

AN EXAMINATION OF MOTOR SKILLS IN CHILDREN WHO STUTTER

A Dissertation

by

ANDREW MARTINEZ JR.

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2012

Major Subject: School Psychology

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Approved by:

Chair of Committee,	Cynthia A. Riccio
Committee Members,	Carl Gabbard
	David Wright
	Glenda Byrns
Head of Department,	Victor Willson

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ABSTRACT

An Examination of Motor Skills in Children Who Stutter. (August 2012)

Andrew Martinez Jr., B.S., Texas A&M University

Chair of Advisory Committee: Dr. Cynthia A. Riccio

Recently, research has postulated that stuttering is a motor disorder that results from brain abnormalities within the central nervous system. Based on evidence of numerous irregularities within various motor systems, it has been suggested that other motor domains may be comprised. In particular, research in individuals who stutter has found fine, gross, and visual-spatial motor impairment. These studies, though, are dated, have numerous methodological concerns, or yielded contradictory results. Thus, this study investigated whether motor skills in children who stutter (CWS) were compromised. Fine motor skills are important in a school environment because students are required to utilize these skills to complete various assignments and projects, such as cutting and folding paper. Gross motor skills are equally as important as children use these skills to move around their environment. Visual-spatial motor skills are vital for children as they are often required to copy notes off of the board. Deficits in any of these areas may have potentially harmful effects on school performance. Thus, in a school setting, school psychologists are a valuable asset, as they are trained to consult and work with “at risk” populations to prevent long-term problems. Given the potential

motor deficits in CWS, school psychologists can intervene and provide appropriate accommodations to remediate any motor deficits.

Participants included 12 CWS and 12 children who do not stutter (CWNS). Participants were recruited from a large urban school district and were administered the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (Bruininks & Bruininks, 2005; BOT-2). Parents completed a demographic questionnaire. One Way Analyses of Variance (ANOVAs) were calculated to compare group means. Results indicated that CWS performed poorer on all but one motor area. Given these results, when a child is identified with a disfluency problem, a broader consideration of issues that may be facing the child is warranted. In particular, school psychologists are in a position to intervene and provide appropriate services to an “at risk” population (i.e., CWS) by conducting a brief motor assessment to identify motor strengths and weaknesses. If warranted, school psychologists can provide accommodations and services to address any identified weaknesses in motor areas.

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CHAPTER I

INTRODUCTION

Stuttering is a speech communication disorder that affects the fluency of one's speech (Ludlow & Loucks, 2003). Buchel and Sommer (2004) defined stuttering as a "disruption in the fluency of verbal expression characterized by involuntary, audible or silent, repetitions or prolongations of sounds or syllables" (p. 159). Approximately 5% of the population, at some time in their life, will stutter, regardless of gender, ethnicity, social class, and language. Stuttering, however, will only persist throughout the lifetime for less than 1% of individuals. Onset typically occurs in early childhood, between the ages of 2 and 5 years (Buchel & Sommer, 2004; Davis, Howell, & Cooke, 2002; Zebrowski, 2003); but by the age of 16, 80% of children who stutter (CWS) will recover naturally or with the help of speech therapy (Andrews et al., 1983). Researchers have yet to identify specific factors that enable a person to become more fluent. Onset occurs equally in males and females, but females are more likely to recover naturally, thus, the long-term male to female ratio for CWS is approximately 3:1 (Zebrowski, 2003).

CWS are primarily serviced by Speech -Language Pathologists (SLP/CCC). SLPs assess CWS based on their speech rate and language skills. Further, if disfluency is observed, the SLP will examine the type, severity, and frequency of the disfluency. Following identification of a CWS, SLPs generally provide speech therapy services that are targeted at increasing one's fluency (Bloodstein & Ratner, 2008). Stuttering is often

This dissertation follows the style of *School Psychology Review*.

portrayed as a silent disorder because the characteristics of stuttering are not readily visible; thus, other associated but detrimental effects may go unnoticed. In particular, CWS often experience significant fine or gross motor coordination difficulties in childhood, as well as mental health issues later in life. In childhood and adolescence, research has demonstrated that CWS often have lower social status and are ostracized by their peers (Davis et al., 2002). CWS may also experience negative psychological symptoms, such as depression and anxiety (Bloodstein & Ratner, 2008), which often continue into adulthood (Iverach et al., 2009). In addition, adults who stutter (AWS) often report experiencing lower self-esteem (Klompas & Ross, 2004), the belief that stuttering negatively affects their job performance (Klein & Hood, 2004), and problems with identity construction (Daniels & Gabel, 2004). CWS often do not receive services for these associated negative outcomes; in fact, these outcomes are often neglected. Many times school personnel assume that stuttering only affects a student's speech or are unaware of the possibility of additional concerns; thus, fluent speech becomes the primary issue addressed through intervention. While SLPs are highly trained to provide adequate speech services, they are often ill-equipped to provide other services (e.g., counseling, evaluation of other motor skills) that CWS may require. While the identification of concomitant areas of need is beyond the scope of this paper, the awareness of these psychosocial effects are important as they may precipitate further impairment in other areas.

Fine, Gross, and Visual-Spatial Motor Skills

In addition to speech and psychosocial problems, CWS often show broad deficits across a broad range of motor skills. This paper will investigate three types of motor skills (1) gross motor skills, (2) fine motor skills, and (3) visual-spatial motor skills. Gross motor skills are movements that utilize large muscle or whole body movements (Hughes & Riley, 1981). Some examples of gross motor skills include walking, jumping, and running. Fine motor skills are movements that involve small muscle movements. Some examples of fine motor skills include drawing, writing, and manipulating objects. (Gabbard, 2008). Visual-spatial motor skills are the ability to coordinate visual abilities with body movements (Gabbard, 2008). Some examples of these skills include copying pictures and shapes or responding to visual stimuli through motor acts.

In general, children develop motor skills as they age, with earlier acquired skills forming the basis for the development of more complex motor skills (Gabbard, 2008). In a school setting, motor skills play an intricate part of a student's functioning, as some researchers believe that sensory-motor functions and attentional processes "serve as the essential building blocks for all of the other-higher cognitive processes" (Miller, 2007, p. 95). Students use their gross motor skills to ambulate through the environment (Decker & Davis, 2010; Hughes & Riley, 1981), while fine motor skills are required to complete many everyday tasks, such as writing, drawing, copying, and cutting (Decker & Davis, 2010). Visual-spatial motor skills are equally as important, as students are required to transcribe notes, often from a board or overhead, as well as transpose answers onto

response booklets (Decker & Davis, 2010; McHale & Cermak, 1992). Impairment in any of these abilities may have significant effects (Decker & Davis, 2010). Deficits with gross motor skills may lead to diminished interactions within a school environment that can limit or impact social engagement (Decker & Davis, 2010; Hughes & Riley, 1981). Fine motor deficits may result in overt characteristics, such as illegible handwriting; this in turn may result in difficulty reading one's own notes (Begyn & Castillo, 2010). Visual-spatial motor difficulties may result in slow and/or difficulty writing and copying information from the board (Decker & Davis, 2010).

As a result of impaired motor skills, a student can experience a range of deleterious effects in the school setting. For example, academic performance may be influenced by an inability to study for assignments or examinations due to illegible or poorly written notes caused by fine motor deficits or incomplete notes caused by visual-spatial motor deficits. Difficulties over time may lead to avoidance of tasks (i.e., class assignments not completed, homework not turned in). Also, with the growing trend towards standardized testing, students are required to transpose answer choices onto a response booklet. A weakness in visual-spatial motor skills may inadvertently affect one's performance, as one incorrectly "bubbled in" answer may trigger more incorrect responses. Furthermore, some of the more subtle fine, gross or visual-spatial deficits mentioned above may exacerbate learning problems (Decker & Davis, 2010) or result in a "snowball effect," in which trivial deficits lead to larger problems in the future. For example, if a student has incomplete or illegible notes from one particular day, they may not understand material presented later that built off of the previous lessons. These

problems may continue to exacerbate depending on the lesson missed. These are just a few illustrations where “subtle” deficits may lead to negative outcomes. It is clear, though, that motor deficits may negatively impact a student’s performance within the school environment.

Implications for School Psychologists

School psychologists are generally trained to intervene and potentially prevent long term psychological effects due to CWS, such as therapeutic interventions targeted at reducing emotional distress. In addition, some school psychology training programs are producing clinicians capable of expanding the traditional role of school psychologists. These programs are incorporating new initiatives, such as conducting neuropsychological assessments and advocating for preventive care. One component of school-based neuropsychological evaluations is the measurement of sensory-motor functions (Miller, 2010). Given the neurological implications of stuttering (discussed in chapter II), and the related effects on motor skills, school psychologists following Miller’s model may be able to evaluate and provide appropriate recommendations in conjunction with other related service personnel (SLPs, occupational therapists, physical therapists). Specifically, a school psychologist might administer a motor functions instrument to an “at-risk” student (i.e., CWS) to determine if additional motor deficits were present. If deficits were observed, the school psychologist could offer functional accommodations (e.g., note taking assistance) based on the deficits. Early identification of deficits allows earlier interventions to remediate these deficits (Goodway & Branta, 2003).

Statement of the Problem

For CWS, their difficulties are not limited to speech motor disfluency, but may also be evident in other motor areas. When the potential for a full range of motor deficits and disfluency are taken together, without appropriate intervention, CWS are at risk, not only for negative school outcomes, but less than optimal mental health outcomes. This study focused on the possible relationship that may exist between CWS and motor skills, as well as comparing the motor skills of CWS with children who do not stutter (CWNS). Information regarding the types of motor deficits that may be present may be useful to school psychologists, and other school personnel (e.g., occupational therapist, physical therapist), in providing adequate services for remediation or accommodation. It is important to note that the services would need to be individualized due to the unique presentation of motor abilities in CWS.

CHAPTER II

LITERATURE REVIEW

While no specific theoretical model postulates motor impairment in CWS, related research has provided the basis for such a proposal. Research supporting the proposal will be discussed in six major divisions: (1) motor systems and their role in motor acts, (2) the etiology of stuttering, (3) brain abnormalities in AWS and CWS, (4) brain anomalies in areas strongly associated with motor acts, (5) the theory that stuttering is a motor disorder, and (6) research on motor skills in AWS and CWS. Collectively, this review will provide the framework for the belief that motor skills may be impaired in CWS.

Motor Acts

First, a brief review of motor acts and the various systems involved is warranted. Motor acts are the result of an “elaborate network of multiple, hierarchically organized feedback loops” (Blumenfeld, 2002, p. 220). In this hierarchy theory, the primary motor cortex (PMC) is at the top and oversees all motor acts; however, competing theories have suggested that motor systems work in parallel to produce movements (Zillmer, Spiers, & Culbertson, 2008). Nevertheless, it is apparent that motor acts are the result of complex communication between multiple cerebral systems through various pathways. Prominent motor systems include the PMC, the secondary motor cortex (SMC), the basal ganglia (BG), and cerebellum (Blumenfeld, 2002; Zillmer et al., 2008).

Located within the frontal lobes, the PMC’s primary role is to supervise details required to perform motor acts. Dysfunction or stimulation to the PMC may result in

minor impairment such as twitching or jerking, or severe impairment, such as the loss of voluntary actions (Zillmer et al., 2008). Also located within the frontal lobes, in a region known as Brodmann's area 6, the SMC organizes and sequentially times movement. The SMC consists of the supplementary motor area (SMA), the premotor area (PMA), and the cingulate motor area (CMA). The SMA is involved in planning sequential motor activities, while the PMA is involved in motor planning, sequencing, and movement readiness. Not much is known about the CMA; however, it is believed to mediate emotional and motivational aspects of movement (Zillmer et al., 2008).

Two other noteworthy systems involved in motor acts are the BG and cerebellum. These systems modulate the output of motor systems and project them back to the motor cortex via the thalamus (Blumenfeld, 2002). The BG are a group of nuclei that are associated with motor acts, and is comprised of the caudate nucleus, putamen, globus pallidus, subthalamic nucleus, and substantia nigra. The caudate nucleus and putamen are known as the striatum and receive all the input to the BG, while the globus pallidus and substantia nigra are responsible for all output (Blumenfeld, 2002). Further, the BG is implicated in various pathways that result in motor movement. In specific, the motor circuit (i.e., BG-thalamocortical circuit) is a well known pathway where inputs travel through the BG and are outputted to the thalamus. From the thalamus, inputs travel to the SMA, PMA, and PMC (Blumenfeld, 2002). Within this pathway, dopamine, a neurotransmitter, plays an important role (Zillmer et al., 2008). As will be discussed later in this review, dysfunction within the BG results in abnormal motor acts (Blumenfeld, 2002; Zillmer et al., 2008). The cerebellum is another system

that influences motor movement and effects coordination, precision, and accurate timing (Zillmer et al., 2008). The cerebellum is divided into three parts. The first part, which consists of the vermis and flocculondular lobes, regulates eye movement and balance. The intermediate part is involved in controlling muscles in the arms and legs, while the lateral part is involved in motor planning (Blumenfeld, 2002). Dysfunction to the cerebellum can lead to jerky or poorly coordinated movements and poor tone and strength (Blumenfeld, 2002; Zillmer et al., 2008). Given the complexity of motor acts, impairment within one or multiple motor systems may lead to dysfunction within the motor circuit, which may manifest as impairment in fine, gross, or visual-spatial motor skills.

Etiological Perspectives

In ancient times, Hippocrates believed that stuttering was caused by dryness in the tongue (Buchel & Sommer, 2004). While this theory was ultimately dispelled, it has long been regarded that stuttering may result from neurological impairment. In the early 20th century, Samuel Orton and Lee Travis were the first scientists who attributed stuttering to an abnormal neurological basis (Orton, 1927; Travis, 1931). These scientists hypothesized that stuttering was the product of the failure to develop lateralized leading or dominant hemisphere for speech language centers in the human brain. This hypothesis became known as the Cerebral Dominance Theory (CDT), and focused on the belief that the lack of left brain hemisphere dominance resulted in speech motor commands reaching both hemispheres of the brain at different times, thus causing disfluency. Since left hemisphere dominance for language is typical, it was believed that

the non-dominant hemisphere caused stuttering. To “cure” stuttering, Orton created a therapy designed to regain left hemisphere dominance by focusing on the right arm and hand. Strengthening the right arm and hand, Orton believed, would contra laterally strength the left hemisphere; thus, “curing” stuttering. Subsequent data, however, did not support the CDT. Although, Orton was never able to validate the CDT, researchers have yet to provide evidence to completely refute this account of disfluency. In 1969, Curry and Gregory provided evidence that supported the CDT, as their study with AWS indicated abnormal lateral auditory processing. Specifically, AWS did not demonstrate right-ear dominance, which suggests left hemisphere dominance, when compared to a matched control group (Curry & Gregory, 1969). Further, research investigating speech production, as well as orofacial movements, have provided data consistent with the CDT (Code, 2005; Graves, Goodglass, & Landis, 1982; Graves & Landis, 1990; Wyler, Graves, & Landis, 1987).

Other models and theories not focused on cerebral differences have been postulated to explain stuttering. Of these, four common themes have emerged and centered on (1) parental factors, such as the way a parent reacts to their child’s speech, which leads to increased anxiety and frustration (Johnson et al., 1959), (2) repeated and frequent communication failures (Bloodstein, 1975), (3) failure of coordination of respiration, phonation, and articulation (Van Riper, 1971), and (4) genetics (Ambrose, Cox, & Yairi, 1997). This paper is not focusing on these theories; however, it is important to note that other theories exist. Johnson et al. (1959) argued that CWS begin speaking similar to their peers, but their parents perceive them as having a speech

defects. Parents seek out a diagnosis and over-react with increased anxiety and frustration of their child's disfluencies, which would lead to more disfluency.

Bloodstein (1975) suggested that stuttering results from tension and fragmentation in speech. These disfluencies lead to anxiety and pressure within the child that, in turn, result in increased disfluency. Van Riper (1971) postulated that stuttering resulted from complex mistiming of respiration, phonation, and articulation. Today, some researchers believe that stuttering may be the result of generations of brain defects; however, genetic disorders can only provide a partial account for disfluency given the disproportion in male/female ratio and the frequency of stuttering in children with no family history (Shugart et al., 2004). Nevertheless, a familial link has been suggested (Buchel & Sommer, 2004; Cox et al., 2000; Dworzynski, Remington, Rijdsdijk, Howell, & Plomin, 2007; Felsenfeld, 2002; Riaz et al., 2003; Riaz et al., 2005; Shugart et al., 2004; Suresh et al., 2006). Today, stuttering is believed to be a multi-faceted disorder involving an abnormality in the central nervous system that is reinforced by environmental factors, such as anxiety (Buchel & Sommer, 2004; Zebrowski, 2003). The following section will review the relationship between stuttering and cerebral abnormalities.

Brain abnormalities

Differences between morphology, as well as functioning will be explored. Through this review, it will be evident that many anomalies are evident in motor systems. Since irregularities are apparent in motor systems, it is postulated that motor impairment is evident in CWS.

Morphological Differences

Given the general consensus of a neurological component to stuttering, brain anatomy differences have been examined and detected in AWS and CWS. Atypical symmetry was originally detected by Strub, Black, and Naeser (1987). They identified one AWS and one CWS who exhibited atypical asymmetries in many regions, especially in the occipital and frontal regions. Given the location of the PMC and the SMC within the frontal lobes, these systems may be impacted by the atypical asymmetries, which may lead to motor impairment. Moreover, irregularities within the occipital lobe, which is the visual processing center (Blumenfeld, 2002), may have an impact on visual-spatial motor skills, as this skill set relies heavily on vision. In another study, brain imaging identified an increase in size of the left and right planum temporale, with a reduction in planar asymmetry, while also showing extra gyri in the frontal operculum and along the length of the superior bank of the sylvian fossa in AWS (Foundas, Bollich, Corey, Hurley, & Heilman, 2001). While these areas are primarily related to language and do not directly relate to motor systems, it provides further evidence that there are numerous morphological differences in AWS. Further, these areas may indirectly affect other systems that interact with motor systems. Foundas et al. (2003) also identified cerebral symmetrical volumes in AWS, rather than the normal right-left asymmetry that adults typically exhibit.

Research has also investigated differences in white matter (WM) and grey matter (GM) volumes. Grey matter are cell bodies that are involved in different aspects of the brain including muscle control, while white matter are glial cells and myelinated axons

that transmit signals to different systems within the brain (Blumenfeld, 2002).

Anomalies in these areas may lead to dysfunction in motor systems indirectly through the motor circuit. Research has found that AWS demonstrate a reduction of WM in the left sensorimotor cortex (Sommer, Koch, Paulus, Weiller, & Buchel, 2002). Reduction within this PMC area suggests that transmitted signal strength may be limited; thus, affecting the motor circuit. AWS also exhibit increased volume of WM in the four following clusters of the right hemisphere: the superior temporal gyrus, the precentral gyrus, the inferior frontal gyrus, and the middle frontal gyrus (Jancke, Hannggi, & Steinmetz, 2004). Of these areas, the precentral gyrus and middle frontal gyrus are implicated in motor planning. While an increase in white matter at times may be a positive attribute, this finding is another example of cerebral differences between AWS and the general population. Last, AWS exhibit symmetric volumes of WM, while the general population displays a leftward WM asymmetry in their auditory cortex (Jancke et al., 2004).

The literature regarding cerebral anatomical differences in CWS is scarce. Chang, Erickson, Ambrose, Hasegawa-Johnson, and Ludlow (2008) detected numerous WM and GM volume anomalies within the bilateral inferior frontal lobe, left anterior cingulate, SMA, PMC and right temporale regions. Similar to AWS (Sommer et al., 2002), CWS exhibit abnormalities in motor systems, specifically the SMA, PMC, and the left anterior cingulate. These systems are implicated in motor acts, and anomalies within these areas may manifest as motor skill impairment. Results of left-right brain symmetry of AWS, though, have not been replicated in children, as CWS exhibit the

left-right brain asymmetries that are typically observed in the general population (Chang et al., 2008; Ozge, Toros, & Comelekoglu, 2004).

It is noteworthy that anatomical differences have been detected in motor systems in AWS and CWS, particularly within the PMC and SMC. Differences within these regions may impair a range of motor abilities in CWS, specifically fine, gross, and visual-spatial motor skills. Likewise, other anatomical differences have been detected. While these anomalies were within areas not typically associated with motor movement, these abnormalities may indirectly influence motor systems through their interactions on various pathways.

Brain Functioning

Studies have also explored brain functioning using a myriad of instruments. In the mid 1900's, it was discovered that direct stimulation of the SMA and ventral lateral thalamic region, which transmits output and input to the PMC, SMC, and BG (Blumenfeld, 2002), instigated disfluent speech (Ojemann & Ward, 1971; Penfield & Welch, 1951). The SMA is noteworthy, because it is a motor system. Three studies utilizing electroencephalography (EEG) demonstrated inconsistent brain wave activity within the right hemisphere in AWS. Given the location of the differences, the authors postulated that these results suggested that the CDT may be valid (Moore, 1984; Moore, Craven, & Faber, 1982; Moore & Lorendo, 1980). With the advancement of imaging instruments, though, researchers have identified other cerebral anomalies (Mock, 2007). Through 133 single-photon emission computed tomography (SPECT), larger right than left asymmetries in the anterior cingulate, superior temporal, and the middle temporal

have been detected in AWS during speaking and nonspeaking tasks (Pool, Devous, Freeman, Watson, & Finitzo, 1991). These areas are related to emotion, speech, and reading areas, respectively, and have no direct relationship to motor systems; however, as previously mentioned, these results highlight more brain irregularities in AWS that may indirectly affect motor systems. Other researchers have identified abnormalities related to motor systems, particularly the PMC and the SMC (Braun et al., 1997; Fox et al., 2000), increased activation within the cerebrum and cerebellum suggesting right cerebral dominance, and deactivation within frontal and temporal areas (Fox et al., 2000; Ingham et al., 1996) through positron emission tomography (PET). Also, hyper activation has been detected within Brodmann's Area (BA) 6, which is associated with the SMA (Fox et al., 1996). These areas are notable as they are motor systems and suggest motor dysfunction.

As summarized by Mock (2007), AWS exhibit three common characteristics. First, they demonstrate hyper activation within motor areas, specifically the PMC, the SMC, and the cerebellum. Second, they exhibit joint or right dominant activation of the prefrontal, frontal, and anterior insula, which is involved in motor control, and the cerebellum. Last, AWS present with hypo active patterns within the left hemisphere anterior and posterior language, auditory and visual areas. Given the numerous irregularities in motor specific regions, it is highly likely that the motor skills of CWS in addition to speech may be compromised.

Abnormalities involving the Basal Ganglia (BG)

In addition to morphological and functioning differences, evidence implicates BG dysfunction as an influence for disfluent speech. As previously noted, the BG is an intricate brain anatomy that is strongly associated with motor acts through the motor circuit. Research implicating stuttering due to dysfunctions within the BG has been hypothesized since the early 1930s (Van Riper, 1982), but, due to more sophisticated research methodologies, researchers have strengthened their claim that the BG plays a critical role in stuttering (Caruso, 1991; Lebrun, 1998; Rosenberger, 1980; Wu et al., 1995).

In his thorough review of stuttering and the BG, Alm (2004) summarized much of the research supporting stuttering as a dysfunction of motor areas. Much of Alm's arguments focused on cerebral anatomical and functional differences in motor systems that were previously reviewed. Alm argued that dysfunction within motor areas (e.g., PMC and SMC) led to mistimed cues within the motor circuit; thus, resulting in disfluent speech. Alm also proposed other arguments to implicate stuttering as a BG dysfunction. Three of these arguments will be reviewed below: (1) research on "neurogenic" stuttering, (2) the effects of dopamine on stuttering, and (3) stuttering and other BG motor disorders (e.g., Parkinson's disease, Tourette syndrome, spasmodic dysphonia and dystonia).

"Neurogenic" Stuttering

Neurogenic (i.e., acquired) stuttering occurs following a traumatic brain injury when individuals, who were previously fluent, begin stuttering. While the etiology is

different than developmental stuttering, the literature is ripe with case studies documenting the onset of stuttering after injury to specific locations of the brain, some of which are identical to the presentation of developmental stuttering such as stuttering severity and rate of stuttering (Lebrun, Leleux, & Retif, 1987; Van Borsel & Taillieu, 2001). Cases of neurogenic stuttering have also suggested that stuttering may result from damage to specific motor systems. According to Van Borsel, Van Der Made, and Santens (2003), stuttering has been the result of damage to all areas of the brain except the occipital lobe. Moreover, the BG-thalamocortical motor circuit has been implicated in neurogenic stuttering cases. As summarized by Alm (2004), injuries to the thalamus (Heuer, Sataloff, Mandel, & Travers, 1996; Ojemann & Ward, 1971; Van Borsel et al., 2003), putamen (Ciabarra, Elkind, Roberts, & Marshall, 2000; Heuer et al., 1996; Ludlow, Rosenberg, Salazar, Grafman, & Smutok, 1987), globus pallidus (Ludlow et al., 1987), and the SMA (Abe, Yokoyama, & Yorifuji, 1993; Van Borsel, Van Lierde, Van Cauwenberge, & Van Orshoven, 1998), which are all components of the motor circuit, have resulted in acquired stuttering. Evidence provided by Andy and Bhatnagar (1992) indicated that stimulation of the thalamus, another system in the circuit, resulted in fluent speech. Collectively, strong evidence from the literature regarding neurogenic stuttering implicates the motor circuit as a contributor to stuttering. Therefore, given the relationship between the dysfunction within the motor circuit and stuttering, it is reasonable to question whether other motor difficulties are impacted.

Stuttering and Dopamine

Since the mid 1900s, dopaminergic drugs have been utilized to treat stuttering. Dopamine blockers were originally tested since they were considered tranquilizers (Kent, 1963). Brady (1991) reviewed nine studies that yielded positive results following the treatment of stuttering using D2-blockers, while Maguire, Yu, Franklin, and Riley (2004) reviewed the literature and suggested that stuttering may be caused by increased dopamine activity. More recent studies have also indicated beneficial effects of D2-blockers (Lavid, Franklin, & Maguire, 1999; Maguire et al., 1999; Maguire, Riley, Franklin, & Gottschalk, 2000; Rothenberger, Johannsen, Schulze, Amorosa, & Rommel, 1994). Given the importance of dopamine to the motor circuit, increased activity may lead to dysfunction within the circuit that leads to motor skill deficits. Positive results have also been achieved following the use of stimulant drugs (Fish & Bowling, 1962, 1965; Langova & Moravek, 1964) and reuptake inhibitors (Gordon et al., 1995; Stager, Ludlow, Gordon, Cotelingam, & Rapoport, 1995). Stuttering has also been induced by the administration of dopaminergic medication (Brady, 1998; Burd & Kerbeshian, 1991; Gerard, Delecluse, & Robience, 1998; Rosenfield, McCarthy, McKinney, Viswanath, & Nudelman, 1994). While these results are somewhat contradictory to research on D2 blockers, it should be expected that specific classifications of medications may affect stuttering differently; thus, it is possible to relate stuttering to dopamine levels within BG areas (Alm, 2004). Given the relationship between dopamine and the BG-thalamocortical pathway, these effects suggest that stuttering is related to dopamine, which may indirectly affect other motor skills as well as stuttering.

Stuttering as a Motor Control Disorder

Given the immense research associating dysfunction within the BG and motor circuit as a precursor to stuttering, researchers have begun to argue that stuttering should be considered a motor control disorder, similar to Parkinson's Disease, Tourette syndrome (TS), spasmodic dysphonia, and dystonia (Kent, 2000; Ludlow & Loucks, 2003). Ludlow and Loucks (2003) proposed that stuttering and other motor disorders demonstrate similar phenomenology (Kiziltan & Akalin, 1996), as individuals report similar experiences. For example, AWS and individuals with TS, dysarthria, and voice disorders are all able to control symptoms for brief periods of time; however, they are not able to control these symptoms indefinitely. Second, stuttering and other motor disorders, such as TS and spasmodic dysphonia, which is a voice disorder caused by muscle spasms in the larynx, often demonstrate similar cerebral aberrations, primarily in the BG (Alm, 2004; Ludlow & Loucks, 2003). Both stuttering and motor disorders are task dependent, such that symptoms are present in some environments, but not in others (Alm, 2004; Bloodstein & Ratner, 2008; Ludlow & Loucks, 2003). For instance, stuttering is only apparent during speaking tasks and not during humming or singing tasks. Similarly, with oral-mandibular dystonia, which is a disorder characterized by forceful contractions of the face, jaw, and tongue, the individual may only exhibit oral-motor muscle abnormalities during speech production, but not during chewing or other oral-motor tasks. Lastly, as central processing demands increase, so do the severity of symptoms (Ludlow & Loucks, 2003). For example, when individuals are asked to speak more, multi-task, or the task difficulty increases, so does the severity of their symptoms.

In the case of an AWS, their stuttering becomes more severe under increased processing demands. While some of these arguments may be debatable, Ludlow and Loucks contended that sensorimotor difficulties were more similar than different; thus, stuttering should be considered a motor disorder.

Motor Skills and Stuttering

The notion that more general motor impairment beyond the primary speech defects may exist in AWS and CWS has been hypothesized since the early 1900s. As such, studies have probed whether differences exist in fine, gross, and visual-spatial motor skills. Often, these studies have examined numerous different motor domains in one study. In this review, the relationship between motor skills and stuttering are explored based on three broad categories, gross, fine, and visual-spatial motor skills.

Gross Motor Skills

Much of the research addressing gross motor skills by individuals who stutter was conducted in the mid 1900s. Westphal (1933) originally discovered that CWS demonstrated inferior grip strength when compared to a control group, as measured by a dynamometer. Arps (1934) detected impairment of rhythm and coordination in CWS. These skills were confirmed by Kiehn (1935), as cited by Finkelstein and Weisberger (1954). In his study, Kiehn revealed that after carrying a glass of water, individuals who stutter exhibited poorer performance; however, study methodology and sample characteristics are unknown. Bilto (1941) noted impairment on strength, coordination, and rhythm tasks in CWS but used a research design that combined CWS with children with articulation disorders; thus, his results were questionable. Kopp (1946) and

Schilling and Kruger (1960) replicated Bilto's study design and substantiated his findings; however, Finkelstein and Weisberger (1954) were unable to replicate the findings of impaired gross motor skills. In their study involving 15 CWS compared to a matched control group, participants completed various coordination tasks (e.g., touch nose, jumping, standing on one foot). Results indicated no group differences; however, the authors noticed that CWS generally performed better than controls on all coordination tasks. Given the paucity of recent research, the numerous methodological concerns with previous studies, and the contradictory results, this is an area that warrants further research.

Fine Motor Skills

Research regarding fine motor skills has primarily employed finger tapping tasks (Ardila, Rosselli, Bateman, & Guzman, 2000; Blackburn, 1931; Forster & Webster, 2001; Max, Caruso, & Gracco, 2003; Seth, 1958; Smits-Bandstra, De Nil, & Saint-Cyr, 2006; Vaughn & Webster, 1989; Webster, 1985, 1986, 1989, 1990). For these tasks, participants perform a repetitive sequential tapping task (i.e., repeatedly tapping a sequence of 1, 2, 3, and 4 where the numbers represent a particular finger) as rapidly and as accurately as possible. Results have been relatively consistent, in that AWS commit more errors and have slow initial responses when performing a novel sequence. Researchers have also explored finger tapping skills with concurrent movements; thus, increasing the complexity assessment with performing this fine motor skill. As would be expected, these studies have revealed that AWS exhibit more difficulty finger tapping

while concurrently speaking (Greiner, Fitzgerald, & Cooke, 1984) and independent of speech while turning a door knob (Webster, 1989) or a crank (Forster & Webster, 2001).

Other manual dexterity tasks not involving finger tapping have also been examined. In the 1930's Westphal (1933) did not discover significant impairment in CWS when placing blocks into hollow holes; however, he noticed a trend towards inferior performance. Therefore, Westphal postulated that CWS exhibit subtle differences in manual dexterity. Cross (1936) did not find differences on unimanual tasks in AWS, but found differences on bimanual tasks. In more recent years, differences have been identified in bimanual tasks (e.g., placing thread into the eye of a needle and picking up a match and striking it into the wooden box) in AWS (Vaughn & Webster, 1989) and CWS (Williams & Bishop, 1992). Differences are not always present, though, as Rotter (1955) and Snyder (1958) did not discover manual dexterity differences between AWS and controls. Given the consensus that AWS and CWS demonstrate finger tapping manual dexterity difficulties, this area does not warrant further research. Not much research, though, has been conducted on other manual dexterity tasks, such as bimanual tasks; thus, this is an area that would benefit from further research.

Visual-Spatial Motor Skills

The literature review only identified four studies that included visual-spatial motor skills as a component of their study. Snyder (1958) initially identified visual-spatial motor skill weaknesses in CWS. While these deficits were minor, Snyder observed increased impairment correlated with stuttering severity. These difficulties

were substantiated following a two sibling case study that detected fine motor integration weakness in CWS and AWS (Strub et al., 1987). Jones, White, Lawson, and Anderson (2002) investigated visual-spatial motor skills in 12 AWS compared to a matched control group. Their tasks measured reaction time to a non-target stimulus and the ability to maintain steady movement and track a target with an arrow. Results did not indicate any differences; however, the authors noted that AWS exhibited slower reaction times and were less accurate on some tracking tasks. Therefore, Jones and colleagues postulated that AWS may exhibit subtle visual-spatial motor skill deficits. One study, however, did not report visual-spatial motor impairment in AWS (Samson & Cooper, 1980). Given the scarcity of studies examining this domain, as well as some conflicting results, this is an area that necessitates supplementary research.

Summary

As previously discussed, stuttering has been described as a motor control disorder caused by abnormalities in the central nervous system, with the motor system playing a pivotal role (Ludlow & Loucks, 2003). While no specific model has been established in the literature, this study is based upon the following two assumptions. First, brain anomalies have been noted in numerous adult studies, as well as a select number of children studies. These irregularities have included motor systems that are strongly associated with the production of movement, such as the PMC, the SMC, the BG, and the cerebellum. Second, research suggests motor skill deficits in AWS. Based on these indications, it is reasonable to question whether CWS will demonstrate similar motor skill deficits. Given the importance of fine, gross and visual-spatial motor skills

in academic performance, as well as social adjustment, identification of motor deficits could lead to intervention and improved outcomes for CWS. Thus, the purpose of this study is to determine the motor abilities of CWS as compared to a control group.

Research Question

Do CWS demonstrate poorer performance in motor skills compared to CWNS?

It is hypothesized that CWS will demonstrate more deficits in motor skills as measured by the Bruininks-Oserestsky Test of Motor Proficiency (Bruininks & Bruininks, 2005).

CHAPTER III

METHODS

To ensure legal and ethical standards, Institutional Review Board (IRB) approval was obtained through Texas A&M University (TAMU), as well as Fort Worth Independent School District (FWISD). Given the low incidence of stuttering, as well as sample sizes throughout the literature, sample size was expected to be relatively small; thus, more sophisticated statistical approaches were not considered. This limitation has been documented in the literature (Jones, Gebiski, Onslow, & Packman, 2002). The study was predominantly descriptive, but adds to the limited research available.

Participants

Participants (n=32) were children recruited through an urban school district in Texas. Each participant was placed into one of two groups. The first group consisted of CWS, while the other group consisted of CWNS (i.e., control group). Since the CWNS group exhibited a higher percentage of older children, a matched control group was utilized yielding a total of 24 participants included for the analyses. Therefore, groups were matched on age, gender, ethnicity and mother's educational level. Father educational level was not always readily available, as some mothers did not know the highest educational level achieved. Those mothers were encouraged to guess. Given the possibility that the father educational level may not be entirely accurate, it was decided to utilize the mother's educational level to match groups. A matched-control is common with this population, as much of the literature utilizes this study design. Table 1 provides demographic information for both groups. Three points are worth nothing in

Table 1
Demographics of Sample

Descriptive Variables	CWS		CWNS	
	Mean (SD)		Mean (SD)	
Age	9.5 (1.75)		9.5 (1.75)	
Grade	3.6 (1.8)		3.6 (1.8)	
Categorical Variables	N	%	N	%
Gender				
Males	6	50	6	50
Females	6	50	6	50
Race/Ethnicity				
African American	4	33	4	33
Caucasian	2	17	2	17
Hispanic	6	50	6	50
Mother Education				
Some High School	5	42	5	42
High School Graduate	4	33	4	33
Some College	1	8	1	8
College Graduate	2	17	2	17
Father Education				
Some High School	6	50	5	42
High School Graduate	4	33	5	42
Some College	1	8	2	17
College Graduate	1	8	0	0

Table 1 (1) there were an equal number of males and females; (2) the sample was predominantly Hispanic, as Hispanics accounted for half of the sample; (3) the mother's educational level was primarily high school graduate or lower. As noted in Table 1, the only difference in the two groups was in father educational level.

For inclusion in this study, children were between the ages of 6 and 13 years ($M=9.5$; $SD=1.75$ for each group) and between first and seventh grade ($M=3.6$; $SD=1.8$ for each group). A minimum age limit was specified so that participants were past the age of typical onset of stuttering and would be of an age that could be evaluated. A maximum age limit was specified to provide a large enough population to recruit a sufficient number of participants, yet not be significantly different in development (e.g., puberty). Six criteria for exclusion were (1) English Language Learner, (2) diagnosis of an Autism Spectrum Disorder, (3) diagnosis of Intellectual Disability, (4) history of a Traumatic Brain Injury (TBI), (5) any type of motor system disorder (e.g., Cerebral Palsy or TS), and (6) medications that may have side effects that interfere with the participant's performance. All children met study guidelines and no participants were taking prescription medications. Exclusion criteria were specified to eliminate confounding factors that could cause spurious results. For the CWS group, an additional criterion of a stuttering diagnosis by a licensed SLP was warranted. Finally, parental consent and participant assent were required.

Recruitment

Following IRB approval from TAMU, several SLPs and speech and hearing clinics in the Houston and College Station area were contacted with the intent to recruit

children at their offices. Approximately 20 clinics were contacted, yet only three clinics agreed to distribute information to their clients. Despite numerous attempts to recruit participants from these specific locations, no participants consented to participate. As a result, approximately twenty clinics in the Dallas-Fort Worth area were contacted. Two clinics were willing to aid in recruitment, yet none of their clients consented to participate. Many clinics expressed a willingness to participate, but none of their clients met study parameters.

Many school-aged CWS receive speech therapy through public school SLPs. For that reason, a large urban school district (FWISD) with more than 80,000 students enrolled was contacted. Upon obtaining IRB approval from FWISD, all SLPs within FWISD were contacted via email. To aid in this process, a supervisor shared study information to all SLPs. Despite repeated attempts to encourage SLPs to distribute information to students meeting study parameters, not many parents consented to participation in this study. It was later revealed that numerous SLPs provided study information to students, but ultimately were unable to obtain parental consent. SLPs did not mention if they followed up with potential participants. Given the population of CWS, a limited sample size is not unusual.

CWNS group members were recruited through FWISD as well. CWNS group members were recruited with the aid of the CWS group, as participants in the CWS group were asked to pass along information to their friends. This recruitment tactic was utilized in order to recruit children with similar demographics, as children generally

befriend children similar to themselves. Further, CWNS group members who had participated in this study were asked to distribute information to their friends.

Procedures

There were three sequential steps in testing students. First, parental consent and child assent were obtained. Second, the primary author contacted each participant's parent(s) and scheduled an appointment to collect data. Third, on the appointment date, the primary author administered the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (Bruininks & Bruininks, 2005; BOT-2) to the participant at their school. Administration followed instrument guidelines. Parents were encouraged to wait outside the room and complete questionnaires. In the event the parents did not attend data collection, questionnaires were sent home and were later returned. Further, all testing was completed after school so that testing would not interfere with their education. For a select number of students, it was not feasible to use the home school. Instead, parents met the primary researcher at the district's central office to collect data.

Measures

Demographic Questionnaire

The demographic questionnaire, developed by the primary author, was completed by the participant's mother. The questionnaire included questions regarding background information (e.g., age, gender, and ethnicity), stuttering history, and educational history (see Appendix A). These items were used to ensure that the participant met the requirements to participate in the study and to allow for comparison of the resulting groups to ensure that group differences are not confounded by demographic differences.

The items were reviewed by individuals with expertise in speech-language, motor, and/or psychology. The reliability and validity of this questionnaire was not examined and was primarily used to provide basic descriptive information. Data from this instrument was utilized to create the matched control group.

BOT-2

In order to obtain a standardized measure of a participant's motor skills, the Bruininks-Oseretsky Test of Motor Proficiency-Second Edition (Bruininks & Bruininks, 2005; BOT-2) was administered. The BOT-2 is a commonly used instrument to assess motor skill proficiency in children between the ages of four and twenty-one. The instrument is designed to yield four composite scores in the following areas: Fine Motor Control, Manual Coordination, Body Control, and Strength and Agility. Composite scores are each comprised from two respective subtests that measure a more narrow ability. The subtests are as follows: Fine Motor Precision (FMP), Fine Motor Integration (FMI), Manual Dexterity (MD), Upper-Limb Coordination (ULC), Bilateral Coordination (BLC), Balance (BAL), Running/Speed/Agility (RSA), and Strength (STR). Table 2 provides a description of all BOT-2 subtests. For the purposes of this study, only subtest scores were utilized.

Table 2
Description of all Subtest Areas

Subtest Areas	Description
Fine Motor Precision	Activities that require precise control of finger and hand movements; relies mostly on fine motor skills, but has a visual-spatial component
Fine Motor Integration	Reproduction of drawings of various geometric shapes that range in complexity; relies on fine motor and visual-spatial components
Manual Dexterity	Activities that involve reaching, grasping, and bimanual coordination of small objects; relies on fine motor, but has gross motor and visual-spatial components
Bilateral Coordination	Tasks that require body control and sequential and simultaneous coordination of upper and lower limbs; relies on fine and gross motor skills
Balance	Skills that are integral for maintaining posture when standing, walking, or performing other common activities; relies primarily on gross motor skills
Running Speed and Agility	Activities that measure speed and agility; relies primarily on gross motor skills, but has visual-spatial components
Upper-Limb Coordination	Ability to visual track arm and hand coordination; relies on gross motor and visual spatial skills
Strength	Measure of trunk and upper and lower body strength; relies primarily on gross motor skills

Items on the BOT-2 are divided within subtests that measure a specific skill set. All tests items are assigned a raw score depending on their performance. These scores are then converted to point scores according to the scoring protocol (i.e., each test item provides a scoring point guide from which to convert the raw score). Next, all point scores are aggregated to yield a total point subtest score. Total subtest scores are transformed into scaled scores based on the normative sample. For the purposes of this study, combined gender-age norms were utilized, so that participants could be compared across different ages and gender. Next, composite scores can be generated from summing the two subtest scores within their respective domain. This summation is then converted to a scaled score based on the normative sample but was not of interest in this study. Subtest scaled scores range from 1 to 35 with a mean of 15 and a standard deviation of 5. Composite scores range from 20 to 80 with a mean of 50 and a standard deviation of 10. Confidence intervals, percentile ranks, age equivalents, and descriptive categories can also be obtained; however, for the purposes of this study, only scaled subtest scores were utilized.

In order to verify that the BOT-2 demonstrated adequate reliability and validity, the standardization process was examined from the BOT-2 manual (Bruininks & Bruininks, 2005). The BOT-2 was standardized on children residing in the United States. Reliability is essential because it ensures that the instrument can produce consistent results. Following is a review of the reliability analysis conducted by the authors of the BOT-2 during standardization of the instrument (Bruininks & Bruininks, 2005). To ensure reliability, internal consistency, test-retest, and inter-rater reliability

coefficients were calculated and provided in the manual. Correlation coefficients are computed within a 0 to 1 range. Generally, coefficients above .70 are considered adequate. Coefficients below .60 are considered poor, while scores between .60 and .70 are considered questionable. Internal consistency was computed using the split-half method. For the split half method, each subtest is divided into two halves where items on each half are similar in content and difficulty. Following, Pearson correlations are computed to estimate the internal consistency. Overall, results reported in the manual were high, with mean scores in three age groups (4 through 7, 8 through 11, and 12 through 21) in the high .70s to low .80s. Further, test-retest reliability was computed and mean coefficients ranged from .69 to the low .80s for the standardization sample. Last, inter-rater reliability measurements were computed and provided in the manual using Pearson correlation coefficients. Scores for this analysis were high, with the Manual Coordination, Body Coordination, and Strength and Agility composite scores yielding coefficients of .98 and .99. The Fine Manual Control was also high with a coefficient of .92. Given these results, the BOT-2 provided evidence of adequate reliability within the standardization sample (Bruininks & Bruininks, 2005).

Validity is equally important because it ensures that the instrument measures what it is intended to measure. Following is a review of the validity analysis conducted by the authors of the BOT-2 during standardization of the instrument (Bruininks & Bruininks, 2005). The authors utilized four different methods, (1) examined all of the test content, (2) investigated the internal structure, (3) calculated differences between clinical groups, and (4) explored the relationship with other tests of motor skills.

Initially, all test content was established through logical and empirical natures. In this stage, content was developed based on evaluating the effectiveness of previous versions. Next, all items were piloted, tried out on children, and standardized. Each of these steps underwent item analysis and feedback to ensure test items were appropriate.

Additionally, item fit and factor analyses were conducted on each item to ensure it was appropriate for the instrument. Factor analysis revealed seven factors. One factor was divided into two groups; thus, eight subtests were created. Next, internal structure was inspected using Pearson correlation coefficients to see how well each subtest conformed to all composite areas. During that analysis, intra-correlations were generally within the .80s, while inter-correlations yielded moderate coefficients in the .30s to .50s. These scores were expected. Further, confirmatory factor analyses (CFA) were conducted to identify the factor structure. Analysis provided strong evidence for a four motor composite scores. Following, clinical groups were also examined to determine whether specific clinical populations differed from non-clinical populations. Evidence from these populations indicated that the BOT-2 was able to establish differences between two populations. Lastly, other motor skill instruments, including the Bruininks-Oseretsky Test Motor Proficiency (Bruininks, 1978; BOTMP), Peabody Developmental Motor Scale-Second Edition (Folio & Fewell, 2000; PDMS-2), and the Test of Visual-Motor Skills-Revised (Gardner, 1995; TVMS-R) were compared to determine whether scales were appropriate. Coefficients from these measurements indicated strong validity, as most coefficients were higher than .70. Overall, evidence provided by the

authors indicated that the BOT-2 demonstrates adequate validity within the standardization sample (Bruininks & Bruininks, 2005).

Collectively, the BOT-2 demonstrated adequate reliability and validity coefficients with the standardized sample. This indicates that the BOT-2 is an acceptable instrument to utilize with different samples; however, it is important to test reliability and validity within that sample. The results with this sample will be discussed in the next chapter with all other analyses.

CHAPTER IV

RESULTS

Results will be presented in three sections. First, the data analytic plan will be summarized. Next, reliability and validity analysis with this sample will be provided to ensure that the BOT-2 demonstrates adequate reliability and validity. Third, one way analysis of variance (ANOVA) and effect sizes will be presented with each subtest to measure group mean differences between CWS and CWNS.

Data Analytic Plan

The primary author was in charge of all data entry and analysis. Data were entered twice into a Microsoft Excel formula file to ensure no data entry errors. If errors were noted, references were made to that specific protocol to verify which response was correct. Next, data were transferred into a dataset using IBM SPSS Statistics 20, where all subsequent analyses were conducted.

To ensure adequate reliability with the current sample, internal consistency was analyzed following Cronbach alpha's method (Cronbach, 1951). For the purpose of this study, Cronbach alpha coefficients were computed for all test items within their respective subtest, as well as scaled scores with their respective composite scores. To ensure adequate validity with the current sample, intra- and inter-correlations of subtests and composite scores were computed using Pearson correlation coefficients.

Next, in order to ensure the data conformed to a normal distribution, normality (i.e., skewness and kurtosis) was examined. This is essential, as most instruments are created to follow a normal distribution. It was determined that the data demonstrated a

normal distribution, and no further analysis was conducted; thus, descriptive statistics for subtests were calculated. One way ANOVAs were also calculated to detect group differences. For the purposes of this study, CWS and CWNS were compared with the following subtest scores: Fine Motor Precision, Fine Motor Integration, Manual Dexterity, Upper Limb Coordination, Bilateral Coordination, Balance, Running/Speed/Agility, and Strength. Given the sample design, similar results would have been obtained utilizing the independent t-tests or univariate ANOVA method; however, one way ANOVAs were selected due to their ease in interpreting, as well as providing necessary information to calculate effect sizes and providing better control for error variance. Last, effect sizes were calculated. Effect size is a statistic that quantifies the size of the difference between groups with greater variability between group memberships resulting in larger effect sizes (Coe, 2002, September). While many researchers use Cohen (1988) benchmarks of “small,” “medium,” and “large” effects, it has long been argued that effect sizes should be interpreted based on values obtained in the literature (Thompson, 2006). Unfortunately, effect sizes in the stuttering literature are not commonly reported. Therefore, effect sizes in this study will be reported, but due to limited context within the literature, effect sizes cannot be compared.

Reliability and Validity Analysis

Ideally, it is best to perform multiple analyses to determine reliability of an instrument; however, due to study constraints (e.g., one rater and one testing session), only internal consistency was measured by calculating the Cronbach alpha coefficient for each subtest and composite score (Cronbach, 1951). To compute the Cronbach alpha

coefficients, correlations of all subtest items were computed together within their respective subtest. As previously stated, correlation coefficients range between 0 and 1. Coefficients above .70 are considered adequate. Coefficients below .60 are considered poor, while scores between .60 and .70 are considered questionable. Overall, correlation coefficients for each subtest were relatively high, as most correlation coefficients were greater than .70. Two subtests, Balance (.65) and Fine Motor Integration (.61), however, fell within the questionable range. Results are summarized in Table 3 and were similar to correlation coefficients presented in the BOT-2 manual (Bruininks & Bruininks, 2005).

Validity was analyzed through inter- and intra- Pearson correlation coefficients among subtest scaled scores within each domain. As would be expected, for the most part, intra-correlation coefficients among subtests within a given domain are higher than inter-correlation coefficients. This is not surprising, as subtests measuring similar skill sets should demonstrate higher coefficients than subtests that are not necessarily related. Generally, inter-correlation coefficients were small to moderate ranging from .24 to .62. .At the same time, however, correlations for the three motor domains created in this study ranged from low to moderate. The visual-spatial domain yielded a low intra-correlation (.19) between the two subtests. It is unclear why these results were low; however, it may be due to the type of subtest, as one is a seated subtest and one is standing. The gross motor domain demonstrated moderate intra-correlations, which is to be expected. Correlations ranged from .31 to .68. The fine motor domain demonstrated low to moderate intra-correlations. Correlations ranged from .23 to .41. The BLC

subtest was involved in lower intra-correlations within this group. Thus, the lower coefficients may be related to the dual nature of the BLC subtest. Overall, results indicated that the BOT-2 demonstrated adequate validity with the current sample for the intended purpose of the instrument, as results were similar to those obtained with the normative sample (Bruininks & Bruininks, 2005), but intra-correlations in the groups created for this study were lower than expected.

Table 3
Cronbach Alpha Analysis

Subtest Score	Coefficient
Fine Manual Precision	.78
Fine Manual Integration	.61
Manual Dexterity	.87
Bilateral Coordination	.79
Balance	.65
Running, Speed, and Agility	.82
Upper-Limb Coordination	.79
Strength	.72

Hypothesis Testing

To ensure the data conformed to a normal distribution, skewness and kurtosis were examined. An excellent value for skewness, which is a statistical characteristic that examines the symmetrical distribution, is ± 1 , while a value ± 2 is considered adequate. An excellent value for kurtosis, which is a statistical characteristic that examines the

relative height and weight of a distribution, is ± 1 , while a value ± 2 is considered adequate (Thompson, 2006). Values for both skewness and kurtosis were excellent except for the kurtosis of FMI, which was adequate. Thus, data transformations were not necessary. Skewness and kurtosis values are summarized in Table 4. All statistics are consistent with what would be expected for normality. Descriptive analysis revealed mean subtest scores ranged from 7.9 to 15.8. In general, CWNS performed better on all tasks. All subtest scores for CWNS revealed an otherwise normal profile (i.e., scores within one standard deviation). CWS, however, performed poorer as FMP, BLC, BAL and STR subtests were more than one standard deviation below the mean. Means and standard deviations are summarized in Table 5.

Table 4
Normality Analysis

Subtest Scores	Skewness		Kurtosis	
	Statistic	SEM	Statistic	SEM
FMP	.33	.47	-.15	.92
FMI	-.17	.47	-1.10	.92
MD	.10	.47	-.76	.92
ULC	.54	.47	.06	.92
BLC	.21	.47	-.46	.92
BAL	.81	.47	-.51	.92
RSA	-.28	.47	-.43	.92
STR	.51	.47	-.10	.92

Note. FMP=Fine Motor Precision; FMI=Fine Motor Integration; MD=Manual Dexterity; ULC=Upper-Limb Coordination; BLC=Bilateral Coordination; BAL=Balance; RSA=Running, Speed, and Agility; STR=Strength

Table 5 Descriptive Statistics for all Subtests

Subtest Scores	CWNS			CWS		
	Mean	SD	Range	Mean	SD	Range
FMP	14.3	3.99	8-22	*9.4	3.34	5-14
FMI	13.1	3.92	6-18	12.3	3.60	7-18
MD	13.6	4.03	7-19	10.8	3.19	5-17
ULC	12.6	4.94	6-22	10.1	3.53	4-15
BLC	12.5	3.00	7-18	*9.2	3.35	4-17
BAL	15.3	5.69	8-24	*9.7	3.11	5-17
RSA	15.8	2.25	13-21	*11.3	4.13	6-20
STR	11.1	2.78	7-17	*7.9	3.37	4-16

Note. FMP=Fine Motor Precision; FMI=Fine Motor Integration; MD=Manual Dexterity; ULC=Upper-Limb Coordination; BLC=Bilateral Coordination; BAL=Balance; RSA=Running, Speed, and Agility; STR=Strength.

Bolded scores are approximately 1 SD from the mean of the normative sample

* Indicates $p < .05$ difference from CWNS

Research Question

All one-way ANOVAs are summarized in Table 6. Results indicated that CWS performed poorer than CWNS and the normative sample on the Fine Motor Precision ($F=10.38, p < .001$), Bilateral Coordination ($F=6.59, p = .02$), Balance ($F=9.15, p = .01$), and Strength ($F=6.31, p = .02$) subtests. Effect sizes were .32, .23, .29, and .22, respectively. On the Running, Speed, and Agility ($F=11.37, p = .00$) subtest, CWS performed poorer than CWNS, but no difference was noted between the normative sample. The effect size was .34. On the Manual Dexterity ($F=3.44, p = .08$) and Upper-Limb Coordination ($F=2.03, p = .17$) subtests, no difference was detected between CWS

and CWNS, but a difference was noted between CWS and the normative sample. Effect sizes were .14 and .09, respectively. No group difference was noted between CWS and the CWNS or the normative sample on the Fine Motor Integration subtest ($F=.30$, $p=.59$). An effect size of .01 was calculated.

Table 6
One Way ANOVAs

Subtest Scores	df	F	η	p
FMP	1, 22	10.38	.32	<.001
MD	1, 22	3.44	.14	.08
BLC	1, 22	6.59	.23	.02
BAL	1, 22	9.15	.29	.01
RSA	1, 22	11.37	.34	<.001
STR	1, 22	6.31	.22	.02
FMI	1, 22	.30	.01	.59
ULC	1, 22	2.03	.09	.17

Note. FMP=Fine Motor Precision; FMI=Fine Motor Integration; MD=Manual Dexterity; ULC=Upper-Limb Coordination; BLC=Bilateral Coordination; BAL=Balance; RSA=Running, Speed, and Agility; STR=Strength.

CHAPTER V

CONCLUSIONS

The purpose of this study was to determine whether CWS present with motor skill deficits when compared to CWNS. Additional consideration was given to comparison to the normative sample given the sample size. The rationale for this study was based on the evidence of cerebral abnormalities in motor systems of the brain associated with AWS, and to a lesser degree, CWS. It was suggested that impairments within the motor systems in individuals who stutter also may result in dysfunction of other motor abilities. Consistent with the literature, results of this study indicated decreased motor skills in CWS when compared with CWNS. There was evidence of motor deficits across numerous motor areas.

Control and Normative Group Differences

As hypothesized, CWS exhibited motor deficits in four areas when compared to the CWNS. In addition, differences were also observed between CWS and the normative sample. The four areas were (1) fine motor precision, (2) bilateral coordination, (3) strength, and (4) balance. On fine motor precision tasks, which included coloring in shapes, cutting paper, connecting dots, and folding paper, CWS performed poorer than CWNS. These skills are critical in a school environment, especially for younger children as class assignments and projects often require the use of fine motor skills. These results are consistent with much of the literature that detected fine motor deficits, but no study has investigated these specific tasks. Results suggest that school psychologists equipped with this knowledge are in a position to provide

appropriate interventions and accommodations for CWS in a school setting who evidence these types of fine motor deficits.

On bilateral coordination tasks, CWS also performed inferior to CWNS and the normative sample. These results indicate that CWS have more difficulty coordinating bilateral fine and gross motor acts. Some of these tasks included the ability to alternate finger and foot taps concurrently, as well as pivot their fingers and complete jumping jacks. Finger tapping deficits are noted throughout the literature (Ardila et al., 2000; Blackburn, 1931; Forster & Webster, 2001; Max et al., 2003; Seth, 1958; Smits-Bandstra & De Nil, 2007; Vaughn & Webster, 1989; Webster, 1985, 1986, 1989, 1990). The other tasks have not been thoroughly examined in the literature. These skills are essential within the school environment as they enable students to function more efficiently in the school environment, including transferring of information or objects from one location to another. For CWS who evidence deficits in bilateral coordination, school psychologists would be able to advocate for school personnel to provide CWS with appropriate intervention and accommodations.

Consistent with the literature from the early 1900s (Arps, 1934; Kiehn, 1935; Kopp, 1946; Schilling & Kruger, 1960) and the hypothesis in this study, CWS revealed inferior physical strength than CWNS and the normative sample. This is consistent with previous research that identified this impairment (Bilto, 1941; Kopp, 1946; Schilling & Kruger, 1960; Westphal, 1933). CWS were unable to complete strength tasks (e.g., situps, push ups, wall sits) at the same rate as CWNS or the normative sample; this substantiates prior research. These skills are generally utilized within a physical

education. Impairment of these skills may put CWS at higher risk for diminished social interactions. With this knowledge, school psychologists may play a vital role in consulting with various school personnel to provide appropriate interventions and accommodations.

Last, CWS performed poorer than CWNS and the normative sample on the ability to balance themselves. On these tasks, participants were asked to walk on a line, stand on one leg, stand with one's eyes closed, and stand on a balance beam. Results are consistent with previous literature that indicated poorer balance (Arps, 1934; Bilto, 1941; Kiehn, 1935; Schilling & Kruger, 1960). Balancing skills are critical in the school environment, as these skills are required to safely move around the environment. Deficits with these skills may lead to clumsiness, which may be unsafe in some situations and alienate them from their peers; thus, with this information, the school psychologist may be able to assess CWS and provide appropriate interventions and accommodations.

Collectively, CWS present with impaired motor skills. These results are not surprising, as numerous motor systems, including the PMC, SMC, BG, and cerebellum, exhibit cerebral abnormalities. These results suggest that CWS may be "at risk" for diminished performance and interactions within a school environment that can limit academic and social functioning. Therefore, it is imperative for school psychologists to properly assess CWS to identify suitable, functional interventions targeted at remediating weaknesses identified for a given individual.

Control Group Only Difference

CWS also performed inferior to CWNS on running, speed, and agility tasks. CWS, though, did not differ from the normative sample. This study is the first of its kind to assess these specific skills. These tasks included running back and forth to pick up an object, moving sideways, and hopping. These skill sets are primarily utilized in physical education classes. Deficits with these skills may lead to impaired social interactions. Given these results, it is important for school psychologists and related school personnel to consider possible weaknesses in this area in order to intervene and provide services to remediate these weaknesses.

Normative Group Only Differences

On manual dexterity and upper limb coordination tasks, the hypothesis of impaired function was not supported. CWS, though, demonstrated differences when compared to the normative sample. In regard to manual dexterity, these results are consistent with Rotter (1955) and Synder (1958), but not with Williams and Bishop (1992) and Vaughn and Williams (1989) who detected group differences on bimanual tasks in AWS and CWS and a control group. Results, though, are similar to those obtained by Westphal (1933) who did not detect statistically significant differences, but noted poorer performance in CWS. In this study, CWS obtained lower scores than CWNS, but not to a statistically significant degree; however, CWS differed from the normative sample. Westphal speculated that more subtle differences may exist in CWS that go undetected depending on the tasks used. It is unclear whether that phenomenon occurred in this study, but it may be possible. On manual dexterity tasks, CWS were

asked to make dots in circles, transfer objects, place pegs into a pegboard, sort cards, and string blocks. These skills are important in the school environment as children are often asked to manipulate various objects for class assignments and projects. As for upper-limb coordination, no study has examined these skills. These tasks required children to throw and catch a tennis ball with one or two hands, dribble a tennis ball with one or two hands, and throw a tennis ball at a target positioned seven feet away. Results suggest impairment when compared to the normative sample. These skills are important as children are required to coordinate their upper body movements in a school environment. Collectively, results indicate that CWS may demonstrate manual dexterity and upper-limb coordination deficits. Therefore, a school psychologist may be in a position to assess the motor ability of CWS and provide functional accommodations and recommendations if deficits are noted.

No Difference

Contrary to the hypothesis, no differences were detected on the ability to copy drawings and shapes. These results are consistent with one study that did not detect fine motor and visual-spatial deficits (Samson & Cooper, 1980), but is inconsistent with other studies that identified deficits (R. D. Jones et al., 2002; Snyder, 1958; Strub et al., 1987). These results indicate that CWS are as capable as CWNS and the normative samples on copying images and shapes they see. Considering the research implicating abnormalities within the PMC, SMC, BG, and cerebellum, it is unclear why this skill set involving fine motor and visual-spatial skills were not impaired. It is possible that, with

the complex interaction of motor and visual systems, there is a capacity for compensation within the functional system and its components.

Implications

Traditionally only seen by SLPs, these results indicate that a collaborative approach to assessment with SLPs and school psychologists is warranted when assessing a CWS. School psychologists possess a unique role in schools, including meeting the needs of children with academic difficulties, emotional distress, developmental delays, and myriad of other concerns. Major implications of this study that are important to school psychologists and the identification of “at-risk” populations included: (1) given the results from this study, it appears that CWS may be classified as “at-risk” for motor skill deficits; (2) SLPs and school psychologists should be encouraged to collaborate when assessing CWS; (3) school psychologists can include brief measures of motor skills as part of the assessment with CWS to determine whether motor skill deficits exist, and if so, in which areas; (4) results of assessment of motor skills can inform specific accommodations and interventions to remediate or accommodate identified weaknesses; (5) the specific interventions and accommodations need to be tailored to the unique skills and deficits of the individual child. It is crucial for school personnel, particularly school psychologists and SLPs to collaborate to meet the needs of CWS. This study suggests that motor deficits are associated with CWS that can affect their academic and social standing in the short term, and adult outcome long term. School psychologists also need to be aware of the potential for motor skills to exacerbate the likelihood of other adjustment issues. Last, results suggest that increased physical activities may help in

addressing some motor deficits; thus, resulting in better academic and/or social functioning.

Limitations and Future Directions

Results from this study should be interpreted with regard to three study limitations. First, this study was conducted with a small sample and this may have resulted in some between group differences that may exist that were not evident. As a result of the sample size, for example, power was negatively impacted. Given the literature, a small sample size is not surprising, as it is difficult to recruit a sufficient amount of participants given the low prevalence rate. Nevertheless, future research should focus on recruiting more participants in order to increase statistical power, possibly using a multi-site approach. In addition, larger sample sizes would allow researchers to determine whether stuttering characteristics (e.g., severity, type, age of onset, etc.) influence this association between stuttering and motor skill deficits. Further, the results of this study cannot be generalized beyond this sample and its characteristics. This sample was rather homogeneous, as all participants were recruited in an urban school district in Texas. Future research may wish to focus on examining CWS in other geographic regions, as well as among more diverse participants.

Another area of limitation may be related to the measure and method of investigating motor function, as only one motor instrument was utilized. The use of additional measures may have introduced different task demands that may have detected additional deficits. Further, research related with oral motor evaluation, a full range of motor skills, educational outcomes, and social well being may be beneficial.

Conclusion

In conclusion, as shown within this sample, CWS demonstrate a range of motor deficits beyond motor control underlying disfluency. These results confirm much of the literature from the early to mid 1900s (cited above) and suggest that for CWS, stuttering is not always the only problem they face. Impairments in other motor domains may exacerbate their difficulties in school socially and academically. Collaboratively, school personnel, particularly school psychologists and SLPs, are in a position to evaluate and provide appropriate services to remediate any other impairment in CWS. The extent to which motor skills are affected and the long term effect of these deficits needs to be further researched to identify possible targeted interventions and improve outcomes.

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APPENDIX

1. What is the age of the child?

- | | |
|----------------------------|-----------------------------|
| <input type="checkbox"/> 6 | <input type="checkbox"/> 10 |
| <input type="checkbox"/> 7 | <input type="checkbox"/> 11 |
| <input type="checkbox"/> 8 | <input type="checkbox"/> 12 |
| <input type="checkbox"/> 9 | <input type="checkbox"/> 13 |

2. What is your child's gender?

- | | |
|-------------------------------|---------------------------------|
| <input type="checkbox"/> Male | <input type="checkbox"/> Female |
|-------------------------------|---------------------------------|

3. What grade is the child currently in?

- | | |
|--|--|
| <input type="checkbox"/> 1 st | <input type="checkbox"/> 5 th |
| <input type="checkbox"/> 2 nd | <input type="checkbox"/> 6 th |
| <input type="checkbox"/> 3 rd | <input type="checkbox"/> 7 th |
| <input type="checkbox"/> 4 th | <input type="checkbox"/> 8 th |

4. Please identify the child's racial background.

- | | |
|---|--------------------------------------|
| <input type="checkbox"/> Caucasian | <input type="checkbox"/> Asian |
| <input type="checkbox"/> African-American | <input type="checkbox"/> Other _____ |
| <input type="checkbox"/> Hispanic | |

5. What is the highest level of education of the child's mother?

- | | |
|---|---|
| <input type="checkbox"/> Some high school | <input type="checkbox"/> Some college |
| <input type="checkbox"/> High school graduate | <input type="checkbox"/> College graduate |

6. What is the highest level of education of the child's father?

- | | |
|---|---|
| <input type="checkbox"/> Some high school | <input type="checkbox"/> Some college |
| <input type="checkbox"/> High school graduate | <input type="checkbox"/> College graduate |

7. Does your child receive special education services in their school?

- | | |
|------------------------------|-----------------------------|
| <input type="checkbox"/> Yes | <input type="checkbox"/> No |
|------------------------------|-----------------------------|

If yes, what type of special education program does this child receive services in?

- Learning Disability (LD)
- Other Health Impaired (OHI)
- Emotional Behavior Disorder (EBD)
- Autism (AU)
- Speech Impairment (SI)
- Orthopedically Impaired (OI)
- Traumatic Brain Injury (TBI)
- Visual Impairment (VI)
- Multiple Disabilities (MD)

8. Does your child stutter?

- Yes No

9. Does your child have a diagnosis from their doctor or a psychologist?

- Yes No

If yes, please list:

If your child stutters, please continue on to the next page. If your child does not, you may discontinue. Thank you!

10. At what age did your child get identified as a child who stutters? _____

- | | |
|--------------------------------------|---|
| <input type="checkbox"/> 1 year old | <input type="checkbox"/> 5 years old |
| <input type="checkbox"/> 2 years old | <input type="checkbox"/> 6 years old |
| <input type="checkbox"/> 3 years old | <input type="checkbox"/> 7 years old |
| <input type="checkbox"/> 4 years old | <input type="checkbox"/> 8 years old or older |

11. Has he/she received any stuttering treatment?

Yes No

If yes, when did treatment begin?

 1 year old 5 years old 2 years old 6 years old 3 years old 7 years old 4 years old 8 years old or older

If yes, how long was treatment?

 1 year 4 years 2 years 5 years 3 years 6 or more years

If yes, what type of treatment? _____

12. Does he/she continue to receive treatment?

 Yes No

13. Has medication been tried as a treatment option?

 Yes No

If so, what medication(s)? _____

Thank you for participating in this study!

VITA

Name: Andrew Martinez Jr.

Address: Department of Educational Psychology
4225 Texas A&M University
College Station, TX 77843-4225

Email Address: Andrew_martinez@tamu.edu

Education: B.A., Meteorology, Texas A&M University, 2007
Ph.D., School Psychology, Texas A&M University, 2012

Internship: Fort Worth Independent School District, 2011-2012

Practica: Assessment, CAC, College Station, TX, 2011
Autism Assessment, BVRC, Bryan, TX, 2011
Forensic, Bryan, TX, 2011
Neuropsychology Assessment, TCH, Houston, TX, 2011
School-based, Cypress Grove, College Station, TX, 2009-2010

Publications: Martinez, A., Cohen, M. & Riccio, C. A. (in preparation).
Behavioral phenotypes of children with epilepsy.
Peterson, L. S., Martinez, A. & Turner, T. L. (2010). Test
review: Process assessment of the learner-second edition.
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Presentations: Darensbourg, A. & Martinez, A. (2010, March). Teacher willingness
to intervene in relational aggression in secondary school.
Presentation at the National Association of School Psychologists.
Martinez, A. (2009, February). Coding Schemes. Presentation at the
Southwest Educational Research Association, San Antonio, TX.

Posters: Martinez, A., Wicker, N., Kao, G., Cohen, M., & Riccio, C. A. (2010,
October). Behavioral profiles of children with epilepsy. Poster
session at the National Academy of Neuropsychology.
Turner, T. L., & Martinez, A. (2010, March). Exploring the links
between ethnic identity, self-concept, aggression, and self-esteem.
Poster session presented at the National Association of School
Psychologists.