive with some research reporting inhibition deficits (Hill, 2004; O'Hearn, Asato, Ordaz, & Luna, 2008) and some not (Ozonoff & Strayer, 2001). As a whole, results have shown that response inhibition problems tend to be more problematic for youth with ADHD than those with ASD (Corbett & Constantine, 2006; Goldberg et al., 2005; Ozonoff & Jensen, 1999; Verte et al., 2006).

Similar to other domains of EF, WM deficits have been documented in individuals with ASD, although again research outcomes have been variable. Some research has documented significant impairments in WM (Corbet et al., 2009; Semrud-Clikeman, Walkowiak, Wilkinson, & Butcher, 2010) while other research has not supported WM deficits (Ozonoff & Strayer, 2001; Salcedo-Marin, Moreno-Granados, Ruiz-Veguilla, & Ferrin, 2013). As with other aspects of EF, differences in study results may be related to the different ways in which WM is defined and measured, the type of WM investigated (e.g., visual, verbal), or the specific ASD group sampled. Of the studies that have shown WM deficits in individuals with ASD, impairment has been

documented in visuospatial WM (e.g., spatial span; Corbett et al., 2009; Goldberg et al., 2005) and verbal WM (Pennington & Ozonoff, 1996). Deficits have also been reported for the phonological loop (Hooper, Poon, Marcus, & Fine, 2006). Steele, Minshew, Luna and Sweeney (2007) found marked impairments in spatial WM, demonstrating that as task demands increased the performance of individuals with ASD weakened relative to that of typical controls. Shuh and Eigsti's (2012) demonstrated that individuals with high functioning Autism had marked WM impairments in both verbal and non-verbal domains performing significantly worse than a comparison group matched on age, gender, nonverbal IQ and language abilities. Shuh and Eigsti (2012) found deficits in short-term phonological WM, spatial WM and more complex verbal WM in individuals with ASD. The verbal WM tasks employed by Shuh and Eigsti included a relatively simple phonological WM task as well as two more complex tasks, to test the possibility that verbal WM impairments in individuals with ASD may emerge as a function of the increased linguistic complexity of a task. They found that verbal WM was impaired regardless of task complexity; however, for complex span tasks, WM problems were exacerbated likely because of greater EF or linguistic demands (Shuh & Eigsti, 2012). Shuh and Eigsti (2012) found that WM ability accounted for significant variance in language skills and symptom severity in participants with ASD.

In contrast, other studies have not shown clear problems in WM in individuals with ASD, in particular, verbal WM (i.e., phonological loop; Ozonoff & Strayer, 2001; Russell, Jarrold, & Henry, 1996). Williams, Goldstein, Carpenter and Minshew (2005) found intact verbal WM yet impaired spatial WM in high-functioning youth, adolescents, and adults with ASD compared to age and cognitive-matched controls. Non-word repetition in youth with high functioning ASD has also been reported to be intact (Whitehouse, Mayberry & Dunkirk, 2006). Ozonoff and

Strayer (2001) reported intact visuospatial WM when they assessed the ability of youth with high functioning Autism to find spatial locations of geometric shapes that had been presented simultaneously on a screen before a short delay.

Although the results are equivocal, enough studies have found WM deficits in individuals with ASD to suggest that this is a cognitive domain that is at risk in this population. In particular, individuals with ASD have been found to have problems with aspects of both visuospatial (Corbett et al., 2009; Goldberg et al., 2005) and verbal WM (Pennington & Ozonoff, 1996).

Written Expression in Youth with ASD

Individuals with ASD are significantly impacted by their qualitative impairments in communication skills, social skills, and behaviours. The severity of impact within each of these domains varies and defines the severity of ASD. Youth with severe forms of ASD (i.e., low functioning) may have accompanying intellectual delays and a complete lack of communication or language. In contrast, youth with high functioning ASD may have strong intellectual and core language abilities, yet qualitative differences in how they use their problem solving and language/communication skills in academic, social, and life situations.

Youth with high functioning ASD, who are the focus of the current study, commonly have comorbid learning disabilities, especially in written expression (Mayes & Calhoun, 2003, 2005, 2007, 2008). Mayes & Calhoun (2005) investigated the rates of learning disabilities in various clinical populations and found that youth with ASD had relatively high percentages (60%) of learning disabilities in written expression. Also, significant discrepancies between IQ and written expression have been seen in individuals with ASD (Mayes & Calhoun, 2003, 2005, 2007, 2008). Youth with ASD, commonly have processing speed difficulties, EF/attention deficits, and graphomotor problems (Mayes & Calhoun, 2003, 2005, 2007, 2008), similar to that

seen in other neurodevelopmental disorders also at risk for problems with written expression (e.g., ADHD).

Adults with high functioning ASD (high functioning Autism and Asperger's Disorder per DSM-IV-TR) are found to have writing difficulties. Brown and Klein (2011) studied adults with ASD and demonstrated that these individuals wrote lower quality narrative/expository texts and narratives of shorter length. In part, these difficulties appeared to be due to motor incoordination and dysgraphia, which would hinder the physical aspect of writing (Goldstein, Johnson, & Minshew, 2001; Green, Baird, Barnett, Henderson, Huber, & Henderson, 2002; Hughes, 1996; Manjiviona & Prior, 1995; Mayes & Calhoun, 2003, 2005, 2007, 2008; Miller & Ozonoff, 1997; Szatmari, Archer, Fisman, Streiner, & Wilson, 1995; Volkmar & Klin, 1998; Wechsler, 2003). However, there are other cognitive difficulties in individuals with ASD (e.g., EF/WM problems) that would contribute to writing problems, including difficulties with organizing and planning writing, the volume of written output, and the revision stage of writing (Casas et al., 2013).

Very few studies have investigated writing in youth with ASD, despite anecdotal reports that writing appears to be a common academic difficulty in this group. Those who have investigated this topic have typically qualitatively analyzed written compositions, highlighting a range of deficits such as lower text quality, shorter written texts, handwriting legibility problems, organization difficulties, and trouble with addressing abstract concepts (Chavkin, 2004; Happé, 1994; Jurecic, 2007, Mayes & Calhoun, 2003, 2005, 2007, 2008; Myles et al., 2003). Myles et al. (2003) compared students with ASD to typically developing youth and found very little difference on their Test of Written Language-3 scores when this test was scored quantitatively; however, when written expression was examined qualitatively the written text of youth with ASD was much briefer and less complex. It has been suggested that writers with ASD tend to use

“highly literal language and have difficulty elaborating on their ideas, that their writing is not cohesive and has a distorted sense of audience, and that the social and psychological aspects of their texts are missing or atypical” (Brown & Klein, 2011, p.1465). Mayes and Calhoun (2003) found that 60% of school-age youth with ASD, who had been assessed, showed a discrepancy of at least one standard deviation between their full-scale IQ scores and writing achievement scores. Research reveals that a high proportion of youth with ASD have difficulty with writing (Mayes & Calhoun, 2003, 2005, 2007, 2008). Specifically, writing difficulties have been observed in planning, attending to the audience, transcription (i.e., graphomotor issues), and organization of written work (Brown & Klein, 2011; Mayes & Calhoun, 2003, 2005, 2007, 2008). Research focused on youth with ASD has also documented problems with various aspects of EF (Hughes et al., 1994; Mayes & Calhoun, 2003, 2005, 2007, 2008; Bishop & Norbury, 2005) that have been associated with writing skills, including flexibility, planning (Corbett et al. 2009), and WM (Hooper et al., 2006; Mayes & Calhoun, 2003, 2005, 2007, 2008; Goldberg et al., 2005; Pennington & Ozonoff, 1996; Williams et al., 2005). Working memory is believed to be core to the writing process (Kellogg, 1996) and as such WM deficits would be expected to severely impact an individual’s ability to write. Working memory difficulties are seen in individuals with ASD (Corbett et al., 2009) and are hypothesized to result in a number of academic, behavioural and social difficulties for these youth (Hughes et al., 1994; Ozonoff & McEvoy 1994). The types of WM deficits observed in individuals with ASD include visuospatial WM (Corbett et al., 2009; Minshew et al., 2007; Goldberg et al., 2005), verbal WM (Pennington & Ozonoff, 1996) and the phonological loop (Hooper et al., 2006).

Given theoretical models and research documenting the importance of EF and WM to the writing process, and the fact that many youth with ASD show cognitive deficits in these areas as

well as writing problems, it may be that some of the writing difficulties in this population could be due to WM problems.

The Current Study

The current study investigated possible associations between WM and aspects of written expression in youth with high functioning ASD (ASD, mild, without accompanying language or intellectual impairment). Writing was explored from the perspective of the FWS (Berninger & Amtmann, 2003), which holds WM as core to the writing process. Working memory was chosen as a cognitive area of focus, due to its close association with writing achievement and Berninger and Amtmann's FWS (2003). Working memory was conceptualized using Baddeley and Hitch's (Baddeley & Hitch, 2000) model of WM, which includes the phonological loop, verbal WM, and the visuospatial sketchpad. The following hypotheses were proposed:

1. Youth with ASD will demonstrate difficulties on standardized measures of WM when compared with typically developing youth.
2. Youth with ASD will have difficulties in written expression when compared with typically developing youth.
3. Difficulties with written expression in youth with ASD will be significantly and positively associated with their performance on WM tasks.

Case study predictions. Based on the literature pertaining to WM difficulties in individuals with ASD (Corbett et al., 2009; Goldberg et al., 2005) it was predicted that youth with ASD would show evidence of WM deficits in the aspects of WM assessed, including the phonological loop, verbal WM, and spatial WM. Based on the literature suggesting that writing difficulties are common in ASD (Mayes & Calhoun, 2003, 2005, 2007, 2008; Brown & Klein, 2011), it was also predicted that youth with ASD would show writing difficulties. Based on

Berninger and Amtmann's the FWS (2003) an individual who has problems with WM will struggle with a variety of aspects of writing including text generation, discourse, theme development, vocabulary (i.e., higher level), EF (i.e., planning and organization, revising, editing and self-regulation) and lower order skills (i.e., transcription; handwriting, spelling). Berninger and Amtmann's FWS (2003) further posits that WM deficits will affect both higher order writing and lower level writing tasks. The following specific predictions were made in youth with ASD, informed by the FWS (Berninger & Amtmann, 2003):

1. Youth with ASD would demonstrate WM difficulties in the three WM components described in Baddeley's system (Baddeley & Hitch, 2000): visuospatial WM, verbal WM, and the phonological loop.
2. Youth with ASD would have difficulty with text generation as evident in an overall low quality of writing, limited written output (i.e., low word count) and less varied/creative use of vocabulary.
3. Youth with ASD would have difficulty in some aspects of transcription. It was predicted that they would have average fine motor skills, but would have difficulties with punctuation and spelling due to WM difficulties.
4. Even though it was predicted the youth with ASD would have average fine motor abilities, deficits in visuospatial WM can impact handwriting through orthographic processing (i.e., the orthographic loop is related to visuospatial skills and refers to one's ability to translate sounds into shapes, important for transcribing while writing [Berninger et al., 2002]). Orthographic difficulties can influence both handwriting and spelling (Berninger & Amtmann, 2003). Therefore, it was predicted that youth would have average fine motor skills yet deficits in orthographic coding and

- spelling/punctuation. This would be also seen in poor essay generation, low word counts and vocabulary difficulties, at least in part due to problems with WM.
5. Although EF was not a focus of this study or directly measured, it was predicted that youth with ASD would have lower organization scores as measured via the WIAT-II scoring guide and observations made during testing. Low organization scores were predicted because research with individuals with ASD has indicated problems with organization and planning (Corbett et al., 2009). See Figure 3 below.

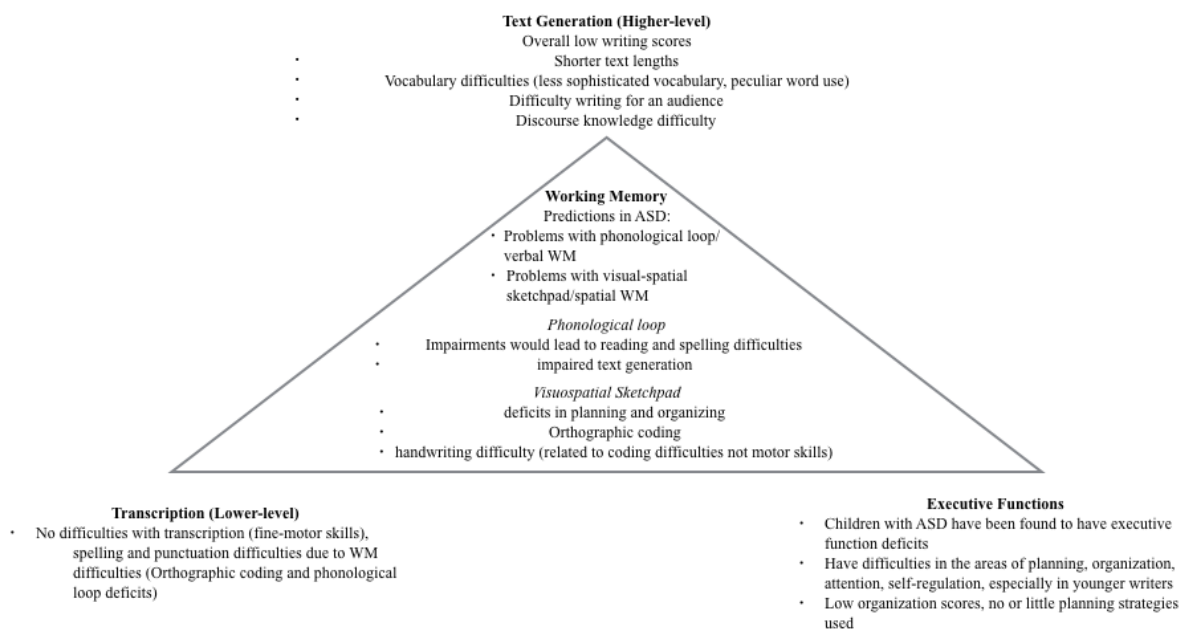


Figure 3. Predictions of ASD Writing Difficulties based on the Functional Writing System (Berninger & Amtmann, 2003)

Chapter 3: Methods

Overview

Chapter 3 outlines the methodology used in the current study. It first describes recruitment procedures and eligibility requirements for the study. Next, it describes the participants' characteristics for both the control (i.e., typically developing) and ASD groups, including age, gender, intellectual functioning, developmental and intervention history, and comorbid diagnoses. Finally, the chapter describes the procedures of the tests that are used to measure intellectual functioning, graphomotor skills, WM, and writing skills.

Recruitment

Youth were recruited from four (i.e., three urban and one rural) school districts and through online and community advertisements. Schools and organizations were contacted initially by telephone (Appendix #4: Telephone Script) and email (Appendix #3: Email Script) and were asked to be third party liaison to potential participants. School districts and organizations were provided with an information letter (Appendix #5 Parent Information Letter) that specified study inclusion criteria. The school districts were asked to send out the information letter to potentially eligible families (Appendix #5: Parent Information Letter), and organizations were asked to contact individuals who met study criterion (Appendix #7: Invitation for Victoria Society for Children with Autism [Email]). Parents were then asked to contact the researchers by phone, email the researcher, or return a signed 'consent to be contacted' form if they were interested in participating (Appendix #5: Parent Information Letter). Flyers describing the study were also displayed in local public areas (Appendix #1: Advertisement), for example in coffee shops, YMCA, and the public library.

Descriptive Statistics of Participants

Study inclusion criteria for the ASD group were youth between the ages of eight and 17 years who had a prior diagnosis of ASD using DSM-IV TR criteria (i.e., Pervasive Developmental Disorder, Asperger's Disorder or Autistic Disorder). The group with ASD either held diagnoses of high functioning Autistic Disorder or Asperger's Disorder, per DSM-IV-TR criteria. The ASD group consisted of five youth; four males and one female (i.e., mean [M] age = 12.6, standard deviation [SD] = 3.6, range [R] = 8.5-17). Two youth within the ASD group held a comorbid diagnosis of ADHD. These individuals were not excluded from the study given the high rates of comorbidity between ASD and ADHD, and challenges recruiting eligible participants. Although six individuals with ASD were originally recruited, one individual was not eligible for the study due to significant language delays. To preserve participant anonymity, each youth within the ASD group will be referred to as a "he".

Typically developing (TD) participants were youth without any neurodevelopmental disorders (i.e., M age = 11.6, SD = 2.3, R = 6). The group with ASD included five females, with no formal psychological or developmental diagnoses, ranging in age from nine to 15 years. In total 10 youth were recruited, five youth with ASD and five typically developing youth. As such, the group with ASD and TD group differed significantly in gender composition. ($p < 0.05$; Table 1).

All youth had overall IQ composite scores above a standard score of 75 on the Kaufman Brief Intelligence Test Second Edition (KBIT-II) and no youth were excluded based on low IQ. An independent samples t-test indicated that the TD group and group with ASD were statistically equivalent on Verbal IQ (i.e., TD group M = 113.2, SD = 13.37; ASD Group M = 103.4, SD = 14.64, $p \text{ value} > 0.05$), Nonverbal IQ (i.e., TD group M = 110.8, SD = 14.57; ASD group M =

104.0, SD = 26.48, p value >0.05) and Overall IQ (i.e., ASD Group M = 104.4, SD = 23.26, R= 75-136; TD group M = 113.8, SD 15.50, R= 94-137, p value >0.05).

Table 1

Age, IQ, and Gender scores for the group with ASD and TD group

Variable	Group with ASD N=5		TD Group N=5		p values ¹
	Mean	SD	Mean	SD	
Age	12.6	3.49	11.6	2.05	>0.05 (ns)
Gender*	0.2	0.447	1	0	<0.05 (s)
KBIT Verbal Standard Score (VIQ)	103.4	14.65	113.2	13.37	>0.05 (ns)
KBIT Nonverbal Standard Score (PIQ)	104.0	26.48	110.8	14.57	>0.05 (ns)
KBIT IQ Composite Standard Score	104.4	23.26	113.8	15.50	>0.05 (ns)

* Female = 1; Male = 0

Note: ¹ 95% confidence interval applied; ns = not significant; s = significant

ASD group. All youth within the ASD group were diagnosed with ASD using BC Standards and Guidelines for diagnosis of ASD (Standards and Guidelines for the Assessment and Diagnosis of Young Youth with Autism Spectrum Disorder in British Columbia, 2003). These standards require a comprehensive clinical diagnostic assessment which includes: (i) detailed developmental history; (ii) review of previous assessments; (iii) consultation with other professionals and disciplines; (iv) use of a standardized, structured, caregiver interview, the

Autism Diagnostic Interview –Revised (ADI-R; Rutter, Le Couteur, & Lord, 2003); (v) use of a standardized, structured observation instrument for ASD, the Autism Diagnostic Observation Schedule (Lord, Rutter, & Le Couteur, 1994; Standards and Guidelines for the Assessment and Diagnosis of Young Youth with Autism Spectrum Disorder in British Columbia, 2003). One child received his diagnosis of ASD in Ontario, where procedures consistent with the BC standards were followed. Youth with ASD had received their diagnoses between the ages of five and 11 years (i.e., $M = 7.2$, $SD = 2.5$). In order to confirm current ASD symptoms, an abbreviated version of the Autism Diagnostic Interview-Revised (Lord et al., 1994) was administered in addition to the Gilliam Autism Rating Scale 2 (Gilliam Autism Rating Scales Second Edition [GARS-2]; Gilliam 2005). All youth in the ASD group exceeded the GARS-2 cut off scores for the probability of having an ASD diagnosis. On the ADI-R, four out of five youth with ASD scored above the cut-off for a diagnosis of ASD across all domains. One individual exceeded the criteria for all of the domains except for the verbal domain (see Table 2 and Table 3). Based on the results of these two screening assessments (see Table 2 and Table 3) all of the individuals with ASD exceeded the GARS-2 and/or ADI-R cut off scores for high probability of having an ASD diagnosis. Overall, youth were in the high functioning ASD range, with P5 showing the strongest profile of ASD symptomology. Participant 5 also performed more poorly on WM and writing tasks than the rest of the ASD group.

Table 2

Gilliam Autism Rating Scales Second Edition Results

Results	Participants				
	P1	P2	P3	P4	P5
Stereotype Behaviour Standard Score	9	8	4	6	11

Stereotype Behaviour Percentile	37	25	2	9	63
Communication Standard Score	6	5	5	4	9
Communication Percentile	9	3	3	2	37
Social Interaction Standard Score	9	4	9	6	8
Social Interaction Percentile	37	2	37	9	25
ASD Index Standard Score	87	72	74	70	96
ASD Index Percentile	19	3	4	2	39

Table 3

Autism Diagnostic Interview-Revised Results Experimental Group

Results	Participants				
	P1	P2	P3	P4	P5
Stereotype Behaviour Score- cut-off score: 3	8	4	7	5	8
Social Interaction Score- cut-off score: 10	12	6	24	18	25
Verbal Score- cut-off score: 8	7	9	16	14	16
Nonverbal Score –cut-off score: 7	6	3	9	6	8
Early Development Score- cut off score: 1	2	1	2	5	4

Scaled scores reported. Mean of 10, and a SD of three.

Youth in the ASD group were screened for comorbid diagnoses based on a telephone interview conducted with parents (see Appendix #2: Interview Questions). Two youth with ASD held a comorbid diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) and were taking medication for attention difficulties during the study. These two youth were not excluded from the study due to the high comorbidity between ASD and ADHD (Sokolova et al., 2017) and limited access to ASD participants. These two participants were taking their stimulant medications during testing days, which would be expected to influence performance on aspects of the test battery (WM and attention measures). Youth with ASD typically display attention and EF problems similar to youth with ADHD. The prevalence rates of comorbid diagnosis of ADHD and ASD range from 28.2–87% (Ames & White, 2011; Frazier et al., 2001; Sinzig, Walter, & Doepfner, 2009). Up to 95% of youth with ASD show clinically significant attention problems, but may not meet the full criteria for ADHD (Sokolova et al., 2017). Some researchers have argued that attention difficulties are a “part of Autism” (Rao & Landa, 2013). Other researchers have proposed that attention and EF problems in individuals with ASD are primarily due to comorbid ADHD (Pennington & Ozonoff, 1996; Corbett et al., 2009). Current theories support the idea that the two disorders, though related, are two distinct disorders that often co-occur (Rao & Landa, 2013). None of the youth within the ASD group held any other diagnoses, including learning disability, intellectual delay, language delay, traumatic brain injury, or other neurological/neurodevelopmental disorders. In addition, none of the youth in the ASD group had received writing intervention prior to the study, although all parents reported that their child had writing difficulties. As expected, some youth with ASD were receiving other types of interventions, including social-skills training (60%), special education (60%), tutoring (60%), speech and language therapy (60%), occupational therapy (80%), music therapy (20%), general

special education services (60%) and behavioural consultation (100%) (see Table 2). None of the ASD group had a full-time educational assistant (EA) supports at school; however, (40%) youth with ASD received approximately one hour per week of support from an EA as a check in/check out at the beginning and end of the school day.

Table 4

ASD Group History of Intervention

Intervention Options	Percentage of ASD group Received
Social-skills training	60%
General special education services	60%
Tutoring	60%
Speech and language therapy	60%
Occupational therapy	80%
Music therapy	20%
Behavioural support	100%
EA support	40%

TD group. The TD group consisted of five girls (i.e., $M = 11.6$, $SD = 2.3$, $R = 6$) without a diagnosis of ASD. As with the ASD group, a screening interview was conducted on the phone with parents/guardians to determine participant eligibility. Although six TD youth were originally recruited, one individual was not included in the study because of a prior diagnosis of ADHD. No youth from the TD group had diagnoses of learning disabilities, language delay, ADHD, traumatic brain injury, intellectual delay, ASD, or other neurodevelopmental disorders. The GARS and the ADIR were not administered to the TD group. Further, no youth from the TD

group had received any academic or social interventions, and none had reported writing difficulties.

Procedure

All youth completed a battery of standardized measures of WM, writing, and visual-motor integration, in addition to IQ and behavioural screening measures. The researcher administered the test battery over the course of one year at variable times as arranged with participants. The location of testing was either at the University of Victoria in the researcher's office or at a quiet room in the youth's home. Test order was counterbalanced across groups, with half the sample completing screening tools first (Beery VMI, K-BIT-2) followed by WM tasks (i.e., digit span, non-word repetition, listening recall and counting recall) and then the writing task (WIAT-II written expression). The other half of the sample received the writing task first, followed by WM tasks, and then the screening tools.

The youth completed the assessment battery one-on-one with the researcher who has been formally trained in Level B assessment administration, interpretation, and reporting. The testing duration ranged from 50 minutes to two hours and 20 minutes with an average testing duration of 1.17 hours (i.e., SD 0.47; ASD group M = 1.36 hours, SD = 0.32; TD group M = 0.97 hours, SD = 0.15). The time of day for testing varied for each participant; however, all of the assessments took place on weekends and it was requested when scheduling testing that youth were well rested. Parent informed consent and child consent/assent were collected before enrollment in the study and double-checked at testing time. The purpose of the study was verbally explained to each youth, and they were given the opportunity to ask questions. Youth signed their consent form at the start of the testing session. Incentives were provided for the youth to participate, including being entered into a draw to win an iPod and being provided with

chocolates at the time of testing. Multiple verbal prompts were required for the ASD group to encourage them to complete the written task. Different examples of the verbal prompts are: “you only have to write for a few minutes”, “you can have a break when it is over”, and “Please begin writing”. When the youth said they “did not know what to write about” the examiner engaged in a quick discussion about the topic to give ideas. None of the TD group required prompting to begin writing. The measures were explicitly chosen so that students would be able to complete them in as short a duration as possible (one to two hours), to capture aspects of WM and writing that were the focus of this study, to characterize the sample in detail, and to rule out certain confounds (low IQ, low language, or motor problems).

Measures

Overview. Information on each of the youth was gathered through a variety of means such as interviews, questionnaires and standardized measures. The tests and interviews were selected to provide an in-depth analysis of each participant's abilities in writing and WM. Screening measures and interviews were administered to determine demographic information, cognitive abilities, supports at school, visual-motor skills, services received and ASD group symptomology. The following measures were administered: The Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition, (BEERY™ VMI) (Beery & Beery, 2010), The Kaufman Brief Intelligence Test, Second Edition (KBIT-2) (Kaufman & Kaufman, 2004), The Wechsler Individual Achievement Test-2nd Edition-Canadian (WIAT-II) written expression, Comprehensive Test of Phonological Processing (CTOPP) non-word repetition, Working Memory Test Battery (WMTB) for Youth listening and counting recall (Gathercole & Pickering, 2001) and the Wechsler Intelligence Scale for Youth, Fourth Edition

digits forwards and backwards (WISC-IV; Kaplan, Fein, Kramer, Delis, & Morris, 2004). The measures will be described in detail below.

Demographic information.

Childhood history questionnaire. A childhood questionnaire was given to parents/guardians (see Appendix #10: Child History Questionnaire), to screen youth for medical, neurological, learning, or other developmental disorders, to ensure that they met study criteria (described above). The questionnaire also asked about the history of academic interventions and other interventions/services (e.g., occupational therapist, speech-language pathologist, etc.; see Table 2 for a summary of interventions), pregnancy/birth complications, chronic illnesses, or injuries. For the ASD group, information was gathered on their diagnosis (i.e., diagnostician, year of diagnosis, and procedures used for diagnosis).

Autism symptomology. The Gilliam Autism Rating Scales Second Edition (GARS-2; Gilliam 2005) was administered to confirm the current symptom status of youth in the ASD group. The GARS-2 (parent and teacher versions) are standardized, norm-referenced scales, designed to provide an index of ASD symptoms for individuals ages three through 22 years. Ratings on the GARS-2 indicate the severity of ASD symptoms yielding standard scores for stereotyped behaviour, communication, and social interaction, in addition to an overall ASD index score. The GARS-2's internal consistency is strong (i.e., $r=0.94$) and test-retest is moderately strong (i.e., $r=0.88$), according to Cohen's kappa (Cohen, 1960). The GARS-2 has been compared to the GARS-1 yielding a correlation of $r=0.47$, showing moderate agreement between scale versions (Gilliam, 2006). See results in Table 19.

In addition to the GARS-2, an abbreviated version of the Autism Diagnostic Interview-Revised (ADI-R; Rutter et al., 2003) was used to confirm ASD diagnosis. The ADI-R is a

clinical diagnostic, standardized, norm-referenced interview for assessing ASD, focused on the key domains of reciprocal social interaction, communication and language, and restricted and/or repetitive, interests and/or behaviours. The ADI-R provides cut-off scores for each of these domains and an individual needs to exceed the cutoffs in all domains to be classified as having ASD per this instrument. To shorten the interview, an abbreviated version of the ADI-R that only included algorithm items was administered (i.e., those items that are most reliable in distinguishing individuals who have ASD from those who do not (Rutter et al., 2003). Correlations between the long form and the abbreviated form of the ADI-R are high (i.e., $r=0.9$). Test-retest and inter-rater reliabilities for the ADI-R are at 0.9 and concurrent validity (i.e., agreement with independent clinician formulation) is moderate (0.74). The ADI-R's ability to discriminate between individuals with ASD versus those without ASD is strong (sensitivity 1.0; specificity > 0.97). Overall, the ADI-R is a reliable and valid measure and considered a gold standard tool for ASD diagnosis (Reaven, Hepburn & Ross, 2008). See results in Table 20.

General cognitive ability. Participant cognitive ability was screened using the Kaufman Brief Intelligence Test, Second Edition (KBIT-2; Kaufman, and Kaufman, 2004). The KBIT-2 is a norm-referenced standardized measure (i.e., $M = 100$, $SD = 15$) that yields a verbal index (i.e., crystallized intelligence), nonverbal index (i.e., fluid intelligence) and overall full-scale IQ (i.e., overall intelligence) and is appropriate for ages four through 90 years. Full-scale scores on the KBIT-2 correlate strongly with the WISC-IV (i.e., $r = 0.77$), supporting its use as a valid screening measure of intellectual ability. The KBIT-2 was selected because it is reliable (i.e., internal consistency $r=0.93$, test-retest $r = 0.90$), valid (i.e., comparison with KBIT-1 ranged from $r = 0.80$ to 0.86), and quick to administer.

Visual-motor integration. All youth completed the Beery-Buktenica Developmental Test of Visual-Motor Integration, Sixth Edition, (Beery VMI 6; Beery and Beery, 2010), a standardized norm-referenced measure (i.e., $M = 100$, $SD = 15$) to assess visual-motor integration/ output. The Beery VMI 6 assesses the coordination of visual and motor abilities (i.e., paper and pencil output), which is of relevance to writing mechanics. Beery VMI scores are associated with writing fluency (Williams, Zolten, Rickert, Spence, & Ashkraft, 1993), and the Beery VMI has been used as a measure of dysgraphia or difficulty with the mechanics of handwriting (Hagborg & Aiello- Coultier, 1994; Maeland, 1992; Tseng & Murray, 1994; Weil & Amundson, 1994). The Beery VMI 6's reliability coefficients are strong for internal consistency (i.e., $r = 0.71-0.89$), and for test-retest reliability (i.e., $r = 0.88$). Validity ranges from moderate to strong (i.e., $r = 0.52-0.75$) when compared to the Beery VMI IV. The Beery VMI 6 was administered as a screening measure to rule out differences in basic graphomotor output as the cause of writing differences between groups.

Writing measure.

The Wechsler Individual Achievement Test-2nd Edition-Canadian (WIAT-II). The WIAT-II written expression subtest was administered to assess writing. On this standardized norm-referenced measure (i.e., $M = 100$, $SD = 15$), youth are asked to either write a paragraph or an essay, based on their age. All youth are given the same prompt and time limit to complete the paragraph/essay (i.e., 10 minutes for the paragraph and 15 minutes for the essay). As per WIAT-II instructions, each student was provided with a sheet of blank paper for brainstorming if needed. The WIAT-II was chosen over the more up to date WIAT-III, because the WIAT-II breaks down the major components of writing to allow for analysis of various subcomponents of writing, including organization, vocabulary, theme development, and mechanics (spelling and

punctuation). These writing components overlap with the FWS (Berninger & Amtmann, 2003), including scoring that allows one to break down the components of writing into lower and higher-order aspects of writing. Although the WIAT-II also has a sentence writing task, the paragraph/essay task was chosen because this is a capstone measure that provides more opportunity to analyze different aspects of writing (Berninger, 1994). On the paragraph version of this task, youth in grades K-6 wrote a paragraph based on a story prompt where they were asked to write about their favourite game. Youth were encouraged to discuss with the examiner about a favourite game before beginning and were required to use good spelling, punctuation, organization, and vocabulary. On the essay task, youth in grades 7-16 (the WIAT-II goes until students are in university, they describe those years as grades 13-16) wrote a letter to the editor as to whether PE should or should not be mandatory at school. Students were asked if they knew what PE was and if they took it in school (all three of the youth who wrote essays did take PE in school). Each youth was provided with a blank sheet of paper for planning their writing, which was collected afterwards for an informal analysis as to whether participants used planning strategies. Scoring was undertaken analytically using the scoring rubric provided in the WIAT-II manual. The analytic scoring rubric has four possible evaluation categories: Mechanics, Organization and Vocabulary (for paragraph and essay) and Theme Development (only for the essay). These categories were summed to create a total writing raw score (i.e., maximum for paragraph = 40, maximum for essay = 55). To compare scores on the paragraph and essay written expression tasks, total raw scores were converted into a percentage. Additional scores included a quartile score for word count and a holistic score for overall quality of written expression. A holistic score, which is subjective, gives the composition a single score on a scale of zero to six based on the overall quality of the writing, not taking into account spelling or

grammar mistakes. To obtain a zero, the writer must have written about something unrelated to the prompt. A score of one states or implies a position and supports it with enough detail to determine that the response is on topic, but may include illogical reasons. A score of six implies a perfectly written essay. Scores on the lower end indicate basic writing ability and on the higher end (three to six) indicate a well-written paragraph or essay. To provide additional information on different aspects of writing, quartile scores¹ are generated for specific writing components including spelling, word count, and punctuation^{2*}. The WIAT-II's reliability coefficients are strong for inter-rater reliability, (i.e., $r = 0.71-0.89$) and for test-retest reliability (i.e. $r = 0.94$). Validity ranges are fair when compared with the WIAT-I (i.e., $r = 0.48$).

Working memory measures. Several WM measures were chosen for this study to assess the phonological loop, verbal WM and visuospatial WM (Baddeley, 2000; Berninger et al., 2006). By assessing different aspects of WM it was hoped to capture different aspects of WM that may be of relevance to writing.

Comprehensive Test of Phonological Processing-2, non-word repetition (CTOPP-2, 1999). Non-word repetition is a norm-referenced standardized measure (i.e., $M = 100$, $SD = 15$) of the phonological loop used by various researchers (Gathercole & Baddeley, 1996; Alloway et al., 2004; Shuh & Eigisti, 2012). On this measure, individuals listen to nonsense words, of increasing length and complexity, and then repeat these nonsense words verbatim. The CTOPP-2's reliability coefficients are strong for internal consistency (i.e., $r = 0.90$) and range from moderate to strong for test-retest (i.e., $r = 0.75-0.92$). The CTOPP-2 has been found to be a "valid

¹ Quartile scores are meant to give general normative information, scores are given a value between 0-100 % and they are divided into four equal parts and are numbered 1-4. A quartile score of 1 represents the lowest 25% (WIAT, 2002). A score of two is represents scores between 25-50 %, a score of three 50-75% and the last upper 25% to a score of four.

measure of phonological processes” through assessment using multiple forms content-description validity and construct-identification validity, with comparisons to the Woodcock Reading Mastery Tests-Revised and the Test of Word Reading Efficiency (Wagner et al., 1999, p.106). The manual reports adequate content, construct and criterion-related validity (CTOPP-2, 1999).

Working Memory Test Battery for Children, listening recall (WMTB-C; Gathercole & Pickering, 2001). Listening recall on the WMTB-C, a standardized norm-referenced WM measure for children (i.e., $M = 100$, $SD = 15$) was administered to assess verbal WM. On this task, the participant judges the semantic properties of sentences while remembering the last word of each sentence in sequence. This task requires participants to remember the sentences, judge their veracity, and then remember the order of the last word in each sentence, demanding the ability to take in, hold and manipulate verbal information. Reliability coefficients are moderate ($r = 0.73$) for internal consistency and strong ($r = 0.88$) for test-retest reliability. Gathercole et al. (2010) determined the WMTB-C test to show internal validity from inter-correlations between subtests, of which listening and counting recall showed the highest association (Gathercole et al., 2010). Also, Gathercole et al. found showed good construct validity (Gathercole et al., 2010).

WMTB-C, counting recall (Gathercole & Pickering, 2001). To assess visuospatial WM the WMTB-C counting recall task was administered. On this task, participants view a series of dots on a set of pages and then are asked to recall, in order, how many dots were present on each page, placing demands on spatial and visual WM. Reliability coefficients are moderate (counting recall $r=0.71$) for internal consistency and strong ($r=0.88$) for test-retest reliability.

Wechsler Intelligence Scales for Children 4th Edition, digit span forward/backward (WISC-IV, Wechsler, 2003). The phonological loop is also termed the verbal storage system and

is directly related to auditory WM. This type of WM is typically assessed by serial recall tasks that involve arbitrary verbal elements such as lists of randomly assorted numbers, letters, and/or words (Alloway et al., 2004). The backwards and forward digit span subtests from the WISC-IV were administered to assess verbal short-term memory (digits forwards) and verbal WM (digits backwards). On these tasks, individuals are required to listen to a series of number lists, presented one at a time (one digit per second). In digit span forwards, they repeat the list of numbers verbatim (i.e., in forward sequence), assessing pure rote verbal short-term memory/recall. In digit span backwards, they repeat the list of numbers in reverse sequence, requiring both short-term memory and WM. Summary scores include the number of lists correctly recalled both forwards and backwards (Gathercole & Pickering, 2001). Digit span reliability coefficients for age eight to 17 for internal consistency using Cohen's (1960) scale were high (i.e., $r=0.81$) for digit span forward and (i.e., $r=0.80$) backward. Test-retest reliability for digit span forward reliability for ages eight to 17 was substantial (i.e., $r=0.78$) and digit span backwards test-retest reliability for the same age group ranges from was substantial (i.e., $r=0.74$).

Qualitative Observations

Data from direct observations. The final source of evidence was collected through informal behavioural observations. Participants were observed during the writing tasks, and detailed observational notes were taken, including information on attention/focus during writing, breaks required, off-task discussion, use of strategies during writing (e.g., brainstorm sheet, rereading, crossing out and editing writing task), time spent on the writing task, efficiency while writing, and stamina/frustration (See Appendix 12).

Chapter 4: Results

Overview

This chapter reports study results, first through non-parametric analysis and then through case study analysis. The non-parametric analysis first compares the relationship between the TD group and the ASD group on their motor skills, WM, and writing abilities searching for significant differences. Then there is a comparison between performance on writing and working measures. Following these results, a series of case study analyses for the ASD group are described. First, predictions for the case studies based on the FWS (2003) are outlined. Then, each youth's profile is presented through a description of their developmental and intervention history, intellectual functioning, visual-motor integration, WM, and writing skills. With respect to their writing, this is analyzed by comparing their writing against each of the main areas described in the FWS: text generation, transcription, and EF. This information is then synthesized and compared to the initial predictions. After the individual case analyses, all cases are analyzed together using a cross-case synthesis/pattern matching approach to determine where their profiles are similar and where they differ.

Section One of Analyses: Non-Parametric Analysis

Nonparametric statistical tests were completed to explore group differences in performance on WM measures, writing measures and the relationship between the two. Nonparametric testing does not require a population's distribution to be normally distributed nor does it require a large sample size. The Mann-Whitney U Test (Salkind, 2010) was used to look at trends in differences between the two groups on WM scores and writing scores. The Mann-Whitney U Test can evaluate differences between independent samples, differences within dependent groups and relationships between variables when there are small sample sizes

(Nachar, 2008). The Mann-Whitney U Test can also be used when the measured variables are ordinal and recorded with an arbitrary versus precise scale, which is the appropriate level of analysis for the writing measure (Nachar, 2008). However, the Mann-Whitney U Test does have limitations and it is not robust to extremely small sample sizes, particularly with samples under 10, and, as a consequence, can fail to reject a null hypothesis even if it is false (i.e., type II error). The Mann-Whitney U Test is only used in this study for data exploration and identification of possible trends and results are considered purely exploratory.

A comparison between WM performance and written expression between the TD and ASD groups was conducted using the Kendall Rank Correlation Coefficient (Kendall, 1955). The Kendall Rank Correlation Coefficient (Kendall, 1955) measures the degree of similarity between two variables by ordering the data by rank. For example, if the data agree and are perfectly consistent the coefficient value is one (Kendall, 1955). The Kendall Rank Correlation Coefficient (Kendall, 1955) is used for small sample sizes that are not evenly distributed, but still has limitations in very small sample sizes. As with the Mann Whitney U above, this test was used exclusively for exploratory purposes in identifying possible trends in WM and writing.

Visual-motor integration. The Beery Visual-Motor Integration Test (Beery VMI 6) was administered to investigate potential differences in visual-motor/graphomotor output between groups. Although graphomotor output was not a specific focus of this study, this is an important variable to consider given that fine motor skills can greatly impact writing. Using the Mann-Whitney U, there was no significant difference found between the TD and ASD groups concerning visual-motor integration (i.e., $U = 2$; $p < .05$). See Table 5.

Table 5

Results of the Mann U for Visual-Motor Integration

Test	ASD group N=5		TD Group N=5		Mann U	Critical p-value (p=0.05)
	Mean	SD	Mean	SD		
Beery VMI (Graphomotor Skills)	96.0	18.8	89.2	10.1	2	0.25

Working memory. To explore if youth with ASD had difficulty with WM when compared with typically developing youth, a WM composite score was calculated by averaging each participant's standard scores on each WM measure. These WM composites were then analyzed using the Mann-U Whitney Test. A significant difference was found in WM between the two groups (i.e., $U = 3$; $p < .05$), with youth with ASD (i.e., $M = 90.8$, $SD = 5.0$) performing significantly more poorly than TD youth (i.e., $M = 101.3$, $SD = 7.0$). See Table 6.

Table 6

Results of the Mann U for WM

Test	ASD group N=5		TD Group N=5		Mann U	Critical p-value (p<0.05)
	Mean	S.D.	Mean	S.D.		
Working Memory Composite Standard Score	90.8	5.0	101.3	7.0	3	0.03

Working memory was also analyzed by investigating group differences on individual WM measures. Each WM measure was administered and scored according to its standardized instructions, and raw scores were converted to standard scores using normative data. Descriptive statistics were run to find the mean and standard deviation of each WM test; then Mann-U Whitney non-parametric test analyses were run on each WM measure to look for between group differences. The results indicated that the ASD group scored significantly lower than the TD group on digit span backward (i.e., $U = 2$; $p < .05$), non-word repetition (i.e., $U = 3$; $p < .05$) and counting recall (i.e., $U = 3$; $p < .05$) (See Table 7 for means and SDs). The groups did not significantly differ on the digit span forward task, which is a measure of verbal short-term memory/rote recall rather than WM. These findings are consistent with research that has documented deficits in WM in individuals with ASD (Schuh & Eigsti, 2012), but not basic short-term memory/rote recall (Schuh & Eigsti, 2012).

Table 7

Results of Mann-Whitney U Analyses on WM Tasks

Variable	ASD group		TD Group		Mann-Whitney U	p-value (one-tailed) at 0.05	Significant Result
	Mean	SD	Mean	SD			
Digit span backward	85.0	6.1	100.0	6.1	2	4	Yes
Digit span forward	95.0	16.2	97.0	9.1	11	4	No
Total digit span	84.0	24.1	96.0	18.2	9	4	No
CTOP non-word repetition	29.6	25.7	63.6	20.8	3	4	Yes

Listening recall	90.2	16.8	95.4	12.2	11	4	No
Counting recall	75.6	15.1	108.0	25.8	3	4	Yes

To investigate differences in writing between the ASD and TD groups, several non-parametric analyses were conducted. First, descriptive statistics were run to find the median (e.g., the median is used when conducting a Mann-Whitney U test) and standard deviation of each subtest; then writing scores were compared between groups using the Mann-Whitney U test. Students either completed the WIAT-II paragraph or WIAT-II essay based on their age. Equivalent numbers of participants completed the paragraph and essay tasks across the ASD group and TD group. Two youth from the ASD group and two from the TD group wrote the paragraph and three from the ASD group and three from the TD group wrote the essay. The paragraph/essay writing subtest of the WIAT-II was administered and scored using standardized guidelines. Scoring was done analytically using the scoring rubric provided in the WIAT-II manual. Raw scores were generated for mechanics, organization and vocabulary (i.e., for both paragraph and essay) and for theme development (i.e., only for the essay), which were then summed to yield a total writing raw score. The WIAT-II does not generate a standard score for just the paragraph/essay writing tasks. Therefore, raw scores were converted to percentages (i.e., actual score out of total possible score) for each of the areas of mechanics, organization, vocabulary, and theme development. Word count was converted to a quartile score (see description above), and essay holistic scores (i.e., between one and six) were assigned. Raw scores were converted into percentages for each writing component because the paragraph and essay have different evaluation criterion and different maximum scores. The total writing score

for each youth was calculated by totalling the raw scores across each domain (i.e., mechanics, organizations, vocabulary and theme for the essay) yielding a maximum possible score of 40 for the paragraph and 55 for the essay. As stated above, raw scores were then converted to percentages to place the paragraph and essay tasks on a comparable scale. Means and standard deviations for the different components of the WIAT-II are presented in Table 8 and results of the Mann-Whitney U test are presented in Table 9. The ASD group achieved an average paragraph/essay score of 18.7% (i.e., SD = 7.6%, R = 18.2%) whereas the TD group achieved an average paragraph/essay percentage score of 37.1% (i.e., SD = 3.8%, R = 9.3%). The TD group scored higher across all the scored categories, including essay organization, assessing sentence structure, sequencing of ideas, and introductory/concluding statements. Informal analysis of writing indicated the ASD group, as a whole, did not tend to support their ideas, defend their positions, or properly introduce/conclude their essays.

Concerning mechanics (i.e., spelling, punctuation and grammar), youth with ASD scored significantly lower (i.e., M = 35.6%, SD=16.5%, R = 44.5%) than the TD group (i.e., M = 68.89%, SD= 19.9%, R = 44.5%). Informal analysis indicated the ASD group made more punctuation areas, but the ASD and TD groups had equivalent numbers of spelling errors. This suggests that the ASD group's low scores for mechanics were primarily as a result of punctuation errors. Lastly, vocabulary looks at unique word use, the use of persuasive language, unusual expressions and specific word use. With respect to Vocabulary the ASD group scored significantly lower (i.e., M = 0%, SD=0%, R = 0%) than the TD group (i.e., M = 32%, SD=9.4%, R = 22.9%). This means that the ASD group tended to use words that were vague and unvaried, in addition to not including unusual expressions in their writing. Results of the Mann-Whitney U test indicated a significant difference between the ASD group and TD group on their

total writing scores (i.e., ASD group $M = 18.7$, $SD = 7.6$; TD group mean = 37.1, $SD = 3.8$; $U = 0$; $p < 0.05$) and on their total word count (i.e., ASD group $M = 49.6$, $SD = 25.1$; TD group $M = 92.5$, $SD = 40.1$; $U = 3$; $p < 0.05$).

Table 8

Means, Standard Deviations, and Range for Writing

Writing Measures	M	SD
ASD group		
Total Raw Score (%)	18.7	7.6
Organization Subtotal (%)	33.3	19.3
Mechanics Subtotal (%)	35.6	16.5
Vocabulary (%)	0.0	0.0
Punctuation Errors (Raw Score, not percentage)	3.0	3.3
Spelling Errors (Raw Score, not percentage)	2.5	2.7
TD Group		
Total Raw Score (%)	37.1	3.8
Organization Subtotal (%)	58.6	12.2
Mechanics Subtotal (%)	68.9	19.9
Vocabulary (%)	32.0	9.4
Punctuation Errors (Raw Score, not percentage)	0.4	0.9
Spelling Errors (Raw Score, not percentage)	2.5	2.7

not percentage)

Table 9

Results of Mann-Whitney U Analyses

Variable	ASD group		TD Group		Mann-Whitney U	Critical p-value (one-tailed) at 0.05	p-value
	Mean	SD	Mean	SD			
Total Writing	18.7	7.6	37.1	3.8	0	4	p < 0.05
Writing Word Count	49.6	25.1	92.5	40.1	3	4	p < 0.05

Association between working memory and writing performance. Finally, nonparametric analyses were run using The Kendall Rank Correlation Coefficient (1955) to investigate the relationship between writing scores and WM performance between groups. A total writing raw score for each youth was calculated and converted to a percentage so that paragraph and essay writing scores were on the same metric (i.e., writing composite). A total WM score (i.e., a WM composite standard score) was calculated by adding the standard scores for each WM subtest and then dividing by the total number of WM subtests (WM composite score; see Table 10). To test for statistical significance, an alpha level of 0.05 was selected, and a one-tailed P value was used. No statistically significant relationship was detected between the composite writing score and WM score (i.e., $\tau = 0.37$, $p = 0.15$, one-tailed). This null finding

could be due to the very small sample size . Alternately, it may be that WM and writing were not associated in this sample.

Table 10

Working Memory Scores Compared to Writing Scores

Participant	Working Memory Composite Standard		Total Writing Score	
	Score			
	Average Score M	Average Score SD	Average Score M	Average Score SD
ASD group	82.6	14.0	18.7	7.6
TD Group	101.3	7.0	37.1	3.8

Summary of nonparametric findings. Overall, the ASD group scored significantly lower than the TD group on all tasks of writing and WM, except for short-term memory/rote recall. There was no association found between writing and WM, possibly due to insufficient sample size as research using larger samples had supported a strong relationship between writing and WM (Kellogg, 2012).

Section Two of Analyses: Case Study Approach

A case study approach was adopted as the research study progressed, due to unanticipated small sample size. It was determined that this information would provide a richer description of how students with ASD struggle with both WM and writing. The case study method of analysis employed was multiple case pattern matching (Yin, 2009). This technique is used to analyze multiple cases, by treating each case as its own case study and then aggregating findings across the cases (Yin, 2009; Figure 4). The constant comparative method of Glaser and Strauss (1967) was also used to summarize data across the cases. This technique according to Glaser and Strauss

(1967) helps to “ensure accuracy of the evidence, establish the generality of a fact, clarify the relevant particulars of a case, and tests and generate theory” (Glaser & Strauss, 1967, p. 36). There are four steps to the constant comparative method; (1) Compare how often an incident arose in a case, then compare to other cases, (2) integrate concepts, noting relationships and variations among the cases and noting when a concept arises and under what conditions, (3) limit categories once some patterns start arising more than others and, (4) construct theory and generalizations as part of the research process. This method was used for looking at how each youth with ASD approached writing, using predictions based on the FWS (Berninger & Amtmann, 2003). Detailed observation notes were taken during the testing sessions and these were summarized, sorted and presented into tables and analyzed to more easily identify trends. The constant comparative technique was used to identify patterns resulting from standardized test findings, behavioural observations, and demographic information.

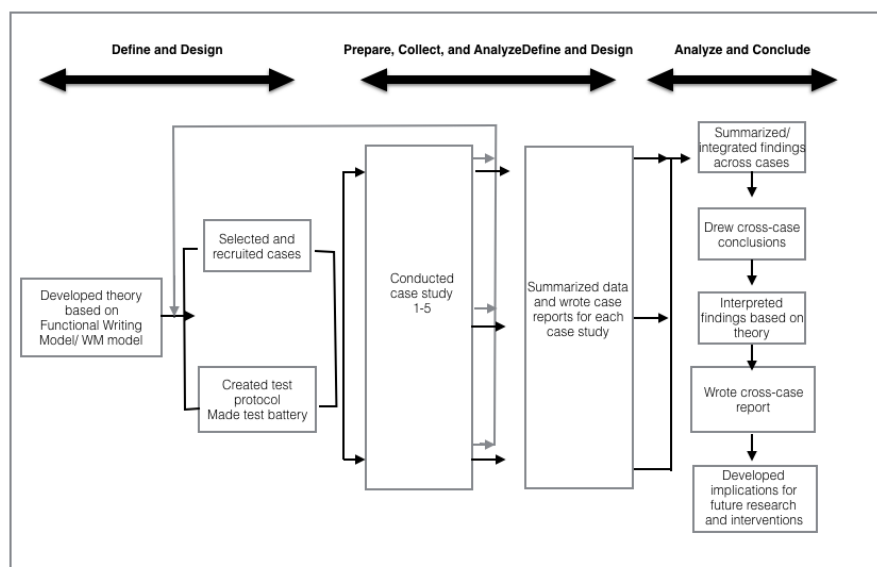


Figure 4. Multiple Case Study Procedure Adapted from Yin (2009)

Data processing for case studies. First, the data from the ASD group was sorted into matrices, guided by predictions based on the FWS (Berninger & Amtmann, 2003). This was done so data could be organized for a comparison of trends across participants. Next, a comprehensive profile for each youth with ASD (i.e., cases one through five) was generated, using the measures described earlier in this thesis. For each youth with ASD, background, demographic and diagnostic information (including clinical symptomatology) was summarized and standardized scores for intellectual function, visual-motor integration and WM were reported. A diagram of all the intersecting data was then developed (see Figure 5). A detailed analysis of each youth's written performance was discussed. Specific strengths and weaknesses were highlighted using standardized scores, informed by contextual information, such as behavioural observations and parent interview data. Lastly, each youth's written performance was compared to their WM profile identifying patterns in their scores. Yin (2009) suggests using a theoretical framework to guide case study analysis and to identify patterns using a variety of methods (e.g., flowchart, graphs, matrices, etc.). As the FWS (Berninger & Amtmann, 2003) guided this study, data was gathered to inform each of the domains of the FWS including; 1) transcription (i.e., Beery VMI), 2) text generation (writing subtest from the WIAT-II), 3) EF (i.e., observations and organization score on the writing measure) and 4) WM (non-word repetition, digit span forward and backward, counting and listening recall). Analyses of each case study was then completed using the FWS (Berninger & Amtmann, 2003) as a framework.

Following an analysis of individual profiles, performance across participants was synthesized to identify patterns and trends, using the cross synthesis (Yin, 2009) and constant comparison (Glaser & Strauss, 1967) methods, described above. Patterns and trends were linked to expectations based on the FWS (Berninger & Amtmann, 2003).

Finally, plausible rival explanations for writing difficulties beyond Berninger and Amtmann's (2003) FWS were explored as the last analytical strategy, including an alternate theoretical model (Kellogg, 1996). Rival explanations for the patterns observed in the data were explored on an individual case and group basis.

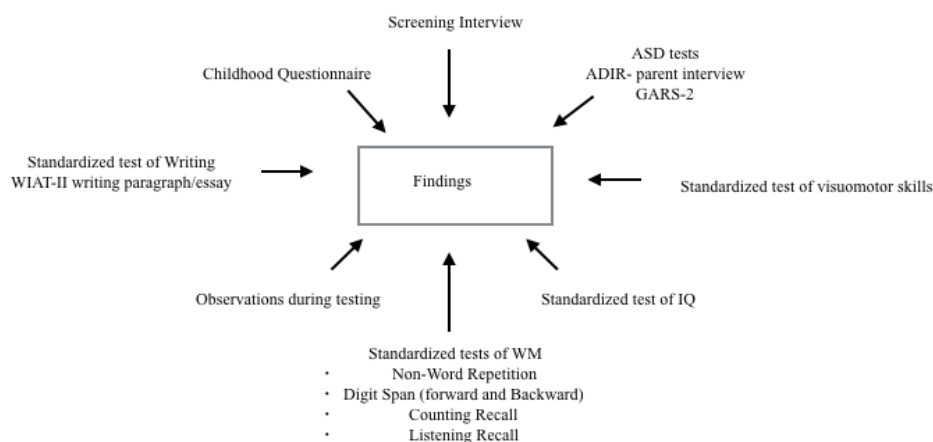


Figure 5. Convergence of Multiple Sources of Information Adapted from Yin (2009)

Case Study Predictions

It was predicted that youth with ASD would struggle in all three major areas of writing from the FWS (Berninger & Amtmann, 2003): text generation, transcription and EF as a result of WM difficulties (See Figure 5). Specific predictions were as follows:

1. Youth with ASD will demonstrate WM difficulties (i.e., visuospatial WM, verbal/phonological WM), which is a central component of Berninger and Amtmann's FWS (2003).

2. Youth with ASD will have difficulty with text generation (words, sentences, discourse) as evident in lower quality of writing, less written output (i.e., low word count) and less varied/creative use of vocabulary, in part due to their WM difficulties.
3. Youth with ASD will have average fine motor skills but will have difficulties with punctuation and spelling in written text due to WM difficulties (orthographic coding).
4. Youth with ASD will struggle with aspects of EF as evidenced by lower organization scores and observations made during testing.

Case summary for Participant 1.

Case history. Participant 1 (P1) was 8.5 years old and in grade four at the time of testing. Participant 1 received a diagnosis of ASD in 2014 at the age of seven years, through an autism assessment network. Using the abbreviated ADI-R, P1's social interaction score fell well above the cut-off for qualitative impairments in social interaction, showing his social skills to be significantly impacted (ADI-R score of 12, cut-off score of 10). His ADI-R verbal score of seven was slightly below the cutoff (cutoff of eight [for verbal subjects]); however, his parents described significant difficulties with communication during their interview, consistent with his diagnosis of ASD (e.g., trouble asking for help, problems communicating his needs, one-sided conversations, will talk for hours). His restricted, repetitive behaviour score fell above the ADI-R cut-off score, and his parents described many restricted interests, including video games, and in particular Pokémon Cards (ADI-R score of eight, a cut-off of three). Participant 1's score for atypicalities in early development score was also above the cut-off (ADI-R score of one, a cutoff of one), due to a lack of pretend play, poor joint attention, and difficulty with self-care (i.e., toileting). On the GARS-2, P1 was rated as having an ASD index standard score of 87 (i.e., scores of 85 or higher mean that the possibility of ASD is 'very likely') with social interaction

and restricted interests being the two areas of greatest challenge. No learning disabilities, language delay, intellectual delays or attention deficit disorders were reported in the past or currently. The only academic difficulties reported by P1's parents were in writing. Specifically P1 displays work refusal at school when it comes to writing. His parents reported that he is a bright and creative student with extreme social difficulties, often being overly friendly and not being aware of personal space. In the past P1 received the support of a behaviour consultant for emotional regulation. He also attended a social skills group at school. He had received no extra supports in school except for EA support for twenty minutes a day for a 'check in / check out' behaviour management program around anxiety. Participant 1 is not taking any medications.

Intellectual functioning. On the KBIT-2, P1 demonstrated strong intellectual capacity both across verbal and nonverbal reasoning domains, with a verbal standard score of 121 (92nd percentile) and a non-verbal standard score of 142 (99.7th percentile), putting him well above average. The difference between his verbal and nonverbal scores was significant ($p < 0.01$) seen in 16% of the population for his age group. His visuospatial abilities were much higher than his verbal abilities; although even in the verbal domain his scores were well above average. Stronger nonverbal than verbal reasoning ability is a pattern that can be seen in some, but not all, individuals with ASD (Coolican, Bryson, & Zwaigenbaum, 2008; Mayes & Calhoun, 2003, 2005, 2007, 2008). P1's overall IQ composite standard score was at a standard score of 136 (99th percentile), placing him well above the norm for his age. Observation of P1's performance on this task indicated that he was motivated to perform well and was focused during testing. Results of intellectual testing indicate that P1 clearly had the cognitive and linguistic ability to perform the writing tasks administered in this study.

Visual-motor integration. Participant 1's visual-motor integration abilities were assessed using the Beery VMI 6. He achieved a standard score of 131, which is again well above the norm for his age (98th percentile). These results suggest that P1's hand-eye coordination and fine motor-skills, at least on this one untimed measure, are strong ruling out serious problems with hand-eye coordination as a cause for writing difficulties.

Working memory. Participant 1 completed four different measures of WM (See Table 11). On digit span forward P1 achieved a standard score of 115 (84th percentile; high average range) showing no problems with rote verbal recall. In contrast, on the digit span backward task, he achieved a standard score of 70, which is below average (2nd percentile), despite giving full effort. The difference between P1's performance on digit span forward and digit span backward was highly significant ($p < 0.05$) and unusual (base rate of less than 1%). This indicates much greater difficulty on tasks of WM when compared with rote recall, a pattern that is common in individuals with ASD (Minshew et al., 2007; Steele, Minshew, Luna, & Sweeney, 2007). On the non-word repetition task from the CTOPP-2, which is a specific measure of the phonological loop, P1's performance was consistent with that seen on digit span backwards. He achieved a standard score of 80 (9th percentile), which is in the low average range. On a measure of verbal WM, where P1 recalled the final word of several sentences read orally, he achieved a score of 101 (53rd percentile), within the average range.

To assess visuospatial WM, counting recall from the WMTB (Gathercole & Pickering, 2001) was administered. Visuospatial WM is related to orthographic coding (e.g., visual shapes and codes of letters), which plays an important role in building spelling skills and mapping sounds to symbols (Berninger et al., 2002; Bourke, Davies, Sumner, & Green, 2013). Here, P1 achieved a standard score of 75 (5th percentile) in the well below average range. During this task

he struggled significantly, often saying that he “could not do it” and that the task was too hard, requiring prompting and encouragement to proceed.

Table 11

Working Memory Scores for Participant 1

Test	Raw Score	Standard Score	Percentile
Wechsler Intelligence Scale for Youth - digit span forward	10	115	84
Wechsler Intelligence Scale for Youth - digit span backward	5	85	16
CTOPP-non-word repetition	9	80	25
WMTB - listening recall	12	101	53
WMTB - counting recall	16	75	5

Writing. Participant 1’s writing was assessed using the WIAT-II written expression paragraph writing task (see Table 12).

Transcription - spelling, punctuation, handwriting. Participant 1 wrote very quickly (i.e., four minutes) and his word count was above average, showing that he did not have basic problems with pencil output speed in writing. In the area of mechanics, P1 achieved a score of three out of a possible nine. He made six spelling errors placing him in the zero quartile range, or lowest 5%. He made word-specific orthographic processing errors in his spelling meaning that he used plausible but incorrect sounds when spelling (e.g., “sh” sounds for “ch”). He achieved a quartile score of two on punctuation (2nd quartile, average 50%) indicating average use of

punctuation. The results suggest that P1 had difficulties with some aspects of transcription (spelling) but not others (punctuation or graphomotor skills).

Text generation – words, sentences, discourse. Regarding the length of his essay, P1 wrote 44 words overall placing him in the 3rd quartile and in the top 75 percent compared to same age-peers, despite only writing for a total of four minutes and 54 seconds and refusing to complete the paragraph. Within his paragraph, P1 achieved a raw score of zero out of a possible five points for vocabulary, because he used only simple vocabulary. He did not use language that would spark interest in the reader and he omitted verbs and adverbs. The overall writing score on the WIAT-II is a composite score that includes mechanics, organization and vocabulary (note: word count is not taken into account for the overall score). Participant 1's overall writing score was low; he achieved a raw score of six out of 40, despite very high intelligence and verbal ability. He achieved a paragraph holistic score of two, on a scale of zero to six, which means that his paragraph contained minimal descriptive information or elaboration.

Executive functions - planning, organization, revising, self-regulation. Concerning organization, P1 achieved a raw score of six out of 10. He achieved scores for providing examples, having a logical order, and for having a unified paragraph. He lost points for sentence structure as his paragraph consisted of a single sentence with no linking expressions (e.g., *for example, therefore, firstly, lastly*). His text quality was low, and observations did not indicate that he had engaged in organization or preplanning processes (Graham, Harris, & Mason, 2005). For example, a planning sheet was provided to P1, but he did not use it. Observationally, multiple verbal prompts were required for P1 to begin writing (e.g., the examiner asked P1 if they were ready to begin multiple times, gave them a few ideas on what to write about “could be your favourite board game”, “you only have to write for ten minutes! It will be over before you

know it”). Participant 1 claimed that he did not know what to write about even after the receiving the prompts. He struggled to initiate writing and found it difficult to select a topic and stated that he “hated writing”. When told he would be completing a written task he refused because he “does not do creative writing”. This type of work refusal could reflect problems with inflexibility, anxiety, frustration levels, or past experiences with writing difficulties. Once P1 completed writing, with prompting, he did not read over his work or engage in any editing strategies (e.g., self-regulation and revising). In general, writing appeared aversive and extremely mentally taxing for P1.

Table 12

Participant 1 - Writing Scores from the WIAT Marking Rubric

Area Assessed	Quartile	Raw Score
Word Count	3	44
Spelling	0	6*
Punctuation	2	2*
Total Mechanics Raw Score		3
Total Organization Raw Score		3
Total Vocabulary Raw Score		0
Total Writing Raw Score		6/40

*number of errors

Participant 1 case analysis. Overall, P1 has superior IQ, very superior non-verbal abilities, superior verbal abilities, superior visual motor skills, and normal rote memory. Areas of weakness included significant deficits in both visual and verbal WM. He also significantly

struggled with several aspects of writing, despite having strong verbal ability and intellect. Discrepancies between P1's IQ and writing scores are consistent with what has been reported in the literature for individuals with ASD (Mayes, Calhoun, Bixler, & Zimmerman, 2009). As predicted based on the FWS (Berninger and Amtmann, 2003), text generation, transcription, WM and EF were compromised.

Regarding WM, P1 had proportionally more difficulty on WM tasks than on short-term memory tasks, as is often seen in ASD (Morris, Rowe, Fox, Feigenbaum, Miotto, & Howlin, 1999). On WM tasks, P1 showed particular difficulties with verbal WM/phonological loop and visuospatial WM, yet verbal WM for more contextually based tasks was average. The visuospatial WM task appeared particularly challenging for P1, as evident through his visible discomfort on this task. Overall, WM was much lower than expected based on P1's IQ scores, with a difference of four standard deviations between his IQ (FSIQ = 136) and spatial WM scores (SS = 75) and three standard deviations between his IQ and verbal memory tasks (SS = 80 and 85). He did not show the same level of difficulty on a task of rote memory (i.e., digits forwards) or on tasks where he could use reasoning to help with retention, suggesting that difficulties were specific to WM rather than simply due to memory problems.

Overall, in the area of text generation, the following predictions based on the FWS (Berninger & Amtmann, 2003) were met: overall low quality of writing (i.e., as seen by total score and holistic scores) and low vocabulary score. The prediction for text length was not met in that P1's written paragraph was longer than predicted. P1's word count was not impacted, but the quality of his writing was poor. This is different than what was reported by Myles et al. (2003) and from the below average text length that would be predicted based on Berninger and Amtmann's (2003) FWS, possibly due to P1's very high intellectual and verbal ability. Similar to

what Brown and Klein (2011) found, writing for an audience was difficult for P1, including the use of highly literal language and failure to elaborate on his ideas. Despite superior verbal IQ, P1's vocabulary scores were low as predicted by the FWS (2003). This could occur due to WM difficulties leading to difficulty holding vocabulary in mind long enough to express words on paper. This pattern would not necessarily be seen in oral language, as WM deficits tend to affect written language more than oral language (Bourdin & Fayol, 2002). Also, as predicted based on the FWS (2003), transcription scores were low. P1 had significant problems with spelling, achieving a score in the bottom quartile (i.e., six errors). Research reveals that spelling difficulties can arise from dysgraphia, which is ruled out for P1 due to normal visual-motor integration, or from WM problems (Berninger, 2003). In P1's case deficits in visuospatial WM (orthographic route) or verbal WM deficits (phonological route) could be the cause of spelling difficulties. In a bidirectional effect, spelling difficulties can also hinder the development of higher order writing skills as underdeveloped lower level writing skills such as spelling can take up WM resources (Ehri, 2005). However, as spelling was not assessed as a separate task (it was only assessed embedded in paragraph writing) it is not possible to determine if P1 had more fundamental problems with spelling or if spelling was only difficult in the context of paragraph writing.

Executive functions (i.e., another component of the FWS) were not a focus of this study and were not directly assessed. However, observations suggested that P1 struggled in aspects of EF including organization, planning, and self-regulation. He also seemed to have some problems with initiation (i.e., getting started on his writing) and with mental flexibility (e.g., moving from one task to another). He did not engage in any visible planning processes when writing, as evidenced by him not using his planning sheet. His organization scores for writing were low, and

he did not revise his work after finishing writing, which overall influenced the end product. These observed difficulties could be due to weaknesses in broader EF abilities, reported in the ASD literature (Chavkin, 2004; Happé, 1994; Jurecic, 2007; Mayes & Calhoun, 2003, 2005, 2007, 2008; Myles et al., 2003), with specific EF abilities such as WM, or a combination of both.

Overall, the results align with what would be predicted by the FWS (Berninger & Amtmann, 2003) in an individual who has WM problems. This is seen in P1's overall writing score, spelling difficulties, and less sophisticated use of vocabulary in writing than would be expected for his IQ. Concerning text generation, WM deficits would be expected to hinder discourse, vocabulary and length of the text. Within the FWS (Berninger & Amtmann, 2003), problems in text generation can arise because of transcription, language difficulties, and/or limited attention/EF. Participant 1 had superior visual-motor skills, strong oral language scores, and demonstrated adequate short-term memory. Therefore, it is posited that many of his writing difficulties could have arisen from WM deficits. Alternate explanations for P1's writing difficulties could be basic challenges with spelling, or broader EFs problems, affecting organization and planning, in addition to anxiety and low motivation during writing. As broad EFs were not formally assessed, the contribution of EF to P1's writing cannot be determined. An additional rival explanation is language usage, which is a core deficit in individuals with ASD (APA, 2000). Even though P1 had excellent verbal reasoning, atypical use of language could influence the quality of his writing.

Based on the FWS (Berninger & Amtmann, 2003) it was predicted that poor WM skills would result in overall low quality in writing, low word count (i.e., due to WM difficulties), spelling difficulties (i.e., due to visuospatial difficulties), and less sophisticated vocabulary use (i.e., phonological loop difficulties; Berninger & Amtmann, 2003). These predictions were met,

however, the underlying cause whether writing difficulties are due to WM deficits, EF/attention difficulties, or other causes, is not clear.

Case summary for Participant 2.

Case history. Participant 2 (P2) was male, nine years and six months old and in grade four at the time of testing with a sole diagnosis of ASD. He was age five years when he received his ASD diagnosis through an ASD assessment unit. Participant 2's current ASD symptomatology was assessed through the abbreviated ADI-R and GARS-2. On the ADI-R, he achieved a social interaction score of six, which is below the clinical cut-off of 10. This suggests that P2's social skills are not severely impaired at this time. He achieved an ADI-R communication score of nine, which is above the ADI-R cut-off of eight. His score for restricted and/or repetitive behaviour was four and above the ADI-R cut-off score of three. Participant 2 had a number of restricted interests, specifically video games. His score for early developmental abnormality was at the cut-off score of one. Participant 2's parents reported that he had made significant gains in his social and communication abilities since his diagnosis. However, it is important to note that this does not negate his diagnosis of ASD as waxing and waning of symptoms in ASD is common, and the ASD clinical diagnosis is based on behaviours at age four to five (Lord, C., Rutter, M., & Le Couteur, A., 1994). Participant 2 displayed social/behavioural/communication atypicalities consistent with ASD, even though he fell below the threshold on the social domain at the time of testing. On the GARS-2, P2 achieved an overall standard score of 72 falling in the 'possible' ASD range for ASD (standard score ranges of 70-84 indicate 'possible ASD'). Stereotyped behaviour was the area of most significant concern on the GARS-2, with evidence of restricted interests. Participant 2's parents reported that he struggled with writing despite enjoying drawing and making comic books. During testing, P2 had a verbal

and agreeable manner, but was often distracted and wanted to discuss and show the examiner favourite video games. There is no evidence of any past or current learning disabilities, language delay, intellectual delays or attention deficit disorders. Participant 2 attended school full time and received no in-class support, but had previously been a part of a learning group. Concerning intervention services, P2 received the support of an occupational therapist, speech and language pathologist and a behaviour consultant for social skills. He also received tutoring services outside of school to help with class work and writing instruction. Participant 2 was not taking any medications at the time of testing.

Intellectual functioning. Participant 2 demonstrated average intellectual ability across verbal and nonverbal domains on the KBIT-II, with a verbal standard score of 100 (50th percentile) and a nonverbal standard score of 106 (66th percentile). There was no significant difference between P2's verbal and nonverbal IQ, and his overall IQ composite standard score was at a standard score of 104 (61st percentile), placing him in the average range. He was deemed cognitively and verbally capable of completing the writing tasks in this study.

Visual-motor integration. Participant 2's visual-motor integration on the Beery VMI 6 was at a standard score of 94 (34th percentile) and in the average range. This suggests that P2's visual-motor integration skills (i.e., on an untimed measure) are average and likely not the cause of any writing difficulties.

Working memory. On a measure of rote verbal recall (i.e., digit span forward), P2 achieved a standard of 120 (91st percentile) indicating strengths in rote verbal recall. On digit span backwards, which places more demands on WM, P2 achieved a standard score of 90 (25th percentile). Although in the average range, his score was significantly lower than his rote/forwards recall ($p < 0.05$) with an unusual discrepancy (base rate of less than 1%). This

shows that P2 struggled significantly more on WM tasks than rote recall tasks, despite a strong effort on both. On CTOPP-2 non-word repetition task, which measures the phonological loop, P2 achieved a standard score of 120 (91st percentile), which is in the high average range. He achieved a standard score of 95 (37th percentile) on the WMTB-C listening recall task (verbal WM), which is again within the average range. On this test battery, P2 showed strengths within the phonological loop (i.e., non-word repetition and digit span forward). Although verbal WM was not as strong, it was still in the average range.

On a measure of visuospatial WM (i.e., WMTB-C counting recall), P2's standard score was 61 (0.5th percentile), which is extremely low. He appeared to be focusing and giving a solid effort but struggled during counting recall. His visuospatial WM is much lower than would be anticipated based on his intellectual abilities and verbal/phonological WM scores.

Table 13

Participant 2 Working Memory Scores

Test	Raw Score	Standard Score	Percentile
Wechsler Intelligence Scale for Youth - digit span forward	9	120	91
Wechsler Intelligence Scale for Youth - digit span backward	6	90	25
CTOPP - non-word repetition	13	120	91
WMTB - listening recall	11	95	37
WMTB - counting recall	12	61	0.5

Writing. P2's writing skills were assessed using the WIAT-II paragraph task (see Table 14).

Transcription - spelling, punctuation, handwriting. P2 wrote quickly and his word count was above average, confirming that he does not seem to have problems with fluency or speed in writing. In the area of mechanics, P2 made three spelling mistakes, placing him in the second quartile (i.e., average range). In the area of punctuation, P2 made seven punctuation mistakes placing him in the first quartile (i.e., bottom 25th percentile), which is significantly below average. Writing mechanics scores, which were at a raw score of three out of nine (30%), were lowered as a result of punctuation difficulties, which is a lower level transcription skill according to Berninger (2003).

Text generation - words, sentences, discourse. Overall, P2 wrote 41 words in five minutes and 14 seconds and finished well before the 10-minute time limit. Despite finishing early, P2 scored in the 3rd quartile for paragraph-length/word count (the upper 75%) performing better than average when compared to same-aged peers, inconsistent with Myles et al. (2003) results suggesting that individuals with ASD produce shorter texts length. Despite the reasonable length, Participant 2's quality of text was very low. He scored a zero in the area of vocabulary because word use was simplistic and not varied. He struggled to write for an audience, did not use words to spark interest in the reader, and did not elaborate on any of his ideas. P2 scored nine out of a possible 40 points (22.5%) on the overall WIAT-II writing score, which included mechanics, organization and vocabulary. He achieved a holistic score of two, meaning that his paragraph barely met minimum requirements. He made punctuation errors, spelling mistakes and lacked the use of creative vocabulary. Despite average phonological processing scores and average verbal reasoning and IQ, P2's overall writing scores were low.

Executive functions - planning, organization, revising, self-regulation. On writing organization, P2 achieved a score of six out of a possible score of 10 showing stronger scores for organization than mechanics. Participant 2's paragraph consisted of two sentences in total. His paragraph was unified and followed a logical order, however, he was observed to struggle with EF; he did not use the pre-planning sheet that was provided and did not go back to revise or edit his work. Based on observations, P2 struggled to begin the task and needed to be verbally prompted a few times (e.g., "You can write about a favourite board game or video game"). He also struggled to stay focused on this task and would stop writing to ask the examiner questions about a different topic (e.g., P2 discussed a particular video game and wanted to show the examiner a video about the game). There appeared to be some difficulties with staying on task, focus, revising, and initiation (i.e., getting started). Overall, P2 had difficulties with the initiation and task persistence aspects of EF. He also had difficulties with attention which could be expected to impact writing in a number of ways.

Table 14

Participant 2 - Writing Scores from the WIAT Marking Rubric

Area Assessed	Quartile	Raw Score
Word Count	3	41
Spelling	2	3*
Punctuation	0	7*
Total Mechanics		1
Organization Raw score		6
Total Vocabulary Raw Score		0
Total writing score		9/40

*number of errors

Participant 2 case analysis. Overall, P2 demonstrated average overall intellectual ability, including average nonverbal and verbal reasoning ability. Visual-motor integration skills were also in the average range. His WM pattern indicated strengths in some areas, but weaknesses in others. He had particular strengths with rote recall and phonological memory and his verbal WM was average. Conversely, P2 showed significant weaknesses on a measure of visuospatial WM. He had difficulties with some aspects of writing, but not others. In particular, punctuation and vocabulary development were low, whereas text length, spelling and organization were in the normal range. With respect to EF, P2 struggled with task initiation and attention control. His overall writing score was reduced due to punctuation errors and low vocabulary, despite scoring well in organization and having an above average word count. When predicting writing performance through Berninger and Amtmann's FWS (2003), one would expect to see difficulties with orthographic writing skills due to poor visuospatial skills (spelling and overall planning), but one would not expect to see problems with translating, revisions, and rereading in an individual with a strong phonological loop, strong verbal WM, and strong rote recall. Other writing skills that depend on verbal WM, including reviewing and translating, would be anticipated to fall within the normal range. Participant 2's strong scores in the phonological loop are not consistent with study predictions for individuals with ASD.

Overall, P2 showed strengths in the phonological loop and in verbal WM, yet significant difficulty with visuospatial WM. His visuospatial WM was much lower than would be anticipated based on his intellectual abilities and verbal WM scores. Based on his WM profile, it was predicted that P2 might have orthographic deficits due to deficits in visuospatial WM, which would be evidenced by planning difficulties, low word count, and spelling difficulties.

Researchers have suggested that visuospatial WM is important for visualizing the outline or plan of written composition and for text generation (Kellogg, 1996; Van der Plaats & Van Galen, 1990) and orthographic abilities, such as letter-sound awareness and spelling (Berninger & Amtmann, 2003). However, Kellogg (1996) and Kellogg, Whiteford, Turner, Cahill, and Mertens (2013) suggested that visuospatial WM correlates less to writing outcomes than the phonological loop, which supports translating and reading. Based on the FWS (Berninger & Amtmann, 2003), visuospatial WM problems might be expected to impact spelling and planning based on difficulties seeing the ‘big picture’, which may have an impact on text generation.

It was predicted that P2’s writing in the areas of text generation, transcription and EF while writing would be affected by problems with WM. The FWS (Berninger & Amtmann, 2003) would predict average text generation for P2 due to average phonological processing abilities. His scores in this area are significantly low, as a result of specific difficulties in punctuation.

Transcription is gauged through motor skills (e.g., handwriting) and low-level skills (e.g., spelling and punctuation). Within the FWS (Berninger & Amtmann, 2003), problems in text generation can arise because of transcription, language difficulties and/or limited attention/EF. It was predicted that P2 would have average handwriting skills because of his Beery VMI test scores, but that his spelling and punctuation skills might be low as a result of visuospatial WM deficits. Participant 2’s spelling was average, but his punctuation skills were significantly impacted, which could be due to visuospatial WM deficits. There may be some EF deficits or attention difficulties that might be influencing the P2’s ability to focus and allocate attention to all aspects of writing, which may result in some areas of writing being well developed and others

are not. Participant 2 was not formally diagnosed with an attention disorder, but appeared to have some attention and EF difficulties

Participant 2 does not fully meet the FWS (Berninger & Amtmann, 2003) predictions in that he had average spelling and above average word count, but very low punctuation skills. The FWS would predict that impacted punctuation skills and low visuospatial WM would affect text generation and lead to a lower word count. However, P2's average spelling and word count scores are consistent with Kellogg et al.'s (2013) findings that visuospatial WM may correlate less with spelling and writing deficits than phonological processing. An alternate explanation (other than WM difficulties) may better explain the cause of writing difficulties for P2. Therefore, it is posited that his writing difficulties could have arisen from WM, EF deficits, or possible attention deficits.

Case summary for Participant 3.

Case history. Participant 3 (P3) was 15 and in grade 10 at the time of testing. Participant 3 was diagnosed with ASD at the age of 10 in British Columbia using BC Standards and Guidelines (Dua, 2003). He also has a comorbid diagnosis of ADHD, diagnosed prior to his ASD diagnosis, and takes medications daily to help with attention and focus. Participant 3 was on medication during testing for the current study. Participant 3's current ASD symptomatology was assessed through the ADI-R and GARS-2. On the ADI-R, P3's social interaction score was 24, well above the ASD cut-off of 10, showing significant impairments in social skills. His ADI-R communication score was 16, falling well above the ASD cut-off of eight. His ADI-R score for restricted and/or repetitive behaviour was seven and well above the cut-off score of three, indicating a high degree of stereotyped/ repetitive behaviours. His early development score was two, falling above the ADI-R cut-off score of one for early developmental abnormalities. On the

GARS-2, P3 achieved an overall standard score of 74, falling in the “possible” range for ASD. Consistent with ADI-R results, social interaction was the domain on the GARS-2 where P3 was identified as having the most impairment. Participant 3’s parents reported during the screening interview that P3 struggles with writing. During testing, P3 appeared nervous and stated multiple times that he was anxious about his upcoming grade 10 essay writing test. No learning disabilities, language delay, intellectual delays have been diagnosed, and his parents did not report problems in these areas during the interview. He attends school full time and has received no in-class support. However, P3 has an extra study block built into his timetable where he receives learning support. Participant 3 reported that this study block had been used to focus on essay writing, to help prepare for his grade 10 written exams. In the past, but not currently, P3 received the support of a behaviour consultant. At the time of his participation, P3 was not receiving any supports outside of school but he was taking stimulant medication.

Intellectual functioning. On intellectual screening (KBIT-II), P3 demonstrated low average intellectual capability across verbal and nonverbal domains, with a verbal standard score of 87 (19th percentile) and a nonverbal standard score of 84 (14th percentile). There was no significant difference between verbal and nonverbal abilities and P3’s overall IQ composite standard score was 83 (13th percentile), placing him just in the low average range for his age. On intellectual screening, P3 was visibly anxious and asked the examiner numerous times if his answers were correct.

Visual-motor integration. Youth with ASD who have comorbid attention problems are particularly at risk for visual-motor integration difficulties (De La Paz, 2001). This was not the case for P3 in that he achieved a standard score of 93 (32nd percentile) on the Beery VMI 6

indicating average visual-motor integration and adequate hand-eye coordination for the purposes of writing.

Working memory. Participant 3's performance for rote recall on the WISC digit span forward subtest was at a standard score of 115 (84th percentile), indicating strong rote verbal memory. He achieved a standard score of 90 (25th percentile) on digit span backwards, measuring WM, which is average but significantly lower than his rote recall (i.e., significant at .05; see Table 15). The proportion of individuals showing this size of gap between rote recall (digit span forward) and WM (digit span backwards) is less than 1% in the general population. Participant 2 achieved a standard score of 70 (2nd percentile) on a measure of the phonological loop (i.e., non-word repetition task from the CTOPP-2), falling well below the average range and standing out from other assessment scores as a particular weakness. Participant 3's performance on a measure of verbal WM that permits use of context (i.e., WMTB-C listening recall) was at a standard score of 92 (30th percentile) and in the average range, indicating better performance when he could use context to remember information. The overall results suggest that P3 had variable verbal WM with strong rote recall and average memory for information in context, but very weak phonological WM. His performance on a measure of visuospatial WM (i.e., WMTB-C counting) was average at a standard score of 97 (42nd percentile). Participant 3's scores can be explained by Shuh and Eigsti's (2012) findings that complex verbal tasks may be more difficult due to greater executive or linguistic demands.

Table 15

Participant 3 - Working Memory Scores

Test	Raw Score	Standard Score	Percentile
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WISC -digit span forward	8	115	84
WISC -digit span backward	7	90	25
CTOPP-2 non-word repetition	10	70	2
WMTB - listening recall	14	92	30
WMTB - counting recall	28	97	42

Writing. Participant 3's writing was assessed using the essay-writing component on the WIAT-II (see description above) appropriate for students in grades seven to 16. See Table 16 for results.

Transcription - spelling, punctuation, handwriting. Participant 3's word count was very low and he struggled with spelling and punctuation. In the area of mechanics, P3 achieved a total raw score of one out of a possible nine, due to problems both with spelling and punctuation. The essay needed to include at least 24 words in order to count spelling or punctuation errors and because of P3's low word count (only 18 words) spelling and punctuation errors were not formally scored. However, it is of note that of the 18 words used four were spelt incorrectly and there were five punctuation errors.

Text generation - words, sentences, discourse. Regarding essay length, P3 wrote 18 words only. He used only a fraction of the allotted time period to write (i.e., three of a maximum of 15 minutes), however, when prompted to write more P3 showed distress and asked not to write anymore. Environmental factors such as being in an unfamiliar setting and associated anxiety, frustration, and past negative experiences with writing could have affected P3's writing performance. Participant 3 stated that writing itself makes him nervous and he did not appear to be nervous on any other measure administered. Based on the WIAT-II scoring guide, P3 scored

in the 1st quartile for essay length (bottom 25% when compared to same-aged peers). This suggests that P3's written output is significantly reduced, which may have in part been due to anxiety around and resistance to writing.

In regards to essay theme development, P3 achieved a score of two out of a total raw score of eight, revealing undeveloped ideas and difficulty with discourse. Although his first sentence contained three supports for his position on the essay topic, he proposed no evidence to support his stance. His essay remained on topic; however, he only wrote two sentences and framed this as an answer to the question rather than a persuasive argument. Concerning his use of vocabulary, P3 achieved a raw score of zero; he only wrote 18 words and his chosen words were not varied, specific or enlightening. Participant 3's overall essay score was four out of a possible raw score of 42 points (7.2%) meaning he scored very poorly on the writing task. Participant 3 achieved an essay holistic score of one; although he implied a position with enough detail to determine it was on topic, he did not provide any logical or specific reasons for his position (WIAT Manual, 2002, p.73). These difficulties with writing are in spite of the fact that P3 has received instruction on essay writing in school, including weekly writing support in a scheduled learning support block for the past year. Participant 3 was asked if he wanted to write more and he declined and said, "I have nothing more to say".

Executive functions - planning, organization, revising, self-regulation. Observations revealed that P3 struggled immensely with writing, displaying attention and inhibition difficulties. He engaged in no reviewing or editing processes and he did not use the blank sheet that was provided for planning. Concerning organization, P3 achieved an overall raw score of one out of a possible raw score of 17, demonstrating extremely poor organization when writing. His essay contained no topic sentence and no linking words or phrases and it was not structured

as outlined in the instructions. It did have an introductory sentence, but there was no concluding sentence. In the FWS (Berninger & Amtmann, 2003), EFs contribute to the ability to plan and organize writing and research has shown a direct link between EF impairments in ADHD and written expression (Barkley, 1997).

Table 16

Participant 3 - Writing Scores from the WIAT Marking Rubric

Area Assessed	Quartile	Raw Score
Word Count	1	18
Spelling	0	0*
Punctuation	0	0*
Total Mechanics Raw Score		1
Total Organization Raw Score		1
Total Vocabulary Raw Score		0
Total Theme Raw Score		2
Total writing score		4/55

*number of errors

Participant 3 case analysis. In contrast to the other youth, Participant 3 has comorbid diagnoses of ASD and ADHD. Participant 3 was on stimulant medication during testing which would likely improve his ability to attend and complete the tasks, particularly measures of WM. His WM scores are therefore potentially higher than they would have been if he were not taking medication. Despite being on stimulant medication he achieved an extremely low phonological WM score (2nd percentile), but other areas of WM were average. As such, P3 was predicted to

have relatively intact writing based on predictions linking WM to writing using Berninger and Amtmann's FWS (2003). However, contrary to expectations, P3 had significant problems with writing in a variety of areas, more so than other ASD youth who had lower WM scores. This may be due to P3's comorbid ADHD diagnosis. Although it is difficult to determine whether P3's writing deficits were ADHD or ASD related, or a combination of the two. Research on ADHD and writing suggests these individuals have particular difficulty with "retaining ideas in their minds, acting upon and organizing ideas, quickly retrieving grammar, spelling and punctuation rules from long-term memory, manipulating information, remembering ideas to write down, organizing the material in a logical sequence, and then reviewing and correcting errors" (Casas et al., 2013, p. 444). It was predicted that with average IQ and average performance across most WM tasks, P3 would have less difficulty with writing than P1 and P2. However, specific deficits in the phonological loop would predispose P3 to experience challenges with spelling, transcribing ideas and rereading in his essay writing. A comorbid diagnosis of ADHD may predict additional difficulties with attention and EF, which could impact the planning/organization aspect of essay writing and focus (Lienemann & Reid, 2008; Kempton et al., 1999).

Overall, P3's WM performance was variable and it is possible that he performed well on some WM tasks due to taking a stimulant medication at the time of testing. He struggled mostly with a measure of the phonological loop but showed better performance on measures of verbal WM and visuospatial WM. Consistent with P1 and P2; verbal rote recall was stronger than verbal WM. According to Baddeley and Hitch's model (1974) the phonological loop is a 'slave system' of the central executive and is responsible for the storage and maintenance of sounds over a period of time; when sounds are rehearsed it results in the maintenance of information.

The phonological loop plays a variety of roles in language learning (Baddeley et al., 1998). Most of the research focused on the phonological loop reports its role in reading skills (Baddeley et al., 1998) and it has been shown to correlate with reading achievements (Baddeley et al., 1998) and efficiency of phonological processing (Brady, 1991; Ziegler & Goswami, 2005). One could hypothesize that deficits in the phonological loop played a larger role in writing for P3 and influenced P3's writing scores. It would also be important to test P3's reading skills to see if they have been impacted at all by phonological processing difficulties. Berninger and Amtmann's FWS does not state which particular aspects of WM influence writing; however, Kellogg's (1996) model predicts that phonological loop difficulties would cause issues in reading and translating of written content. Kellogg (1996) argues that the phonological loop is employed when individuals are translating and reviewing, in particular, when they are reading. As seen in Table 16, P3 struggled considerably during essay writing, which could be due to phonological loop deficits. The FWS predicts that poor WM skills, in particular, verbal WM, would result in overall lower quality of writing.

Participant 3 struggled immensely on the writing task. Participant 3's writing scores are significantly lower than would be anticipated when looking at his WM scores and average visual-motor integration. Participant 3 struggled with all three aspects of writing: transcription, text generation and EF. This level of difficulty was unanticipated but could have resulted from a combination of challenges with phonological WM affecting literacy more generally, in addition to possibly experiencing a greater degree of attention/EF problems as a result of having both ADHD and ASD.

Concerning transcription, based on phonological loop deficits, it was predicted that in addition to problems with text generation, P3 would have difficulties in spelling, punctuation and

orthography. He had average visual-motor skills on the Beery VMI 6, suggesting adequate hand-eye coordination for pencil output, even though some students with ADHD have motor output deficits (Adi-Japha et al., 2007). In the area of transcription, his word count was so low that spelling and punctuation errors could not be scored. However, he made four spelling errors (20% of his words were spelled incorrectly) and five punctuation errors. His difficulties with writing mechanics may have been due to phonological WM deficits. In addition, this may also be associated with his comorbid ADHD diagnosis as studies have shown that students with ADHD struggle in the mechanics of writing, making more spelling errors and grammatical errors (Adi-Japha et al., 2007; Casas et al., 2013).

Overall, in the area of text generation, the following predictions based on the FWS (Berninger & Amtmann, 2003) were observed: overall low quality of writing (e.g., total score and holistic scores), low vocabulary scores (e.g., less sophisticated vocabulary), low theme development scores and short text length. The severity of writing problems was not predicted because of P3's average WM abilities. These difficulties could be resulting from poor phonological WM, or broader attention and EF difficulties due to ADHD, despite his being on stimulant medication. It is likely that P3's comorbid ADHD and ASD mean that he has more severe and broader attention and EF deficits that were not measured in the battery administered here, given that children with comorbid ASD and ADHD tend to have more severe attention and EF problems (Goldberg, Mostofsky, Cutting, Mahone, Astor, Denckla & Landra, 2005). Although not formally tested, examiner observations of P3 suggest challenges with attention and EF in that he showed significant difficulties with focus, attention, and initiation, which would be expected in a student with comorbid ADHD and ASD (Adi-Japha et al., 2007; Casas et al., 2013). Participant 3's difficulties could also be attributed to higher levels of frustration than the

other youth in the study and his visible anxiety on the writing task. Participant 3 could also have past negative experiences with writing that would affect his current performance.

In summary, looking at the FWS (Berninger & Amtmann, 2003) it was expected that P3's writing in the areas of text generation, transcription and EF would not have been severely impacted because of his average WM, except for phonological memory. Participant 3 had average visual-motor skills, as seen on his Beery VMI 6 scores, average oral language scores (verbal IQ), and adequate short-term memory (digit span forward). Given this profile, one expects that P3's writing scores should have been higher. His unexpectedly low writing scores could be due to more severe attention/EF problems due to comorbid ADHD/ASD. This student also had lower, albeit average cognitive ability than the other youth, so perhaps he had also less cognitive reserve for writing. Observationally, P3 demonstrated anxious behaviours in regards to writing, which could have further hindered his writing output.

Case summary for Participant 4.

Case history. Participant 4 (P4) was 14 years old and in grade nine at the time of testing. He received a diagnosis of ASD at the age of eight years using BC Standards and Guidelines, including ADOS and ADI-R. Participant 4 has a reported comorbid diagnosis of ADHD, although it is not known when this diagnosis was made or by whom. Participant 4 was on stimulant medication during testing. Participant 4 had one febrile seizure (age unspecified) although this type of seizure is not uncommon in young children and has no negative prognoses associated with it. In regards to current ASD symptomology, P4's social interaction score on the ADI-R was 18, which fell above the ADI-R clinical cut-off of 10, indicating that P4 currently has significant difficulties with social interactions. His ADI-R verbal score was 14; again, well above the ADI-R clinical cut-off of eight, showing current difficulties with communication skills.

Participant 4's score for restricted and/or repetitive behaviour was five, above the ADI-R clinical cut-off score of three and, indicating significant ongoing restricted/repetitive behaviours and/or interests. His early development score was five and well above the ADI-R clinical cut-off score of one, indicating several early abnormalities in development. On the GARS-2 rating scale, P4 achieved an overall ASD index standard score of 70, which falls in the range of 'possible ASD'. The areas on the GARS-2 that were most significantly elevated were the domains of stereotyped behaviours/interests and social interaction. No learning disabilities, language delay, intellectual delays have been previously diagnosed or reported, and P4's parents did not report problems in these areas during the interview. Participant 4 was on medications for ADHD at the time of testing. He attended school full time and received no in-class supports. In the past P4 received the support of a speech-language pathologist, an occupational therapist, and a behaviour consultant. Concerning intervention services received at the time of testing, P4 was receiving tutoring outside of school focused on writing tasks but was not receiving in-school supports.

Intellectual functioning. Participant 4 demonstrated superior intellectual capability across verbal and nonverbal domains with a KBIT-II verbal standard score of 120 (91st percentile) and a nonverbal score of 121 (92nd percentile). There was no significant difference between verbal and nonverbal IQ and P4's overall IQ composite was at a standard score of 124 (95th percentile), placing him in the superior range for his age. As such, P4's cognitive and language abilities were more than adequate to complete the tasks in this study and his high intellectual abilities would predict high academic achievement (Mayes et al., 2009). Many researchers have found that individuals with a high IQ make better progress in reading and writing (Shaywitz, Fletcher, Holahan & Shaywitz, 1992) and IQ has been shown to be a strong predictor of word reading, reading comprehension, math and written expression scores for

individuals with ADHD (Mayes & Calhoun, 2007) and ASD (Mayes & Calhoun, 2008).

Therefore, it was predicted that P4's writing achievement would be strong based on his IQ and verbal scores.

Visual-motor integration. Participant 4 achieved a standard score of 87 (19th percentile) on the Beery VMI, which is in the low average range for his age. Scores in this range are not indicative of severe visual-motor integration problems, and would not be expected to be a significant contributor to transcription difficulties when writing. However, this score is indicative of mild difficulties in hand-eye coordination.

Working memory. It should be noted that P4 was on stimulant medication during testing, which could have improved his performance on attention/WM testing. On a measure of rote verbal recall (i.e., WISC-IV digit span forward), P4 achieved a standard score of 85 (16th percentile), which is in the low average range. He had greater difficulty on WISC-IV digit span backwards, which places greater demands on verbal WM, where he achieved a standard score of 75 (5th percentile; well below average). Although the difference between these two scores was not statistically significant, the results suggest that P4 shows mild difficulty on tasks of rote recall and significant difficulty when task demands increase. Participant 4's scores on these two tasks fall two and three SD below his full-scale IQ, respectively. He achieved a standard score of 70 (2nd percentile) on the non-word repetition task from the CTOPP (phonological loop) in the extremely low range. On the WBMT listening recall task, assessing verbal WM in context, P4 achieved a standard score of 61 (0.5th percentile) and in the extremely low range. This result is surprising because of his extremely high verbal IQ scores. The difference between P4's verbal IQ and his scores for phonological loop and listening recall ranging from 50 to 59 standard score points (four standard deviations) which is highly unusual. He was observed to be focused and

making an effort, so these low scores cannot be attributed to poor focus or motivation. Overall, on tasks of verbal WM, P4 had variable results; he was in the low average range on less complex tasks of rote recall, yet his performance significantly decreased on tasks with higher language recall and WM demands. These scores suggest particular difficulties with verbal WM and the phonological loop, which would be predicted to impact writing by effecting reading and translating processes.

On a measure of visuospatial WM (i.e., WMTB-counting recall), P4 achieved a standard score of 83 (13th percentile), which is in the low average range when compared to same age peers and two standard deviations below his FSIQ. However, these scores are not as low as his verbal WM scores.

Table 17

Participant 4 – Working Memory Scores

Test	Raw Score	Standard Score	Percentile
WISC - digit span forward	8	85	16
WISC - digit span backward	5	75	5
CTOPP - non-word repetition	9	70	2
WMTB - listening recall	8	61	0.5
WMTB - counting recall	24	83	13

Writing. Participant 4 completed the essay writing component of the WIAT-II.

Transcription - spelling, punctuation, handwriting. Participant 4 wrote somewhat quickly (i.e., six minutes) and his word count was in the average range, indicating adequate

visual-motor output/efficiency. Regarding essay mechanics, P4 achieved a raw score of one out of a possible raw score of nine, primarily due to him making six punctuation errors (0th quartile), clearly showing that P4 struggled in the area of punctuation. He made only one spelling error, placing him in the 3rd quartile (i.e., normal range) compared to same-aged peers for spelling. Punctuation is a lower-level skill, and problems in this area would be expected to use up WM capacity, and in turn, affect other aspects of writing.

Text generation - words, sentences, discourse. In regards to word count, P4 wrote 86 words in six minutes, of the 15 minutes allotted. His text length falls in the 2nd quartile, which is in the average range. With respect to essay theme development, P4 scored three points out of a possible five raw score points. His first sentence contained three supports for his position on the topic, and he did not have any off-topic information; however, he did not support his position with evidence and therefore lost marks. Further, P4 framed his response as an answer to a question rather than a persuasive essay. Participant 4 achieved a score of zero in the area of vocabulary, as he did not use strong or specific vocabulary, which is surprising given his high verbal IQ. Participant 4's overall paragraph writing score, which is a composite of his scores for mechanics, organization, theme development and vocabulary, was 13 out of a possible 55 raw score points (23.6%). He achieved a holistic score of two in that he stated or implied a position in his writing and supported it with one reason, but his reason was nonspecific and undeveloped. During testing, P4 was cooperative with the examiner except when it came to the writing task where he showed some noncompliant behaviour (e.g., he stated, "I did write an intro, middle and concluding sentence" after he had written a single word and stopped writing). Participant 4's low score for vocabulary and overall writing are consistent with predictions based on the FWS (Berninger & Amtmann, 2003). However, his scores for spelling, text length, and theme

development are higher than expected as they are in the average range, possibly due to the compensatory effects of high IQ.

Executive functions - planning, organization, revising, self-regulation. Observationally some EF problems were noted as P4 had difficulties with initiation and staying on task. In the area of organization, P4 achieved a total raw score of six out of a possible eight points, which is a strength in writing for him. However, when looking at P4's essay, it consisted of only three sentences, with very little supporting detail, and it was a single paragraph. His essay contained a topic sentence (i.e., thesis statement), but it did not contain linking words or phrases, an introductory sentence, or a concluding sentence. Participant 4 did not use organization to persuade and did not follow instructions as to how the essay should be structured. He engaged in no preplanning strategies and did not use the planning sheet provided; rather, he started the essay right away. He also did not engage in any revising strategies.

Table 18

Participant 4 - Writing Scores from the WIAT Marking Rubric

Area Assessed	Quartile	Raw Score
Word Count	2	86
Spelling	3	1*
Punctuation	0	6*
Total Mechanics Raw Score		4
Total Organization Raw Score		6
Total Vocabulary Raw Score		3
Total Theme Raw Score		0
Total writing score		13/55

*number of errors

Participant 4 case analysis. Overall, P4 has a superior IQ (FSIQ = 124, 95th percentile), with superior verbal and nonverbal abilities. Although his rote memory is not particularly strong, P4 experienced particular weaknesses in verbal WM and phonological WM. Specifically; he had mild difficulties with rote recall and more significant difficulties with complex aspects of verbal WM. Although visuospatial WM was in the broadly normal range (low average), it still fell three deviations below his IQ scores and therefore represents a relative weakness. Participant 4 had extreme WM difficulties despite being on stimulant medication during testing, which would typically improve performance on attention and WM tasks (Santosh, Baird, Pityaratstian, Tavare & Gringras, 2006).

Based on the above noted difficulties, a number of challenges with writing would be predicted. With the constraints placed on P4's verbal WM, we would expect to see disfluent writing and text generation difficulties, in particular, grammar, spelling, and vocabulary difficulties (Chenoweth & Hayes, 2003; Levy & Marek, 1999; Mueller, Seymour, Kieras, & Meyer, 2003). Chenoweth and Hayes (2003) showed that verbal WM supports "the inner voice" in writing. Expert writers are able to go back and read as they are creating the text and if these skills are not fluent this process interrupts handwriting and places extra demand on writing (Hayes, 1996). Therefore, P4 may have difficulties with going back and rereading and revising his work. Mild difficulties with visuospatial WM would predict mild orthographic coding difficulties according to the FWS (Berninger et al., 2002; Bourke et al., 2013). This may impact a writer's ability to visualize images and organize diagrams and other visuospatial representations as they plan. A low average score on the counting recall task would also predict

problems with spelling and spatial planning when writing (Berninger et al., 2002). With the constraints placed on P4's verbal WM and visuospatial WM we would expect to see disfluent writing and text generation difficulty; however, his high IQ could mediate the effects of WM deficits. It is predicted that with superior IQ and below average to extremely low WM abilities P4 would have low text generation scores, spelling and grammar difficulties and low organization scores and that he would not edit or revise his work.

On essay writing, P4's scores were lower than expected given his IQ. Overall Participant 4 did have some grammatical problems and did not re-read or revise his work; however, his spelling, word count, and organization scores were all higher than predicted. This could be due to the compensatory effects of high IQ, in particular, strong oral language scores. Despite some areas of strength in writing, P4 achieved a raw score of 13/55 (23.6 %) on the overall essay, showing serious difficulties in writing. In the area of text generation, his overall writing quality was low. His use of vocabulary was very limited, despite high verbal IQ. Although his severe deficits in verbal WM might predict shorter written texts, P4's word count was in the average range, possibly due to compensatory effects of high IQ. Despite producing a reasonable length of text, his ideas were undeveloped and had no reasons or explanations to support his ideas.

Due to the bidirectional relationship between WM and transcription, and given P4's significant WM deficits, the FWS (Berninger & Amtmann, 2003) would predict difficulties with spelling and punctuation. Given broadly normal visual-motor integration scores on the Beery VMI 6, handwriting difficulties would not be anticipated. Consistent with predictions, Participant 4 struggled with some lower level skills such as punctuation, but he did not have problems with writing speed or spelling.

In the area of EF, P4 engaged in no planning or reviewing processes. Participant 4 performed better than predicted in that he scored well on organization. With low phonological processing scores and verbal WM, grammatical, phonological, and orthographic encoding difficulties when writing was expected, in addition to problems with reading and revising (Chenoweth & Hayes, 2003; Levy & Marek, 1999; Mueller et al., 2003). Participant 4 met the predictions for behavioural EF difficulties. However his high scores in organization did not meet predictions.

In summary, P4 had below average to extremely low WM scores (particularly verbal WM and the phonological loop) in the context of a very high IQ and strong oral language (verbal IQ). He demonstrated adequate short-term attention (i.e., digit span forward), potentially due to stimulant medication and average visual-motor skills. Participant 4 did show some writing difficulties, which could be arising from WM or possibly EF deficits. The FWS (Berninger & Amtmann, 2003) would have predicted deficits across all areas; however, P4 showed strengths in some areas (e.g., word count, spelling, and organization) possibly due to the compensatory effects of high IQ.

Case summary for Participant 5.

Case history. Participant 5 (P5) was 17 and was entering grade 12 at the time of testing. He attended school full time, participated in a learning support block and received support from an EA. Participant 5 received a diagnosis of ASD in 2003 at the age of five years. In regards to current ASD symptomology, P5's social interaction score on the ADI-R was 25, well above the clinical ADI-R cut-off (10) showing that P5's social skills are very weak. His verbal (17), non-verbal (11) and restricted/repetitive behaviour (six) scores also fell above the ADI-R clinical cut-offs of eight, seven and three, respectively. His early development score was measured to be two,

and also above the ADI-R cut-off of one, showing early developmental anomalies. Participant 5 struggled in the area of language development with delayed speech and his parents reported unusual social play with peers. On the GARS-2, P5 achieved an overall standard score of 95, placing him in the “extremely likely” range for ASD, with stereotyped behaviour as the domain most affected. During testing, P5 was cooperative and gave reasonable effort/focus. During the telephone screening interview, Participant 5’s mother reported that he has difficulty with writing tasks. Regarding past supports and services, P5 has received the support of a speech and language pathologist, an occupational therapist, a behaviour consultant, and has participated in social skills training. Participant 5 was healthy at the time of assessment and was not taking any medications.

Intellectual functioning. Based on the KBIT-II, P5 demonstrated low average intellectual ability in the verbal domain and extremely low ability in the nonverbal domain, with standard scores of 89 (23rd percentile) and 67 (1st percentile), respectively. There is a significant difference (one SD) between verbal and nonverbal abilities (i.e., $p < 0.01$), which is unusual for individuals his age (as seen in 16% of the population his age). This is opposite to the cognitive pattern sometimes reported for ASD where nonverbal IQ tends to be higher than verbal IQ (Coolican et al., 2008). Participant 5’s overall IQ composite standard score was at a standard score of 75 (5th percentile), placing him in the below average range. Further, because of the large discrepancy between his verbal and non-verbal scores, P5’s overall IQ composite is not a valid measure of his potential. For the purposes of this research, due to his higher verbal IQ, P5 was deemed appropriate for inclusion in the study with respect to his ability to understand instructions and complete writing tasks.

Visual-motor integration. Participant 5 achieved a standard score of 75 (5th percentile) on the Beery VMI 6, which is below average. His below average visual-motor integration ability could negatively impact the automaticity of transcription such as handwriting. With reduced efficiency in transcription, WM capacity could be used up leading to fewer WM resources for other aspects of writing, such as text generation and planning.

Working memory. Participant 5 achieved a standard score of 80 (9th percentile) for both rote recall and verbal WM when recalling series of digits forwards and backwards (i.e., digit span forwards and backwards). These two scores are consistent with P5's verbal IQ (SS = 89) and do not stand out as a particular area of weakness. On a measure of verbal WM that permits the use of context (WMBTC listening recall), P5 achieved a standard score of 102 (55th percentile), in the average range. In contrast, P5 achieved a standard score of 70 (2nd percentile) for phonological WM (CTOPP-2 non-word repetition) falling one standard deviation below his verbal IQ (SS = 89). Overall, P5 has a specific difficulty with phonological WM and adequate performance on other measures of verbal WM. Specific deficits in phonological WM could lead to challenges with phonological decoding and spelling. However, given that other aspects of verbal WM are average, other aspects of writing (i.e., grammar, word count, vocabulary, theme development) may be relatively preserved (Chenoweth & Hayes, 2003; Levy & Marek, 1999; Mueller et al., 2003).

To assess spatial WM, counting recall was administered. Participant 5 achieved a standard score of 62 (1st percentile) on the counting recall task, showing extreme difficulties with visuospatial WM, consistent with his low nonverbal IQ. Difficulties in this area would predict planning and organization difficulties during writing (Berninger et al., 2002; Bourke et al., 2013), particularly when combined with weaker visual motor integration skills.

Overall, P5 has a wide range of abilities in the area of WM, spanning from average to severe deficits. Visuospatial tasks were an area of significant difficulty for P5, but he showed some strength in aspects of verbal WM. On a task that required the phonological loop, P5 struggled more. He did better on a verbal WM task that provided context.

Table 19

Participant 5 – Working Memory Scores

Test	Raw Score	Standard Score	Percentile
Wechsler Intelligence Scale for Youth -digit span forward	7	80	9
Wechsler Intelligence Scale for Youth -digit span backward	7	80	9
CTOPP-non-word repetition	10	70	2
WMTB - listening recall	16	102	55
WMTB - counting recall	18	62	1

Writing. Participant 5's writing was assessed using the essay writing component on the WIAT-II (see description above) for grades seven to 16.

Transcription - spelling, punctuation, handwriting. In the area of transcription, P5 made a number of spelling errors (i.e., eight in total), scoring at a quartile of zero; however, he made no punctuation errors. Overall, he received a score of five out of a possible raw score of nine in the area of mechanics, with adequate punctuation, but weak spelling. Consistent with low scores on the Beery VMI 6, P5 had difficulties with handwriting output. His hand writing was

challenging to read and at times illegible. Writing was observed to be effortful and slow for P5 (i.e., he pushed hard on the page to the extent that the pencil broke through the page).

Text generation - words, sentences, discourse. Participant 5 wrote a total of 59 words in eight minutes and scored within the 1st quartile (i.e., the bottom 5% when compared to same-aged peers). His handwriting was slow and effortful, and transcription difficulties appeared to play a large role in his writing difficulties, possibly due to impairments in visual-motor integration and visuospatial WM. In the area of theme development, P5 achieved a raw score of three out of a possible raw score of eight. He presented some supports for his ideas, but they were undeveloped in that he provided no evidence to support his position, nor counter-arguments. Despite broadly normal verbal IQ, P5 achieved a raw score of zero in vocabulary, in that he did not use descriptive or specific words to strengthen his statements or to persuade the audience. His total essay score, comprised of mechanics, organization, theme development and vocabulary, was a raw score of 14 out of a possible 55 points. He achieved a holistic essay score of two, which indicates low quality of writing overall, despite being focused during the essay and expressing excitement about the topic.

Executive functions - planning, organization, revising, self-regulation. In the area of organization, P5 achieved a raw score of six out of a possible 17. He did use reasonable sentence structure, a topic sentence, sequencing of sentences, and an introductory sentence. However, he did not use any linking words or phrases (e.g., ‘for example’, ‘however’), did not follow the instructions on how to structure the essay, did not conclude his essay with a closing sentence and did not organize his ideas to support his argument. Observationally, P5 did not revise or edit his work once complete and did not use the planning sheet that was provided. Unlike the other youth

with ASD, P5 did not struggle with initiation as he started the writing task right away and stayed focused until he felt that he had completed the essay (i.e., eight minutes).

Table 20

Participant 5 - Writing Scores from the WIAT Marking Rubric

Area Assessed	Quartile	Raw Score
Word Count	1	59
Spelling	0	8*
Punctuation	4	0*
Total Mechanics Raw Score		5
Total Organization Raw Score		6
Total Vocabulary Raw Score		3
Total Theme Raw Score		0
Total writing score		14/55

*number of errors

Participant 5 case analysis. Overall, P5 had a low average verbal IQ and well below average nonverbal IQ. He had below average visual-motor integration skills and was the only youth in the ASD group to have difficulties with motor skills. In terms of WM, he had average to low average scores for verbal WM and a significant weakness in phonological and visuospatial WM. Based on the FWS (2003), given his cognitive profile it was predicted that P5 would have the following difficulties: 1) impairments in transcription skills because of low visual-motor integration; 2) impaired text generation, due to anticipated difficulties with transcription and low

phonological WM; and 3) impairments in the planning aspects of writing because of visuospatial WM deficits.

Concerning his writing ability, P5's handwriting was difficult to read. Considering the FWS (Berninger & Amtmann, 2003), fluent transcription skills play a large role in freeing up WM processes for text generation (Berninger & Amtmann, 2003). Participant 5's disfluent handwriting likely played a large role in his low essay writing scores. Further testing of P5's handwriting fluency to confirm this theory is required. Participant 5 met assumptions in that transcription and word count were low, in addition to text generation, because of lower level transcription difficulties.

In summary, looking at the FWS (Berninger & Amtmann, 2003), it was expected that P5's writing in the areas of text generation, transcription and EF were impaired due to problems with visuospatial/phonological WM and visual motor integration. Concerning text generation, WM and graphomotor difficulties would be expected to hinder discourse, vocabulary use and length of text. However, it can't be ruled out that P5's difficulties in writing could have been due to other cognitive concerns including lower intellectual ability, language atypicalities, and/or broader EF difficulties.

Section Three of Analyses: Cross-Case Synthesis/Pattern Matching

A cross-case analysis was undertaken to examine each domain in which difficulties were predicted; WM and the various aspects of writing assessed (i.e., text generation and transcription). This section will begin with a synthesis of scores for the youth with ASD scores, including ASD symptomology, IQ, Beery VMI 6 scores, WM scores, and writing scores. Then, an analysis of the relationship between WM and writing scores within the ASD group will be explored in terms of how this does or does not fit predictions made by the FWS (Berninger &

Amtmann, 2003). An alternative model of writing will be explored to see if it provides a better fit with the profiles of the ASD group in this study.

Comorbid disorders. All youth met criteria for ASD based on their prior diagnosis and current screening (see participant description). Two youth (P3 and P4) had comorbid ADHD and ASD, which will be factored into the case analysis summary. It is possible that these youth's comorbid diagnoses would have led to greater difficulty with WM, writing and academics overall; however, both were on stimulant medication during testing. Taking stimulant medication for attention difficulties during the assessment may have increased performance on WM testing. It is important to note that information regarding the severity of ADHD was not gathered. Due to the fact that IQ is a significant moderator of attention problems and impulsivity in children with ADHD (Buchman, Gierow & Reis, 2011), it was predicted that P4's attention difficulties might be moderated by his very high intellectual ability. This would not be the case for but may not be the case for P3 who had average intellectual ability. In reviewing P3 and P4's WM composite scores (Table 21), P4 had the lowest WM scores within the sample yet the second highest writing score. In contrast, P3's WM scores were the third highest, but he achieved the lowest writing score, possibly due to high levels of anxiety during writing. No major conclusions can be drawn from this small sample; however, this data highlights the complexity of comorbid disorders and how these might overlap with IQ, WM and academic abilities.

Table 21

Working Memory Scores Compared to Writing Scores - Experimental Group

Participant	WM Composite Standard Score	Total Writing Score
	Average Score	Percentage
Participant 1	94.33	15.00

Participant 2	99.33	22.50
Participant 3	79.83	7.20
Participant 4	65.67	23.60
Participant 5	74.00	25.40

Intellectual functioning. Participant IQ varied from low average to superior. With the exception of P5, no youth showed a significant discrepancy between verbal IQ and non-verbal IQ. All youth had normal range verbal IQ (which includes a subtest that assesses vocabulary), yet this did not translate into effective use of vocabulary while writing. Participant 1 and P2 had superior FSIQ with strengths in both verbal and nonverbal domains. Although high IQ is predictive of high academic achievement (Mayes et al., 2009), this was not the case here as both youth struggled with writing. In fact, qualitative analyses revealed that these two youth experienced the most significant difficulty with writing, including writing refusal and noncompliant behaviour during the writing task. All youth had the intellectual and verbal capacity to participate and complete the study, yet qualitatively they appeared to have disproportionate difficulty with writing when compared to their oral language abilities.

Table 22

Intellectual Scores for ASD group (KBIT-II)

Participant	<u>Verbal</u>			<u>Nonverbal</u>		
	Raw	Standard	Percentile	Raw	Standard	Percentile
Participant 1	64	121	92	42	142	99.7

Participant 2	54	100	50	30	106	66
Participant 3	67	87	19	29	84	14
Participant 4	89	120	91	42	121	92
Participant 5	74	89	23	74	67	1

Visual-motor integration. Although motor skills problems are common in individuals with ASD (Miller, Chukoskie, Zinni, Townsend, & Trauner, 2014), this was not the case for this particular group. Only one of the 5 ASD youth had difficulties with visual-motor integration. Participant 1 had superior visual-motor integration and, P2, P3 and P4's visual-motor integration was in the average range. Participant 5 was the only youth to show difficulties with visual motor integration, with his score falling in the well below average range. These results would predict that all youth, except for P5, would have fluent graphomotor skills. Looking at the FWS (Berninger & Amtmann, 2003), fluent motor skills would free up valuable WM resources and in turn may help with text generation; however, despite generally normal visual motor abilities, all youth struggled with text generation, possibly due to the impact of lower level transcription deficits unrelated to visual-motor integration.

Table 23

Experimental Group Scores of Visual-Motor Integration

Beery VMI Test of Visual-Motor Integration	Raw Score	Standard Score	Percentile
Participant 1	24	131	98

Participant 2	21	94	37
Participant 3	26	93	32
Participant 4	24	87	19
Participant 5	22	75	5

Working memory compared across cases. The central executive, and its two slave systems; the phonological loop and the visuospatial sketchpad (visuospatial WM), play different roles in the production of written text (Baddeley, Gathercole & Papagno, 1998). The central executive is employed during all components of the writing process. Kellogg (2013) noted that the central executive is used for planning, translating, reviewing, and transcribing. The phonological loop, an aspect of verbal WM, has been theorized to support the translation of ideas into writing and the ability to hold in mind letter/word sounds and representations that are generated during text composition (Baddeley, Gathercole & Papagno, 1998).

It was predicted that the ASD group would show difficulties in the phonological loop, verbal WM and visuospatial WM. Looking at Figures 6, which shows the experimental group's standard scores (SS) on each WM measure on which they were assessed. One can see that overall, across all youth and on most of the tasks, the ASD group scored below the average, with some variability. In general, counting recall was consistently the lowest score, followed by phonological memory digit span backwards, listening recall, then lastly digit span forward (See Figure 6). In this graph one can see there are only four scores above a SS of 100, and two of them belong to Participant 2. Even on the digit span forward, an easier task of rote recall, one

can see that three youth scored below a standard score of 100 and their overall mean is below a standard score of 100.

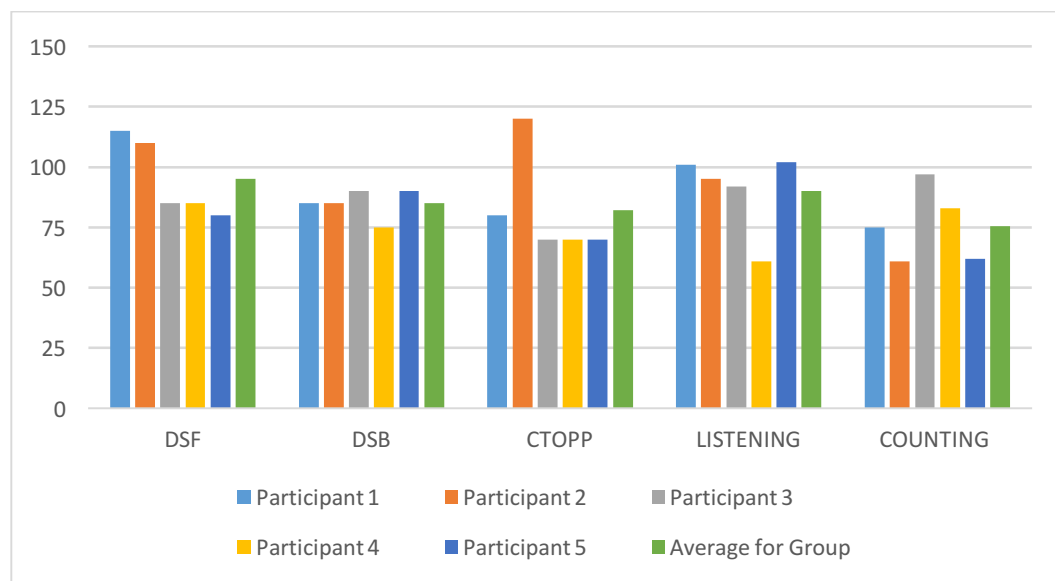


Figure 6. ASD group Standard Scores on WM Measures (M =100 and SD=15)

With respect to rote recall, as predicted the ASD group generally scored better on this task than on tasks of WM. On the digit span forward task most of the group scored in the low average range with P1 scoring in the high average range. Participant 1, P2, P3, and P4 all scored significantly lower on digit span backward test than forward; however, P5 scored the same on both tasks and was still in the low average range. Overall, the ASD group achieved a mean standard score of 90 on digit span forward and a mean standard score of 74 on digit span backwards. The difference between these two mean scores is one standard deviation, representing a meaningful difference. This finding is consistent with Corbett et al.'s (2009) research that found significant differences on span measures for both forward and reverse span. Williams et al. (2005) used spatial span tasks to assess WM in individuals with ASD and found

significant differences between the ASD group and TD groups in WM. According to Steele et al.'s 2007 study, WM deficits with individuals with ASD would not involve an increased rate of forgetting over time except when more information is added and there is the need to keep this information active. This appears to be true for four out of five youth in the current study. Overall, the entire ASD group struggled more on digit span backwards than digit span forwards, indicating greater difficulty with verbal WM tasks than with rote recall, a pattern commonly seen in the ASD population (Minschew et al., 2007).

Concerning phonological WM, overall, the ASD group mean was at a standard score of 82 and in the low average range. Participant 1 scored in the low average range, consistent with the group mean (i.e., $SS = 80$) and two standard deviations below his FSIQ. Participants 3, 4, and 5 all had significant difficulties with phonological WM performing in the below average range ($SS=70$, 2nd percentile). In contrast, P2 achieved a standard score of 120 (i.e., one SD higher than his FSIQ) on this task. As P2 skewed the overall mean, median standard scores for the ASD group was 75, which are more reflective of the groups' overall abilities in phonological WM.

In general, WM for information presented in context (sentences vs. random digits) was a stronger area for the majority of the ASD group. Four of the five youth (all except for P4) demonstrated strengths on the listening recall task and overall the group mean was at a standard score of 90.2. Given that this sample was high functioning and had strong language abilities, they were likely able to capitalize on these stronger verbal abilities to aid recall for information in context. Participant 4, on the other hand, had significant difficulties in listening recall despite having superior verbal IQ, which could be due to this participant's comorbid ADHD that would impact attention and memory more generally.

Overall, concerning verbal WM the ASD group had greater difficulty on WM tasks than on tasks of rote recall. In particular, they showed difficulties with the phonological loop. The results are consistent with research that has looked at WM in individuals with ASD, showing that individuals with ASD may have intact WM on simple tasks that rely temporary storage, but struggle on more complex tasks that use both the storage and maintenance of information in WM (Schuh & Eigsti, 2012). Observations also supported that on WM tasks the ASD group, when compared to the TD group, gave up faster and more often refused to continue yet they were cooperative and persevered on rote recall tasks.

Overall, in the ASD group, visuospatial WM stood out as a particular area of weakness. Impairments in visuospatial WM have been documented in individuals with ASD (Corbett et al., 2009; Goldberg et al., 2005). Overall, the overall group mean on visuospatial working memory tasks was at a standard score of 75.6, with most youth scoring in the below average range. In fact, the visuospatial WM task was the only measure used in this study where all youth showed some difficulty. Difficulties with visuospatial WM are thought to predict orthographic difficulties (Berninger et al., 2006), difficulties with visualizing the outline or plan of the written composition (Kellogg, 1996), and/or coordinating motor integration during text generation (Van der Plaats & van Galen, 1990). Berninger (2006) advocates that visuospatial WM supports orthographic coding (e.g., assigning sounds to letters). Kellogg (1999) proposes that visuospatial WM is used to visually map the layout of the text. Further, it has been proposed that visuospatial WM contributes to motor skills in handwriting (Olive & Piolat, 2002). The current study suggests that visuospatial WM problems could lead to organization and planning difficulties.

Overall, predictions for WM difficulties in the ASD group were met overall. All of the ASD group showed at least some problems in specific aspects of WM either visuospatial, verbal,

phonological or all of the above; however, the pattern of WM deficits differed across participants. This is consistent with the literature showing variability in the ASD population as to whether there are deficits in the phonological loop/verbal WM and/or visuospatial WM (Shuh & Eigisti, 2012; Corbett et al., 2009; Goldberg et al., 2005). In general, aside from a few outliers, WM scores were much lower than what would be predicted based on the ASD group's IQ scores. With respect to how this might affect writing, difficulties in verbal/phonological processing skills could lead to lower level difficulties with spelling and punctuation (transcription) and higher order difficulties with word count, vocabulary usage, theme development and overall writing quality (text generation).

Table 24

Means and Standard Deviations of Working Memory Tasks: Group with ASD

Working Memory Measures	Mean	Standard Deviation	Minimum	Maximum	Median	Range	Percentile
Digit Span Backwards	74.0	15.2	50	90	80	40	4
Digit Span Forward	90.0	32.4	60	130	70	70	25
Digit Span Score	84.0	24.1	60	110	70	50	14
Non-Word Repetition	82.0	21.7	70	120	70	50	12
Listening Recall	90.2	16.8	61	102	95	41	25

Counting Recall	75.6	15.1	61	97	75	36	5
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Writing compared across ASD participants. The entire group with ASD struggled with paragraph/essay writing, consistent with all parents' reports of their child having difficulty with writing. Three of the five ASD youth (60%) were receiving help for writing, despite not having a formally diagnosed learning disability. Four out of five (80%) youth needed to be prompted to begin the writing task. Four of the five youth (80%) complained about having to complete a writing task, and four of five youth (80%) stated that they disliked writing. One youth claimed that he could "absolutely not do creative writing" and only started writing after the examiner told him that this was not creative writing. Another participant said that writing, "scared him" and that he was worried about failing his provincial exam because of writing. Youth with ASD spent between three and eight minutes on the writing task, and not one youth used the entire time allotted to complete the writing task (i.e., $M =$ five minutes and 25 seconds, $SD = 0.07$). Three of the five youth (60%) stopped writing after writing only one sentence stating that they were finished. One youth wrote one more sentence after prompting, and the other two refused to continue. None of the youth used brainstorming tools to assist with their writing and no one used the planning sheet. Three of five youth (60%) needed a break or took a break when writing.

With average to below average WM skills, it was predicted that the group with ASD would struggle in text generation and that they would have low word counts, low overall writing scores, difficulty with vocabulary, problems writing for a topic (i.e., discourse), and low spelling and punctuation. Overall, all participants in the ASD group struggled with writing, including low overall writing scores, low vocabulary usage, lack of enjoyment of writing, and difficulty with spelling/punctuation.

Transcription - spelling, punctuation, handwriting. Regarding low-level writing skills (transcription) most of the ASD group did not have visual-motor integration difficulties (i.e., except for P5). Participant 1 had superior visual motor skills whereas P5 had significant weaknesses in visual-motor integration yet both youth struggled with spelling, likely for different reasons. Participant 5's visual-motor integration difficulties could have contributed to his spelling difficulties (De la Paz, 2001), but this was clearly not the case for P1. Participants 2 and 4 made a number of punctuation errors. Participant 3's word count was too low to count spelling and punctuation errors, but observationally they struggled with both skills. In sum, all members of the ASD group struggled with transcription, as defined by the FWS (2003), yet the specific aspects of transcription that were weak (handwriting, spelling, punctuation) varied. Weaknesses in any aspect of transcription would be anticipated to "interrupt" the coordination of the writing process, place a strain on WM, and hinder text generation (Berninger & Amtmann, 2003).

Text generation - words, sentences, discourse. Text generation is the highest level of writing described in the FWS (Berninger & Amtmann, 2003). Text generation consists of the actual written words, sentences and quality of the written words used. When analyzing text generation, we look at vocabulary, length of the written text, theme of the essay, overall essay scores, and the holistic score. All youth with ASD had significant difficulties with vocabulary usage when writing, despite ranging from average to superior in their verbal IQ/language-reasoning abilities. Concerning text length, word counts ranged from the 1st to 3rd quartile with most of the youth having low word counts. Two of the youngest youth (i.e., P2 and P1) scored in the average range for word count; however, it must be noted that at their specific ages the expectations for word count are fairly low. Also, despite having average word counts, P1 and P2's scores for theme development scores were low. Overall for the participants in the ASD

group, overall writing scores averaged 18.7% which is very low. In terms of text generation, the group with ASD struggled enormously. Clearly, youth with ASD within this sample had difficulties with writing, even without any formal diagnosis of a Learning Disability in writing.

Executive functions - planning, organization, revising, and self-regulation. In the FWS (Berninger & Amtmann, 2003) EF are important for freeing up WM capacity for other aspects of writing. These EF include the ability to attend, plan, review, revise and self-regulate (Berninger & Amtmann, 2003). Broad EF were not assessed in this study formally, although observational data suggested that most youth had some difficulties with planning, getting started on writing (initiation) and checking their work (revising/editing). One of the ASD participants used planning strategies, reviewed their work, or read it over before indicating they were finished. In contrast, three out of the five TD group used the planning sheet, and two of the five TD participants went back and revised their work before completing their writing.

Table 25

Writing Scores Means and Standard Deviations Experimental Group

Writing Measures	Mean	Standard Deviation	Minimum	Maximum	Range
Total Raw Score (%)	18.7*	7.6	7.2	25.4	18.2
Organization Subtotal (%)	33.3*	19.3	5.9	60.0	54.1
Mechanics Subtotal (%)	35.6*	16.5	11.1	55.6	44.4
Vocabulary (%)	0.0*	0.0	0.0	0.0	0.0
Punctuation Errors (Raw	3.0	3.3	0.0	7.0	7.0

Score)

Spelling Errors (Raw Score)	2.5	2.7	0.0	6.0	6.0
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*out of a possible 100%

Working memory and writing summary. With just five participants in the case analysis portion of this study, it is difficult to fully judge the extent that WM plays in the role of writing in ASD. However, preliminary observations based on predictions using the FWS can be drawn. First, it was anticipated that each participant would struggle with visuospatial WM and verbal/phonological WM, which are core components of the WM space within Berninger and Amtmann's FWS (2003). Berninger (2003) predicts that WM deficits would affect both lower level and higher order writing skills. Based on this, it was predicted that each youth with ASD would struggle with WM tasks and that this would affect their text generation and transcription

In the ASD group, it was expected that youth would show lower-level (punctuation, and spelling) and higher-level (poor essay generation, low word counts, and vocabulary problems) writing difficulties and low WM abilities, but intact visual-motor integration skills. Although standard scores could not be generated for the overall essay score on the WIAT-II, qualitative information indicates that writing did stand out as a weakness when compared with performance in other areas (IQ). Each ASD participant struggled with at least one aspect of lower-level writing (i.e., transcription, spelling, punctuation) and one aspect of higher-level writing (i.e., text generation). Observations also suggested some difficulties with EF (i.e., organization, planning, revising), which could have an impact on writing.

The participants in the ASD group presented with different patterns of WM difficulties, although all individuals showed problems in at least one aspect of WM. This suggests that some

of the writing difficulties in this group could have been due to WM problems. However, difficulties in writing could also be due to a variety of other cognitive differences, including broader EF difficulties, language usage problems, basic attention deficits, anxiety and resistance to writing, or other areas not assessed in this study. In terms of WM difficulties, each participant had an area of WM where they struggled. There was variability in the group with ASDs WM scores, which could have been due to the protective effects of high IQ in some cases and the impact of comorbid ADHD in other cases. Many participants had difficulties with phonological/verbal WM that might have impacted low-level writing (i.e., spelling, punctuation) and text generation (e.g., low word count, poor text quality, lack of thought or development of ideas and poor vocabulary use). Visuospatial WM deficits stood out as a clear area of weakness, which could have led to problems with structuring/organizing writing. Observations suggested that many youth had some EF difficulties, including general planning, organizing, and monitoring when writing, which could have lowered their performance. Based on variable WM profiles across youth and generally poor writing, it may be that any deficits in any aspect of WM can influence the writing process in different ways. In other words, different types of WM deficits may lead to the same end product of challenges in writing.

It was predicted that the participants would have average visual motor integration, but difficulties with punctuation and spelling in written text due to WM difficulties. All youth except for one (P5) had normal visual-motor integration. Participant 5 struggled with visual-motor integration and showed clear signs of exertion and fatigue during writing. In addition, P5 showed more severe signs and symptoms of ASD than the rest of the youth with ASD and had lower IQ scores. Participant 5 therefore, may have had additional cognitive challenges, not seen in other members of the ASD group. Despite the fact that four out of the five youth with ASD had

average visual-motor integration, the majority showed lower level writing problems. This may have possibly been due to orthographic processing deficits (Berninger et al., 2002), which can influence both handwriting and spelling (Berninger & Amtmann, 2003). Participant 5 made the most spelling errors (eight errors, zero quartile), which may have been because of visual-motor integration deficits and lower overall intellectual functioning. Participant 1 made the next highest number of spelling errors (six errors, zero quartile), yet this participant had superior IQ and superior visual-motor integration. Participant 1's spelling difficulties could have been due to WM difficulties, which were considerably lower than his IQ scores. Participants 3 and 4 had stronger spelling; however, P3 made the most punctuation errors (six errors, zero quartile). Participant 4 had superior verbal IQ, perhaps masking spelling and punctuation difficulties. Not all youth with ASD had spelling problems, in that some students had strong spelling yet weak punctuation. As a result of WM deficits and the fact that WM is a limited resource system, it is possible that the youth were only able to focus on one aspect of writing (spelling or punctuation), but could not manage both at the same time

It was predicted that youth with ASD in this study would struggle with text generation as evident in overall low quality of writing, less written output (i.e., low word count) and less varied/creative use of vocabulary, in part due to WM difficulties. Predictions were met for low overall quality of writing in that essays were of generally low quality, even in those individuals with high verbal abilities and high IQ. Sixty percent of the participants had low word count with older participants experiencing lower word counts than younger students. All youth with ASD struggled with vocabulary use, despite varying levels of verbal ability (some up to the superior range). For the three youth with ASD who wrote the essay, their theme development scores were low, indicating that they did not build on or elaborate their ideas in writing. All youth with ASD

had difficulties with text generation, despite variable verbal reasoning ability. Participant 1 and P4, who had very high language and verbal ability, struggled when task demands increased and when more WM resources were utilized. When task difficulty/complexity increases, there are higher demands on WM, language, transcription, and EF and WM difficulties are compounded. Writing scores were lower than oral language scores (i.e., verbal reasoning), which was anticipated given that WM has a greater impact on written language than oral language (Bourdin & Fayol, 2002). Also, writing scores were consistently low despite variable WM, suggesting that problems with various aspects of WM may interfere with writing (whether this be verbal, visuospatial or phonological). Current theory supports because WM is a limited resource system once WM resources are exhausted, for whatever reason, writing performance should be significantly hindered (Bourdin & Fayol, 2002). However, the FWS (Berninger & Amtmann, 2003) does not delineate which aspects of WM are most important for specific components of the writing process. Much of the research suggests that there is a processing cost when writing and that every aspect of the writing process uses processing components that are drawn from the same pool of WM resources (Bourdin & Fayol, 1994, 2002; Brown, McDonald, Brown, & Carr, 1988; Graham et al., 1997). Bourdin and Fayol's (1994, 2002) studies indicate that the processing cost for written language is much higher than that for oral language. The current study supports that the WM demands of writing seemed to be higher than in other language domains (i.e., verbal reasoning, oral vocabulary), as seen in consistently higher oral language than written language abilities. In keeping with this finding, studies have shown that texts written by young youth are often much less well developed than dictated texts (Bourdin & Fayol, 2002).

Although EFs were not a focus of this study or directly measured, it was predicted that youth with ASD would struggle with aspects of EF during testing. Observations during testing

indicated that all ASD participants showed EF difficulty. In particular, organization when writing appeared to be a difficult area, in addition to task initiation for topics that were not within their special interest areas. Attention and focus appeared to also be a problem for all ASD participants, even though only two had a comorbid diagnosis of ADHD. Planning when writing seemed to be low in that no participant used the planning sheet or went back to review their work, which is in contrast with the TD group. Three youth with ASD struggled with cognitive flexibility as evidenced by work refusal, task delay, and refusal to engage in a “particular” type of writing. Writing seemed to be particularly aversive for the ASD participants; there was more frustration and less cooperation during the writing task than for the TD participants and more frustration when writing than on other study tasks.

The variations seen in WM scores and writing, suggest that WM is likely not the only contributor to writing difficulties in ASD. Given the variability in WM profiles, it is hard to know which aspects of WM most significantly impacted writing. Indeed, it is possible that any type of WM difficulty, and consequent limits on WM resources, may contribute to lower writing skills.

Chapter 5: Discussion and Summary

Overview

This study examined why individuals with ASD struggle in the area of writing using Berninger and Amtmann's FWS (2003) as the theoretical lens for analysis. The FWS (Berninger & Amtmann, 2003) is a framework for how written output is created. Berninger and Amtmann (2003) propose that the writing process is coordinated by WM, which coordinates lower-level writing skills (e.g., handwriting, spelling, punctuation) with higher-order skills (e.g., text composition) to produce written text. This chapter examines the findings that were presented in the previous chapters as they pertain to ASD, writing, and intervention.

Writing is crucial for success in life, including academic and occupational performance. Individuals who fail to develop writing skills are likely to experience difficulties in school and with future employment (Mercer & Mercer, 2010). This study examined the writing skills of individuals who have a diagnosis of ASD. This population is reported to have challenges with writing that influence school enjoyment and success, hindering the ability to complete assignments, demonstrate knowledge, succeed academically, and enjoy school (Church, Alisanski, and Amanullah, 2000). Specific difficulties in writing seen in ASD include problems with handwriting, organization and addressing abstract concepts, which may be exacerbated in by higher levels of noncompliance in this group (e.g., behavioural difficulties when trying to instruct students with ASD) that lead to less instructional time in writing (Church, Alisanski, and Amanullah, 2000). Research has demonstrated that individuals with ASD show a variety of writing deficits across critical writing areas (Goldstein et al., 2001; Green et al., 2002; Hughes, 1996; Manjiviona & Prior, 1995; Mayes & Calhoun, 2003, 2005, 2007, 2008). A growing body of literature supports the idea that deficits in EF such as WM could explain some of the academic

difficulties seen in individuals with ASD, including problems with writing (Mayes & Calhoun, 2003, 2005, 2007, 2008). Working memory is seen as playing a crucial role in coordinating writing processes (Kellogg, 2012). Because individuals with ASD often have WM challenges and because WM is central in Berninger's FWS (2003), ASD was felt to be an appropriate population through which to explore the link between WM and writing.

Three hypotheses were proposed in this study: (1) youth with ASD would demonstrate difficulties on standardized measures of WM when compared with TD youth; (2) youth with ASD would have difficulties in written expression when compared with TD youth and; (3) difficulties with written expression in ASD would be significantly and positively associated with their performance on WM tasks.

Results Summary

The FWS (Berninger & Amtmann, 2003) states that the writer must coordinate lower-level text generation and executive control processes within a capacity limited WM framework. Therefore, lower-level skills, such as fluent text generation and encoding (i.e., spelling), must be automatized to free up valuable cognitive resources needed to translate ideas into quality text. To investigate the association between WM and writing, results were analyzed first non-parametrically then using a case study approach.

With respect to ASD and WM, non-parametric testing trends found a significant difference between the TD and ASD groups on WM tasks. In particular, the group with ASD struggled more tasks of WM than the TD group, but performed equivalently to the TD group on measures of rote recall. Exploring the ASD group further using the case study approach, variability was found in WM patterns. However, despite this variability, all youth with ASD showed at least some difficulties in certain aspects of WM. In general, as WM task demands

increased, youth with ASD presented with greater difficulty, performing well on simple measures of rote memory but struggling on complex WM tasks. This may be relevant to writing in that WM deficits may be less apparent in tasks that are simple and require less WM load (i.e., spelling to dictation) than on more complex tasks (i.e., essay writing). In essay writing, where there are multiple skills being coordinated, WM difficulties may be compounded. The majority of the group with ASD had deficits on a task of phonological WM. Phonological processing/WM is important for spelling, punctuation, orthographic coding, rereading and editing when writing. Indeed, nearly every ASD participant experienced difficulty with spelling, punctuation, or both, and no participant took the time to re-read or edit their work. Visuospatial WM was very weak for three of the five youth with ASD and was not a strength for any ASD participant, which could have contributed to difficulties with planning and organizing written work. Listening recall, a verbal WM task for information presented in context, was average overall possibly due to a generally strong IQ and language abilities in this group. Interestingly, listening recall is considered a measure of verbal WM which is theorized to be directly associated with language development (Pennington & Ozonoff, 1996).

Individuals with ASD have been found to exhibit a variety of difficulties in WM, including visuospatial WM, verbal WM and phonological processing/WM (Corbett et al., 2008). The range of WM results seen in the current study is consistent with the variability reported in the literature (Mayes & Calhoun, 2003, 2005, 2007, 2008; Pennington & Ozonoff, 1996; Goldberg et al., 2005; Hooper et al., 2006; Williams et al., 2005).

Concerning written expression, study results showed that the youth with ASD had significantly lower writing scores than their TD counterparts. Overall, all of the ASD participants scored lower than their TD counterparts in at least one aspect of writing. Areas of specific

difficulty varied but included lower word count, errors in spelling and grammar, punctuation problems, lack of organization while writing and poor vocabulary usage. Despite the fact that two ASD participants had superior verbal IQ and the remaining three participants had average verbal IQ, vocabulary scores were very low for the entire group. Converging lines of evidence based on parent interviews, observational data, and testing indicated that all youth with ASD struggled with aspects of writing. Each youth with ASD self-reported writing difficulties and had received some form of writing support, either currently or in the past. Transcription skills were impaired in all individuals, either due to spelling errors, punctuation errors and (in one case) visual-motor integration difficulties. Across the group, text generation scores were also low overall, due to poorly organized and elaborated written texts, low word count, and/or difficulties with word usage/vocabulary. Youth with ASD from grades seven through 12 who wrote the essay version of this task, had low scores in theme development. It is possible that various types of WM difficulties overloaded their WM capacity during demanding writing tasks, using up available resources for vocabulary selection. In addition, limited WM could have hindered the ability to edit/revise their written products. At the same time, other contributors such as broader EF difficulties, language usage differences, and anxiety/resistance, could be ruled out.

The third hypothesis that difficulties with written expression in youth with ASD would be significantly and positively associated with their performance on WM tasks is difficult to answer within the context of this case study. Indeed, the ASD group did struggle with both written and WM tasks, but the strength or direction of the relationship, in addition to the relative contribution of WM and other factors, cannot be determined. The FWS (Berninger & Amtmann, 2003) posits that WM resources are finite and that when one has limited WM or when one is using WM for other tasks, there is less available to allocate to writing. In other words, WM problems of any

type would reduce WM resources and in turn the capacity to perform lower-level writing skills. Subsequently, limitations in lower-level writing skills would draw WM resources away from higher-level writing skills. Other factors such as intelligence and anxiety could also impact WM through either increased WM capacity (in the case of high IQ) or lowered WM capacity (in the case of anxiety). As a result of this study's design, it is not possible to parse out which component of WM had a greater impact on writing. Further, as the current study did not explicitly measure EF, the impact of broad EF deficits (problems with planning, organization, flexibility) on writing cannot be evaluated. The FWS (Berninger & Amtmann, 2003) does not specify which aspects of WM lead to which types of writing failures and, as such, there may be other models that better explain the link between WM and writing (e.g., perhaps neuropsychological models such as [Hooper, Costa & McBee et al., 2011]). In the current study, nonparametric analyses did not show a significant association between WM impairment and writing difficulties, although these statistical procedures were severely limited by very low sample size. Overall, writing difficulties for individuals with ASD likely result from a variety of causes, although results are suggestive that WM is at least in part a contributor to writing difficulties.

Chapter 6: Alternative Explanations, Implications, Limitations, Future Research, and Conclusions

Overview

This chapter explores the limitations in the current study and proposes alternative reasons or rival explanations (as termed by Yin, 2009) for why the ASD group struggled in the written task in the present study. Next, it outlines the implications of the current research and what the results mean for practice and theory building. The limitations of the current study are outlined and areas for future research are discussed. Finally, the conclusions of the study are presented.

Rival Explanations

Age. Writing and WM skills improve with age. In two studies, Bourdin and Fayol (2002) reported a distinct relationship between age and WM. On serial recall and sentence span tasks the authors noticed that younger children (i.e., seven to 10 years of age) performed better on oral language tasks than written language tasks, but that there was no discrepancy in adults. It is possible that both WM and writing were low due to the age of the participants in the current study. Hitch et al. (1989) have suggested that typically developing children start to spontaneously record visual stimuli into phonological form around the age of 7 years and it is possible that this skill takes longer to develop in individuals with ASD. Being able to spontaneously link visual and phonological information is an important skill for developing inner speech and phonics during reading and writing (Berninger, 2006). Given the small number of participants in the current study, it is not possible to determine whether low WM performance was due to age.

IQ. High IQ is related to higher academic achievement (Mayes, Calhoun, Bixler & Zimmerman, 2009). In this study a range of IQs were reported in the group with ASD, including

two youth who scored in the superior to very superior range of IQ, predicting both higher WM and writing scores. However, contrary to this prediction writing and WM scores were low even in the youth with very high IQ in this sample. These results are similar to what Schuh and Eigsti (2012) found in that WM was disproportionately weak in comparison to IQ and that individuals with average to above average IQs had marked impairment in WM. Therefore, children with ASD may have disproportionate difficulty with WM compared to their IQ, as was seen in the current cases. Intelligence may not act as a protective factor for WM in ASD, which can be seen in the performance of Participants 1 and 4. For the purpose of this research, all youth were high functioning and verbal intelligence might not have played a large role in the ASD group's writing difficulties.

Language development. Social-communication deficits are a core symptom of ASD (Volkmar, 2014). Further, many individuals with ASD also have deficits in basic language, including the delayed development of language, atypical use of language, and difficulties using language to communicate orally or in writing (Volkmar, 2014). The participants' verbal IQ scores from the K-BIT were reviewed to determine the presence of language deficits and early language development was investigated through the ADI-R. The only language delay reported was in P1, although at the time of testing he achieved a verbal IQ standard score of 121. Within the ASD group the verbal IQ scores ranged from average to superior, although this does not rule out atypical use of language or other communication deficits that would influence one's ability to write for an audience. Although all participants in this sample had normal verbal reasoning abilities (and by extrapolation adequate basic language), this study did not undertake exhaustive language testing, and we cannot rule out the possibility that low writing scores could have been associated with subtle language problems or pragmatic language deficits.

Knowledge base. Difficulty in writing could arise from a lack of knowledge about the essay topic. Research has shown that the more people know about a topic, the higher the quality of text is produced and less “mental effort” required (Kellogg, 2001). The writing prompt used for the paragraph writing task in this study (grade six and below, i.e., “What is your favourite game”) can be regarded as open-ended and participants were encouraged first to engage in conversation with the examiner about the topic. Specific game topics were generated by the participants based on the generic writing prompt. For the essay composition task in this study (grades seven to 12), students were asked to write about whether they should be required to take physical education classes. Although most youth would be familiar with this topic and all participants in the ASD sample took PE, some may find the topic more interesting than others. This was seen in P5, who was very excited to write about this topic, but was not the case for the other participants who had limited interest in this topic. Therefore, student knowledge base did not appear to play a large factor in the writing difficulties, though some of the ASD youth refused to talk about a topic until it was slightly altered (“favourite game” was first interpreted as a favourite sport by one participant and was clarified that it could be a board game or video game).

Executive functions and attention. As EF and attention were not explicitly assessed during this study, the contribution of EF and attention difficulties to writing difficulties cannot be ruled out. Executive functions that pertain to writing, such as organization, were indirectly evaluated through the participants’ writing; there was a wide range in scores in this area, spanning from strong to extremely low. Observationally, the examiner noticed a wide range of EF difficulties, including problems with task initiation, cognitive flexibility, and planning. Monitoring of writing was also weak in that none of the group with ASD went back and

reviewed their texts. Executive functions play a vital role in writing, and deficits in this area would be expected to hinder writing. Of note is that many of the ASD group also struggled with focus during the assessment, particularly when writing. Attention difficulties also cannot be ruled out as a contributor to low writing scores. Executive functions and attention ability should be assessed in future studies to explore the role they play in writing difficulties in ASD.

Implications

It is clear that the youth with ASD in this study struggled with writing. More research is needed to further parse out the causes, by systematically evaluating the alternative explanations proposed above. These results do suggest, however, that it is important to undertake early screening of writing in this population as they seem to be more at risk for writing problems and anxiety around writing. The level of frustration shown by the youth with ASD, when asked to write, supports the value of early intervention, to avert frustration, discouragement, and resistance to writing. Undertaking early assessment and intervention may prevent writing struggles from being compounded by high levels of frustration and discouragement.

Implications for instruction/intervention. Noticeably, the entire ASD group struggled with written expression; they demonstrated anxiety and work refusal around writing and had low scores in this area. All of the ASD participants lacked skills in higher writing skills, including planning, revising, writing development, and vocabulary. Further, most of the group struggled with lower-level writing skills, such as spelling and punctuation. It will be important to screen early for writing difficulties, and to consider intervening early in those children who show signs of early writing problems. If we intervene early and reduce academic stress, we could potentially avoid behavioural and academic difficulties around writing. Early intervention and specifically tailored writing interventions for youth with ASD should be developed.

Writing interventions that focus on both lower and higher-level skills should be implemented in ASD. None of the group with ASD used any writing strategies to assist them in the written task, demonstrating either a lack of knowledge, interest, or skill in applying these writing strategies and techniques. Research suggests that students with exceptionalities are provided with fewer opportunities to learn written expression skills during their formal schooling years when compared with peers without diagnosed exceptionalities (Joseph & Konard, 2009). There are few interventions specifically designed for individuals with ASD in the area of writing. Writing intervention could be easily incorporated into standard early interventions for youth with ASD. In addition to systematic writing intervention, evidence of WM problems in this population suggests that EF/WM intervention programs may also be helpful (Kerns, & Macoun, 2015; Tamm et al., 2013). At the very least, given the link between WM and writing, writing interventions should include a component that focuses on improving WM. There is relatively little research on procedures for remediating EF and WM deficits in the ASD population. A small number of studies have evaluated approaches to improving WM, often focusing on youth with ADHD, Fetal Alcohol Spectrum Disorder, or Down syndrome (Kerns, & Macoun, 2015; Tamm et al., 2013). There are a number of existing interventions for individuals with ASD, such as intensive early intervention, which focus mainly on building behavioural and educational skills to improve core symptomology. Some research shows, however, that intervention focused on WM and EF may also improve function in these areas (Corbett et al., 2009; Keehn, Lincoln, Müller, & Townsend, 2010; Luna, Doll, Hegedus, Minshew, & Sweeney, 2007). Pennington and Delano (2012) conducted a review of 15 studies focused on writing interventions for youth with ASD. They examined strategies that have been successful in other populations, such as technology, strategy instruction, and sentence combining. They found that explicit instruction in

writing can be beneficial to students with ASD, but that more research is necessary to establish an evidence-base for these interventions (Pennington & Delano, 2012).

Based on the results of the current study, it is recommended that skills in the processes of planning, revising, vocabulary use, spelling, and punctuation be explicitly deconstructed and systematically taught to students with ASD. While intervention is being conducted, students should also be given opportunities to experience success in writing and be provided with strategies to offset WM deficits. For example, if spelling skills are hindering writing, allow the students to use spell-check software or to have a list of commonly misspelt words to refer, to free up WM resources while writing. For students with ASD who have visual-motor integration problems, focus on improving writing fluency and automaticity to free up WM resources. Spelling interventions are also crucial. Berninger et al., (2002) and Graham and Harris (2003) support teaching spelling skills during text composition, in particular, because spelling difficulties may not be apparent alone and only evident during written composition (e.g., if spelling difficulties are arising due to WM problems). Strategies and tools to work around WM difficulties include the use of visuals such as graphic organizers (e.g., cues about topics, the organization and planning in the writing process, EF).

The Self-Regulated Strategy Development Intervention, developed by Graham and Harris (2003), specifically looks at building self-esteem, and teaching planning, organizational techniques, revising and spelling in context. The Self-Regulated Strategy Development Intervention uses a number of strategies that address WM deficits, including mnemonics, graphic organizers and visuals while building writing skills, all strategies that have been proven to work with individuals with ASD. Currently, there is little research on the use of the Self-Regulated Strategy Development Intervention in ASD, although emerging literature is showing promise

(Asaro-Saddler, 2014). Variations of the Self-Regulated Strategy Development Intervention approach have been successfully used to improve the writing of youth with learning disabilities (Graham et al., 2003), students with emotional and behavioral disorders (Mason, Kubina, Valasa & Cramer, 2010; Mastropieri, 2009) and ADHD (Reid & Lienemann, 2006), and most recently youth with ASD (Asaro-Saddler & Bak, 2012). The Self-Regulated Strategy Development Intervention might be particularly successful in ASD because it targets self efficacy while allowing the interventionist to model crucial skills that help the individual to adopt their own strategy (Graham et al., 2005). Moreover, the Self-Regulated Strategy Development Intervention encourages students to monitor, evaluate, and revise their writing promoting self-regulation skills (i.e., an important EF), areas which appeared problematic in the current study.

A theme that emerged from the ASD group in this study was the high level of anxiety and stress around writing that each participant displayed either through their behaviour or direct statements. Each participant knew that writing was an area of weakness for him. To increase motivation for writing, four out of five youth with ASD required incentives and rewards to convince them to write, even in a very supportive, one-on-one environment. Anxiety around writing certainly contributed to some of the writing challenges seen. It is also important to note that it is very challenging for students who struggle with writing to engage in and learn to write in settings where their writing is being evaluated and where there are high levels of distraction (i.e., school settings). In the current study, ASD participants found writing highly frustrating and discouraging, which may not have been the case if writing problems had been recognized and addressed earlier in their schooling. Learning disabilities in students with ASD tend not to be a treatment priority, as other impairments such as social, communication and behavioural deficits take precedence (Volkmar, 2014). Perhaps, learning disability assessment and intervention

should be incorporated into ASD evaluation/treatment approaches, given that this is a particular risk in this group and can exacerbate other problems. Executive function and WM interventions may also be helpful and may have carry-over effects into other impairments. For example, self-esteem and self-efficacy in writing is an area of research that should be further explored in the ASD population and should be considered when designing an intervention for individuals on the spectrum.

Teaching interventions and strategies to support WM and writing can be easily adapted into the classroom. Teachers can use technology to offset WM deficits and transcription difficulties to help with writing. Technology can be an aid during writing tasks, although technology should not supplant direct writing intervention. Teaching and modelling the writing process to youth with ASD is crucial, to avoid youth with ASD believing that writing is an unattainable skill. WM in writing can be supported by providing visuals, models of written work, and first brainstorming ideas. Student interests and motivators should be capitalized on to keep youth with ASD engaged in writing. Using specific areas of interest and positive behaviour supports could help to keep youth with ASD engaged and deter work refusal. Dictation applications could be used to work around transcription difficulties, and spelling and punctuation apps could be used to help with editing and revising. Provide explicit intervention in the area in which a student struggles; during times when there is lower pressure to learn these skills. ASD youth should also be taught that there are different types of writing (e.g., poetry, story, essay) that require different approaches and be provided with concrete, graphic organizers to scaffold different types of writing. Explicit, clear feedback should be given to youth on their writing promptly after it is completed, with a focus on positives.

Implications for theory. This study has been informative in considering how the FWS (Berninger & Amtmann, 2003) explains writing difficulties in individuals with ASD. First, it was predicted that youth with ASD would demonstrate WM difficulties (i.e., visuospatial WM and verbal/phonological WM), a core component of Berninger's FWS (2003). As a result of these WM difficulties, it was predicted that individuals with ASD would struggle in all three major areas of writing as outlined in the FWS (Berninger & Amtmann, 2003; text generation, transcription and EF). In the current sample, some but not all predictions were met (Berninger & Amtmann, 2003). The group with ASD showed variable WM abilities, and even though collectively their overall writing was poor, different profiles of strength/weaknesses both in WM and writing were evident. In particular, the FWS does not specify which WM memory processes contribute to different writing components, nor does it take into account the intellectual and language abilities of the writer. The FWS (Berninger & Amtmann, 2003) does not explain all of the cognitive contributors to writing, and therefore cannot address the various cognitive deficits in individuals with ASD that could impede writing. Therefore, it is important to consider other writing models that might better explain writing deficits in ASD. Most importantly, this study has shown the need to further explore different models of writing and WM in individuals with ASD to gain a better understanding of the cognitive processes underlying writing difficulties in this population. One possible explanatory model is Kellogg's (1996) writing model, which is directly linked to Baddeley and Hitch's model of WM. Kellogg's (1996) model, updated in 2013 (Kellogg, Whiteford, Turner, Cahill, & Mertens, 2013) breaks down specifically which components of WM contribute to different writing functions. In contrast, the FWS (Berninger & Amtmann, 2003) approaches WM as a general construct that supports writing, but does not consider the relative contribution of different WM processes.

In Kellogg's (2013) model, all areas of writing draw to some extent from the central executive. Like the FWS (Berninger & Amtmann, 2003), Kellogg's (2013) model presumes that handwriting and typing become automatic in writers; once these processes are fluent, they no longer pose any demands on the central executive and are left out of the model. The three components of Baddeley and Hitch's (1974) model were elaborated in Kellogg's model (1996) as to their specific roles in the act of writing. Vanderberg and Swanson (2007) found that the central executive reliably predicted higher order writing skills, punctuation and vocabulary in story composition. An impaired central executive would impact text generation, overall writing scores, punctuation and vocabulary (Vanderberg & Swanson, 2007). The phonological loop plays a key role in sentence generation, orthographic encoding, reading during review of the text already produced, the translation of ideas into sentences and editing (Kellogg, 2013). In Kellogg's (2013) model, verbal WM plays a stronger role in writing than visuospatial WM. This is consistent with results from the current study, in that youth with ASD who had verbal WM difficulties generally seemed to struggle more than those who had specific visuospatial WM deficits. Within the present study, participants with ASD struggled with different aspects of WM, and it would be interesting to see if Kellogg's (2013) model can be used to link specific WM problems with specific writing difficulties. As an example, P2 had strengths in phonological processing, which would predict stronger sentence generation, orthographic encoding skills, reviewing skills and editing using Kellogg's model (2013). These predictions were almost all met with P2 in that P2 had above average word count and average spelling abilities, yet problems with reviewing and editing. Kellogg's model (2013) could be used to map specific difficulties in WM onto specific writing problems in ASD, to see if it better explains the link between WM and

writing problems in ASD. This will be important to explore because of the variable WM profiles and variable writing deficits in ASD.

Limitations

There were a number of limitations in the current study. The most significant limitation noted throughout is the very limited number of participants. Having a much smaller sample than initially planned led to a change in the original study design from a quantitative to case-study approach. As a result, significant caution should be taken when interpreting the results. This study set out to examine the relationship between WM and writing in students with ASD when compared with typically developing youth, but due to recruitment challenges, the sample size was insufficient for the initially proposed analyses. The study had insufficient power for parametric testing and as a result two alternative approaches were used to explore the data. First, nonparametric testing was conducted to examine potential trends in group differences between WM and writing; however, even nonparametric analyses have limitations in such small samples (Nachar, 2008). Based on nonparametric testing an association was found between group status and writing performance and group status and WM, but WM and writing were not related. Due to the significant limitations of the non-parametric analyses, the data was then explored using a case study approach. However, as the study was not originally set up as a case study design, the measures/approaches were not ideal and results must be interpreted with caution.

The second limitation is that this study did not measure or include additional cognitive assessments to rule out alternate explanations for writing difficulties, such as assessments of language, EF, attention, and other cognitive domains. Therefore, it cannot be determined whether the observed writing difficulties in the ASD group were due to WM deficits, or due to other common difficulties in ASD such as language and communication atypicalities, social

referencing problems, or broader EF/attention problems. Specifically, other than WM, the study did not measure other types of EF abilities, which are a key component of the FWS (Berninger & Amtmann, 2003). Therefore, the impact of broader EF deficits on writing in students with ASD cannot be determined.

Third, youth involved in the study had cognitive and language abilities in the normal range and would be considered on the higher end of the ASD spectrum. Therefore, the results of the study cannot be generalized to the entire ASD population. More research focused on youth with both mild and more severe symptoms of ASD, as well as youth with low and high intelligence and language abilities, is needed to identify and clarify the extent to which writing and WM difficulties are found across the spectrum of ASD. Further, due to recruitment challenges there was a significant gender imbalance between the TD group and the group with ASD, so the groups were not matched on this important dimension.

Finally, the researcher who administered the tasks also scored them, potentially creating an examiner bias. However, this was not felt to be a significant concern as this would have had the greatest impact on the written essay/paragraph more so than the other measures, and the essay/paragraph task administered has highly objective scoring criteria.

Future Research

This study highlights the need for continued research on writing processes in individuals with ASD and the causes of writing difficulties, including WM deficits. Other writing models should be explored to see if they can better account for writing deficits in ASD. This study also demonstrates a strong need to develop evidence-based writing and WM interventions tailored to individuals with ASD. Future studies need larger populations with matched groups and should explore different theoretical models of writing to see which models are most predictive of

writing problems. It will be crucial to map further out the relationship between specific WM deficits and how they relate to writing difficulties in individuals with ASD to design more targeted and effective interventions for this population. It will be important to research WM profiles in ASD to highlight trends and look for specific WM patterns. The relationship between WM and writing has been explored in TD populations and with other neurodevelopmental disorders (e.g., Dyslexia, and ADHD), but has yet to be fully explored in ASD. Future studies should also examine the role of EFs in writing and how WM deficits interact with broader EF problems, language difficulties and IQ, to influence writing output. These studies should be completed with individuals having different severities of ASD, with a broader range of ages and a wider range of language/intellectual abilities, and should be conducted with larger sample sizes. This would help determine if there are different profiles of WM/writing impairment in ASD that would lend themselves to different types of intervention approaches. The development and research of different interventions will also be important in teaching and supporting this population to develop literacy skills. Research on early intervention in WM is showing benefits and should be further explored in terms of its contributions to writing (Corbett et al., 2009). Research on learning disorder prevention through early WM intervention is an area that would be particularly crucial to examine, as this could prevent a cascade of ongoing academic problems and difficulties included associated secondary disabilities (e.g., low self-esteem and anxiety). Special educators should consider the efficacy of combined WM/writing intervention approaches to determine if these are more effective than either intervention alone.

Conclusion

In conclusion, the purpose of this study was to explore writing difficulties and their relationship to WM deficits in individuals with ASD. The FWS (Berninger & Amtmann, 2003)

was the framework used to analyze writing and WM. The youth with ASD in this study struggled significantly with writing and were shown to have variable WM profiles. While some preliminary relationships between WM and writing were found, it cannot be concluded that WM difficulties were the only or primary contributor to writing difficulties in this sample.

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Appendices

Appendix 1: Advertisement



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

x 3010 STN CSC Tel (250) 721-7799
a British Columbia Fax (250) 721-6190
N4 Canada Web www.uvic.ca/epls

A study is being conducted by the University of Victoria to investigate writing in children and youth with Autism Spectrum Disorder (ASD)

This study is exploring writing skills in children with Autism Spectrum Disorder. Many children with ASD have difficulties with writing, which negatively impacts their school experience. We want to better understand what these difficulties are, in order to provide better supports and interventions

Writing is an important task for success in schools and beyond; the British Columbia Ministry of Education views language (including written language) as fundamental to “thinking, learning, and communicating in all cultures” (British Columbia Ministry of Education, 2007, p.3). Furthermore, teaching children to use written language is one of the main goals of the school curriculum. Children and youth with ASD struggle in many different areas of writing including; including planning, handwriting, organization, addressing abstract concepts, they have been found to write lower quality narrative and expository texts, texts that are much shorter in length, they have also been found to have handwriting legibility problems, organization difficulties. It is also reported that individuals with ASD have relatively high percentages (60%) of learning disabilities in written expression.

This research project is seeking children and youth ranging in age from 9 to 17 years with and without a diagnosis of Autism Spectrum Disorder. The study will take approximately an hour at the University of Victoria and the students will be given a small incentive for their participation and entered to win a prize. The activities are similar to what one might do at school and many children may enjoy the 1:1 interaction. This project is being conducted by Sarah May-Poole, a certified teacher and graduate student who is currently completing her master’s degree in special education at the University of Victoria. Please feel free to call or email for more information.

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 2: Parent Telephone Screening Interview



**Department of
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and Leadership Studies**
MacLaurin Building A439

Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 2Y4 Canada Web www.uvic.ca/epls

Thank you for your interest in participating in our study that is investigating writing in children and youth with Autism Spectrum Disorder. We really appreciate you calling and would like to answer any questions you may have in addition to asking you some questions to determine whether your child is eligible to participate.

First, are there any specific questions about the study that we can answer for you at this time?

Second, we would like to ask you a few questions to determine whether your child would be eligible to participate in the current study:

1. What is the age of your child?
2. Please describe your child's strengths?
3. What does your child find difficult?
4. Does your child have a formal diagnosis of Autism Spectrum Disorder? (if no, then thank you for their time, or refer to control group questionnaire).
 - a. If yes,
 - i. When did the diagnosis occur? And by whom?
 - ii. Was the diagnosis made in British Columbia?
 - iii. Are you aware of whether the Autism Diagnostic Observation Schedule (ADOS) and Autism Diagnostic Interview Revised (ADIR) were administered as part of the diagnosis?
 - iv. Based on the assessment would your child be considered to be functioning within the high end of the Autism Spectrum (diagnosis of Asperger's Disorder or High Functioning Autism)?
5. Does your child hold any other specific diagnoses, such as a Learning Disability, Intellectual disability, severe Language Delay, or Attention Deficit Disorder?
6. Does your child have any diagnosed medical conditions?
7. Has your child ever been diagnosed with a traumatic brain injury or concussion, or sustained a blow to their head warranting medical investigation and/or treatment?
8. Does your child have any academic difficulties? What types of difficulties?
9. What types of supports or interventions has your child received?
10. Does your child have any diagnosed intellectual delays?
11. Does your child have functional language? (i.e. Can he/she talk and can he/she follow basic directions?)
12. Please describe your child's writing skills? Can he/she write a paragraph?
13. Does your child find writing an extremely frustrating task? Has your child received any interventions for writing?
14. Are there any behavioural concerns that we should be aware of?
15. Is your child currently experiencing any significant stresses?
16. Any other questions or concerns?

Thank you, so much for your participation in this interview.

either

We would be pleased to invite you to participate in the study and would like to set up an appointment time for you and your child to meet with Sarah May-Poole at the University of Victoria.

Or

Unfortunately, your child is not eligible to participate in this study at the current time, for _____ reason (did not meet criterion, either they had a diagnosis of ASD but did not meet basic language requirements and/or had other conflicting diagnoses or they did not have a diagnosis of ASD but had a conflicting diagnosis) and if applicable:

Do you think that you would like general resources pertaining to autism in Victoria? (if yes, then researcher can provide a list of resources with the special education teacher or agency that referred the participant).

You also are free to check back with our office in the future to enquire about any other ongoing studies.

Appendix 3 Email script: Invitation for Schools to Participate



**Department of
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MacLaurin Building A439

Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
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SCHOOL DISTRICT 61, 62, 63/ GLENLYON NORFOLK, ST. PATRICKS, ST. ANDREWS, PACIFIC CHRISTIAN SCHOOL

This text can be cut and pasted into an e-mail:

e-Mail Subject Line: Research opportunity; writing and ASD

My name is Sarah May-Poole and I am a graduate student currently completing my master's degree in special education at the University of Victoria. I am a certified teacher and have spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. My current area of interest IS the writing difficulties that face individuals with Autism.

I am emailing you today in regards to a research study being conducted at the University of Victoria. This study is looking at the connection between writing difficulties in students with Autism Spectrum Disorder (ASD) and working memory. The purpose of this study is to look at the connection between writing and working memory in order to better understand where problems arise in the writing process. Hopefully this study will help shed some light on writing difficulties in individuals with ASD and provide information to help us develop more targeted interventions in the future.

Writing is an important task for success in schools and beyond; the British Columbia Ministry of Education views language (including written language) as fundamental to "thinking, learning, and communicating in all cultures" (British Columbia Ministry of Education, 2007, p.3). Individuals with ASD struggle in many different areas of writing including; including planning, handwriting, organization, addressing abstract concepts, they have been found to write lower quality narrative and expository texts, texts that are much shorter in length, they have also been found to have handwriting legibility problems, organization difficulties, AND writing difficulties. These issues in writing may be due to working memory problems. Many children with ASD experience significant difficulties with working memory tasks which influence their behaviour, social relations, communication, and academic performance. This is the particular area that this research project will be looking at, the connection between writing and working memory difficulties.

I am hoping to work with your school/school district in order to recruit participants for this research study. This research project is looking for individuals ranging from ages 9 to 17 years either with a diagnosis of Autism Spectrum Disorder or without who are willing to participate in this study. I am hoping that teachers/ special education teachers will help identify potential participants for the study. Potential participants for the study will be both individuals with autism spectrum disorder and without. Individuals with ASD must be verbal, have some written ability, and be formally diagnosed with ASD. Individuals without ASD can be typically developing children without a diagnosis of ASD or any other neurodevelopmental disorders they should also have no formal diagnosis of a learning disability.

The study will only take approximately an hour at the University of Victoria, the student will work one on one with me, and the tasks will be similar to those done on a regular school day and the students will be entered to win a

prize. This project is being conducted by Sarah May-Poole at the University of Victoria. Please feel free to call or email for more information.

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 4: Telephone script: Invitation for Schools to Participate



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

x 3010 STN CSC Tel (250) 721-7799
a British Columbia Fax (250) 721-6190
N4 Canada Web www.uvic.ca/epls

SCHOOL DISTRICT 61, 62, 63/ GLENLYON NORFOLK, ST. PATRICKS, ST. ANDREWS, PACIFIC CHRISTIAN SCHOOL

Hello,

I am following up on an email I sent to your school (or school board), with regards to a study being conducted at the University of Victoria.

My name is Sarah May-Poole and I am a graduate student currently completing my master's degree in special education at the University of Victoria. I am a certified teacher and have spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. My current area of interest IS the writing difficulties that face individuals with Autism.

This study is looking at the connection between writing difficulties in students with Autism Spectrum Disorder (ASD) and working memory. The purpose of this study is to look at the connection between working memory and writing in order to better understand where problems arise in the writing process. Hopefully this study will help shed some light on writing difficulties in individuals with ASD and provide information to help develop interventions.

I am hoping to work with your school/school district in order to recruit participants for this research study. This research project is looking for individuals ranging from ages 9 to 17 years either with a diagnosis of Autism Spectrum Disorder or without who are willing to participate in this study. The study will only take approximately an hour at the University of Victoria, the student will work one on one with me, and the tasks will be similar to those done on a regular school day and the students will be entered to win a prize.

I am hoping that learning support/special needs teachers will be a third party liaison to parents whose children fit the participant description. All they would have to do is pass information about the study and a consent to contact form to the individual's parent/guardians.

I would be pleased to meet in person to discuss the study more, and provide you with more details in regards to the study, and perhaps the ethics procedure for your school/school board.

Thank you so much for your time, you can contact me at:

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 5: Parent Information Letter



**Department of
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and Leadership Studies**
MacLaurin Building A439

x 3010 STN CSC Tel (250) 721-7799
a British Columbia Fax (250) 721-6190
N4 Canada Web www.uvic.ca/epls

(To be distributed by school personnel or personnel at community organizations)

Dear parent/guardian,

Would your child like to participate in a research study being conducted at the University of Victoria?

My name is Sarah May-Poole and I am a graduate student currently completing my master's degree in special education at the University of Victoria. I am a certified teacher and have spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. My current area of interest IS the writing difficulties that face individuals with Autism.

School district _____, or your child's school (name of the private school) or _____ (name of community organization) has agreed to send this letter to you on my behalf. No personal information about you or your child has been provided to me.

This study is looking at the connection between writing difficulties in students with autism spectrum disorder and working memory in order to better understand where problems arise in the writing process. Hopefully this study will help shed some light on writing difficulties and provide information to help develop better supports and interventions for students with writing difficulties. We are looking for you between the ages of 9-17 with and without autism spectrum disorder.

We are sending this letter from them to you, after having reviewing the study objectives and criteria for participation. The University of Victoria researcher will only be aware of you, should you contact them and indicate an interest in participating. The study will take approximately an hour at the University of Victoria and the students will be provided a small prize for their participation. Your child will also be entered to win a prize at the end of the study.

Should you be interested in participating, please feel free to return this form with your contact information to _____ school or _____ community organization or to contact Sarah May-Poole if you are interested.

Sincerely,

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Consent to Contact

This section of the form is too allow the principle researcher, Sarah May-Poole, to contact you in regards to this study. You only have to fill this form out if you are interested in participating and would like more information. At any point you may withdraw without providing a reason.

This research project is looking for individuals ranging from ages 9 to 17 years either with a diagnosis of Autism Spectrum Disorder or without who are willing to participate in this study. First, a screening interview will be conducted to see if your child matches criterion to participate (approximately 15 minutes), if your child matches The participant criterion, and you and your child agrees to participate, you will be asked to fill out a childhood questionnaire, and if your child has Autism, Fill out an Autism rating scale. The study will only take approximately an hour for your child at the University of Victoria, the student will work one on one with me, and the tasks will be similar to those done on a regular school day and the students will be entered to win a prize. Please feel free to call or email for more information.

By signing below you agree to allowing Sarah May-Poole, to contact you either by phone or email in regards to the study "Evaluating Working Memory Deficits and their Effects on Writing in Adolescents with Mild Autism Spectrum Disorder".

Contact Information

Name

Signature

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 6: Invitation for Pivot Point to Participate (Phone Call)



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 2Y4 Canada Web www.uvic.ca/epls

Hello,

I am calling today with regards to a study being conducted at the University of Victoria.

My name is Sarah May-Poole and I am a graduate student currently completing my master's degree in special education at the University of Victoria. I am a certified teacher and have spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. My current area of interest is the writing difficulties that face individuals with Autism.

This study is looking at the connection between writing difficulties in students with ASD and working memory. The purpose of this study is to look at the connection between working memory and writing in order to better understand where problems arise in the writing process. Hopefully this study will help shed some light on writing difficulties in individuals with ASD and provide information to help develop interventions.

I am hoping to work with Pivot Point in order to recruit participants for this research study. This research project is looking for individuals ranging from ages 9 to 17 years either with a diagnosis of ASD or without who are willing to participate in this study. The study will only take approximately an hour at the University of Victoria, the student will work one on one with me, and the tasks will be similar to those done on a regular school day and the students will be entered to win a prize.

I am hoping that you will act as a third party liaison to parents whose children fit the participant description. All I ask is if you would pass information about the study and a consent to contact form to the individual's parent/guardians.

I would be pleased to meet in person to discuss the study more, and provide you with more details in regards to the study, and perhaps the ethics procedure for your organization.

Thank you so much for your time, you can contact me at:

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 7: Invitation for Victoria Society for Children with Autism (Email)



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

PO Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 3N4 Canada Web www.uvic.ca/epls

This text can be cut and pasted into an e-mail:

e-Mail Subject Line: Research opportunity; writing and ASD

My name is Sarah May-Poole and I am a graduate student currently completing my master's degree in special education at the University of Victoria. I am a certified teacher and have spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. My current area of interest is the writing difficulties that face individuals with Autism.

I am emailing you today in regards to a research study being conducted at the University of Victoria. This study is looking at the connection between writing difficulties in students with ASD and working memory. The purpose of this study is to look at the connection between working memory and writing in order to better understand where problems arise in the writing process. Hopefully this study will help shed some light on writing difficulties in individuals with ASD and provide information to help develop interventions.

I am hoping that you would allow me to advertise for the research study in your monthly newsletter in order to recruit participants. This research project is looking for individuals ranging from ages 9 to 17 years either with a diagnosis of Autism Spectrum Disorder or without who are willing to participate in this study. The study will only take approximately an hour at the University of Victoria, the student will work one on one with me, and the tasks will be similar to those done on a regular school day and the students will be entered to win a prize. Please feel free to call or email for more information.

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies
Faculty of Education

Appendix 8: Parent Consent Form (Parent/Guardian)



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

PO Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 3N4 Canada Web www.uvic.ca/epls

Evaluating Working Memory Deficits and their Effects on Writing in Adolescents with Mild Autism Spectrum Disorder

You are invited to participate in a study entitled Evaluating Working Memory Deficits and their Effects on Writing in Adolescents with Mild Autism Spectrum Disorder that is being conducted by Sarah May-Poole.

Sarah May-Poole is a graduate student currently completing her master's degree in special education at the University of Victoria. She is a certified teacher and has spent many years working with children with Autism Spectrum Disorder (ASD) in an academic capacity. You may contact her if you have further questions by calling -. As a Graduate student, I am required to conduct research as part of the requirements for a degree in Educational Psychology. It is being conducted under the supervision of Dr. Sarah Macoun. You may contact my supervisor at [PHONE NUMBER].

The purpose of this study is to explore writing difficulties in children/youth with ASD and if working memory plays a role within these difficulties. The overall research goal is to better understand the role of working memory and its impact on writing skills in this population, which will provide insights into appropriate educational interventions and strategies. Evidence demonstrates a high proportion of children with ASD have problems both with WM and with writing. Specifically, problems have been documented in the areas of planning, attending to the audience, transcription and organization of written work which are skills related to WM. The research questions to be addressed include:

1. Do Children/Youth with ASD demonstrate difficulties on standardized measures of working memory when compared with typically developing controls?
2. Do Children with ASD demonstrate difficulties in written expression when compared with typically developing controls?
3. Will difficulties in written expression in children with ASD be significantly and positively associated with their performance on working memory tasks?

Writing is an important task for success in schools and beyond; the British Columbia Ministry of Education views language (including written language) as fundamental to "thinking, learning, and communicating in all cultures" (British Columbia Ministry of Education, 2007, p.3). Writing is key to academic success and yet this is an area where students with ASD struggle. Students with ASD struggle in many different areas of writing including; planning, handwriting, organization, addressing abstract concepts, they write lower quality narrative and expository texts, and texts that are much shorter in length. It is also reported that individuals with ASD have relatively high percentages (60%) of LD in written expression. There is evidence that executive functions contribute unfalteringly to the development of writing skills in elementary school students as seen in many research studies. Therefore, research into the different components of executive functions (in this case working memory) and understanding working memory problems in individuals with ASD could help with developing effective interventions for youth with High Functioning ASD to enable them to be more successful at school. Academic struggles reduce quality of school life for individuals with ASD and understanding writing in this population and contributors to writing problems can help us to support them better, provide better education, and provide more targeted interventions. This will lead to a better educational experience and hopefully better academic outcomes.

Participants Selection

You are being asked to participate in this study because your child was identified as fitting the participant criterion. This study is investigating writing in children ages 9 through 17 years. There are two target populations in this study; children formally diagnosed with Autism Spectrum Disorder (Mild, High Functioning, or Asperger's Disorder), and those who have not. These participants have been selected using the help of Special Educators, and a community to identify potential participants and an advertisement in an ASD newspaper.

If you consent to voluntarily participate in this research, your participation will include for parents an initial phone call to see if your child fits criterion, then an informed consent procedure phone call, a background childhood questionnaire and an Autism rating scale. For your child they would only have to the University of Victoria, for about 1 hour in which your child will complete a series of paper and pencil tasks assessing working memory and writing. Participants will also complete a brief screening of general ability. Most individuals do not find the tasks any more stressful or frustrating than the regular types of activities that they engage in at school.

In appreciation for your participation in the study, you and your child will receive small 'thank you' gifts during the assessments. Your child will receive a \$5 gift after the assessment sessions. It is important for you to know that it is unethical for us to provide undue compensation or inducements to research participants. If you agree to participate in this study, the form of compensation discussed above should not be your only reason for participation. You will be compensated for the cost of parking at the University of Victoria.

Your child will be asked to sign a consent or assent form indicating his or her willingness to participate in this project. At the beginning of the session, we will ask your child whether he/she wishes to participate in the study's activities.

Participation is entirely voluntary. You or your child may withdraw at any time from this study, without explanation, with the option of having all relevant data destroyed or allowing the researchers to use the data collected to that point. If you or your child withdraws their participation, then he or she will be able stop and they will still receive his/her gift for the session. There are no known or anticipated risks or adverse consequences to participating in, not participating in, or withdrawing from this project.

Please initial here if you upon withdrawal from the study you would consent to use of your child's data that had been collected up to that point in the study. _____ (initial)

Participant's anonymity will be guaranteed by using code numbers, rather than names, to identify the obtained results. Raw data (e.g., filled-out questionnaires, etc.) will be kept in a locked filing cabinet within Sarah May-Poole's supervisor, Dr. Macoun's, locked office at the University of Victoria. Only Sarah May-Poole and Dr. Macoun will have access to raw data. The key linking code numbers with individual participants will be stored in a password-protected data file including coding, and will be deleted one year following completion of data analysis. Original paperwork (raw questionnaires) will be shredded one year following successful completion of the study. Anonymous data will be stored in a password-protected computer file indefinitely. The information gathered from this research project may be used for publication (such as in a journal or at a scholarly meeting) now or in the future. Individual names or identifying information will not be included in any of the information gathered in this project. You will receive a written summary of the findings about 3 months following completion of the study.

You may contact Sarah May-Poole at – if you have any questions or concerns at any point during the project. In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Name of Child/Youth Participant

Parent Signature

Date

Name of Parent

Telephone Number

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix 9: Child/Youth Consent/Assent



**Department of
Educational Psychology
and Leadership Studies**
MacLaurin Building A439

PO Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 3N4 Canada Web www.uvic.ca/epl

You are participating in a study entitled “Evaluating Working Memory Deficits and their Effects on Writing in youth with Mild Autism Spectrum Disorder.” This research project is being conducted by a graduate student, Sarah May-Poole, at the University of Victoria, who is very interested in writing and working memory. Working memory is how you hold information in your mind and use it. The purpose of this study is to find out how working memory relates to writing. Young people in the study will only need to meet for an hour to answer some questions, write a paragraph and play some memory games.

For this session you just need to do your best, as they can be really hard, but you can’t fail them. What matters is that you try your best! To thank you for doing this so that you can be in the study we will enter you into a draw to give you a prize and \$15, because we know it will be a lot of thinking and some hard work!

We will make sure that how you do in the tasks are kept private. All information and scores will be kept in a locked filing cabinet. Only Sarah May-Poole and her supervisor Dr. Macoun will have access to that information. While we will write a report about the study, we would never tell anyone your name or information that would identify you, or talk about how you did specifically. Your individual results will not be made available to anyone – not even your parents. Your parents will know you are participating in this study, but your friends and classmates won’t know about the study unless you tell them. At the end of the study, overall group results might be shared in research articles, however, individual participant results from this study will not be made available.

If you want to ask more about this, you or your parents can call Sarah May-Poole at -. As well, people at the university are making sure that this project is approved and if you or your parents had any concerns, you could call the Human Research Ethics Office at the University of Victoria (250-472-4545).

Even if you have said ‘yes’, you can stop if you really don’t want to do it anymore. You would not be in trouble with anybody, and you would get to keep all the gifts or rewards that you had gotten already. If you wanted to stop at any time you can, you would leave and go back to your day.

If you say yes, this means that you understood all the stuff about the study and that we answered all of your questions and that you still want to be in the study.

Name of Child/Youth Participant

Examiner’s signature of assent given

Date

Witness

Sarah May-Poole M.A. Candidate
Principal Investigator
Educational Psychology and Leadership Studies

Faculty of Education

Appendix 10: Child History Questionnaire



**Department of
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and Leadership Studies**
MacLaurin Building A439

PO Box 3010 STN CSC Tel (250) 721-7799
Victoria British Columbia Fax (250) 721-6190
V8W 3N4 Canada Web www.uvic.ca/epl

This questionnaire was designed as a measure to obtain basic information about your child. We appreciate your participation in what we feel is an exciting and important study.

Child's name _____ Sex M _____ F _____

Address _____

Date of Birth _____ Age _____

DEVELOPMENTAL/MEDICAL HISTORY

Pregnancy with this child:

Were there any complications with your pregnancy with the referred child (e.g. anemia, high blood pressure, toxemia, diabetes, infections, hospitalizations etc.)

Were any medications/drugs used during the pregnancy (If yes, please explain)

Complications during birth:

Induced _____

C-Section _____

Forceps _____

Fetal Distress _____

Breech (feet First) _____

Twins _____

Other (e.g. breathing problems, cord around neck):

Newborn:

Following delivery, was the baby:

Blue at birth _____

Require oxygen _____

Have jaundice _____

Require Phototherapy _____

Have seizures _____

Other: _____

Was medication used? Yes _____ No _____ If yes, reason.

Childhood:

Has your child ever experienced:

Very high fever _____ Polio _____ Dizzy spells _____

Measles _____ Whooping Cough _____ Frequent colds _____

Mumps _____ Chicken Pox _____ Scarlet Fever _____

Seizures _____ Asthma _____ Freq. Ear infections _____

Meningitis _____ Encephalitis _____ Head injuries _____

Heart Disease _____ Migraines _____ Headaches _____

AIDS _____ Visual defects _____ Hearing defects _____

Other: _____

Food Allergies: _____

Drug Allergies: _____

Are there any medical problems currently affecting your child. If yes, please explain.

Is your child currently receiving medication (specify)?

Has your child received or been involved in any of the following?

	Grade/Age
Learning Disabilities/Special Education Class	_____
Behavioural Adjustment Class	_____
Tutoring	_____
Enrichment/Gifted	_____
Language Immersion	_____
Other	_____

Appendix 11: Parent Screening Interview – Control Group (Phone Call)



**Department of
Educational Psychology
and Leadership Studies**
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Interviewer: hello, I would like to thank you for wanting to participate in this study. This study will be looking at writing and working memory in two populations and comparing the results. The two populations are individuals diagnosed with autism spectrum disorder and those who have had no diagnosis. I would like to ask you a couple of questions in regards to your child's eligibility to participate in the study.

1. Does your child have a formal diagnosis of autism spectrum disorder? (if yes, then thank you for their time, or refer to experimental group questionnaire)
2. Does your child have any formal diagnosis?
3. What age is your child?
4. Do they have any other medical conditions?
5. Do they have any academic difficulties?
6. Do they receive any supports in school?
7. Do they have any developmental delays?
8. Do they have functional language? (i.e. Can they talk?)
9. How are their writing skills?
10. Do they find writing an extremely frustrating task?
11. are there any behavioural concerns that we should be aware of?

Thank you, so much for your participation in this interview.

Either

We would be pleased to invite you to participate in the study and would like to set up an appointment time for you and your child to meet with Sarah May-Poole at the university of Victoria.

Or

Unfortunately, your child is not eligible to participate in this study at the current time, for _____reason (did not meet criterion, either they had a conflicting diagnosis i.e. ADHD, or did not meet age requirements).

And if applicable:

Do you think that you would like general resources pertaining to autism or special needs in Victoria? (if yes, then researcher can provide a list of resources with the special education teacher or agency that referred the participant). You also are free to check back with our office in the future to enquire about any other ongoing studies.

Appendix 12: Experimental Group Behaviour Observations

Experimental Group Behaviour Observations

Participant	Difficulty in Writing Reported by Parents	Prompt Needed to Begin Writing Task	Planning Tool Used for Writing Task	Utilized Full Writing Period	Breaks Needed During Test Battery	Behaviour Observation During Writing Task	Topic Written About
1	Yes	Yes (4)	No	No	Yes (2)	Refused to write at first	Video game
2	Yes	Yes (4)	No	No	Yes (10), Would take breaks to talk about other topics	Took several minutes to begin, did not know what to write about	Video game
3	Yes	Yes (3)	No	No, asked to stop after 18 words	Yes (1)	Said writing made him very nervous. Needed	Essay

						multiple promptings	
				No, after 1 sentence,		Refused to finish, gave up	
4	Yes	Yes (4)	No	prompted to write more	Yes (1)	early, wrote minimal amount.	Essay
		No (special interest					
5	Yes	in sports and gym-essay topic)	No	No	No	No	Essay
