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DOES SPEECH-TO-TEXT ASSISTIVE TECHNOLOGY PAIRED WITH GRAPHIC ORGANIZERS IMPROVE THE WRITTEN EXPRESSION OF STUDENTS WITH TRAUMATIC BRAIN INJURIES?

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ABSTRACT

DOES SPEECH-TO-TEXT ASSISTIVE TECHNOLOGY PAIRED WITH GRAPHIC ORGANIZERS IMPROVE THE WRITTEN EXPRESSION OF STUDENTS WITH TRAUMATIC BRAIN INJURIES?

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Dissertation supervised by Dr. Ara. J. Schmitt

A traumatic brain injury (TBI) can range from mild to severe and can cause debilitating outcomes that require children to need specialized medical or educational services post-injury. Outcomes vary and are dependent on the location of injury, age, severity, and environmental factors. Some common deficits that happen as a result of a brain injury are fine motor and executive functioning skill difficulties. Fine motor and executive functioning skills are an important component of written expression. Therefore, this current study utilized a brief experimental analysis in order to determine the effects that speech-to-text assistive technology along with a graphic organizer has on the written output and writing quality of an individual with a TBI. The results revealed that, AT+GO resulted in the highest performance for total writing quality and also consistently resulted in greater written output (TWW). Future studies should use these experimental procedures to investigate other individuals with a TBI that have differing severity levels, locations of injury, age and environmental factors.

DEDICATION

I want to dedicate this dissertation to everyone who has believed in me when I did not believe in myself and to the ones who were with me on this crazy/incredible journey through graduate school. First, to my parents, who believed in me and saw my potential from a young age. I can never repay you or say “thank you” enough for all the sacrifices you both made to get me where I am today, they did not go unnoticed, and I love you both very much. Also, thank you for being understanding and patient with me when I was busy or simply just being there when I needed someone to talk to. Second, to my whole family, who brought me tons of laughs, joy and love when I came home to visit even though there were times that they were far and few in between. To my fiancé, Brian, who was a late addition to the process but nonetheless is one of the most important people in my life who stuck by my side, helped and pushed me to continue to work towards my goals and stayed up with me for late nights selflessly. To Dr. Privitera, who inspired and taught me in undergrad to love research and added me to every project because he believed in my work, goals, and dedication. Who also steered me towards graduate school and was one of the first people who believed in my potential. Dr. O’Donovan, who allowed me to collect my data during my internship, believed in me and gave me one of the most important lessons I have ever been taught and keep with me every day, to be fearless. Finally, Dr. Schmitt who was always in my corner from the first year to the last, helping me through everything and keeping me on track to graduate. I appreciate everyone that I have mentioned more than I can express and am forever thankful and grateful for each and every one of you.

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CHAPTER I

INTRODUCTION

Traumatic brain injury (TBI) is a chronic health condition that can affect people of all ages. The Centers for Disease Control (2018) defines a TBI as a "disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (p. 5). Traumatic brain injuries can range in severity from "mild" (e.g., related to a brief change in mental status or consciousness) to "severe" (e.g., related to an extended period of unconsciousness or memory loss after the injury" (Centers for Disease Control and Prevention [CDC], 2017, p. 1). In recognition of the commonplace occurrence of TBI, along with the negative consequences of such injuries, there has been increased attention to this topic among researchers, psychologists, educators, and parents. This is particularly the case as TBIs may differentially impact the development of a child's brain, which subsequently be discussed (CDC, 2018).

Causes of TBI in Childhood

There are many different ways by which a TBI can be sustained and these causes vary by age range (CDC, 2018). Statistics associated with pediatric TBI also vary by information source. The leading causes of TBI in children aged 0-14 years old are unintentional falls or being hit by or against an object. Conversely, the leading causes of TBI for people ages 15-24 include motor vehicle accidents or falls. Also worth noting, 325,000 children who played sports and participated in recreational activities visited the emergency room for TBIs in 2012 (CDC, 2018). Children from 0-4 are the age group that most frequently visit the emergency room for TBIs, however.

Incidence and Prevalence

In 2013, approximately 640,000 people were seen in the emergency room for TBI and roughly 18,000 were admitted to the hospital due to their TBIs. Although mild TBI is the most common form of injury seen in ERs, TBI can be chronic and debilitating, leading some children to require specialized medical and educational services post-injury (CDC, 2018). The more severe a TBI, the more likely a child is to be hospitalized and have lifelong deficits. In one study, researchers found 62% of children who experienced a moderate-to-severe TBI developed a subsequent disability, while only 14% of children who have experienced a mild TBI had deficits (CDC, 2018). Tragically, TBIs also result in death. In 2013, 1,500 children, aged 0 to 14, succumbed to their injuries (CDC, 2018). Across ages, it is well-established is that males are more likely to sustain a TBI than females (CDC, 2018).

Psychoeducational Consequences

Intellectual Functioning. When suffering from head trauma, a child may experience significant deficits in their intellectual functioning. Recent studies have demonstrated that verbal and nonverbal abilities can be affected by this trauma (Anderson et al., 2004; Anderson et al., 2005; Taylor et al., 1999). One's nonverbal abilities may be decreased due to the demands of the tasks that measure this construct such as speed, motor output, and fluid problem-solving skills (Yeates, 2010). When examining pre-concussion and post-concussion performance on a measure of cognitive ability, one may see a decrease in the individual's overall level of intellectual functioning (Chadwick et al., 1981). However, children may recover intellectual functioning after sustaining a TBI (Yeates, 2010). The largest increase of intellectual functioning typically occurs immediately after the head injury, with increases tapering off 1-2 years post injury (Yeates, 2010). With this decrease in intellectual functioning, and concomitant decline in

academic performance (Ewing-Cobbs et al., 2004) comes the questions of what services are necessary for a student to best transition back to school post-head injury and learn long-term.

The outcomes and symptoms that a person can experience after sustaining a TBI are dependent upon multiple factors and are different for every child (Lee et al., 2012). These include the severity of the head injury, the area in which there was an insult, environmental factors, and the age that the person was at the time of injury. For example, the more severe the head injury, the poorer the outcomes may be. In addition, neuropsychological outcomes can vary based upon which area of the brain is injured. Specifically, if the temporal lobe has been damaged, then the patient may experience trouble with their speech.

Attention. Attention deficits after sustaining a head injury are one of the most commonly-experienced impairments among child TBI patients (Yeates, 2010). In order to maintain attention, one must be able to focus on the task at hand. In addition, those with typical attention can refocus and return to a previous task and complete or continue to work on it (i.e., cognitive shifting). This domain of functioning is particularly important because it directly impacts all other mental processes (Stierwalt & Murray, 2002). Impaired attention will then impact cognitive functioning, memory, language, etc. (Stierwalt & Murray, 2002). Additionally, deficits in attention impact recovery and rehabilitation efforts. Many tasks that children must perform at school require them to maintain attention for sustained periods of time.

Motor Skills. Fine motor skills are small movements that our hands, wrists, and feet carry out. After a TBI, children may have difficulty performing these tasks due to changes in signals that travel from the brain to the muscle (The Royal Children's Hospital Melbourne, 2010). Depending upon the area and severity of the injury, both sides of the body can be affected. Spasticity is one of the deficits that can affect fine motor skills, which can limit a

child's ability to move, or they may experience difficulty moving certain body parts such as fingers or hands (Bell & DiTommaso, 2016).

Executive Function. Another skill that can be affected is executive functioning (EF). Executive functioning is an umbrella term used for a diversity of hypothesized cognitive processes carried out by prefrontal areas of the frontal lobes (Otero et al., 2014). Difficulties that are related to executive functioning can present emotionally, cognitively, and behaviorally (Yeates, 2010). Some processes that fall under this term are inhibition, shift, emotional control, initiation, working memory, planning/organization, and self-monitoring (Cooper-Kahn & Dietzel, 2019).

Another deficit that may manifest after a TBI is working memory. Children who have sustained a head injury may have trouble with completing tasks because they do not retain information long enough in their working memory to accurately and successfully execute the task at hand (Neumann & Lequerica, 2018). Furthermore, EF encompasses the ability to plan and organize (Yeates, 2010). When the individual does not have the ability to organize a task it may mean that he or she cannot put information in order, which leads to difficulty executing the task properly and in a timely fashion. Additionally, the individual may have difficulties trying to plan out steps in order to effectively complete a task. Finally, self-monitoring is one's ability to measure their own performance. Children with TBI may not be able to survey their progress or accuracy on an assignment or test (Cooper-Kahn & Dietzel, 2019).

Academic Functioning. Many areas of academic functioning can be impacted as an outcome of a TBI (Yeates, 2010). It is important to highlight the areas in which children may experience difficulties after a TBI to inform school personnel and to increase their knowledge regarding the deficits. This will help guide them toward better practices to best serve the

individual needs of the students. With this knowledge, school personnel can help make the reintegration and school process run smoother for students with TBI. Areas in which children may experience deficits after sustaining a TBI are in reading, spelling, arithmetic, and written expression (Catroppa et al., 2009; Savage et al., 2005). For the purposes of this study, the focus will be on the academic deficit written expression. Since writing is an integral part of a student's academic day, the deficits in writing likely will affect the student across subjects. Particularly, this area is affected due to the complexity and combination of skills that go into the process of writing (Carmichael & Hale, 2019).

Overview of Written Expression

All of the psychoeducational skills previously discussed allow an individual to function and perform successfully in a school setting. Any disruptions in any area can lead to specific deficits, or overall poor academic achievement. One area of academic functioning likely to be impacted by a TBI is written expression. The process of writing involves high-order cognitive skills, including executive functioning and language skills (Berninger, 1999; Graham et al., 2014).

Flower and Hayes (1980) provide a framework that separates the construct of written expression into three components in order to capture the processes that underlie writing. The first skill necessary to write is planning. This part of writing involves generating ideas, setting goals for writing, and organizing the piece. The second skill is translating, which is what allows the writer to produce text in order to form a sentence. Berninger and colleagues described translation as being comprised of two different sub-processes: generation skills and transcription skills (Berninger & Graham, 1998; Berninger & Swanson, 1994, Berninger & Winn, 2006). Generation skills are processes that happen internally, in which the individual takes their ideas

from memory and translates them into lexical representations (Puranik & AlOtaiba, 2012). These presentations are usually well planned out and include fully-developed ideas. Transcription skills are the physical act of writing words down and spelling them out (Flower & Hayes, 1981). The final step in their framework is reviewing. This part is completed at the end of the writing process in order to give the writer a chance to reread their work and to edit if needed.

Transcription Skills. Children who have experienced a TBI may have difficulties using their transcription skills. Transcription skills require the individual to use their motor skills in order to achieve output. Children need motor skills to accomplish and be successful in the academic setting (Feder & Majnemer, 2007). Individuals who have a moderate to severe TBI may have trouble grasping the pencil, which may manifest in difficulty in even starting the writing process to do schoolwork (Graham et al., 1997). Spelling is an area that can be particularly affected by deficits in motor skills because around 40% of the variance in spelling is due to motor skills (Swanson, 2000). In addition, deficits in motor skills can lead a student's handwriting to be illegible. This will lead to them having greater difficulty when getting their ideas down out or points across (Feder & Majnemer, 2007). Children with transcription skill deficits also take longer to write which makes the process long and laborious leading to shorter products that are not well thought out or complete (Jones & Christensen, 1999).

Generation Skills. Additionally, a child's generation skills may be compromised due to their brain injury. For an individual to generate, organize, plan their writing, and hold ideas in their mind, one must have intact executive functioning and working memory skills (Jones & Christensen, 1999). Executing all of these tasks simultaneously may lead the child to feel overwhelmed and ultimately, to exhibit poor written output. Students with these deficits in generation skills may experience poor idea generation when deciding on what to write, write in a

simplistic style, make poor connections between concepts, and have a poorly planned and organized written pieces (De La Paz, 1999; Jones & Christensen, 1999).

Accommodations to Bypass Impaired Transcription and Generation Skills

Given the motor deficits that often accompany a significant head injury, student transcription skills may be compromised, resulting in labored and illegible writing, and shortened general output (Noakes et al., 2019). Likewise, due to text generation skills requiring higher-level cognitive skills, a student with a significant TBI is likely to have difficulty in carrying out the tasks required in order to compose an elaborated written response with sufficient word choice, supporting details, and organization (Noakes et al., 2019). Accommodations are frequently used in order to overcome some of these deficits that are experienced by students with TBI. Noakes et al. (2019) demonstrated that when utilizing the accommodation of speech-to-text AT a student with a TBI will increased the total written output, but the overall quality of composition for these students will still not meet teacher expectations. Therefore, AT only allows the student to bypass the transcription skills necessary for writing. This current study will further investigate how to bypass generation skill deficits in order to increase the quality of a student's writing by utilizing a graphic organizer.

Definition of Assistive Technology. In 1988, Congress passed The Technology-Related Assistance for Individuals with Disabilities Act in order to increase access to, availability of, and funding for assistive technology. Additionally, in 1998 (amended in 2004), the Assistive Technology Act was signed in order to state the importance of and the value that assistive technology (AT) can have on improving students' achievement and lives with disabilities (Ohio Center for Autism and Low Incidence [OCALI], 2013). The Individuals with Disabilities Education Act (IDEA; 2004) defines AT as a "device means any item, piece of equipment, or

product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability. The term does not include a medical device that is surgically implanted, or the replacement of that device." (Federal Register, 2000, pp. 80504).

Speech-to-Text AT. Assistive technology can be used to accommodate children who have difficulty with handwriting and spelling. A study conducted by MacArthur and Graham (1987) investigated how handwriting, word processing, and dictation affects the writing products of students with learning disabilities. The results demonstrated that the writing samples that were completed using dictation were significantly longer, of higher quality, and had fewer grammatical issues. Speech-to-text software allows the child to speak into a microphone, with their verbalizations being converted into printed words on the computer screen, allowing the writer a grace period to edit the document. When this AT is utilized, the child may focus more on information he or she wants to relay instead of focusing on the processes of forming letters and composing ideas into written words (Noakes et al., 2019). Dragon Naturally Speaking is a common brand of speech-to-text software that will be utilized for this study. When a child utilizes this speech-to-text software, it will allow him or her to bypass transcription deficits by removing the burden of handwriting.

Studies of Speech-to-Text AT and Students with TBI. Even though a variety of studies have demonstrated the positive effects that speech-to-text AT has upon children with learning disabilities' ability to write, a gap in the research exists when examining the effects of TBIs upon writing skills. A comprehensive search of available literature on this topic resulted in only two articles that studied the effects of AT on written expression skills after children had suffered a TBI. Manasse et al. (2000) conducted a case study on a 19-year-old female who sustained a TBI

in a motor vehicle accident 15 months prior to the start of the study. When the researchers examined her school records, they found no evidence of a disability prior to the head injury. The purpose of this study was to observe whether speech-to-text AT and word processing (keyboarding) had positive effects on this student's written expression. When she utilized the word processor, she produced a greater amount of output than with the speech-to-text AT. However, the quality of writing did not appear to differ between the two methods. Even though the quantity of her writing did not improve, the quality of her writing had more structural complexity when using AT.

Noakes and colleagues (2019) conducted a study with three middle school students who had sustained a moderate-to-severe TBI and also had writing difficulties. The purpose of this study was to implement speech-to-text AT and measure how well it bolstered the students' abilities to handwrite and spell. For this specific investigation, there were two conditions: handwriting and AT. Each student was given a story prompt and had to either handwrite or use AT to respond to it. For each condition, the students were given a new story prompt. These story starters were taken from *AIMSweb* and were randomly selected. The students written/AT piece was then scored in consideration of three different curriculum-based measurements, which were the dependent variables. One of the variables was total words written (TWW), which measures the quantity of written output. The next measure was words spelled correctly (WSC), which measured the students' ability to spell the words in their written piece correctly and is a measure of quality. The last variable was correct writing sequence (CWS), which was a measure of writing quality. The results of this study indicated that overall, when the students utilized the speech-to-text AT, their writing performance was improved. Furthermore, the utilization of speech-to-text AT was far superior to the students' handwriting samples. This study provided

evidence that speech-to-text AT can be an appropriate and effective accommodation for students who have experienced a head injury and have difficulty with written expression.

Again, both of these studies really only provided support for AT to be used in order to bypass the students' impaired handwriting (transcription skills). However, these studies did not necessarily demonstrate improvement of the students' quality of writing. Noakes et al. (2019) discussed the limitations of the study and noted that advanced planning coupled with speech-to-text AT may have provided more robust results in terms of the children's quantity and quality of their writing samples. Due to previous studies focusing heavily on bypassing transcription skills, in the current study, I will focus on generation skills. The purpose of this study, then, is to explore the effects that a graphic organizer coupled with speech-to-text AT may have on a student's quality of writing. No known literature has examined the use of graphic organizer with students with TBI. However, the use of graphic organizers has been well studied as applied to students with learning disabilities.

Graphic Organizers (GO) for Writing

Graphic organizers have been used for many years in order to help students in various academic areas. Specifically, GOs are used to plan and organize a task at hand. Since writing can be a tedious task, this tool can help a student layout out their ideas to make sense of them and help their ideas to flow together. Graphic organizers allow students to have a visual representation of their ideas that will be the focus of the written text (Ewoldt & Morgan, 2017). Having a prewriting process allows the student to then just focus on developing their ideas into a well written piece.

Graphic Organizers Research Regarding Graphic Organizers for Writing. A comprehensive search of the literature was completed in order to identify articles that studied

children and/or adults with TBIs and the use of a graphic organizer to increase the quality of writing. The results of this search deemed that there are no empirically based studies pertaining to this content area. There is, however, an immense amount of empirically based literature that pertains to students with writing disabilities and the implementation of GO. In fact, GOs have found to be particularly advantageous for students with a learning disability in written expression (Baker et al., 2003; Dexter & Hughes, 2011).

Evmenova et al. (2016) demonstrated that the use of a computer-based graphic organizer improved the quality and quantity of the students' writing. Boon and colleagues (2018) conducted a comprehensive review of the literature in order to explore the effects that graphic organizers have on the written output of students with learning disabilities in grades K-12. Their findings demonstrated that graphic organizers were indeed effective in improving their writing skills when writing a narrative and expository type of essay. In particular, there were seven studies in this comprehensive review that focused on narrative writing. Gonzalez-Ledo and colleagues (2005) conducted a study on the use of a teacher-generated computer-based story map that was given to the students as a pre-writing tool. Results indicated that this intervention was helpful for students with specific learning disabilities to write a narrative piece. An additional study utilized a story map template that consisted of three columns. The first column was the stories' elements, the second column was used for the students to write down their ideas that were related to the stories' elements, and the third column was a self-check to guide students to make sure they were adding the stories elements to their pieces. Results demonstrate that the intervention increased the number of story elements that the students integrated into their written pieces (Martin & Manno, 1995).

Purpose of this Study

This study examined the effects of graphic organizers coupled with speech-to-text AT upon the quality of writing for a student who sustained a TBI. Although there are numerous studies that have examined the bypassing of transcription skill deficits, there are no known studies that have specifically investigated the effects of coupling the two accommodations described, particularly in reference to generation skill deficits. In order to improve the quality of writing for students with TBI's, investigations such as these are sorely needed in the extant literature so that better options are available to assist students with head injuries in getting back to maximum productivity and clarity in their writing.

Research Questions

Research Question One: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, speech-to-text assistive technology, or speech-to-text assistive technology with a graphic organizer result in greaest writing output (as measured by TWW)?

Hypothesis: AT+GO will result in greater TWW as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer, and the use of speech-to-text assistive technology.

Research Question Two: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, use of speech-to-text assistive technology, or speech-to-text assistive technology with a graphic organizer result in greatest writing quality (as measure by overall writing quality score that included evaluation of sentence complexity, mechanics, grammar, and number of story components)?

Hypothesis: At+GO will result in greater overall writing quality score as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer and the use of speech-to-text assistive technology.

Summary

Traumatic brain injuries are a chronic health condition that can range in severity from mild to severe. These injuries and their neurological consequences are individualized based on the areas of injury, age of onset and level of severity. Some neurological consequences that can occur for individuals that have sustained a TBI are intellectual, motor, executive functioning, and academic skill deficits. One academic skill that is particularly affected by these injuries is writing. Many studies have been examined the effects of the accommodation's speech-to-text and/or graphic organizers on students with learning disabilities written expression skills. In addition, two studies have demonstrated that speech-to-text can be advantageous for individuals with TBIs to increase their quantity of written output. However, no known studies have examined the effects of using graphic organizers in order to increase the quality of an individual with a TBI writing. Therefore, this current study examined coupling speech-to-text with graphic organizers to increase a student with a TBI written output and quality of writing.

Chapter II: Literature Review

Traumatic Brain Injury

Definition of TBI

Traumatic brain injury (TBI) is a chronic health condition that can affect people of all ages. The Centers for Disease Control (2018) defines a TBI as a "disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (p. 5). Traumatic brain injuries can range in severity from "mild" (e.g., related to a brief change in mental status or consciousness) to "severe" (e.g., related to an extended period of unconsciousness or memory loss after the injury" (Centers for Disease Control and Prevention [CDC], 2021, p. 1). In recognition of the commonplace occurrence of TBI, along with the negative consequences of such injuries, there has been increased attention to this particular topic among researchers, psychologists, educators, and parents. This is particularly the case as TBIs may differentially impact the development of a child's brain (CDC, 2018).

Causes by Age Group

There are many different ways by which people can sustain a TBI. The leading causes of TBI in children aged 0-14 years old are unintentional falls or being hit by or against an object. The leading causes of TBI for people aged 15-24 are motor vehicle accidents or falls. In addition, 325,000 children who played sports and participated in recreational activities visited the emergency room for TBIs in 2012 (CDC, 2018). Boys are more likely to sustain a TBI than girls. Children from 0-4 are the age group that most frequently visit the emergency room for TBIs. Statistics from different sources vary in their reports of the causes of TBIs (CDC, 2018).

Incidence and Prevalence

In 2013, approximately 640,000 people were seen in emergency rooms for TBI and roughly 18,000 were admitted to the hospital due to TBIs (CDC, 2018). While mild TBIs are the

most common form of injury seen in ERs, TBIs also can be chronic and debilitating, leading some children to require specialized medical and educational services post-injury (CDC, 2018). The more severe a TBI, the more likely a child is to be hospitalized and have lifelong deficits. In one study, researchers found 62% of children who experienced a moderate-to-severe TBI developed a subsequent disability, while only 14% of children who experienced a mild TBI had deficits (CDC, 2018). Tragically, TBIs also result in death. In 2013, 1,500 children, aged 0 to 14, succumbed to their injuries (CDC, 2018). Across ages, it is well-established that males are more likely to sustain a TBI than females.

Severity and Categories

The severity of TBIs can be separated into three different categories, determined by the symptoms with which the patient is presenting at the time of the visit. These categories are mild, moderate and severe. The level of severity is primarily determined by the way in which the patient exhibits behavior as well as performs on a measure called a coma scale. One coma scale is called the Glasgow Coma Scale (GCS), which is utilized to evaluate adult patients, and another is the Pediatric Coma Scale (PCS), which is used to assess children (CDC, 2018). The GSC measures the consciousness level in a person, examining an individual's ability to open their eyes, register and articulate pain, verbalize responses and demonstrate motor responses and orientation regarding the conversation with the clinician. A mild TBI is considered to be a score of 13-15, which accounts for 70-90% of emergency room visits. For a moderate TBI, the patient would have a score of 8-12, while scores 8 or less on the GSC are considered to be severe.

Neuropathy of TBI

Traumatic Brain Injuries are related to several forms of neuropathology and pathophysiology (Yeates, 2010). The insults to the brain may be internal or external. Injuries that

result from closed-head trauma and that are observable are separated into two categories. Injuries that are a direct result of the trauma to the brain are called primary injuries. These may include "skull fractures, contusions/lacerations, and mechanical injuries to nerve fibers and blood vessels" (Yeates, 2010, p. 116). When injuries indirectly arise from the trauma to the brain, they are called secondary injuries, including "brain swelling/edema, hypoxia/hypotension, increased intracranial pressure and mass lesions" (Yeates, 2010, p. 116). Brain swelling is a neurochemical insult that can manifest after a brain injury, as well. Due to the trauma that the brain sustains, changes to the axons occur, which can lead to changes in the biochemical and metabolic reactions in the brain. In addition to the primary and secondary injuries that occur during a TBI, there are late effects that have been discovered through neuroimaging. After sustaining this injury, there is cortical thinning and degeneration of the brain's white matter.

Common Neuropsychological Consequences

The outcomes and symptoms that a person can experience after sustaining a TBI are dependent upon multiple factors and are different for every child (Lee et al., 2012). These include the severity of the head injury, the area in which there was an insult, environmental factors, and the age that the person was at the time of injury. For example, the more severe the head injury, the poorer the outcomes may be. In addition, neuropsychological outcomes can vary based upon which area of the brain is injured. Specifically, if the temporal lobe has been damaged, then the patient may experience trouble with their speech.

Orientation and Alertness. Traumatic brain injuries can affect one's ability to be oriented and alert. This is particularly true for someone who is just in the beginning phases of recovery. Children who have experienced a moderate to severe head injury may experience disorientation, confusion, and memory loss after the injury. These symptoms that are

experienced after sustaining a TBI are called posttraumatic amnesia (PTA). Posttraumatic amnesia is one way in which a physician can measure injury severity

Intellectual Functioning. When suffering from head trauma, a child may experience significant deficits in their intellectual functioning. Recent studies have demonstrated that verbal and nonverbal abilities can be affected by this trauma (Anderson et al., 2004; Anderson et al., 2005; Taylor et al., 1999). One's nonverbal abilities may be decreased due to the demands of the tasks that measure this construct such as speed, motor output, and fluid problem-solving skills (Yeates, 2010). When examining pre-concussion and post-concussion performance on a measure of cognitive ability, one may see a decrease in the individual's overall level of intellectual functioning (Chadwick et al., 1981). However, children can demonstrate a recovery in their intellectual functioning after sustaining a TBI (Yeates, 2010). The largest increase of intellectual functioning typically occurs immediately after the head injury, with increases tapering off 1-2 years post injury (Yeates, 2010). With this decrease in intellectual functioning, and concomitant decline in academic performance (Ewing-Cobbs et al., 2004) comes the question of what services are necessary for a student to best transition back to school post-head injury and learn long-term.

Academic Functioning. Many areas of academic functioning can be affected as an outcome of a TBI (Yeates, 2010). It is important to highlight the areas that children may have difficulties in after a TBI to inform school personnel and to increase their knowledge on the deficits. This will help guide them toward better practices to best serve the individual needs of the students. With this knowledge, school personnel can help make the reintegration and school process run smoother for students with TBI. Areas that school personnel may see deficits in after a child has sustained a TBI include reading, spelling, arithmetic, and written expression

(Catroppa et al., 2009; Savage et al., 2005). For the purposes of this study, the focus will be on the academic deficit written expression. Since writing is an integral part to a student's academic day, the deficits in writing will affect the student across subjects. Particularly, this area is affected due to the complexity and combination of skills that go into the process of writing (Carmichael & Hale, 2019).

Language Skills. Following a TBI, children may also experience deficits in their expressive or receptive language skills. Expressive language includes the way in which an individual uses their language skills to communicate, while receptive language is the understanding of information (Altinkaynak, 2019). For children, communication is an important component of maintaining relationships and succeeding in school. Receptive language skills may be affected after the injury, with the child demonstrating difficulties recognizing previously-learned vocabulary words. In addition, students may need information to be repeated more frequently than before their injuries. It is also common for children to have trouble maintaining focus on conversations. In terms of expressive skills, children may rapidly speak, ramble about certain topics, and switch from related to unrelated topics. Moreover, individuals suffering from TBI may interrupt others while they are talking, make inappropriate comments, or behave inappropriately. The previously discussed effects of a TBI can certainly have detrimental effects upon maintaining meaningful relationships (Turkstra et al., 2015; Hawley et al., 2019). In addition to these deficits, survivors of severe TBIs can experience word aphasia (Manasse et al., 2000).

Aphasia occurs when certain parts of the brain becomes damaged as a result of an injury. Aphasia can be separated into two categories: fluent and nonfluent. Injuries to specific parts of the brain result in the different aphasias. For example, when the temporal lobe is damaged it may

cause Wernicke's aphasia. Individuals who have Wernicke's aphasia may speak in complete and long sentences; however, the sentence usually makes little to no sense at all. An individual with this type of aphasia can be difficult to follow, have weaknesses in understanding speech, and is often unaware of their mistakes when talking. One type of nonfluent aphasia is called Broca's aphasia, which usually primarily affects the frontal lobe of the brain. Individuals with this type of aphasia may understand speech and may even be able to plan/know what they want to say; however, when they verbalize their thoughts, these are typically expressed short phrases and important words of the sentence are omitted [National Institute on Deafness and Other Communication Disorders [NIDCD], 2017].

Attention. Attention deficits after sustaining a head injury are one of the most common impairments among child TBI patients (Yeates, 2010). In order to maintain attention, one must be able to focus on the task at hand. In addition, those with typical attention are able to refocus and return to a previous task and complete or continue to work on it (i.e., cognitive shifting). This domain of functioning is particularly important because it directly impacts all other mental processes (Stierwalt & Murray, 2002). Impaired attention will then impact cognitive functioning, memory, language, etc. (Stierwalt & Murray, 2002). Additionally, deficits in attention impact recovery and rehabilitation efforts. Some of the areas that present difficulty for recovery include increased levels of distractibility that the individuals face due to the overload of accommodating multiple thoughts at the same time, which in turn poses the problem of staying on task to focus on the rehabilitation efforts (Robertson & Schmitter-Edgecombe, 2017). Many tasks that children must perform at school require them to maintain attention for sustained periods of time.

Motor Skills. Fine motor skills are smaller movements that our hands, wrists, and feet carry out. These movements can include but are not limited to manipulating objects, reaching, or

grasping objects such as a pencil. After a TBI, children may have difficulty performing these tasks due to changes in signals that travel from the brain to the muscle ("Brain injury-Fine motor skills", 2020). Depending on the area and severity of the injury, both sides of the body can be affected. Some of the deficits children may encounter include having stiff muscles, which can limit their ability to move or have difficulty moving certain body parts (Bell & DiTommaso, 2016). These difficulties can lead to trouble planning and executing movements. Planning movements allows an individual to perform or complete a task.

Executive Function. Another skill that can be affected is executive functioning (EF). Executive functioning is an umbrella term used for a diversity of hypothesized cognitive processes carried out by prefrontal areas of the frontal lobes (Otero et al., 2014). Difficulties that are related to executive functioning can present emotionally, cognitively, and behaviorally (Yeates, 2010). Some of the processes that fall under this term are inhibition, shift, emotional control, initiation, working memory, planning/organization, and self-monitoring (Cooper-Kahn & Dietzel, 2019).

Inhibition is the inability of someone to stop their behaviors and thoughts at an appropriate time. Children that have sustained a TBI may have trouble with this ability, and consequently, may appear impulsive. Impulsivity can present itself in many ways, such as risky behaviors, verbalizing without thinking, etc. Another ability, shifting, describes how an individual can be engaging in a task and then switch to another. Additionally, this may apply to an individual's thought processes, such as being able to think of one topic and then switch to a different topic. Children who have difficulties in shifting may have trouble during transition times and applying previously learned skills/knowledge from one class to another, etc. (Cooper-Kahn & Dietzel, 2019).

Emotional control is another area that is encompassed in the definition of EF, which is one's ability to control and express one's emotions in an appropriate way. Individuals who have experienced a TBI can experience emotional regulation difficulties. Another EF is initiation, which is the ability to begin a task in a timely manner. These tasks can include independently generating ideas, responding, and problem-solving. Children that sustain a TBI may have difficulties with such tasks requiring them to have to answer quickly and provide thoughtful responses on their own without being prompted.

Another deficit that may manifest after a TBI is working memory. Children who have sustained a head injury may have trouble with completing tasks because they do not retain information long enough in their working memory to accurately and successfully execute the task at hand (Neumann & Lequerica, 2018). Furthermore, EF encompasses the ability to plan and organize (Yeates, 2010). When the individual does not have the ability to organize a task, it may mean that he or she cannot put information in order, which leads to difficulty executing the task properly and in a timely fashion. Additionally, the individual may have difficulties trying to plan out steps in order to effectively complete a task. Finally, self-monitoring is one's ability to measure their own performance. Children with TBI may not be able to survey their progress or accuracy on an assignment or test (Cooper-Kahn & Dietzel, 2019).

Social-Emotional/Behavioral Deficits. Another long-term consequence of TBI can be social-emotional or behavioral challenges. Up to 50% of children that have sustained a head injury will be at risk for presenting some behavioral problem (Li & Liu, 2013). These problems can be internalizing (e.g., anxiety and depression) or externalizing (e.g., conduct and AD/HD). Internalizing behaviors are difficult to recognize because of their covert symptoms, and thus, assistance may not be offered to the child. Externalizing behavior problems are behaviors that

are manifested in an individual's outward behavior (i.e., physical aggression, crying, acting out) and these behaviors may be targeted at the environment or students surrounding them (Liu, 2004). Moreover, personality changes have been noted after a TBI (Li & Liu, 2013). Two years after sustaining a TBI, 36% of children with moderate-to-severe injuries are diagnosed with a new psychiatric disorder (Max et al., 1997). An additional study conducted by Schwartz and colleagues (2003) provided evidence that three years post injury, children with moderate-to-severe TBI's experienced increased behavioral problems. Furthermore, if a child presented with internalizing or externalizing behavior problems before the injury had occurred, he or she will be more at risk or have poorer behavioral outcomes than children who did not experience those symptoms previously (Gagner et al., 2018).

Luria's Working Brain

The theoretical framework that aligns with the deficits associated with TBI is Luria's Working Brain. Luria (1973) theorized a way to understand cognitive disorders through disruptions in cognitive paths. Even though Luria's framework (1973) was developed using an adult population, his theory can also be applied and used to understand a disruption in a child's brain development due to a TBI. Luria (1973) described the brain to be highly complex and interrelated. His theory suggests that if any links in the complex workings of the brain become disrupted, changes in behavior and mental processes can occur.

Luria's (1973) work discussed how specific neuropsychological skills work together in order, like a chain, in order to complete a task. This chain can also work bidirectionally (Kolb & Whishaw, 2003). If one of these skills are disrupted by an outside force, such as a TBI, a functional impairment may be a result (Luria, 1973). Human mental processes are complex and they are not neatly conducted by one single area of the brain. In fact, many areas of the brain

work simultaneously to provide a unique contribution to processing of behaviors and mental processes, and work together to complete a task. Luria (1973) posited that the brain has functional organization presented in a hierarchical manner that permits an understanding of how information is processed and behaviors are produced. The three principle hierarchical units that are necessary for any sort of mental activity are: primary, secondary, and tertiary cortical areas. The primary unit is a critical one; without this unit, higher levels of cognition may not occur. Additionally, this unit is responsible for cortical activity and alertness. The second unit is concerned with the synthesis of the reception, analysis, and storage of information from visual, auditory, and general sensory information. The third unit is a zone of overlapping, which is necessary for a human to perform most complex forms of mental activity, which requires the participation of many cortical areas.

With respect to written expression, Luria (1973) discussed five neuropsychological domains that are important for output. These are symbolic perception, spatial orientation, internal speech, attention, and memory. For example, difficulty with one's attention can lead to trouble with focusing long enough to formulate a written piece. As discussed previously, a child's executive functioning and fine motor can be compromised due to a brain injury. According to Luria (1973), the dorsolateral prefrontal cortex functions as the brain's skill area of motor planning, organization and regulation. If this area of the brain has been compromised when the injury occurred, the student would need significant assistance in these areas. Furthermore, if there is damage to the motor cortex, the student may display difficulties in composing written work and would need assistance in order to successfully provide written work. This study aims to provide this assistance in terms of planning, organizing, and composing narrative pieces using a

graphic organizer and speech-to-text in order to support the students to succeed with writing tasks.

Overview of Written Expression

All of the neuropsychological skills previously discussed allow an individual to function and perform successfully in a school setting. Any disruptions in any area can lead to specific deficits, or overall poor academic achievement. One area of academic functioning likely to be impacted by a TBI is written expression. The process of writing involves high-order cognitive skills including executive functioning and language skills (Berninger, 1999; Graham et al., 2014).

Flower and Hayes (1980) provides a framework that separates the construct of written expression into three components to capture the processes that underlie writing. The first skill necessary to write is planning. This part of writing involves generating ideas, setting goals for writing, and organizing the piece. The second skill is translating, which is what allows the writer to produce text in order to form each sentence. Berninger and colleagues described translation as being comprised of two different sub-processes: generation skills and transcription skills (Berninger & Swanson, 1994; Berninger & Graham, 1998; Berninger & Winn, 2006). Generation skills are processes that happen internally, in which the individual takes their ideas from memory and translates them into lexical representations (Puranik & AlOtaiba, 2012). These presentations are usually well planned out and include fully-developed ideas. Transcription skills are the physical act of writing words down and spelling them out (Flower & Hayes, 1981). The final step in their framework is reviewing. This part is completed at the end of the writing process in order to give the writer a chance to reread their work and to edit if needed.

Transcription Skills. Transcription skills require a student to use cognitive and physical acts to form written language (McCutchen, 2000). Graham et al. (1997) evaluated the mechanical requirements to spell and handwrite, and results demonstrated that transcription skills are lower-level skills. This means that students should be able to perform such tasks in a more automatic way and be able to focus on higher order skills such as planning and content. If a student demonstrates difficulties with the lower level skills, then they will also exhibit difficulties with the higher skills.

Children who have experienced a TBI may have difficulties using their transcription skills. Transcription skills require the individual to use their motor skills in order to achieve output. Children need motor skills to accomplish and be successful in the academic setting (Feder & Majnemer, 2007). Individuals who have a moderate to severe TBI may have trouble grasping the pencil, which may manifest in difficulty in even starting the writing process to do schoolwork (Graham et al., 1997). Spelling is an area that can be particularly affected by deficits in motor skills because around 40% of the variance in spelling is due to motor skills (Swanson, 2000). In addition, deficits in motor skills can lead a student's handwriting to be illegible. This will lead to them having greater difficulty when getting their ideas down on paper (Feder & Majnemer, 2007). Children with transcription skill deficits also take longer to write which makes the process long and laborious leading to shorter products that are not well thought out or complete (Jones & Christensen, 1999).

Generation Skills. Additionally, a child's generation skills may be compromised due to their brain injury. In order for an individual to generate, organize, plan their writing, and hold ideas in their mind, one must have intact executive functioning and working memory skills (Jones & Christensen, 1999). Executing all of these tasks simultaneously may lead the child to

feel overwhelmed and ultimately, to exhibit poor written output. Students with deficits in generation skills may experience poor idea generation when deciding on what to write, write in a simplistic style, make poor connections between concepts, and have poorly planned and poorly organized written pieces (De La Paz, 1999; Jones & Christensen, 1999).

Accommodations to Bypass Impaired Generation and Transcription Skills. Given motor deficits that often accompany a significant head injury, student transcription skills may be compromised resulting in labored and illegible writing and shortened general output (Noakes et al., 2019). Likewise, due to text generation skills requiring higher-level cognitive skills, a student with a significant TBI is likely to have difficulty in carrying out the tasks required to compose an elaborated written response with sufficient word choice, supporting details, and organization (Noakes et al., 2019). Accommodations are frequently used in order to overcome some of these deficits experienced by students with TBI. Noakes et al. (2019) demonstrated that when utilizing the accommodation of speech-to-text AT, students with TBI increased total written output, but the overall quality of composition for these students still did not meet teacher expectations. Therefore, AT only allowed the students to bypass the transcription skills necessary for writing. This current study will further investigate how to bypass generation skill deficits to increase the quality of a student's writing by utilizing a graphic organizer.

Assistive Technology to Accommodate for Impaired Writing Component Skills

Definition of Assistive Technology. In 1988, Congress passed The Technology-Related Assistance for Individuals with Disabilities Act in order to increase access to, availability of, and funding for assistive technology. Additionally, in 1998 (amended in 2004), the Assistive Technology Act was signed to ensure the importance that assistive technology (AT) can have on improving the lives and achievement of students with disabilities is recognized (Ohio Center for

Autism and Low Incidence [OCALI], 2013). The Individuals with Disabilities Education Act (IDEA; 2004) defines AT as a "device means any item, piece of equipment, or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of a child with a disability. The term does not include a medical device that is surgically implanted, or the replacement of that device." (Federal Register, 2000, pp. 80504).

Need for Assistive Technology. The need for AT is required to be discussed when developing the student's individualized education program (IEP). Moreover, public agencies, such as schools, must guarantee that AT devices or AT services, or both, are made readily available to a child with a disability if required as a part of the child's special education, related services, or supplementary aids and services. However, when the parent requests a specific AT device or service, it is not always guaranteed that the child will receive that particular one. A district is not required to supply a more expensive device that may provide better assistance to the child. The district is only required to purchase the device that will sufficiently help the child with their disability. The school district will agree on what type of AT device or service that the child needs (Federal Register, 2000, pp. 80504). This law states that AT must be paid for and provided by schools at no cost to their family. Due to some families not being able to afford AT devices, the law provides that students with disabilities are not discriminated against because of family income.

Assistive Technology Literature

In 1999, De La Paz conducted a literature review on speech-to-text AT. Before modern technological advances, dictation was originally the job of a stenographer, who transcribed letters, records, reports, etc. by using a typewriter or word processor to generate the copy. In

1972, a dictation and word processing system were combined in order to make one of the first speech recognition systems. This system required the writer to speak one word at a time into the computer. The voice was then detected by the software and compared to already known vocabulary in the system. Further advances in technology led to text systems starting to use complex matching algorithms "in which linguistic and phonetic information was added to the matching process, simultaneously allowing the system's vocabulary to be updated" (De La Paz, 1999, p. 174). Current technology now allows the writer to speak aloud into the computer while their speech is converted to text. After the writer has completed their work, the new technology allows him or her to edit the text (De La Paz, 1999).

Assistive technology can be used to accommodate children who have difficulty with handwriting and spelling. A study conducted by MacArthur and Graham (1987) investigated how handwriting, word processing, and dictation affects the writing products of students with learning disabilities. The results demonstrated that the writing samples that were completed using dictation were significantly longer, of higher quality, and had fewer grammatical issues. Speech-to-text software allows the child to speak into a microphone, with their verbalizations being converted into printed words on the computer screen, allowing the writer a period of time to edit the document. When AT is utilized, the child may focus more on information he or she wants to relay instead of focusing on the processes of forming letters, planning out the essay, organizing, and composing ideas into written words (Noakes et al., 2019). Dragon Naturally Speaking is a common brand of speech-to-text software, which will be utilized for this study. When a child utilizes this speech-to-text software, she may be able to bypass transcription deficits by removing the burden of handwriting.

Many studies have explored the use of speech-to-text assistive technology for students with learning disabilities (LD). It has been hypothesized that dictation can be advantageous for individuals with LD (De La Paz, 1999, Wetzel, 1996). In one study, researchers explored the use of speech-to-text in order to bypass transcription skill deficits and found that the software allowed the child to write longer and evidence a higher quality of writing with fewer grammatical errors (Reece, 1992). Lee (2011) studied the effects of the use of speech recognition technology (SRT) on students with writing difficulties that have been identified with learning disabilities. This study in particular explored if SRT would increase the students fluency, quantity and quality of writing when compared to a traditional paper-pencil writing or the use of a digital recorder. Results revealed that both the SRT and digital recorder were more helpful in increasing the students ability to fluently write and use proper mechanics. However, there was very little differences between handwriting, SRT and the digital recorder conditions when examining syntactic complexity and story structure level of writing (Lee, 2011). Hetzroni and Shrieber (2004) investigated whether using a word processor would increase academic outcomes of three students with writing disabilities. The students either used a computer with a word processor or used a computer without. Each students in-class materials were examined for number of spelling and reading errors, number of words used and overall structure and organization. The outcome of this study notated that when a student had to handwrite, they had more spelling and reading errors and had difficulties with organization and structure compared to the word processor condition.

Two studies looked further into the use of speech-to-text technology and paired it with students planning their writing in advance in order to improve their overall writing quality. De La Paz and Graham (1997) conducted a study with fifth-, sixth-, and seventh-grade students with

learning disabilities, in order to utilize planning before handwriting or dictating to see if there was a positive effect upon the students' writing. The results demonstrate that in the condition in which the students were able to plan their essays in advance and use dictation, the students "produced essays that were longer, more complete, more cohesive, and qualitatively better" than the other conditions (p. 178). Additionally, Quinlan (2004) investigated the effects of advanced planning and the use of speech recognition technology (SR), finding that utilizing both significantly increased the length of the composition and decreased the surface errors. Moreover, Quinlan found that both advanced planning and SR separately could help support a student's writing generation skills (Quinlan, 2004). In both of these studies, it was demonstrated that with the use of speech-to-text AT, the student was able to bypass their impaired transcription skills.

Use of Speech-to-Text AT Post-TBI

Even though a variety of studies have demonstrated the positive effects that speech-to-text AT has on children with learning disabilities and their ability to write, a gap in the research exists when examining the effects of writing skills and TBI. A comprehensive search of available literature on this topic resulted in only two articles that studied the effects of AT on written expression skills after children had suffered a TBI. Manasse et al. (2000) conducted a case study on a 19-year-old female who sustained a TBI in a motor vehicle accident 15 months prior to the start of the study. When the researchers examined her school records, they found no evidence of a disability prior to the head injury. The purpose of this study, then, was to observe whether speech-to-text AT and word processing (keyboarding) had positive effects on this student's written expression. When she utilized the word processor, she produced a greater amount of output than with the speech-to-text AT. However, the quality of writing did not appear to differ

between the two methods. Even though the quantity of her writing did not improve, the quality of her writing had more structural complexity when using AT (Manasse et al., 2000).

Noakes et al. (2019) conducted a study with three middle school students who had sustained moderate-to-severe TBI and also had writing difficulties. The purpose of this study was to implement speech-to-text AT and measure how well it bolstered the students' abilities to handwrite and spell. For this specific investigation, there were two conditions: handwriting and AT. Each student was given a story prompt and had to either handwrite or use AT to respond to it. For each condition, the students were given a new story prompt. These story starters were taken from *AIMSweb* and were randomly selected. The students were then scored on their written/AT piece in consideration of three different curriculum-based measurements, which were the dependent variables. The results of this study indicated that overall, when the students utilized the speech-to-text AT, their writing performance was improved. Furthermore, the utilization of speech-to-text AT was far superior to the students' handwriting samples. This study provided evidence that speech-to-text AT can be an appropriate and effective accommodation for students who have experienced a head injury and have difficulty with written expression.

Each of these studies provided support for AT to be used in order to bypass the students' impaired handwriting (transcription skills). However, these studies did not necessarily demonstrate improvement of the students' quality of writing. Noakes et al. (2019) discussed the limitations of their study and noted that advanced planning coupled with speech-to-text AT may have provided more robust results in terms of the children's quantity and quality of writing samples. Due to previous studies focusing heavily on bypassing transcription skills, in the current study, I will focus on generation skills. The purpose of this study, then, is to explore the effects that a graphic organizer coupled with speech-to-text AT may have on a student's quality

of writing. No known literature has examined the use of graphic organizer with students with TBI. However, the use of graphic organizers have been well studied as applied to students with learning disabilities.

Graphic Organizers (GO) for Writing

Graphic organizers have been used for many years in order to help students in various academic areas. Specifically, GOs are used to plan and organize a task at hand. Since writing can be a tedious task, this tool can help a student lay out their ideas in advance and help their ideas to flow together. Graphic organizers allow students to have a visual representation of their ideas that will be the focus of the written text (Ewoldt & Morgan, 2017). Having a prewriting process allows the student to then just focus on developing their ideas into a well written piece prior to having to produce written output. Therefore, the student focuses on generation of ideas first and then transcribing instead of having to focus on both tasks simultaneously.

Further exploration of the literature identified an immense amount of empirically based articles that pertain to students with writing disabilities and the implementation of GO. In fact, GOs have been found to be particularly advantageous for students with learning disabilities in written expression (Baker et al., 2003; Dexter & Hughes, 2011). Students with learning disabilities have difficulties with writing due the higher level executive functioning skills, that must be deployed while writing, like students with TBI. In return, their writing is unorganized, poorly planned, does not include well developed thoughts and lacks major components of essays that help the student provide a quality essay. Santangelo et al. (2007) noted that GO's support a student's learning to write. Graphic organizers do this by simplifying the writing process by chunking up the task, providing steps to complete the task and help the student visualize the end product.

Deatline-Buchman and Asha (2006) completed a study that taught students with learning disabilities how to plan, write, edit and revise an argumentative essay. This was completed in multiple steps and phases. The first phase included the teacher instructing the students on the importance of argumentative writing, providing a sample of a well and poorly written argumentative written essay and teaching the students how to identify critical components in the essays. The second phase had the teacher model how to plan an argumentative essay by first thinking out loud and brainstorming some points she would like to include in her essay. Then the teacher put her ideas on a planning sheet. The teacher then modeled how to use the planning sheet to draft the essay. The students then wrote an argumentative essay. The teacher then taught the students how to edit and revise their work by using the COPS strategy (capitalization, overall appearance, punctuation, and spelling). Fading of instruction was then completed in order to help the students become more independent with their writing abilities. Students' argumentative essays were then scored based on the quantity and quality of their writing to see if instructing helped the students learn the proper tools to be able to write a well written essay. Quantitative measures in this study were number of words and planning and composing time and qualitative measures were PSSA quality index (focus, content, organization, style and conventions) and clarity and persuasiveness. Results demonstrated that the students written output increased in both quality and quantity across all measure and planning/writing intervention transfer effects were noted (p. 48). This study then provides evidence that teaching students with learning disabilities the skills that are need to plan and organize their writing can be possible.

Evmenova et al. (2016) explored the effects of a computer-based graphic organizer (CBGO) on students with high-incidence disabilities writing. Researchers examined the students written output for number of words, sentences, transition words, essay parts and an overall quality score

across three different conditions. These conditions included, using word processor without CBGO, using a word processor with CBGO and a maintenance phase. Results demonstrated that the CBGO condition improved the students quality and quantity of writing. Computerized GO's were also found to be effective for students with learning disabilities in a study completed by Gonzalez-Ledo et al. (2015). Results of this study indicated that computer-based GO's students increased written output, planning time and helped the students include more story elements in their written narratives.

Boon and colleagues (2018) conducted a comprehensive review of the literature in order to explore the effects that graphic organizers have on the written output of students with learning disabilities in grades K-12. Their findings demonstrated that graphic organizers were indeed effective in improving writing skills when writing narrative and expository essays. In particular, there were seven studies in this comprehensive review that focused on narrative writing. Gonzalez-Ledo et al., (2005) conducted a study on the use of a teacher-generated computer-based story map that was given to the students as a pre-writing tool. Results indicated that this particular intervention was helpful for students with specific learning disabilities to write a narrative piece. An additional study utilized a story map template that consisted of three columns. The first column included the stories' elements, the second column was used for the students to write down their ideas that were related to the stories' elements, and the third column was a self-check to guide students to make sure they were adding the stories' elements to their pieces. Results demonstrate that the intervention increased the number of story elements the students integrated into their written pieces (Martin & Manno, 1995).

An additional comprehensive search of the literature was conducted to identify articles that studied children and/or adults with TBIs and the use of a graphic organizer to increase the

quality of writing. The results of this search deemed that there are no known empirically based studies pertaining to this content area.

Purpose of this Study

In the current study, I examined the effects of a graphic organizer, coupled with speech-to-text AT upon the quality of writing of individuals who have sustained a TBI. While there are numerous studies that have examined the bypassing of transcription skill deficits, there are no known studies that have specifically investigated the effects of coupling the two accommodations described, particularly in reference to generation skill deficits. In order to improve the quality of writing for students with TBIs, investigations such as these are sorely needed in the extant literature so that better options are available to assist students with head injuries in getting back to maximum academic performance.

Summary

Traumatic Brain Injury (TBI) is a chronic health condition that can affect people of all ages. The Centers for Disease Control (2018) defines a TBI as a "disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (p. 5). TBIs can range in severity from mild to severe and are individualized based on the areas of injury, age of onset and level of severity. Some neurological consequences that can occur for individuals that have sustained a TBI are intellectual, language, orientation and alertness, motor, social-emotional/behavioral, executive functioning and academic skill deficits. One academic skill that is particularly affected by these injuries is writing. Since writing is an integral part of a student's academic day, the deficits in writing likely will affect an individual across subjects. One accommodation that has been found to be advantageous for individuals with TBI's is speech-to-text assistive technology. Speech-to-text helped students with TBI's increase

their written output but did not help them overall with their quality of writing. In school, students are required to provide quality written work. One way to increase the quality of a student's writing is with a graphic organizer. Many researchers have demonstrated the usefulness of graphic organizers as an accommodation for students with learning disabilities. However, no known studies have demonstrated or examined the usefulness of graphic organizers to increase the quality of writing for students with TBIs. Therefore, the current study examined the effects of a graphic organizer, coupled with speech-to-text AT upon the quality and quantity of writing for a student with a TBI.

Chapter III: Method

Participant and Setting

The participant that was recruited for this study was a high school student who had sustained a TBI and, as a result, has fine motor deficits. The participant attended a local school district located in Southwestern Pennsylvania. The researcher started with contacting an administrator that works for a special education intermediate unit. The administrator was responsible for a school that is known to service students with significant TBIs. The administrator agreed to let the researcher conduct the study at their school and identified a possible participant.

Then, the researcher emailed a parent permission form, a brief recruitment letter, and a child demographic form to the participants' parent. The child demographic form included various questions on it such as; the students' age, grade, and sex, the category in which the student is eligible for special education under the Individuals with Disabilities Education Act (IDEA), age in which the TBI happened, cause of TBI, indicators of injury severity and psychoeducational performance. The parent then reviewed, signed, and filled out the forms to give permission for their child to be included in the study and to provide the researcher with the proper background information. The participants' parent also gave further permission to gather additional information about their child through their Individualized Education Plan (IEP) and evaluation report. The forms were then printed and returned to the school with the child to give to the researcher. Within the permission form, the parent or guardian was encouraged to contact the researcher if they had any questions or concerns. The parent/guardian was also notified that their child would receive a tablet at the end of the study. Then, the special education administrator introduced the researcher to the intervention specialist that assisted with data

collection for this study. Next, a data collection schedule was created. The intervention specialist then introduced the participant to the researcher.

For the purposes of this study, the participant will be referred to as Brian. Brian is an 18-year-old, African American male enrolled in the 12th grade. When Brian was three years old, he fell out of a second-story window, which resulted in him sustaining a TBI. In 2017, Brian was evaluated using the *Wechsler Abbreviated Scale of Intelligence, Second Edition*, which assessed his cognitive profile (WASI-II; Wechsler, 2011). Brian's scores that he earned on the WASI-II were as follows: Verbal Comprehension Index = 64 (Vocabulary, T=32; Similarities, T=23), Perceptual Reasoning Index = 73 (Block Design, T=39; Matrix Reasoning, T=28) and Full-Scale Intelligence Quotient (FSQI) = 66. In 2020, Brian's teacher completed a *Vineland Adaptive Rating Scale-3* (Sparrow et al., 2016). Results revealed that Brian's adaptive functioning skills fell in the low to moderately low range. Academically, Brian's injuries have caused significant difficulties with his written expression skills, specifically with formulating complete sentences, spelling, and his expressive and receptive language skills.

The results of this evaluation determined that Brian was eligible to receive special education services under the primary disability category of TBI and secondary disability categories of Intellectual Disability and Speech and Language Impairment. Brian's current education needs require him to be educated in a life skills support classroom and receive intensive speech and language services.

Materials

Intelligibility Assessment. The *Assessment of Intelligibility of Dysarthric Speech* (Yorkston & Beukelman, 1984) is made up of a list of 50 random single words. The 50 words were randomly selected from the 600-word pool. The participant was then asked to repeat the 50

selected words back to the researcher. The researcher then judged if each word spoken by the participant was intelligible. This instrument was administered in order to estimate if the speech-to-text assistive technology could reasonably understand what the participant would speak.

Story Prompts. The participant was provided with six different story prompts during the six-day data collection period (i.e., one story prompt for the no accommodation handwriting control condition, one story prompt for the handwriting and graphic organizer condition, one story prompt for the speech-to-text condition, and three-story prompts for the speech-to-text and graphic organizer condition),

The story prompts were gathered and auto-generated from *AIMSweb* and were randomly selected for the purposes of this study (Powell-Smith & Shinn, 2004). An appropriate grade level story prompt was provided to the participant on a blank sheet of lined paper. An example of one of the story prompts that were selected for this study was, "I opened the front door very carefully and…". In order to evaluate the effectiveness of the interventions, each narrative was scored for Total Words Written (TWW), sentence complexity, mechanics, grammatical structure, and was assigned a story component score.

No Accommodation Handwriting Control Condition Materials. The participant was provided with a typed story prompt on the top of a lined sheet of paper. The lined paper was provided for the participant to write down their narrative that expanded upon the story prompt. The participant was also provided a sharpened pencil with an eraser. Additionally, the researcher used a stopwatch to time the participant to ensure a five-minute planning period and a ten-minute writing period. When the participant stopped before the allotted times, the experimenter recorded the time.

Handwriting Plus Graphic Organizer Condition Materials. The participant was provided with another typed story prompt on the top of a lined sheet of paper. The lined paper was provided for the participant to have space to write down their narrative that expanded upon the story prompt that they were given. In addition, the participant was given a graphic organizer on a piece of paper. The graphic organizer utilized for this study included headings that prompted the student to select a main idea, three supporting details, and a conclusion. These headings were chosen for the graphic organizer to set the participant up to include all the components of a quality essay. The graphic organizer was used for the participant to tell the intervention specialist what he wanted to write down during the five-minute planning period. The researcher and the intervention specialist prompted the participant to explain his ideas for his writing to fill out the organizer in completion. The participant was also provided a sharpened pencil with an eraser. The researcher used a stopwatch to ensure he was only allotted a five-minute planning period using the graphic organizer and ten minutes for writing. When the participant stopped prior to the allotted times, the experimenter recorded the time.

Speech-to-Text Condition Materials. The participant was provided with a tablet that had *Dragon Naturally Speaking* (*DNS*) installed on it. This software is a voice-recognition program. The tablet was equipped with a built-in microphone, so when the participant spoke, his words were dictated onto the tablet screen in text format. In addition, the student was provided with a lined sheet of paper with a story prompt on the top of it. The lined sheet of paper was used to present the story prompt to the participant. The researcher used a stopwatch in order to ensure that the participant was given a five-minute planning period prior to writing and then a ten-minute writing period. When the participant stopped prior to the allotted times, the experimenter recorded the time.

Speech-to-Text Plus Graphic Organizer Condition Materials. The participant was provided with another typed story prompt on the top of a lined sheet of paper. The lined piece of paper was only provided to present the story prompt to the participant. In addition, the participant was given a blank graphic organizer. The graphic organizer that was utilized for this study included headings that prompted the student to select a main idea, three supporting details, and a conclusion. These sections were chosen for the graphic organizer to set the participant up to be able to include all the components of a quality essay. The graphic organizer was used for the participant to tell the intervention specialist what he wanted to write down during the five-minute planning period. The intervention specialist and the researcher prompted him to tell her his ideas to fill out the organizer in completion. Again, the researcher used a stopwatch to ensure that the participant only explained their ideas to the interventionist for up to five minutes and only wrote for ten minutes. When the participant stopped prior to the allotted times, the experimenter recorded the time.

Experimental Design

The experimental design of this study can be considered a brief experimental analysis (BEA) case study. A brief experimental analysis is a single-case design that is most utilized to compare the effects of two or more interventions on a subject's academic performance or behaviors (Martens et al., 1999; Martens & Gertz, 2009). These procedures are also used to help determine which accommodation condition is the most effective for a student. Once the most effective condition is discovered, that condition is repeated to ensure the level of performance was maintained.

For the purposes of this study, a brief experimental analysis was utilized to compare the effects of four different experimental conditions: 1) a no accommodation handwriting control

condition, 2) a handwriting condition with a pre-writing exercise, in which a graphic organizer was utilized, 3) the application of speech-to-text and, 4) the application of speech-to-text along with a pre-writing exercise in which a graphic organizer was utilized. The purpose of the second and the fourth condition was to determine whether the graphic organizer improved the quantity and quality of the participants' writing.

For this study, one data point was collected for each experimental condition. The performance of each condition was evaluated to determine which condition had the best overall performance. The condition with the best overall performance was then repeated to confirm that the level of performance was maintained. Due to the variable performance on the most effective condition, one more data point was collected to establish the repeated effect. This allowed the study's findings to be able to be reported without reservations.

General Experimental Procedures

Need for Virtual Experimental Procedures. Due to COVID-19 mitigation efforts that were created by the Centers for Disease Control and Prevention (CDC), data collection could not be completed in person. Therefore, another plan to collect data was formulated by the dissertation advisor and the researcher. The school district that the participant attended had an intervention specialist that offered to help with the virtual data collection. The intervention specialist and researcher met through Zoom to meet and create a data collection schedule. After this schedule was made, Zoom meetings were set up for the agreed upon days.

Once the intervention specialist was given the tablet with the *Dragon Naturally Speaking (DNS)* software, she and the researcher met again in order to ensure that she understood how to turn on the application and how to start and stop the application from dictating. The intervention specialist and researcher then started the data collection. Prior to the start of each data collection

day, the researcher would send the proper materials that the intervention specialist would need to present to the participant. The intervention specialist would then print them out and have them ready for the participant. After the data were collected, the intervention specialist would scan or screenshot the participant's narrative, dictation and/or graphic organizers and emailed them to the researcher.

Intelligibility Assessment. Before implementing the BEA procedures, the researcher assessed the participant using the *Assessment of Intelligibility of Dysarthric Speech*. This assessment is made up of a list of 50 random single words. The 50 words are randomly selected from a 600-word pool. The researcher then said each selected word one at a time, and the participant was asked to repeat each individual word. The researcher judged if someone unfamiliar with the test would understand that word was spoken (i.e., the word was intelligible). This assessment took approximately 10 minutes to complete.

Speech-to-Text Training Session. Before the beginning of the experiment, the researcher provided the participant with an introduction and a training session to the software, *DNS*. Additionally, the researcher conducted a training session regarding the use of the built-in microphone, and tablet prior to the start of administration. Through this training, the participant learned about the purpose of the software, how to position the microphone in order to achieve a clear recording, and how to command the software to add punctuation and grammar to his writing. For example, the participant was told that he needed to prompt the software by saying "comma" or "period" to add punctuation where he found it appropriate during the writing period. In order to ensure all the equipment was working correctly, the participant practiced dictating. During this time, the experimenter asked the intervention specialist to check to ensure the audio was set to the correct volume for the ease of communication to the software for the participant.

The intervention specialist watched the tablet as the participant practiced to confirm that the set-up process was successful. Furthermore, a check for punctuation and grammar was done to make sure that the participant understood that he needed to command the software to add that for him. Ultimately, through this process, the experimenter increased the accuracy with which the program interpreted the participant's dictated narrative and made sure that he understood how to add punctuation and grammar to his writing. The *DNS* training session took approximately 10 minutes to complete. After the set-up was completed, the researcher had the participant read an AIMSweb story prompt out loud. This allowed the researcher to double-check on the equipment and let the student have further practice using the system.

Graphic Organizer Training. After the training for *DNS* was completed, the researcher provided the participant with training on how a graphic organizer is set up and the purpose of utilizing one. Through this training, the participant learned the use of a graphic organizer, how to fill one out and what components make up a well-written paragraph. The experimenter explained to the participant that a good paragraph includes a main idea, three supporting details, and a conclusion. The participant was also told that when he is asked to fill out the graphic organizer, the intervention specialist would write down his thoughts and prompt him to fill out each section of the organizer. In order to practice using a graphic organizer, the student was given an AIMSweb story prompt to read. After, he was asked to provide a main idea, three supporting details, and a conclusion. The intervention specialist and the experimenter walked the participant through each component to make sure he understood how a graphic organizer works. The graphic organizer training took approximately 10 minutes to complete.

No Accommodation Handwriting (H) Control Condition Procedures. Before the participant arrived for the session, the experimenter emailed a lined piece of paper with a typed

story prompted on top to the intervention specialist. The intervention specialist then printed this document. Once the participant arrived, he was provided with the blank lined sheet of paper with the typed story prompt on top. The lined sheet of paper was used for the participant to expand upon the given story prompt. The participant was also provided with a sharpened pencil with an eraser. The participant was instructed not to pick up the pencil until the instructions were completed and he heard the phrase, *"Now begin writing."* The participant was given a five-minute planning period to reflect on the story starter and ten minutes to write his narrative. A stopwatch was used to time the participant to ensure the participant was only planning (five minutes) and writing (10 minutes) for the allotted time. Prior to the start of the planning period, the participant was given specific oral instructions: *"You are going to write a story, First, I will read the beginning of a sentence, and then you will write a story about what happens next. You will have five minutes to think about what you will write and 10 minutes to write your story. Remember to do your best work. If you don't' know how to spell a word, you should guess. Do you have any questions?"* The participant then gave a response as to whether he had questions or not.

Additional oral instructions were given to start the planning period: *"Before you is a piece of lined paper with a story starter on top of it. For the next five minutes, think about 'Yesterday, a monkey climbed through the window at school and…' You will have five minutes to think about what you want to write. Tell me when you are finished."* The researcher then started the stopwatch for the five-minute planning period. After the time was up, the researcher said *"Stop,"* or when the participant indicated that he was finished, the researcher recorded the time.

Next, the participant was provided with another set of oral instructions: *"Now you will be given 10 minutes to write your story about the story starter on the top of the page that reads*

'Yesterday, a monkey climbed through the window at school and…' Now you tell me what happened next, now begin writing." The researcher started the stopwatch for the ten minutes writing period. If the participant stopped before the allotted time given on the writing period, the researcher asked, *"Do you have anything more to add?"* If the participant did not want to expand on his writing, the researcher then would record the time that he was completed with his narrative. If the ten minutes ended, the researcher commanded the student to *"Stop."* The intervention specialist then scanned over the students writing sample for scoring purposes.

Handwriting + Graphic Organizer (H+GO) Condition Procedures. Prior to starting this condition, the experimenter emailed a blank graphic organizer and a piece of lined paper with a typed story prompt on the top of it to the intervention specialist. The intervention specialist printed these two documents out ahead of time. During this condition, the intervention specialist helped the participant fill out the graphic organizer. Once the participant arrived, the lined sheet of paper with the typed story prompt on top and the graphic organizer was presented to him. The lined sheet of paper was used for the participant to expand upon the given story prompt. The graphic organizer was used for the participant to have his ideas in front of him and to organize his writing. The participant was also provided with a sharpened pencil with an eraser. The participant was instructed not to pick up the pencil until the instructions were completed and he heard the phrase, *"Now begin writing."* The participant was given a five-minute planning period to reflect on the story starter and 10 minutes to write his narrative. A stopwatch was used to time the participant in order to ensure the participant was only planning (five minutes) and writing (10 minutes) for the allotted time. Prior to the start of the planning period, the participant was given specific oral instructions: *"You are going to write a story. First, I will read the beginning of a sentence, and then you will write a story about what happens next. You will have*

five minutes to think about what you will write and 10 minutes to write your story. Remember to do your best work. If you don't' know how to spell a word, you should guess. Do you have any questions?" The participant then gave a response as to whether he had questions or not.

Additional oral instructions were given to start the planning period: *"Before you is a piece of lined paper with a story starter on top of it that reads 'Yesterday the children went for a picnic and…' Next to it is a blank graphic organizer. Now, we are going to fill out this graphic organizer together. You are going to be given five minutes to tell us your ideas for your writing. Remember that a graphic organizer is used to make your writing more organized and easier to formulate ideas. During these five minutes, Mrs. S will write down anything you tell us so that you may use it later in your writing."* The researcher then started the stopwatch to ensure that the participant was given five minutes exactly. In order to assist in completing the graphic organizer, the researcher provided set by step oral instructions: *"A good paragraph has a main idea. What is your main idea for this story? Mrs. S will write it down for you. Are you finished with that idea? Paragraphs usually have three supporting ideas. What is the first detail you want to add? Mrs. S will write it down for you. Are you finished with that idea? What is the next supporting detail you would like to add? Mrs. S will write it down for you. Are you finished with that idea? What is the third detail you want to add? Mrs. S will write it down for you. Are you finished with that idea? Paragraphs should end with a conclusion statement. What is your thought to wrap up this paragraph? Mrs. S will write it down for you. Are you finished with that idea?"* After the time was up, the researcher said *"Stop,"* or when the participant indicated that he was finished, the researcher recorded the time.

Then the researcher prompted the transition to writing the narrative by saying, "*Now you will be given 10 minutes to write your story about the story starter on the top of the page that*

reads 'Yesterday the children went for a picnic and…' Now you tell me what happened next, now begin writing." The researcher started the stopwatch for the ten-minute writing period to ensure the participant only wrote for the allotted time. During the ten-minute writing period, the researcher prompted the student to use the graphic organizer during their writing period time frame by saying: "*Your introduction idea was…Now write as much as you would like about that idea. Are you finished with that idea? Your first supporting detail was….Now write as much as you would like about that idea. Are you finished with that idea?" "Your second supporting detail was... Now write as much as you would like about that idea." "Are you finished with that idea? Your third supporting detail was… Now write as much as you would like about that idea. Are you finished with that idea? Your conclusion idea was…. Now write as much as you would like about that idea. Are you finished with that idea?"* If the participant stopped prior to the allotted time given on the writing period, the researcher asked, *"Do you have anything more to add?"* If the participant did not want to expand on his writing, the researcher then recorded the time when he was completed with his narrative. If the ten minutes ended, the researcher commanded the student to *"Stop."* The intervention specialist then scanned over the students writing sample for scoring purposes and the graphic organizer.

Speech-to-Text Assistive Technology (AT) Condition Procedures. By continuing to follow strict procedural guidelines, data points for the speech-to-text condition were collected. Before the participant arrived, the experimenter emailed a lined piece of paper with a typed story prompted on the top to the intervention specialist. The intervention specialist then printed this document. Once the participant arrived, he was provided with the lined sheet of paper with the typed story prompt on top. The lined sheet of paper was just used to present the story prompt. The intervention specialist then opened the tablet and started up *DNS.* The participant was

instructed not to touch or talk to the tablet until he heard the phrase, *"Now begin writing"* The participant was given a five-minute planning period to reflect on the story starter and 10 minutes to use the speech-to-text technology to dictate his narrative. A stopwatch was used to time the participant in order to ensure the participant was only planning (five minutes) and writing (10 minutes) for the allotted time. Prior to the start of the planning period, the participant was given specific oral instructions: *"You are going to write a story using the Dragon Naturally Speaking software program. First, I will read the beginning of a sentence, and then you will write a story about what happens next. You will have five minutes to think about what you will write and then 10 minutes to write your story by clearly speaking into the microphone and commanding the software to add grammar and punctuation when needed. Remember to do your best work. If you don't' know how to spell a word, you should guess. Do you have any questions?"* The participant then gave a response as to whether he had questions or not.

Additional oral instructions were given to start the planning period: *"Before you is a piece of lined paper with a story starter on top of it. For the next five minutes, think about 'We were paddling on a beautiful lake in the woods when our boat tipped over and…' You will have five minutes to think about what you want to write. Tell me when you are finished."* The researcher then started the stopwatch for the five-minute planning period. After the time was up, the researcher said *"Stop,"* or when the participant indicated that he was finished, the researcher recorded the time. After five minutes or less, the researcher orally instructed the participant again by stating, *"Now you will have ten minutes to use the Dragon app to write your story by clearly speaking into the microphone and telling the software to add punctuation and grammar when needed. Remember to do your best work. Now begin writing."* Once the participant said his first word, the researcher started the stopwatch and the intervention specialist hit the record button. If

the participant stopped prior to the allotted time given on the writing period, the researcher asked, *"Do you have anything more to add?"* If the participant did not want to expand on his writing, the researcher then recorded the time that he completed his narrative. If the 10-minute time limit was up, the researcher said, *"Stop."* The intervention specialist then screenshotted the student's dictated story and scanned it over to the researcher for scoring purposes.

Speech-to-Text Assistive Technology + Graphic Organizer (AT+GO) Condition

Procedures. Before the participant arrived, the experimenter emailed a blank graphic organizer and a piece of lined paper with a typed story prompted on the top to the intervention specialist. The intervention specialist then printed these two documents out. Once the participant arrived, he was presented with the lined sheet of paper with the typed story prompt on top and the graphic organizer. The lined sheet of paper was just used to present the story prompt. The graphic organizer was used for the participant to have his ideas in front of him and to organize his writing. The intervention specialist then opened the tablet and started up Dragon. The participant was instructed not to touch or talk to the tablet until he heard the phrase, *"Now begin writing"* The participant was given a five-minute planning period to reflect on the story starter and 10 minutes to use the speech-to-text technology to dictate his narrative. A stopwatch was used to time the participant in order to ensure the participant was only planning (five minutes) and writing (10 minutes) for the allotted time. Prior to the start of the planning period, the participant was given specific oral instructions: *"You are going to write a story using the Dragon Naturally Speaking software program. First, I will read the beginning of a sentence, and then you will write a story about what happens next. You will have five minutes to think about what you will write and then 10 minutes to write your story by clearly speaking into the microphone and commanding the software to add grammar and punctuation when needed. Remember to do your*

best work. If you don't' know how to spell a word, you should guess. Do you have any questions?" The participant then gave a response as to whether he had questions or not.

Additional oral instructions were given to start the planning period: *"Before you is a piece of lined paper with a story starter on top of it that reads 'I opened the front door very carefully and…' Next to it is a blank graphic organizer. Now, we are going to fill out this graphic organizer together. You are going to be given five minutes to tell us your ideas for your writing. Remember that a graphic organizer is used to make your writing more organized and easier to formulate ideas. During these five minutes, Mrs. S will write down anything you tell us so that you may use it later in your writing."* The researcher then started the stopwatch to ensure that the participant was given five minutes exactly. In order to assist in completing the graphic organizer, the researcher provided set by step oral instructions: *"A good paragraph has a main idea. What is your main idea for this story? Mrs. S will write it down for you. Are you finished with that idea? Paragraphs usually have three supporting ideas. What is the first detail you want to add? Mrs. S will write it down for you. Are you finished with that idea? What is the next supporting detail you would like to add? Mrs. S will write it down for you. Are you finished with that idea? What is the third detail you want to add? Mrs. S will write it down for you. Are you finished with that idea? Paragraphs should end with a conclusion statement. What is your thought to wrap up this paragraph? Mrs. S will write it down for you. Are you finished with that idea?"* After the time was up, the researcher said *"Stop,"* or when the participant indicated that he was finished, the researcher recorded the time.

The researcher then prompted the transition to writing the narrative by saying, *"Now you will have ten minutes to use the Dragon app to write your story by clearly speaking into the microphone and telling the software to add punctuation and grammar when needed. Remember*

to do your best work. Now begin writing." Once the participant said his first word, the researcher started the stopwatch and the intervention specialist hit the record button for the ten-minute writing period to ensure the participant only wrote for the allotted time. During the ten-minute writing period, the researcher prompted the student to use the graphic organizer during their writing period time frame by saying: "*Your introduction idea was…Now write as much as you would like about that idea. Are you finished with that idea? Your first supporting detail was….Now write as much as you would like about that idea. Are you finished with that idea?" "Your second supporting detail was... Now write as much as you would like about that idea." "Are you finished with that idea? Your third supporting detail was… Now write as much as you would like about that idea. Are you finished with that idea? Your conclusion idea was…. Now write as much as you would like about that idea. Are you finished with that idea?"* If the participant stopped prior to the allotted time given on the writing period, the researcher asked, *"Do you have anything more to add?"* If the participant did not want to expand on his writing, the researcher then recorded the time when he was completed with his narrative. If the ten minutes ended, the researcher commanded the student to *"Stop."* The intervention specialist then scanned over the students writing sample for scoring purposes and the graphic organizer.

Dependent Variables

One of the tools utilized in this study to measure the quantity of the student's written output was total words written (TWW), which is one of the measures for written expression curriculum-based measurement (WE-CBM). Noakes et al. (2019) used TWW in order to measure a student's written output to see if implementing the intervention speech-to-text AT would increase a student's written output. Results demonstrated that when utilizing speech-to-text AT, a student's written output did increase. Quality indicators that are more commonly used

for WE-CBM are correct written sequences (CWS) and Words Spelled Correct (WSC). These indicators are generally suitable measures to evaluate a student's handwritten samples. However, the participant in this study used speech-to-text AT in two of the conditions. Due to this, these indicators were no longer reflective of the student's quality of writing given the application of speech-to-text AT because the AT perfectly accommodated the student and produced words that were correctly spelled, which is a hallmark characteristic of WSC and CWS. Furthermore, CWS is largely a two-part test. In order to have a CWS, one must spell the word correctly and be grammatically correct. Since the AT fixed the spelling for the student, this measure was no longer valid. These quality indicators also do not measure the students' word choice, number of ideas, or sentence quality. To measure the student's quality of writing when utilizing AT accommodations accurately, it was critical to use an alternative method other than CBM's. Therefore, a rubric was used to measure the student's quality of writing in this study.

TWW. Total words written is a measure of the students' written output. A word is qualified as a word if it has any group of letters separated by a space and it is counted despite the spelling (Powell-Smith & Shinn, 2004). The way in which TWW is calculated is by underlining the isolated words produced and summing the total. For example, The rabbit jumped over the fence. In this case, the TWW equals 6. The participant's narratives for each condition had different amounts of written output.

Rubric. One measure utilized to evaluate the quality of the students' writing was a rubric created by Allen and his colleagues (2018). This rubric utilizes a four-point Likert scale in which the higher the score that the student received reflects the complexity of the piece. The components of this rubric measures are sentence complexity, mechanics, and grammar.

Sentence Complexity Rubric. The first component of the rubric was classified as sentence type. Scoring was laid out from zero to three. If the student earned a zero, it meant that the sentence did not contain any recognizable words. If the student earned a score of one, the sentence included at least one word to several legible words. A score of two meant that the student had written a complete simple sentence. When the student received a score of three, it meant that the sentence was either compound or complex.

Mechanics Rubric. The second scoring indicator was mechanics, which was also measured on the four-point Likert scale. Similar to the sentence type scoring, a zero was awarded for no use of capitals or punctuation, a one for initial capital letters or punctuation, a two for initial capital letters and correct punctuation, and three for no errors at all.

Grammar Rubric. The third measure of quality was grammatical structure. For this indicator, zero was awarded for a sentence that had multiple errors or the meaning of the sentence was unknown, one for two or more errors, or errors that changed the meaning of the sentence, two for one grammatical error that did not alter the meaning of the sentence, and three for a grammatically correct sentence.

Story Component Score. The second measure used to evaluate the students' quality of writing was a story component score. The student had the opportunity to earn a score from zero to five on this measure. Each narrative was evaluated for whether there was an introduction, three different supporting ideas, and a conclusion. Each of these components was worth one point.

Reliability and Validity of the Dependent Measures

TWW Reliability. According to the Powell-Smith and Shinn (2004), the test-retest reliability of TWW has been studied among many different researchers. Research has

demonstrated that test-retest reliability ranges for TWW are .42 to .91, which indicates moderate to strong correlations (Germann, & Deno, 1983; Marston & Deno, 1981; Marston, 1982; Shin, 1981; Tindal & Deno, 1983).

TWW Validity. Further investigation of the AIMSweb WE-CBM probes was conducted by reviewing and consulting the AIMSweb manual (Powell-Smith & Shinn, 2004) for the criterion validity of TWW. Research has demonstrated that TWW criterion validity ranges from .13 to .84, which indicates a wide range between weak and strong (Espin et al., 1999; Espin et al., 2000; Fewster & MacMillan, 2002; Gansle et al., 2002; Marston, 1982; Videen et al., 1982).

Written Expression Rubric. Many researchers use and create rubrics to target specific academic skills that they would like to evaluate. Written expression is a well-known academic area that is assessed with rubrics. Emerging research studies are focusing on pairing both a trait-based rubric with CBM measures in order to provide the most effective and accurate way to assess and capture a student's writing performance (Allen et al., 2018). Therefore, for this study, TWW and a rubric were used to evaluate the students' writing in order to capture a comprehensive representation of both the quantity and quality of the students' written pieces.

Treatment Integrity

A treatment integrity worksheet was developed to provide the researcher with a checklist to note the procedural steps completed for each of the four experimental conditions. The researcher completed this checklist for each condition. Furthermore, a graduate student was handed the same worksheet and sat in on two out of the six-day collection period in order to make sure that all experimental procedures were being completed. The graduate student checked off each procedure that was completed by the researcher. Overall, the researcher completed all of the procedures needed in these conditions.

Each writing sample was then scored by the researcher using WE-CBM criteria for Total Words Written (TWW), the rubric, and story components. The writing samples were then scored and verified by the dissertation advisor in order to calculate inter-scorer reliability of each of the conditions (H, H+ GO, AT, and AT+GO). The following formula was used to calculate inter-scorer reliability: Agreements/(Agreements + Disagreements) X 100 (AMSweb, 2004). The result of this calculation was that there was 98% agreement amongst scores.

Data Analysis Plan

A brief experimental analysis is a single-case design that is most commonly utilized to compare the effects of two or more interventions on a subject's academic performance or behaviors (Martens et al., 1999; Martens & Gertz, 2009). In this current study, a BEA analysis was used in order to measure the effects of the interventions (AT and GO) across four experimental conditions. These conditions included: 1) a no accommodation handwriting control condition, 2) a handwriting condition with a pre-writing exercise, in which a graphic organizer was utilized, 3) the application of speech-to-text and, 4) the application of speech-to-text along with a pre-writing exercise in which a graphic organizer was utilized. The participant's writing samples were then collected and scored for TWW, overall writing quality score, sentence complexity, mechanics, grammar, and number of story components. After the scoring was completed, the researcher entered the data into a graph form so that the data was able to be visually analyzed to determine which condition had the greatest amount of TWW and the highest total quality score. Once the most effective condition was determined, that condition was repeated to ensure the level of performance was maintained.

Research Questions

Research Question One: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, speech-to-text assistive technology or speech-to-text assistive technology with a graphic organizer result in greatest writing output (as measured by TWW)?

Hypothesis: AT+GO will result in greater TWW as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer, and the use of speech-to-text assistive technology.

Research Question Two: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, use of speech-to-text assistive technology or speech-to-text assistive technology with a graphic organizer result in greatest writing quality (as measure by overall writing quality score that included evaluation of sentence complexity, mechanics, grammar, and number of story components)?

Hypothesis: AT+GO will result in greater overall writing quality score as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer and the use of speech-to-text assistive technology.

Summary

A brief experimental analysis was utilized to compare the effects of four different experimental conditions (a no accommodation handwriting control, handwriting with graphic organizer, speech-to-text and speech-to-text along with a graphic organizer). Specific experimental procedures were followed, and a data point was collected for each of the four conditions. Each written or dictated narrative was then collected and scored by the researcher and dissertation advisor for TWW and overall writing quality that included evaluation of

sentence complexity, mechanics, grammar and number of story components. The data was then graphed and visually analyzed to determine which condition was the most effective to repeat that condition to ensure the level of performance was maintained.

Chapter IV: RESULTS

The purpose of this study was to evaluate the effects of speech-to-text assistive technology (AT) and use of a graphic organizer (GO) on the written expression of a student with a traumatic brain injury with marked fine motor deficits. Prior research conducted by Noakes et al. (2019) demonstrated that speech-to-text AT increased TBI student total words written and correct written sequences compared to a handwriting condition. This study extended that research by exploring if application of a written expression graphic organizer along with speech-to-text AT can further increase the total words written and writing quality of students with TBI.

Brief experimental analysis procedures were used to compare the effects of four different experimental conditions regarding Brian, a high school student who acquired a TBI at 3 years old. The first was a no accommodation handwriting control condition (H). The second was a handwriting condition coupled with use of a graphic organizer (H +GO). The third condition involved application of speech-to-text assistive technology (AT). The fourth condition applied speech-to-text assistive technology along with the use of a graphic organizer (AT+GO). The conditions were evaluated across six days of data collection with a single condition occurring in each session. The primary dependent variables of this study included total words written (TWW) and an overall writing quality score that included evaluation of sentence complexity, mechanics, grammar, and number of story components.

Research Question One: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, speech-to-text assistive technology or speech-to-text assistive technology with a graphic organizer result in greatest writing output (as measured by TWW)?

Hypothesis: AT+GO will result in greater TWW as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer, and the use of speech-to-text assistive technology.

Research Question Two: Compared to a no accommodation handwriting control condition, does handwriting with the use of a graphic organizer, use of speech-to-text assistive technology or speech-to-text assistive technology with a graphic organizer result in greatest writing quality (as measure by overall writing quality score that included evaluation of sentence complexity, mechanics, grammar, and number of story components)?

Hypothesis: At+GO will result in greater overall writing quality score as compared to the no accommodation handwriting control condition, handwriting with the use of a graphic organizer and the use of speech-to-text assistive technology.

Anecdotal Observations to Contextualize the Results

Review of Brian's handwritten product (H) revealed that he was handwriting unusually large letter sizes for his age. The size and accuracy of his letter formation was like that of a beginning writer. Furthermore, he was unable to spell or produce words correctly as he would string together random letters, without spaces, to mimic the writing of words that form a sentence. The handwritten product did not convey any meaning. This confirmed that Brian did possess impaired handwriting (i.e., fine motor) skills and might benefit from an assistive technology accommodation.

The legibility of Brian's handwriting improved during the handwriting plus graphic organizer condition (H+GO). This condition involved the on-site interventionist constructing a graphic organizer with Brian to guide his composition. Important to recall from the methodology section is that the interventionist carefully transcribed Brian's ideas onto the graphic organizer

given his impaired handwriting skills. The interventionist wrote with excellent penmanship. Brian was observed to actively use the graphic organizer in the H+GO to literally copy what the interventionist transcribed, but not elaborate on ideas much. This resulted in great increased in measurable total words written and writing quality indicators within the H+GO condition, as compared to the no accommodation handwriting control condition.

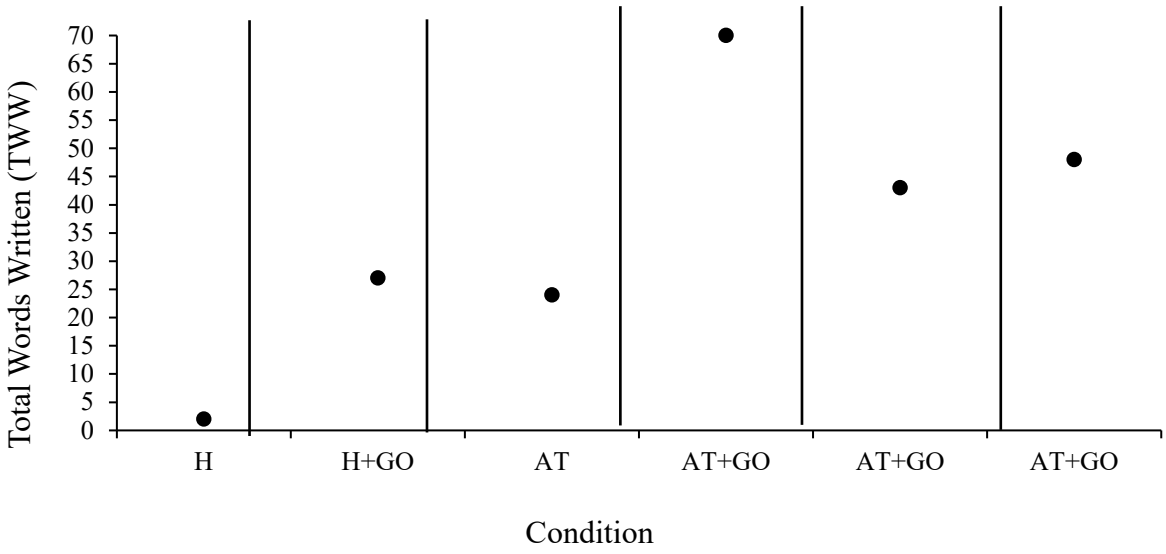
Total Words Written (TWW)

Figure 1 displays TWW for each experimental condition applied within the BEA for Brian. Under the no accommodation handwriting control condition, Brian produced 2 TWW. Application of each subsequent condition resulted in higher TWW. Use of the graphic organizer resulted in a greater number of TWW (27). When the AT condition was applied next, Brian's TWW increased by 2 to 24 TWW. Brian's TWW was greatest when the fourth condition was implemented, AT+GO (70 TWW). Brian used the graphic organizer to orient himself to what he wanted to produce and verbalized more information than was present on the graphic organizer.

Visual analysis of the level of each data point revealed that the AT+GO condition resulted in the greatest TWW. Consistent with BEA procedures, this condition was repeated to verify that the level of performance would be maintained and remain greater than the other three experimental conditions. Results revealed that the second and third application of the AT+GO maintained a higher level of TWW (43 and 48, respectively), compared to the other three conditions. In sum, the H+GO condition results in the greatest amount of written output – and written output that conveys meaning – for Brian. The next section conveys which of these conditions resulted in the greatest writing quality for Brian.

Figure 1

Total Written Output



Writing Quality Indicators

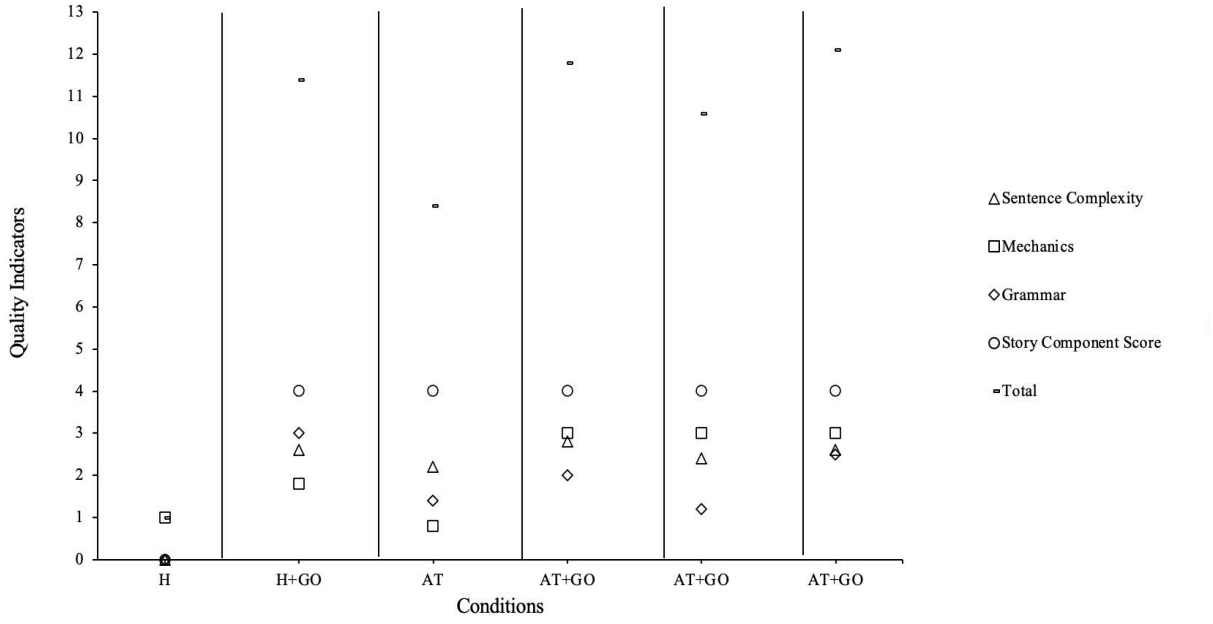
Figure 2 displays the total writing quality value, as well as the sentence complexity, mechanics, grammar, and story component scores for each respective condition. Consistent with TWW analyses, the no accommodation handwriting control condition resulted in the poorest performance across conditions. Brian earned 1 total quality point as he earned only 1 point for writing Mechanics. Brian earned one point for including an initial capital letter. Next, the H+GO condition was applied. This condition resulted in increased total writing quality as that sample earned a score of 11.4. Third, the AT condition was tested with Brian. This sample resulted in a total quality score of 8.4 which is lower than the H+GO condition. Again, recall that Brian used the graphic organizer to copy words that he dictated to the interventionist. The fourth condition applied was the AT+GO condition and this condition resulted in the greatest total score of the four conditions (11.8).

Because AT+GO resulted in the greatest TWW and total writing quality score, it was repeated to verify that the level of performance would remain the greatest of all four

experimental conditions applied with Brian. The reapplication of the AT+GO condition resulted in a slightly lower total writing quality performance (10.6). This performance dipped below that of the second condition, H+GO. At this point in BEA procedures, the superiority of AT+GO with respect to total writing quality was not maintained. Visual analysis of the specific quality indicators revealed that Brian's grammar score was next to lowest in this replication condition, with only the no accommodation handwriting control condition being lower (and not decipherable). The other writing quality indicators remained relatively stable. Also note that the superiority of AT+GO with respect to TWW was maintained after the first replication. Taking these facts together, it was determined that AT+GO would be replicated again. The value of the total writing quality score then increased to 12.1, and greater than the H+GO value obtained in the second experimental trial.

Figure 2

Performance of Quality Measures



Note. The total writing quality score for the H condition is 1 as only the Mechanics indicator earned a point.

Treatment Acceptability

Treatment acceptability was examined across the participant and intervention specialist. Treatment acceptability is the extent in "which intervention strategies are seen as fair, reasonable, feasible and appropriate by consumers for addressing behavioral or academic concerns" (Kazdin, 1980; Kazdin, 1981). Brian reported that using the tablet with *DNS* on it and graphic organizers will help him in his academic classes and to be able to write more clearly. The intervention specialist noted that both accommodations used in this study are easily implemented in the classroom and were effective.

Summary

Overall, AT+GO resulted in the highest performance for total writing quality when examining two out of the three attempts. Furthermore, AT+GO consistently resulted in greater written output (TWW). Although editing was not a focus of this study, TWW allows for more written output to be produced and therefore allows for more opportunities for editing to be conducted without handwriting being necessary (his impairment). Given the consistently highest TWW performances, AT+GO performances, and the practical implications of Brian's poor handwriting skills and practical implications just stated, data suggest that AT+GO would be the intervention condition that manifests in the greatest writing potential for Brian.

Chapter V: DISCUSSION

A traumatic brain injury (TBI) is defined as "a disruption in the normal function of the brain that can be caused by a bump, blow, or jolt to the head, or penetrating head injury" (p. 5). Traumatic brain injuries can range in severity from "mild" (e.g., related to a brief change in mental status or consciousness) to "severe" (e.g., related to an extended period of unconsciousness or memory loss after the injury" (Centers for Disease Control and Prevention [CDC], 2017, p. 1). The manifestation of a TBI can widely vary and depends on the area(s) of the brain implicated, the age at which the TBI occurred, the time since injury, injury severity, and other environmental factors, like family functioning (Yeates, 2010). Although mild TBIs are the most common injury seen in emergency rooms, more severe TBIs can be debilitating, requiring children to need specialized medical or educational services post-injury. Furthermore, in more severe cases, these injuries can lead to death (CDC, 2018).

Researchers have studied the outcomes that brain injuries have on an individual's functioning (e.g., Bazarian et al., 2009; Li & Liu, 2013; Schwart et al., 2003). Common neuropsychological deficits associated with TBI include decreased intellectual and academic functioning and motor, attention and executive functioning skills (Anderson et al., 2004; Ewing-Cobbs et al., 2004; Kuhtz-Buschbeck et al., 2003; Yeates, 2010). The current study focused on the intersection of TBI during the school years and the ability of a student with a TBI to communicate through writing. A TBI can impact a student's written expression through deleterious effects on fine motor and executive functioning skills, which in turn impacts a student's ability to transcribe, generate ideas, organize, plan, and use their working memory in order to produce a written narrative. At least one previous study has demonstrated that speech-to-text assistive technology (AT) can improve the written output of students with TBIs.

Noakes et al. (2019) demonstrated that by using speech-to-text assistive technology, a student with a TBI could increase their written output by bypassing often impaired handwriting skills. However, the overall quality of student writing, as gauged by number of distinct ideas, use of supporting details, and logical organization, in that study did not appreciably improve. The need for further study of the writing of students with TBI was evident as teachers, and future employers, evaluate not only the quantity of writing, but also the quality of one's writing.

Graphic organizers (GOs), like the one used in this study, can help students plan and organize their writing. They also can provide the student with a memory aid to allow the student to focus more mental effort on producing quality written work. Graphic organizers can also be used to help students remember to include important components of a written composition. The present study aimed to study the implementation of speech-to-text AT (*Dragon Naturally Speaking*) and graphic organizers to determine if quality indicators, as well as writing quantity indicators, can be increased in a student with a TBI. This study specifically studied if TWW, overall writing quality score, sentence complexity, mechanics, grammar, and number of story components can be improved.

Previous studies have examined the effects of the use speech-to-text AT on individuals with learning disabilities and TBIs written output (Beers et al., 2017; Noakes et al., 2019). Research has also demonstrated that utilizing graphic organizers increases the quality of an individuals with learning disabilities writing (Ellis & Howard, 2007; Ewoldt et al., 2017; Gozalez-Ledo et al., 2015; Singleton & Filce, 2015). However, no known study has investigated the effects of coupling the two commonly used educational accommodations (AT and GO) in order to increase the quantity and quality of writing for a student with a TBI. Therefore, a brief experimental analysis was used in order to explore the effects that these accommodations had on

the writing of a student with a TBI. A brief experimental analysis is defined as a single-case design that is most commonly utilized to compare the effects of two or more interventions on a subject's academic performance or behaviors (Martens et al., 1999; Martens & Gertz, 2009). The four conditions examined in this study were the no accommodation handwriting control (H), handwriting plus graphic organizer (H+GO), assistive technology (AT) and assistive technology plus graphic organize (AT+GO).

The participant within this study was Brian, an 18-year-old African American male that had sustained a TBI as a result of falling out of a second-story window. He was three years old when he sustained this injury and has been being educated in a self-contained classroom for students with significant intellectual disabilities. Brian had significant fine motor deficits that impacted his written expression skills. As a result, he was a good candidate for participation in this study. Prior to the start of the study, Brian was trained on how to use both *Dragon Naturally Speaking* and the graphic organizer. In addition, the researcher and the intervention specialist facilitated a practice run with Brian on how to use speech-to-text technology and how to complete a graphic organizer with a story prompt.

The procedures of this study were modified due to the impact of the COVID-19 pandemic and restrictions against visitor in public schools. As a result, the experiment was implemented through the Zoom (i.e., researcher was present through Zoom) and the assistance of an in-person school district interventionist. The intervention specialist worked with the primary researcher via Zoom to assist in completing the experimental procedures, as was common during the time period of the present data collection (Florell et al. 2020). The intervention procedures were conducted in real time, though the materials that were used in each condition, graphic

organizers and Brian's written output, were sent to the researcher by the intervention specialist through email.

Qualitative data was collected during each of the handwriting conditions. It was observed that Brian formed unusually large letter sizes when writing for his age. Brian's handwriting skills were indicative of a beginner writer. In addition, Brian had difficulty spelling or producing legible, meaningful words and properly spacing letters and words apart. These observations allowed us to confirm that Brian had impaired fine motor skills and may benefit from the use of speech-to-text AT.

BEA techniques were applied across the four experimental conditions, which resulted in varied performance when calculating Brian's total words written. In the no accommodation handwriting control condition (H), Brian's written output resulted in a score of 2 TWW. Brian's writing in this condition was a string of random letters that were unidentifiable. The second condition, H+GO, resulted in Brian producing 27 TWW. During this condition, Brian was able to write significantly better and produce more written output due to copying exactly what the interventionists wrote on the graphic organizer. In the AT condition, Brian's written output resulted in a score of 24 TWW. For this condition, Brian independently used the technology to expand on a story starter. These results are comparable to what has been found in previous studies noting that AT improves total written output compared to handwriting. The final condition, AT+GO resulted in Brian having 70 TWW. Therefore, it was determined that AT+GO was the condition that resulted in the greatest amount of written output even across the repeated conditions. Especially noted is that Brian's written output in this condition was meaningful and identifiable, unlike when he produced a handwritten story independently. Overall, visual analysis of Brian's results of his written output reveals a positive pattern with, the lowest TWW occurring

at the no accommodation handwriting control condition and the highest TWW at AT+GO. However, this study was examining beyond what previous research had already determined, AT is an effective intervention to increase written output, this study was also looking at improving the quality of a student's written output that has a TBI.

Brian's written output was further analyzed to determine the effects of the interventions on the quality of his writing across the four conditions. For the no accommodation handwriting control condition, Brian earned a total quality score of 1. As previously stated, Brian's written output, when independently handwriting, was a string of random letters that were unidentifiable. The next condition, H+GO, Brian earned a score of 11.4. Again, for this condition, Brian wrote down verbatim what the intervention specialist wrote on the graphic organizer and did not expand on the story starter. The third condition, AT, resulted in Brian earning a total quality score of 8.4. With the use of AT, Brian was able to independently expand upon a story starter. However, this condition produced a lower total quality score. The last condition, AT+GO, resulted in Brian earning his highest total overall quality score of 11.8. In order to follow BEA techniques, the AT+GO condition was repeated in order to verify that the level of performance would remain the greatest in the AT+GO out of all four experimental conditions applied with Brian. The first repetition of the application of AT+GO was slightly lower than what was expected resulting in a score of 10.6. This total quality score was lower than the H+GO condition, therefore; Brian's overall score for total quality was not maintained. Visual analysis of all individual measures of quality remained relatively stable across the application of AT+GO. In addition, AT+GO continued to be the most effective condition when looking at TWW across all four conditions. Therefore, it was determined that AT+GO would be replicated an additional time. Brian's overall total quality score then increased to 12.1 and was then greater than H+GO.

Thus, the AT+GO condition was determined to be the intervention condition that would allow Brian to provide his greatest writing in terms of quality and quantity.

Implications of the Findings

Interventionist can use BEA techniques in order to test out different interventions and combinations of interventions. Completing this preliminary research allows for researchers to make an informed decision regarding which intervention or combination of interventions work best for an individual student. As previously discussed, researchers have already discovered that AT can increase an individual's written output, which is not a surprising result. This recent study used BEA techniques and determined that using GOs plus AT can increase a student with TBI's quantity and quality of writing. Therefore, results of this study have meaningful implications for students and individuals with TBIs and interventionists who work with persons with TBIs.

One important implication is that these accommodations require little training and are both efficient to implement. These interventions are already used within the educational setting for other students with or without learning disabilities. Therefore, schools would be able to utilize the findings of this study to help students with TBIs communicate more clearly. As previously noted, prior to the use of any of the accommodations or combining of the accommodations, Brian's written output was not detectable and instead was a string of random letters that did not produce meaning. Furthermore, both Brian and the intervention specialist found using the tablet with *DNS* and a graphic organizer was feasible, easily implemented, and an effective way to address fine motor and executive functioning deficits that impact the written expression of an individual with a TBI.

Another way in which these findings are useful is that it may allow and help other students with TBIs by giving them a way to participate in school without as many limitations.

Written expression is an important skill when it comes to learning because writing is required across all subjects. These accommodations gave Brian the opportunity to provide written quality work that is required in a school setting. Therefore, allowing individuals to participate in written assignments that help students further analyze information that has been taught in the classroom.

In addition, these results may allow for individuals with severe TBIs to have more job opportunities than what was previously thought possible. This is due to many jobs requiring individuals to be able to write and clearly communicate. An example of a job that could use these accommodations could be an office job that requires an individual to transfer written records or notes over to electronic copies. Another example could be a job that requires an individual to disseminate information to a company from a typed-up advertisement via email. These accommodations gave Brian the means and allowed him to exhibit the skills required to be successful at a job like the one described.

Limitations and Future Studies

Although this study filled a significant gap in the TBI literature and discovered important findings for individuals with TBIs that have fine motor and executive functioning deficits, this study did not go without limitations. One of the limitations of this study was that this data was only collected with a single individual with a TBI. Due to previous research, we know that individuals with TBIs experience a variety of deficits and outcomes. Therefore, these results can only be understood with the context of Brian, including the nature and severity of his injury, time since injury, and current complement of neuropsychological and functional skills.

Therefore, a future study could examine if the outcome of this study would remain similar using the same experimental procedures but with more participants that have different

areas of injury, age of onset and level of severity. A larger, more diverse sample size would allow these results to be further generalized across the population of individuals with TBIs.

Another limitation is that this experiment had to be completed entirely remotely due to COVID-19. Therefore, the researcher was not able to administer all the experimental procedures and needed to communicate and work with the intervention specialist through Zoom in order to execute the experiment. The intervention specialist was however, given specific instructions and scripts to reproduce what the researcher would have done if the study had been completed in person. Therefore, the researcher was still in control of all the experimental procedures. A future study may be able to be completed with just one individual collecting data and running the experimental procedures making it more straightforward and less complicated.

Another study could examine the current study's experimental procedures over a more extended period of time. Therefore, collecting additional writing samples and using the assistive technology and graphic organizers for longer. By implementing these accommodations longer, it could allow us to see if the student's ability to independently use the accommodations increases. It would also allow us to see if the AT would increase in accuracy due to more time being able to be spent training the Dragon software to the individuals speaking patterns.

Furthermore, the current study procedures may be used to explore the effects of using a variety of different graphic organizers in combination with AT on individuals with TBIs written output. In addition, a future study could examine the effectiveness of the use of AT and a graphic organizer when a student is asked to produce different writing styles (i.e., expository, persuasive, creative and descriptive). Intuitively, this would require a different structure of graphic organizer.

Finally, TBIs are one of the many neurological disorders that have fine motor and executive functioning skill deficits. Spina bifida is a neural tube defect that occurs in an early stage of embryonic development and may impact fine motor movement (CDC, 2020). This condition has various outcomes that can result from malformation of the spinal cord but one of the deficits that can result from this is fine motor difficulties. Another condition that causes fine motor difficulties as a result of genetic mutation is muscular dystrophy (CDC, 2020). Over time, muscles weaken and one of the ways that an individual can be affected is by their motor skills decreasing. Therefore, this study could also be replicated in order to examine the effects that these accommodations have on these conditions written expression skills.

Conclusion

In conclusion, speech-to-text technology along with the use of a graphic organizer, was the most effective across all four conditions when analyzing a student's written output for both quality and quantity. By applying these accommodations in combination, Brian's overall quality and TWW increased significantly. Before any accommodations were provided, Brian's handwriting was illegible, unidentifiable, and comprised of a string of random letters. These findings can be applied to help individuals with TBIs with their academic requirements, to be able to communicate more clearly and could afford more job opportunities for them in the future by assisting them to not only being able to produce written output but also help them to provide writing that is of quality.

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