

VARIANCE IN SCORES IN
ASSESSMENTS FOR AUTISM AND STUTTERING

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ABSTRACT

For decades, developmental disorders such as stuttering and autism have both been subject to much theorizing and research. Along the way, key discoveries and insights have been produced about each of these developmental disorders along a number of dimensions, including heritability, behavioral and cognitive characteristics, neurological associates, onset and development, and intervention approaches. To this end, there are areas of convergence and divergence between these two disorders that can potentially provide new insights relating to the spectrum view of developmental disorders. The primary aim of this project is to evaluate recently published studies in the areas of autism and stuttering that utilize two prominent standardized assessments, the SSI-4 and the ADOS, to compare and contrast the distributions of scores between the two disorders. The main finding was both SSI-4 and ADOS scores resemble a normal distribution, suggesting that, within each disorder, there exists a range of scores within each diagnostic category. Results are interpreted to suggest that, based on the similarity of these distributions (particularly for the ADOS Total), stuttering could, like autism, be considered a “spectrum” disorder. However, as will be discussed, there are other areas of divergence that would argue against a spectrum view for stuttering.

LIST OF ABBREVIATIONS

ADOS – Autism Diagnostic Observation Schedule

SSI – Stuttering Severity Instrument

PDD – Pervasive Developmental Disorder

ASD – Autism Spectrum Disorder

ADD – Attention Deficit Disorder

DS – Developmental Stuttering

ASHA – American Speech-Language Hearing Association

DSM – Diagnostic and Statistical Manual of Mental Disorders

APA – American Psychiatric Association

MRI – Magnetic resonance imaging

fMRI – Functional magnetic resonance imaging

DTI – Diffuser tensor imaging

CSS – Calibrated severity score

RRB – Restricted repetitive behaviors

SA – Social affect

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Part I: Introduction

Professionals within the field of communication sciences and Communicative Disorders treat and research a number of developmental disorders, two of which are Developmental Stuttering (DS) and Autism Spectrum Disorder (ASD). Although both disorders have been subject to significant research over the last several decades, the cause for either remains unknown. There appear to be, however, many similarities between these two developmental disorders which can potentially provide some important insights pertaining to either. This includes the heritability, age of onset, behavioral and cognitive characteristics, neurological associates, onset and development, and intervention approaches. In addition, these disorders can be compared or contrasted in terms of the subjective experiences of people with either disorder, which might be attributed to differences in cognitive and/or social skills.

Although both of these disorders have a rich history of research and theorizing (e.g., Bloodstein & Ratner, 2008; Evans, 2013), few, if any, highlight the similarities in both disorders or explore ways in which one disorder might inform the other. At a surface level, both of these developmental disorders are part of a class of disorders that seem to originate due to anomalies in cerebral lateralization (Asenova, 2018), have a similar heritability and affect about 3-4 times more boys than girls, and cannot be “cured” but only managed over a lifetime after onset or persistence has occurred (Manning, 2018). These remarkable similarities indicate that not only might one be able to obtain key insights about one disorder from the other but invites the question as to the current literature and studies which explore diagnosis and assessments relating

to each, drawing comparisons between inclusion criteria for the two disorders within these studies.

However, to date, clinicians and researchers have not apparently seen reason to directly compare the two in any formal manner, perhaps because for many clinicians and researchers in the field of Communicative Disorders, there would appear to be no obvious connections between the two disorders. Researchers and clinicians may devote significant time and resources to any single disorder or area of Communicative Disorders, potentially neglecting connections between any two disorders that might be revealed by in-depth knowledge of both literatures. This leaves room for research in which one might be able to learn more about one from the other. For this project, the primary avenues of inquiry concern a number of important dimensions associated with developmental disorders in general: A) heritability, B) behavioral and cognitive characteristics, C) possible neurological origins in the brain, D) onset and development, and E) intervention. In addition, developmental stuttering and autism can be compared on distributions of data acquired from published studies, with an eye toward considering to what extent stuttering, like autism, would fit a “spectrum” view.

Part II: Background in Stuttering

A. Heritability

Heritability is a useful measure of the genetic contribution to any trait or behavior, including those associated with developmental disorders. In brief, heritability is the contribution of genetic inputs on a developmental disorder relative to environmental contributions (Tick et al., 2015). To date, the heritability of stuttering has been examined by a number of studies which include estimates ranging from 0.4 to 0.8 (e.g., Frigerio-Domingues, 2017; Rautakoski, 2012), with many scholars suggesting that about 0.6 is an accurate estimate (Dworsynski, et al., 2007). This means that, given that a child does stutter, about 60% of the variance in its onset can be explained by genes, and the other 40% by the environment. It is important to note that because the heritability is neither 0.0 nor 1.0, it is likely the case that for nearly all people who stutter that both genetic and environmental factors are necessary for stuttering to onset in the first place.

Although a number of studies have investigated the heritability of stuttering, these studies often utilize different approaches to ascertain a more precise estimate (e.g., twin studies versus genome wide association studies). For example, the authors of a twins study comparing children who persisted or recovered concluded that heritability in developmental stuttering to be around 0.6, or 60% (Dworzynski et. al, 2007). For monozygotic twins, who share the same DNA, the concordance rate is about 85%, whereas for dizygotic twins, who share 50% of their DNA, the concordance rate is about 40% (Kraft & Yairi, 2012). This means that even sharing the same DNA with a twin can lead to different developmental outcomes, although that developmental outcome is much more likely. This would suggest that the heritability of stuttering extends

beyond a single gene or small set of genes, but rather involves the accumulation of hundreds or thousands of genes.

Other studies have investigated the possible role that specific genes play in developmental stuttering. A recent study concluded that mutations of four genes (i.e., GNPTG, NAGPA, AP4E1, and GNPTAB) cumulatively contribute to 20% of the heritability of stuttering (Frigerio-Domingues, 2017). Although focusing on specific genes might one day provide some promising leads for understanding the genetic contribution to stuttering, understanding the precise role that certain genes might play as they co-act with the environmental factors to result in familiar developmental outcomes is unclear (Gottlieb, 2007).

B. Behavioral and Cognitive Characteristics

Stuttering has been defined as a disruption of speech experienced by the speaker as loss of control (Perkins, 1983). This loss of control may manifest in a variety of ways, both represented in acoustic signal available to a listener as primary stuttering characteristics such as syllable repetitions or prolongations, or available visually to a listener as physical manifestations such as facial grimaces, jaw tension, loss of eye contact, among others. Thus, to the listener, behaviors associated with stuttering are typically classified into two perceptual categories: core behaviors and secondary behaviors. These perceptual categories can be used for clinical purposes as a means to determine whether a child or adult is stuttering on a standardized scale such as the Stuttering Severity Instrument (SSI; Riley, 2009). These behaviors may also be measured to determine effectiveness of a treatment or intervention plan either post-treatment or during the intervention process.

From a perceptual standpoint, all overt stuttering behaviors could be thought of as acoustic signals which can be heard as interruptions of fluent speech in the speaker's voice and are the basic manifestations that seem beyond the voluntary control of the stutterer (Roth, 2021). Thus, repetition of sounds, syllables, or whole words (e.g. "d-d-don't do that," or "my-my-my friend") sound prolongations (e.g. the "m" in the phrase "my friend"), or block of airflow that are transmitted within an acoustic signal can be interpreted by a listener as struggle in moving forward in speech. During blocks, phonation ceases and speech is interrupted. Different individuals may exhibit more instances of one type over the others, though in excess, these auditory symptoms all indicate a fluency disorder.

Secondary Behaviors, also sometimes referred to as physical concomitants, are behaviors in stuttering which occur simultaneously to or in anticipation of a disfluency. The American Speech-Language-Hearing Association (ASHA) defines these behaviors as eye blinking and head nodding, or other movements of the extremities, body, or face and are often visible to the listener as jaw grimaces, head nods, loss of eye contact, toe taps, facial and neck tension, and other physical traits (ASHA, 2021). These behaviors are classified as secondary because they are not actually part of speech but seem to manifest as part of the struggle to move forward in speech, or in other words to "get the word out" (Conture, 2001). A secondary behavior which presents itself audibly is known as circumlocution, or the speech that one produces in avoidance of a feared word or sound. In circumlocution, the speaker will restructure sentences and phrases so as to avoid a word or speech sound that is often recognized as particularly challenging to say (Bloodstein & Ratner, 2008)

Although stuttering behaviors are classified as primary versus secondary by clinicians and researchers, some have argued that both are a core part of stuttering and function as coping mechanisms for those individuals who experience the feeling of loss of control (Perkins, 1983). To this end, both primary and secondary stuttering behaviors develop over time in the life of the individual who stutters and are likely learned by a speaker as a means of helping to work through a stuttering event (Brutten & Shoemaker, 1975). Manning (2018) notes that these behaviors develop as a result of the speaker's awareness of the stutter (p. 50). These secondary behaviors are included in some standardized fluency assessments such as the Stuttering Severity Instrument (Riley, 2009). Secondary characteristics of stuttering can function as targets of intervention along-side primary stuttering characteristics, as most clinicians agree that they don't actually contribute to fluent speech, but rather get in the way (Manning, 2018).

Although stuttering can be defined in terms of behaviors, there is also an important element of a person's subjective experience, including emotions such as fear and anxiety about stuttering in front of other people as well as feelings of shame that occur when one does stutter in front of others (Boyle, 2014). Thus, an important aspect of stuttering is that much of it can be covert and the manner in which a person copes with stuttering is largely subjective. For example, some individuals may experience anticipation of stuttering on upcoming words or contexts, but choose not to speak. Many people who stutter also experience high levels of antisocial behavior and/or anxiety brought on by the experience of stuttering (Menzies et al., 1999; Messenger et al., 2004; Craig, Blumgart, & Tran, 2009). Intervention for people experiencing negative emotions about stuttering may focus on modifying stuttering behavior along with addressing feelings of

guilt and shame through group therapy, self-help groups, and counseling (Cheasman et al., 2015). The prevalence of covert stuttering might parallel important aspects of autism in that many of the symptoms might be hidden from public view.

Emotions are of particular importance in childhood stuttering. In a study which examined daily emotions as they related to tasks and observed intensity of stuttering by caregivers, event intensity proved to be significantly related to the observed stuttering of a child (Treleaven, Buhr, & Coalson, 2018). This study also found that as negative emotional intensity increased, so did stuttering. While emotions may play a significant role in the instances of stuttering in some individuals, it should be noted that stuttering need not be caused by emotions. Children who stutter have also been rated by their parents to experience more emotional reactivity and less emotional regulation compared to their typically fluent peers (Karrass et al., 2006). The onset of stuttering in children is often related to events such as divorce, moving to a new house, attending daycare, or the birth of a new sibling (Manning, 2018). Taken together, these studies indicate that stuttering often accompanies emotional arousal in childhood, whether that emotion is positive or negative, suggesting factors in the environment that elicit emotional arousal also trigger stuttering behaviors (Treleaven, Buhr, & Coalson, 2018).

C. Neurological associates

Numerous researchers in the field of stuttering have attempted to pinpoint a “problem area” or single cause in the human brain in order to locate a causality and origin of fluency disorders. The range of potential causes of stuttering that have been investigated include both linguistic and motor processing and their assumed neural points of origin. Language acquisition

and development has also been a factor which has been explored as corresponding with the prevalence of stuttering in young children. Recent studies, however, have disproved the theories behind correlation between stuttering and language delays, finding that many children who stutter have average or above average expressive and receptive language skills when compared to their peers (Ambrose & Yairi, 2005).

There are two main types of imaging techniques which have been used in stuttering research: magnetic resonance imaging (MRI) and diffusion tensor imaging (DTI). Each of these techniques offers benefits and allows for analysis of different information in comparison with the other. Magnetic resonance imaging utilizes magnetic radio waves to display organs and tissues in the human body. MRI images are helpful in visualizing and identifying tumors, indicators of strokes, ruptured blood vessels, and signs of aneurysms among other structural anomalies. Similarly, functional magnetic resonance imaging (fMRI) is a technique which not only analyzes the structure of organs and tissues, but the functional quality associated with them. Diffusion tensor imaging is a type of MRI imaging technique which utilizes anisotropic diffusion to determine the organization and distribution of white matter in the human brain. Typically, once the image has been captured using DTI, a technique known as fiber tractography is used to reconstruct a three-dimensional image portraying the white matter using the information gathered during the imaging process.

Research using brain imaging technology such as functional magnetic resonance imaging (fMRI) has shown a number of brain areas that seem to differ at least somewhat compared to people who do not stutter (e.g., Chang, 2018). One of the common findings from these studies is

that people who stutter exhibit over-activation of the right hemisphere compared to the left hemisphere, relative to people who do not stutter (e.g., Alm et al., 2013; Beal et al., 2007; Chang et al., 2009). This finding was first reported by Orton and Travis (1929), who reported this same finding using EEG, which they took to indicate a lack of cerebral lateralization for people who stutter. This might suggest that the left hemisphere, which is lateralized for language (Geschwind & Galburda, 1985), may function aberrantly relative to the right hemisphere. It should also be pointed out that the right hemisphere is more lateralized for emotion (Geschwind & Galburda, 1985), suggesting that greater right hemisphere activity would be expected given the intense, negative emotions associated with stuttering.

Another possible neurological etiology of stuttering is that people who stutter utilize less efficient motor planning processes in the brain which may lead to less efficient motor pathways. One study to support this theory comes from Alm (2004), who concluded in his review that due to possible basal ganglia dysfunction, people who stutter might rely more on the cerebellum for speech production, relative to people who do not stutter. It has also been suggested that people who stutter might rely more on feedback than feedforward sensorimotor processing, potentially due to underdeveloped or insufficiently activated internal models for speech motor control (Max et al., 2004).

Additionally, recent studies have shown a difference in the prevalence of white matter not only between people who stutter and typical speakers, but between people with adult-onset stuttering and those with developmental stuttering. Using Diffusion Tensor Imaging (DTI), a type of imaging technique which analyzes fractional anisotropy, or the density and myelination

of white matter within the human brain, Chang concluded that right hemisphere fractional anisotropy was greater in people with developmental stuttering than in those whose stuttering developed beyond childhood (Chang et. al, 2010). This discrepancy in white matter density could likely be caused by the coping behaviors and emotions associated with developmental stuttering which have resulted in more right-sided compensation when compared with those whose stuttering developed later. It should also be noted that these differences in myelination may represent changes in speech-motor planning as they are manifested in the brain.

Finally, in line with studies showing overactivation of the right hemisphere, those areas of the left hemisphere that appear to be reduced in people who stutter include the inferior frontal gyrus, including Brodmann areas 44, 45, and 46 (Loucks et. al, 2011). These findings could indicate differences in rapid temporal sequencing which is typically associated with fluent speech. Additionally, these findings could indicate language processing in individuals who stutter may occur in an atypical manner, apart from Broca's area. In summary, neurological factors, while not necessarily being the primary cause of the onset or persistence of stuttering, could continue to play some role in stuttering behaviors throughout a person's life, with between-group differences in imaging studies revealing differences in brain development over a lifetime of stuttering.

D. Onset and development

The onset of stuttering generally occurs at about 33 months of age (Ambrose & Yairi, 2015). Most children who begin stuttering at this age will recover on their own within about 2-3 years, but sometimes within six months to a year, without any formal intervention. For children

who persist past the age of about six years, stuttering will require lifelong management.

Assessment and diagnosis of fluency disorders are conducted by a licensed Speech-Language Pathologist in a clinical or school setting. There are many measures and assessments which can be used to evaluate the extent of stuttering in children and adults, although the two which are most frequently utilized include the *Stuttering Severity Instrument - 4th Edition* (SSI-4; Riley, 2009) and *Test of Childhood Stuttering* (TOCS; Gillam, 2009). The scoring criteria for these assessments cover elements related to the severity of stuttering: type of stuttering (e.g. prolongation, block, repetition), duration of disfluency produced, and number of disfluencies per passage (typically in passages greater than 150 syllables).

It is estimated that as many as 85% of children who begin stuttering in the preschool years will recover on their own, often with no formal intervention (e.g., Kefalianos, 2014). This estimate is based on inviting parents of children who have recently started stuttering and tracking their development over a period of 2-3 years (e.g., Kefalianos, 2014; Yairi & Ambrose, 1992,1999). However, this is also some evidence to suggest that the onset of stuttering can even occur later in childhood (Chang et. al, 2010). While the reasons underlying persistence or recovery in any particular child is unclear, some risk factors for persistence include being a male and a history of persistent stuttering within the family. Although one study by Paden and Yairi (1999) found that children who would eventually persist scored significantly lower in phonological skills than age- and gender-matched children who recovered, their standard scores on the Hodson Test of Phonological Proficiency (HAPP) were still within normal limits. To date,

there does not appear to be compelling evidence that children who begin to stutter or those to persist differ from children who do stutter in terms of language development or proficiency.

For people who persist into adulthood, any further change in stuttering can be due to a number of factors, including effective management of stuttering over a lifetime, and sometimes something approaching spontaneous recovery in some individuals (Anderson & Felsenfeld, 2003; Finn, 1996). For many individuals who receive treatment and make initial gains in fluency, up to 70% of these individuals experience some degree of relapse., which is thought to be the result of intervention approaches that focus on speech fluency to the exclusion of inner feelings of guilt and shame (Manning, 2018). Thus, effective clinical intervention for people who have persisted should involve some combination of meaningful counseling and behavioral changes toward more fluent stuttering. Intervention approaches will be discussed next.

E. *Intervention*

Intervention for preschool-aged children generally includes those that are direct or those that are indirect. The most widely used direct treatment approach for children is likely the Lidcombe (Jones, et al., 2008; Onslow et al., 2001), which asks parents to point out their children's stuttered speech in a neutral manner, praise fluent speech on occasion, and ask children to try "bumpy" speech again. Such treatment is deemed to be successful after a child's percent of stuttered syllables is reduced to less than 1%. This approach to stuttering is usually referred to as a "direct" or "operant" approach in that the parent or clinician is actively targeting stuttered speech and asking the child to make direct changes in their speech. In contrast, indirect approaches to childhood stuttering ask parents to make changes in their daily routine that are

thought to facilitate fluent speech as well as talking about stuttering and giving a child ample time to talk (e.g., Millard et al., 2008). This includes talking openly about stuttering, providing the child time to speak, parents speaking in an unhurried manner, and achieving a more consistent daily routine.

In a large study based on the Netherlands, indirect and direct approaches were directly compared with samples of nearly 100 children in each treatment group (de Sonnevile-Koedoot et al., 2015). Results showed that both groups of children made gains in terms of increased speech fluency at 3 months and again at 18 months, but it was not clear that either intervention approach showed greater effectiveness than natural recovery. More research is needed to evaluate the extent to which interventions in childhood stuttering is effective, and to the extent that it is, what factors might be common to positive treatment outcomes.

Interventions for adolescents and adults who have persisted, on the other hand, may include a combination of strategies to assist individuals in navigating moments of disfluencies by altering the manner of articulation. Strategies such as these are referred to as “speak more fluently” approaches, also referred to as “fluency shaping.” As mentioned above, focusing solely on the mechanics of speech to the exclusion of inner feelings about stuttering is associated with high percentages of relapse (Manning, 2018). Fluency shaping strategies may encompass practicing a slower rate of speech and easy onset (i.e., gentle start), to modify the phrasing of overt speech. Each of these strategies is thought to promote decreased tension in the vocal tract and/or light articulatory contact. This idea requires that the speaker place the tongue in various

places of articulation as gently as possible. Clients may use any combination of these strategies in a variety of phrases and words to better manage stuttering.

While the benefits of each strategy may be beneficial to certain populations, clinicians must also consider factors such as age of the client and other comorbid conditions which could hinder the individual's comprehension of the strategy. In adolescents and adults who stutter, "light articulatory contact" may be beneficial in navigating through moments of disfluency. Clinicians may also instruct clients to implement voluntary stuttering in which an individual purposefully stutters and analyzes his or her own feelings as well as reactions from the listener with the goal of reducing the feelings of anxiety or fear associated with moments of disfluency (Roth, 2021). A similar technique is referred to as freezing and involves purposefully extending the moment of disfluency. This is thought to increase the client's tolerance for and control of stuttering (Roth, 2021).

Stuttering can have many emotional effects on individuals who experience it and incite anxiety. Many scholars have argued that counseling should play a significant role in the treatment process. Manning (2018) suggests that counseling is an essential part of the therapeutic change process for individuals who stutter. He cites humanistic traits such as listening skills, empathy, and humor as beneficial traits in clinicians as they treat individuals who stutter. Additionally, Manning states that the goal is not to fix emotions associated with stuttering but rather help the individual take action and function in spite of them. Similarly, while some clients seek to completely cure or remove stuttering from their speech, this is not a probable result of intervention and thus should not be a targeted goal of treatment. Treatment should instead consist

of ways to manage disfluencies and decrease the incidence of stuttering in running speech in addition to the secondary behaviors which accompany stuttering.

Finally, it is interesting to note that both a systematic review and a meta-analysis have shown that it is not the particular intervention approach that is chosen for working with a person who stutters, but rather the factors such as the therapeutic alliance with the clinician, whether the client finds the therapy meaningful (Herder et al., 2006; Bothe et al., 2006), and where the client is at in terms of their “readiness” to make change (Floyd et al, 2007). These factors that seem to be the most important factors for long-term change are the focus of the Common Factors Model (e.g., Wampold, 2015). These factors seem to suggest that changes made within a person and how that person feels about themselves in relation to others are the driving forces of positive change (Manning, 2018).

Part III: Background in ASD

A. Heritability

Autism Spectrum Disorder is a developmental disorder which affects areas of life such as language, cognition, social skills, and often involves restrictive areas of interest and repetitive behaviors (Robson, 2013). Researchers' and medical professionals' views on ASD have evolved through the years, originating with misunderstanding of the nature of the disorder accompanied by ineffective treatments, moving toward newfound enlightenment with regard to the cognitive, behavioral, and genetic aspects of the disorder (Silberman, 2015). Although many researchers have sought to identify specific "autism genes" that contribute to the prevalence of the disorder in individuals, any genes believed to cause Autism are likely far too numerous for a few specific genes to be responsible for its origin (e.g., Plomin, 2019). Environmental factors almost certainly play a contributing role as well in the onset and/or development of autism.

Much like stuttering, the heritability associated with autism is significant, with researchers estimating the genetic contribution to autism to be anywhere from 64% to 91% (Tick et. al, 2015). In a meta-analysis which examined monozygotic twins, heritability correlations were found to equal .98, a nearly perfect correlation ratio (i.e., nearly perfect concordance), indicating a high very heritability factor in the onset of autism. Autism, similarly to other developmental disorders, exhibits male bias with a prevalence of 4 affected males to 1 affected female (Werling & Geschwind, 2013). Additionally, some research has shown that behaviors in autism may manifest differently in males and females (Werling & Geschwind, 2013). Although severity of symptoms experienced by individuals with a diagnosis may not be due to the

differences in gender, some phenotypes which have been found to be more common in one gender versus the other. Males with autism have been found to exhibit more externalizing behaviors such as aggression, hyperactivity, reduced prosodic behavior, and increased repetitive or restrictive behaviors. Conversely, females may experience internal symptoms such as depression or anxiety, as reported by parents (Werling & Geschwind, 2013). The differences in phenotypes combined with the prevalence ratio are most likely attributable to both environmental and genetic factors which are both subject to ongoing research.

B. Behavioral and Cognitive Characteristics

Behaviors associated with Autism Spectrum Disorder typically broadly take the form of impaired social interactions and communication (American Psychiatric Association, 2013). While such behavior may be accompanied by knowledge or specialization regarding a particular skill or topic, some people may exhibit this behavioral characteristic to extreme lengths, for example, perseverating on one single topic at the expense of social involvement and peer interaction. There additionally exists variability in language skills for people with autism, resulting in limitations in the ability to verbally communicate in some individuals, while others experience minor pragmatic deficits and relatively intact verbal skills. Physical behaviors are also common in individuals with ASD and are typically categorized as self-soothing or regulation behaviors that are more colloquially known as “stimming.” These behaviors may serve a variety of functions, but many researchers have insisted that stimming fulfills a temporary need for sensory input for the individual experiencing the symptoms (e.g., Kapp et al., 2019). Other researchers have suggested that such behaviors are exhibited as a means of self-

regulation to compensate for dysfunctional physiological parasympathetic control of sympathetic arousal (e.g., Porges, 2005). Although stimming is a physical manifestation of the disorder, it falls under one of the criteria for diagnosis of ASD as highlighted by the DSM which notes “restrictive or repetitive behaviors” as being one of the primary characteristics (APA, 2013).

Important cognitive characteristics of autism involve what has been referred to as lack of “theory of mind,” or in other words, difficulty reading the intentions of other people as a means of achieving appropriate social behavior (e.g., Baron-Cohen, 1995). Because intention reading is thought to be a necessary capability to learn language (Tomasello, 2003), for some children with autism, this means persistent deficits or delays in language ability, which can manifest in difficulties understanding pragmatic uses of language such as understanding irony, jokes, and using metaphor.

Children with autism who would be placed on a more “severe” position on the autism spectrum may exhibit difficulty in social interactions due to the cognitive deficits associated with the disorder. In many cases, social interaction as a whole is generally avoided. To some, these children may appear to only exist within their own world in which they exhibit great interest in systems, often resulting in the fixation on objects or concepts of particular interest, such as mathematics, history, mechanics, etc. This contributes to the many similarities which exist between autism and stuttering, as individuals who stutter may at times withdraw from society as to avoid stuttering and communication due to anxiety related to the condition.

Another behavioral hallmark of autism is the tendency for these individuals to adhere to familiar ideas, routines, or objects. For some, this may manifest in taking the same route to work

each day, or perhaps eating the same meal on a certain day of the week. This sense of familiarity can be comforting as the breakup of a routine or familiar system which has been in place can be quite jarring for individuals with an autism diagnosis.

C. Neurological Origin

The symptoms and signs of ASD are typically associated with deficits in the right hemisphere of the brain, manifesting within human behavior as loss of joint attention, inability to read facial expressions or non-verbal forms of language or communication, reduced prosodic elements (suprasegmentals of speech) in running speech, and an inability to comprehend figurative or metaphorical language, among other various features. Many of these prodromes can be seen in infancy as early as 9-12 months (Tomasello, 2003). Oftentimes a lack of joint attention at a very early age can be indicative of ASD. An apparent deficit in the concept of “pretend play,” or the ability to use objects in a way that departs from their intended function, is additionally considered to be a possible indicator of ASD.

The joint attentional deficits prevalent in ASD point to a deficit in “theory of mind,” the overarching idea which underscores all human interaction. “Theory of mind” is a concept which is described by Michael Tomasello as exhibited in the following ways: 1) the ability to share attention with other persons to objects and events of mutual interest; 2) the ability to follow the attention and gesturing of other persons to distal objects and events outside the immediate interaction; 3) the ability to actively direct the attention of others to distal objects by pointing, showing, and using of other nonlinguistic gestures; 4) the ability to culturally learn the

intentional actions of others, including their communicative acts underlain by communicative intentions (Tomasello, 2003).

Finally, autism is considered to be part of a class of developmental disorders, like stuttering, which is associated with anomalies in hemispheric lateralization (Asanova, 2018). The deficits associated with autism can be attributed to developmental anomalies in the right hemisphere. Linguistic elements such as rate, pitch, tone, and other aspects of prosody are found in the right hemisphere (Geschwind, 1985). Other elements of communication believed to be associated with the right hemisphere include comprehension of non-verbal cues and language, use of figurative language or metaphors, and expression or comprehension of emotions of others (e.g., McGilchrist, 2009). Thus, although the phonological and symbolic aspects of language are lateralized to the left hemisphere, deficits involving the right hemisphere can contribute to language deficits in individuals with autism. For many, these deficits can be debilitating and detrimental to social interactions. Some children with autism may have difficulties acquiring expressive or receptive language skills due to these deficits. Some individuals, however, may only exhibit minimal difficulties with non-verbal communication and other social skills. Acquisition and use of language as it relates to the two hemispheres is imperative in our understanding of autism and the variability of the severity of these deficits contribute largely to its diagnosis as taking place on a spectrum.

D. Onset and Development

As mentioned above, the typical age of onset of children diagnosed with ASD is within the first year of life, often as early as eight or nine months (Tomasello, 2003). Furthermore, to

the extent that a child does not begin to show symptoms of autism at this early age, there is little evidence that autism will occur later, although symptoms may be acknowledged at a later age. This is in contrast with stuttering, in which a child might experience a few years of relatively fluent or non-stuttered speech before stuttering onset occurs in the 3rd, 4th, or 5th year of life (Ambrose & Yairi, 2015). Thus, the developmental trajectory for autism seems to be largely set within the first year of life and can only be managed somewhat as a result of effective intervention. There also appears to be no evidence that a child with autism experiences anything like the recovery that appears to be the case with many individuals with developmental stuttering.

Unlike developmental stuttering, it does not appear that, over the course of development, that the behavioral or cognitive characteristics of ASD change dramatically. For example, for children diagnosed with a more severe form of ASD, there does not appear to be much change in either behavioral or cognitive characteristics (Woodman et al., 2015). However, there is some evidence that for other children diagnosed with ASD that there is some degree of change in these behaviors over the succeeding years, and this is often attributed to intervention on behalf of the clinicians or parents (Woodman et al., 2015). However, to the extent that these cognitive characteristics are present, it would not appear to be the case that they can be changed; rather, intervention can function to help provide tools for the person to manage autism. Intervention provides the tools or techniques that enable affected individuals to participate in everyday social or communicative interaction, whereas typically developing individuals exhibit these skills naturally. There does not appear to be any evidence that the onset of autism manifests later in

life, meaning that if symptoms do not manifest within the first year of life, they will not manifest at all.

There are a number of disorders which fall under the broad category of Autism Spectrum Disorder. Developmental disorders such as Asperger's Syndrome, Pervasive Developmental Disorder (PDD), and childhood disintegrative disorder (Charan, 2012) are all possible pre-existing diagnoses which are part of an overarching family of disorders in addition to Autism. In 1994, the American Psychiatric Association (APA) released the Diagnostic Statistical Manual of Mental Disorders (4th edition; American Psychiatric Association, 1994) which identified each of these disorders as sharing important characteristics with Autism, each with its own variability of symptoms. This manual was the first to officially recognize ASD diagnoses as taking place on a spectrum, due to the high variability of symptomatic behavior. In 2013, the APA released the fifth edition of the DSM, or DSM-V, introducing clarity in the diagnosis of the four disorders described in the fourth edition. According to the APA information sheet preceding the release of the DSM-V, a study conducted by Huerta et. al (2012) concluded that the majority of children with a DSM-IV PDD diagnosis retained their diagnosis of ASD as outlined by the criteria in the DSM-V (American Psychiatric Association, 2013). These findings suggest that the increased amount of research has allowed for more consistency in the symptoms and diagnosis of disorders which are found under the broader category of ASD. The diagnostic criteria which are outlined by the DSM-V as contributing to the overall diagnosis of ASD fall under two categories: impaired social communication and/or interaction and restrictive and/or repetitive behaviors. Prevalence of ASD has continued to increase in recent years. According to data collected by the

CDC in 2020, 1 in 54 children presents with Autism Spectrum Disorder, indicating increased awareness and a heightened need for services for individuals with a diagnosis (Maenner et al., 2021).

E. *Intervention*

Evaluation and diagnosis of ASD must come from a licensed behavioral therapist or psychiatrist with certification in intervention for or diagnosis of ASD. There are a few common assessments which can be utilized for evaluation, two of which are the *Autism Spectrum Rating Scales* (ASRS) and the *Autism Diagnostic Observation Schedule* (ADOS). Each of these assessments focuses on the two diagnostic criteria to achieve an official diagnosis, mainly impaired social communication and/or interaction and restrictive and/or repetitive behaviors. Overall, intervention for individuals with ASD varies greatly depending on 1) age, 2) severity of symptoms and 3) impact on the individual's daily life.

Intervention and therapy for children with an autism diagnosis will likely focus on skills such as nonverbal language and joint attention. Intervention programs which are available to individuals with an ASD diagnosis include the *Program for the Education and Enrichment of Social Skills* (PEERS) and other various social skills groups (Laugeson et al., 2011). Enrollment and availability of each of these services may depend on the age of the individual along with the cognitive abilities associated with the severity of the diagnosis. PEERS includes an assessment to conduct during the evaluation process called the *Test of Young Adult Social Skills Knowledge*, (TYASSK-R, Laugeson & Frankel, unpublished). This assessment covers a variety of categories in social behavior such as confrontation and dating etiquette. Licensed psychiatrists and Speech-

Language Pathologists (SLPs) are typically involved in the intervention process and may collaborate with other professionals (e.g. Occupational therapists, primary physicians) depending on the severity of social impact and cognitive impairment of the disorder.

Intervention for adults with a diagnosis of ASD may focus on social skills, with many approaches helping a person with autism to learn what is socially appropriate, or those pragmatic skills that might be described as intuitive to people without autism. Adults may participate in the PEERS program as well as other programs which target social skills. SLPs often are involved in this type of intervention as many of the skills which are targeted during the sessions are within their scope of practice as outlined by ASHA. Examples of goals highlighted by ASHA include initiating spontaneous communication in functional activities, engaging in reciprocal communication interactions, and generalizing skills across activities, environments, and communication partners (ASHA, 2021). Additionally, SLPs may target perception and comprehension of prosodic elements of speech such as rate, tone, and pitch, particularly in relation to emotions. According to recent data, there exists a subset of individuals with autism who exhibit hypernasality in their speech (Kasthurirathne et al., 2019).

An issue which has been subject to significant research recently is career choices and opportunities for individuals with autism. Ideas such as “neurodiversity” suggest that individuals who fall within multiple ranges on the autism spectrum are necessary and contributing members of society (e.g., Silberman, 2015). The purpose of the neurodiversity movement is to encourage employers and others in society to conceptualize disorders such as dyslexia and autism as normal human variations (Krzeminska et al., 2019). According to ASHA, integration into society and the

workforce falls under the scope of practice for Speech-Language Pathologists, as communication and social deficits are often reasons for un- or underemployment for people with autism.

Part IV: Summary

From the preceding literature review of the five domains for both developmental stuttering and autism, both areas of convergence and areas of divergence between the two disorders will be discussed. This will provide the basis by which to conduct a deeper inquiry as part of the thesis.

A. Areas of convergence

First, it would seem that heritability is a significant factor in the onset of both disorders. While there have been many studies aimed at determining a particular gene or genes associated with the disorders, there prove to be far too many variables to constitute a single genetic origin responsible for their onset. Rather, each disorder must result from an accumulation of genes which can be manifested in a variety of phenotypes and behaviors. Several studies have examined the heritability and genetic factors associated with both disorders, with none proposing a heritability of 1.0, meaning that environmental factors play at least some role in the onset of each disorder.

Second, the onset of stuttering and autism appear to occur well after birth. Although there are risk factors associated with probability of onset of each (e.g., family history), one cannot determine at birth whether onset will occur for either disorder. While there are treatments and intervention plans which can assist one in managing each disorder, there is no “cure” for either, meaning treatment of both consists of active management of the symptoms and behaviors associated with each. Additionally, being that each is a developmental disorder, there does not

seem to be evidence of a means of “preventing” the onset of either of the disorders, whether through behavioral or pharmacological means.

Third, although the origin of each disorder might be associated with hemispheric differences in the brain, there is no evidence that definitively shows which specific areas of the brain underlie the behaviors associated with either disorder. Although research shows that many cognitive abilities are lateralized in one hemisphere or the other (e.g., Geschwind, 1985), the development of cerebral lateralization or any associated developmental anomalies could be a significant contributor of the cognitive characteristics and/or behaviors associated with each of these disorders. While there are some similarities in brain imaging studies within individuals who possess either disorder, the areas of interest vary greatly among individuals as well as the specific brain areas under focus.

B. *Area of Divergence*

First, the greatest inconsistency between the two disorders is that the first symptoms of autism appear within about the first year of life, whereas stuttering onset tends to occur in the second to third year of life (Ambrose & Yairi, 2015), and in some cases can onset a few or several years after that. This might suggest that whatever genetic contribution is at play for either disorder, its coaction with environmental factors are different (Gottlieb, 2007). For example, stuttering might emerge from later developmental milestones not being met, whereas autism might emerge from earlier developmental milestones not being met.

Second, while a person who stutters in adulthood will likely always stutter to some degree, full recovery can occur for most children who begin stuttering in the preschool years,

with nearly all symptoms and behaviors associated with stuttering no longer present after recovery. Something close to full recovery can also occur in some individuals later in life following effective therapy or other social changes across a lifetime. In contrast, there does not yet exist evidence to show that symptoms of autism cease later in life. Treatment and intervention may aim to teach social skills and communicative tactics which could assist the individual with autism in social networking and everyday situations, but difficulties in the areas of social interactions and communication deficits will likely always exist to some extent, with many behaviors often being triggered by social-environmental factors. This indicates that the subjective experience of people with either disorder differs greatly from one another.

Third, there appears to be little compelling evidence to suggest that people who stutter are appreciably different from people who do not stutter other than the prevalence of stuttering itself, with evidence suggesting that the language skills of people who stutter are on par or perhaps more advanced than people who do not stutter. Individuals with autism, however, often present with deficits in social skills and expressive and receptive language skills. Deficits in these areas are the defining characteristics and primary criteria for diagnosis of autism. This indicates that the characteristics associated with autism are more wide-ranging compared to stuttering, or in other words, characteristics of a “deeper” etiology.

Part V: The Current Thesis Project

Given both the areas of convergence and divergence between developmental stuttering and autism, it is interesting that autism is considered to be on a spectrum, but stuttering is not. For example, the overall high heritability of each disorder would suggest that each should be on a spectrum, yet the onset of stuttering (i.e., 33 months) typically occurs much later than the first symptoms of autism, which can be noticeable within the first year of life.

The term “autism” was coined in 1911 by German psychiatrist Eugen Bleuler, the same psychiatrist who discovered the phenotype of schizophrenia (Evans, 2013). According to Bleuler, “autism” represented a severe case of schizophrenia, in which a child rejected reality and attempted to satisfy the “inner self” with fantasies and hallucinations. However, in the 1960’s researchers in Great Britain began to utilize the term “autism” as it took on the exact opposite meaning from Bleuler’s. These researchers and psychiatrists concluded that the term referred to the lack of unconscious and symbolic life.

In the late 1970’s Lorna Wing and Judith Gould suggested that the symptoms which had been previously denoted as “childhood psychosis” or “childhood schizophrenia” should be reconceptualized as social impairments. In a paper in 1979, Wing and Gould proposed that children with autism be diagnosed on a continuum with typically developing children (Wing & Gould, 1979). Additionally, Wing coined the term “Asperger’s syndrome” in reference to pediatrician and researcher Hans Asperger. While Asperger’s syndrome would not be officially added to the DSM until 1994, Wing’s expansion of the broader autism phenotype allowed for significant progress in the field of autism research.

One of the diagnostic instruments commonly used by behavioral health professionals and those in the field of communicative disorders is the *Autism Diagnostic Observation Schedule* (ADOS) (Lord & Rutter, et al., 2012). The ADOS typically takes 1 hour and may be used to assess children from 12 months of age through adulthood. The format of this standardized assessment is behavioral observation. Each module of the ADOS provides cutoff scores for autism and autism spectrum classifications. Module 1 is typically administered to young children with little-to-no verbal skills and each consecutive module corresponds with an increase in verbal abilities, with Module 4 typically being utilized with adolescents and adults. Additionally, modules 1 through 3 contain comparison scores for children of similar ages with a diagnosis of autism for reference. Administration of the ADOS also requires certification and training in addition to knowledge of behaviors typically associated with autism acquired via formal education.

In contrast, the most often used diagnostic instrument for stuttering is the Stuttering Severity Instrument, 4th edition (SSI-4; Riley, 2009). This instrument can be used with children at preschool-age to adults. The SSI-4 consists of three components: an overall frequency score per 100 words from reading and/or speaking, a measure of the duration of the 3 longest stuttering behaviors, and a rating in terms of noticeability of concomitant behaviors, such as eye blinks, facial grimaces, and muscle tension in the neck. The measures are summed to create a raw score ranging from a minimum of 4 to a maximum of 50, which can be standardized to produce a severity score ranging from Very Mild to Very Severe. In general, the cutoff between a diagnosis of stuttering is any raw score of 12 or greater.

Thus, both the autism and stuttering autism diagnostic instruments are associated with a continuum of scores with categorical boundaries imposed from above, such that a diagnosis of either necessitates a minimum raw or standard score. It is generally thought among clinicians and researchers that the symptoms or characteristics associated with autism are distributed across a population of people, and individuals at one end of this continuum experience enough of these symptoms to constitute a disorder. Thus, it is the case that even though people who are diagnosed with autism experience a greater frequency or severity of these characteristics, at least some of these characteristics might be present in most or all people within a population. It is also the case that all people who speak produce at least some speech disfluencies. Like autism, within a population of people, those who produce more speech disfluencies, in frequency and/or severity, are often diagnosed with stuttering (Riley, 2009), suggesting that stuttering might also be considered to be “spectrum” disorder.

However, there are a few reasons to argue that stuttering should *not* be on a spectrum. First, stuttering is quite variable from day to day and across a lifetime. Whatever might be the cause of stuttering, the manifestation of stuttering within a single person can change dramatically depending on the timescale one is looking at. In contrast, it would appear that the characteristics associated with autism don’t seem to change that much over the course of a lifetime, although treatment can provide a client with strategies or tools to help manage those characteristics in the social environment. This would suggest that autism falls within the category of neurodiversity. Second, because the onset of stuttering generally takes place well after a child has already begun speaking, stuttering is more likely a problem of development itself. Although the severity of

stuttering is continuous across all people who stutter, and the frequency of speech disfluency is continuous across all speaker within a population, this does not necessarily mean that either stuttering or speech disfluency are part of a spectrum disorder. However, the variability of stuttering and its relatively later onset indicates that it does not fall into the category of neurodiversity.

One way to evaluate to what extent stuttering ought to be placed on a spectrum is to evaluate a continuum of stuttering severity scores for comparison to a continuum of autism scores. Both the ADOS and the SSI-4 require the measurement of a small range of behaviors from which a raw score is produced for conversion to a standard score. This implies that raw scores acquired from a population of people with either disorder can be fit to a normal distribution. This also implies that raw scores from a large population of people who do and do not have the disorder can be fit to a normal distribution. In other words, one might see a normal distribution of scores within a population of people already diagnosed with autism or stuttering. One might also see a normal distribution of scores across a random sample of all people within a population.

The purpose of this thesis is to evaluate the extent to which people diagnosed with autism and with stuttering can be fit to a normal distribution. Although it is beyond the scope of this project to randomly sample people from a larger population, it is possible to acquire both ADOS and SSI scores from published studies and evaluate their distributions cumulatively. To this end, one might be able to gain some insight into whether people diagnosed with autism or stuttering

are on a continuum from mild to severe, and whether this fits a normal distribution. To date, such an analysis has never been conducted.

This thesis project has three aims. The first aim is to evaluate to what extent ADOS scores fit a normal distribution, using measures of skewness, kurtosis, and dispersion (i.e., coefficient of variation). This will help provide some insight on the continuum associated autism. The second aim is to evaluate to what extent SSI scores fit a normal distribution, using measures of skewness, kurtosis, and dispersion (coefficient of variation). This will help provide some insight on the continuum associated with stuttering. The third aim is to compare the distributions associated with the ADOS and the SSI in terms of skewness, kurtosis, and dispersion, as one means of providing a metric of whether stuttering might be placed on a continuum or spectrum. The three Aims are restated below:

1. Do ADOS scores acquired from peer-reviewed studies fit a normal distribution within the category of people recruited to a study because they have autism, as indicated by measures such as skewness, kurtosis, and coefficient of variation (cv)?
2. Do SSI-4 scores acquired from peer-reviewed studies fit a normal distribution within the category of people recruited to a study because they stutter, as indicated by measures such as skewness, kurtosis, and coefficient of variation (cv)?
3. Are the distributions of ADOS and SSI scores similar in terms of measures such as skewness, kurtosis, and coefficient of variation (cv)?

Part VI: Methods

PubMed Central (PMC) was used as the primary database from which to identify articles for this study. PMC is the online database as provided by the US National Library of Medicine and National Institutes of Health. A protocol was put into place to identify articles according to a set of inclusion and exclusion criteria. They are as follows.

First, a set of search timers was used to identify studies for both stuttering and autism. For stuttering, the terms utilized were “developmental stuttering” and “SSI.” For autism, the terms utilized were “autism” and “ADOS.” In addition, both searches were constrained to the time period of 1990 to 2020. This functioned to identify more recent studies that were most likely to utilize more recent versions of the common testing instruments, the SSI-3 or SSI-4 or the ADOS. Overall, this resulted in the identification of 42 articles that pertained to stuttering, and 42 articles that pertained to autism (see Table 1).

Table 1. Number of articles obtained initially and after application of inclusion and exclusion criteria for the SSI and the ADOS.

	SSI	ADOS	Criteria
Initial Search	190	5,178	- “autism” and “ADOS” - “developmental stuttering” and “SSI”

			- published between 1990-2020
Second Round	66	51	- reporting of specified demographic information - reporting of specified scores
Third Round	44	44	- exclusion of any review articles which included duplicate articles
Total	42	42	- final total

Next, a set of criteria was applied to both sets of articles for the purpose of selecting those that fit the aims of the current study. This set of criteria included:

- 1) Each article had to include at least 2 participants to avoid single subject designs.
- 2) Each article had to report demographic information including average age or individual age of participants, number of participants, and sex of participants.
- 3) Each article had to report mean or median standardized or total assessment score or individual assessment scores; studies must report the edition of the assessment utilized, such as SSI-4 or SSI-3; studies may be clinical or research in nature.

A total of 190 articles were identified in the initial search for studies pertaining to developmental stuttering and SSI scores. Out of these articles, 66 articles were identified as those which fit the aforementioned criteria. Out of these 66 articles 22 were further eliminated due to insufficient reporting of demographic or assessment score data. Upon analysis of each article 2

articles from the remaining 44 were additionally eliminated due to the reporting of duplicate data (see Table 1).

A total of 5,178 articles were identified in the initial search for studies pertaining to autism and ADOS scores. Given the disparity between the number of SSI and ADOS articles, a comparable number of ADOS articles were selected for the purposes of this study. As such, 51 articles which fit initial inclusion criteria were identified in the first 300 articles in the search. These 51 articles were assumed to be a representative sample of all other articles initially targeted in the search.

To ensure consistency and cohesiveness in communication, editing, and managing documents throughout the research and data collection process, online databases were utilized. All articles which were initially identified as aligning with the aforementioned inclusion criteria (a total of 117) were uploaded into a Google Drive folder, and data acquired from these articles were assembled in spreadsheets. The key information for all articles included:

1. First author of the study
2. Year the study was published
3. Journal the study was published in
4. Overall number of participants in the study (including gender)
5. Mean score (and standard deviation) of measure

The above information from both sets of articles, for stuttering and ASD, can be found in the Appendix. Such information was generally identified in tables or the texts within the

Methods section of each study. Studies that did not report information consistent with inclusion criteria were not used in the final analysis.

Finally, when acquiring data from selected studies, it was discovered that two articles in the stuttering group were review articles. Because data from these articles were likely redundant with data from other articles, it was decided to remove these articles from final analysis. In addition, it was discovered in the ASD group that some studies reported CSS and other studies reported the total score. Because of the variability of reporting of scores and to ensure a comprehensive analysis of all data reported, studies which reported either CSS or total scores were included and analyzed separately when compared with scores from the studies pertaining to the SSI. Additionally, there were significantly more SSI studies which reported individual participant scores than ADOS studies. As such, studies which reported individual SSI scores were included in the final round after application of inclusion criteria but are not included in the results portion of this study given the nature of analysis for this project. This is evident in the discrepancy between the final number of SSI studies in the final total (see Table 1) and number of studies represented in Appendix 1.

Part VII. Results

Results for the SSI and for the ADOS are each organized in three parts. First, measures of skewness and kurtosis are reported. Skewness measures whether the distribution of the data is skewed to the left (negative) or right (positive). A value close to 0 means no skewness. Kurtosis is the measure of the combined weight of a distribution's tails. Kurtosis of a normal distribution is 3. It is common to compare the kurtosis of a distribution to this value. Distributions with kurtosis less than 3 are said to be platykurtic. Distributions with kurtosis greater than 3 are said to be leptokurtic.

Next, the coefficient of variation (CV) is reported for each dataset. The CV is the ratio of the mean of the dataset to the standard deviation of the dataset and is calculated by dividing the standard deviation by the mean. Also referred to as the *relative* standard deviation, CV is a measure of the overall *dispersion* of the dataset. Dispersion can be thought of as the variability of values in a dataset relative to the mean. In general, a CV that is greater than 1 is assumed to be associated with high dispersion, whereas a CV that is less than 1 is assumed to have low dispersion. For both the SSI and both ADOS scores, histograms and boxplots are presented to visually represent the three measures reported.

Finally, tables are presented for both SSI and ADOS scores. These show means and standard deviations of scores across age and group. Age was categorized by preschool, school-age and adult for both stuttering and ASD. Group was categorized by non-stuttering, stuttering, persistent, and recovered for studies using the SSI. Group was categorized as with ASD and control for the studies using the ADOS.

SSI

The skewness of the distribution across all participants for the SSI studies was -1.095, while the kurtosis was 3.701. These values indicate that the dataset was slightly skewed to the left and was slightly leptokurtic. As can be seen in the histogram in Figure 1, the presence of studies reporting data for non-stuttering participants, in which the SSI score is less than 5, contributed to this negative skewness. The kurtosis value means the overall shape of the distribution is slightly greater, or steeper, compared to what would be expected from a normal distribution. The coefficient of variation (cv) for the SSI data was 0.266. This indicates low dispersion, as can be seen in Figures 1 and 2.

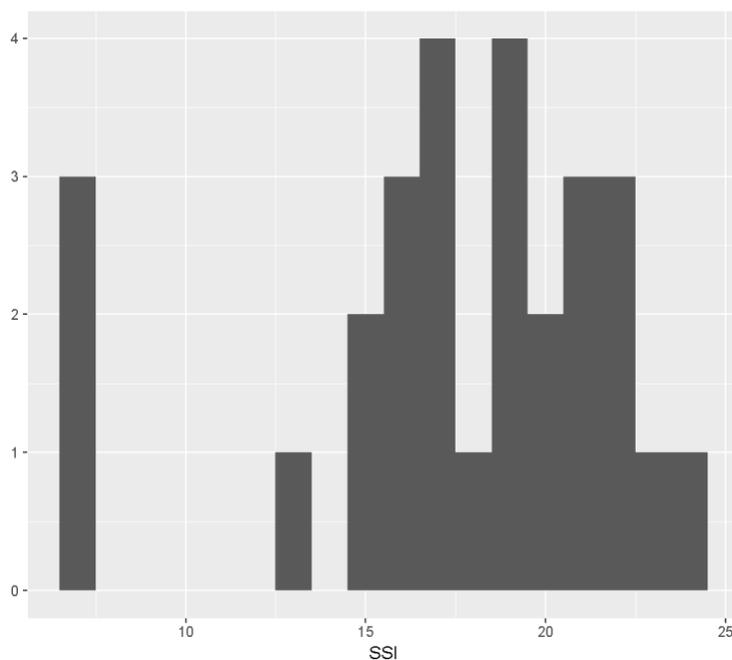


Figure 1. Histogram of SSI data.

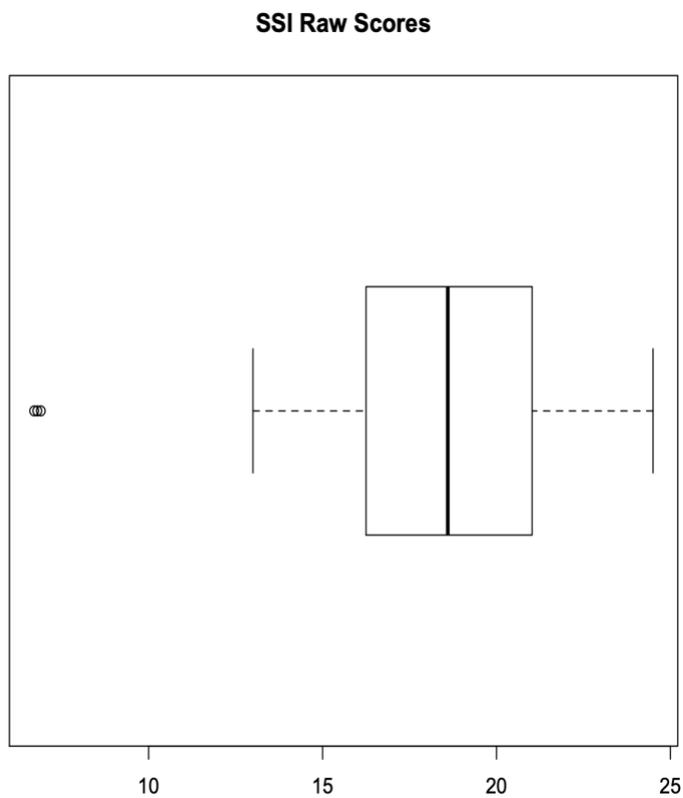


Figure 2. Box Plot of SSI scores.

Finally, Table 2 presents SSI scores across age and group. As one would expect, SSI scores are high for participants categorized as stuttering compared to those who were not. This is

not at all surprising because group categorization was contingent upon study designs. It is also apparent that there is not much difference in means across stuttering groups, suggesting that in general, people who stutter, when they are currently stuttering, do not exhibit greater or lesser stuttering severity than other stuttering groups.

Finally, it can be seen in Table 2 that some bins do not have data and so are marked NA. This indicates that within the number of studies analyzed for this project, there were not any studies of school-age children and adults that included a control group. Rather, most of the studies conducted over the past three decades are oriented toward childhood stuttering in general, and persistence versus recovery in particular.

Table 2. Mean (count) SSI-4 score across age and group.

	Non-stuttering	Stuttering	Recovered	Persistent
Preschool	6.80 (3)	18.68 (5)	17.50 (3)	18.39 (3)
School-age	NA	19.43 (5)	15.75 (4)	21.85 (4)
Adult	NA	24.50 (1)	NA	NA

Number of studies in each cell

ADOS

Because some studies reported results in terms of CSS and other studies reported results in terms of Total score, both results are reported here.

First, for the CSS, skewness of the distribution across participants was -2.115, while the kurtosis was 8.536. The values indicate that the distribution was negatively skewed, as can be

seen in Figures 3 and 4. The distribution was also much steeper than what one would expect from a normal distribution. Finally, the CV was 0.216, which indicates low dispersion of data.

Second, for the Total score, skewness of the distribution across participants was -0.488, while the kurtosis was 2.467. These values indicate a slight negative skewness of the dataset, as can be seen in Figures 5 and 6, and that the dataset was slightly broader or flatter than what one would expect from a normal distribution. Finally, the CV was 0.432, which indicates low dispersion of the data.

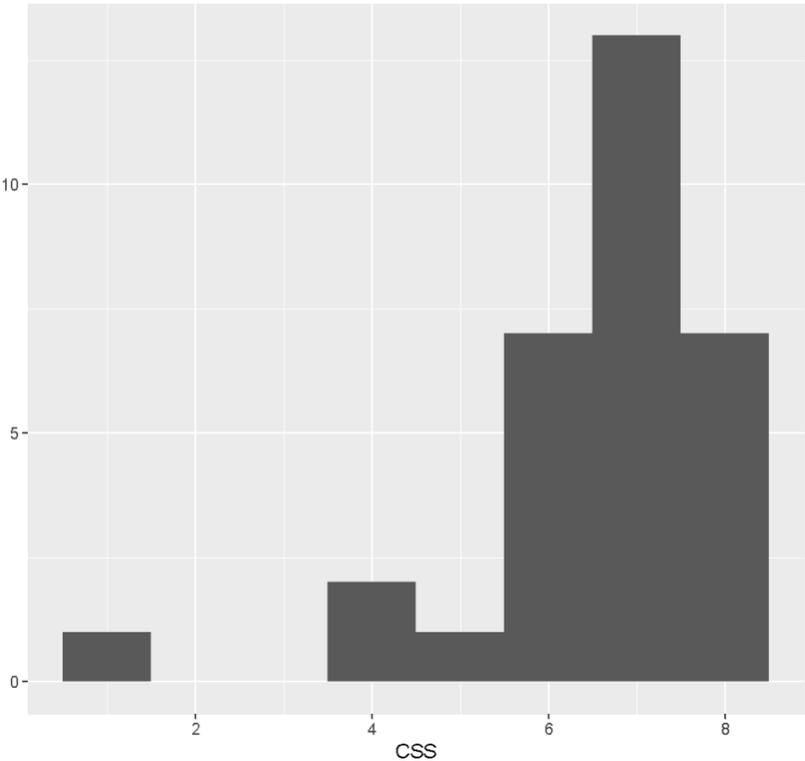


Figure 3. Histogram of CSS scores.

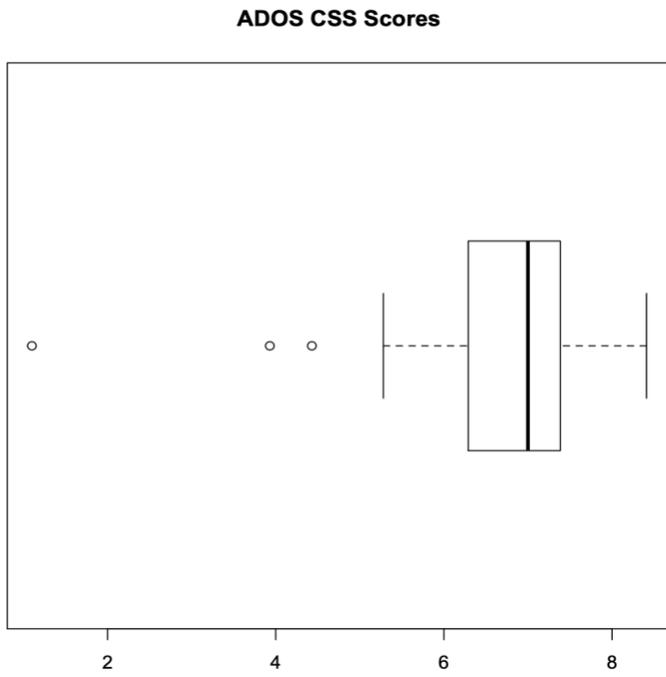


Figure 4. Box plot of CSS scores.

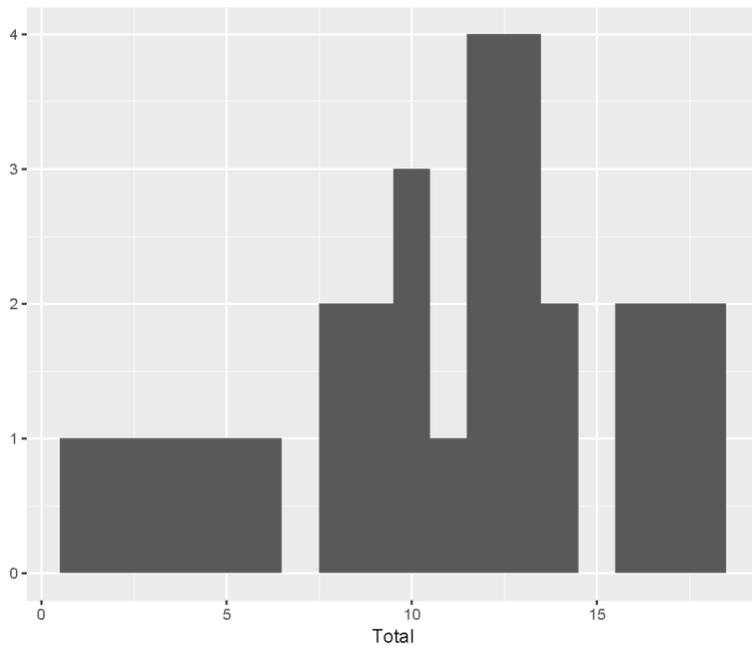


Figure 5. Histogram of Total scores.

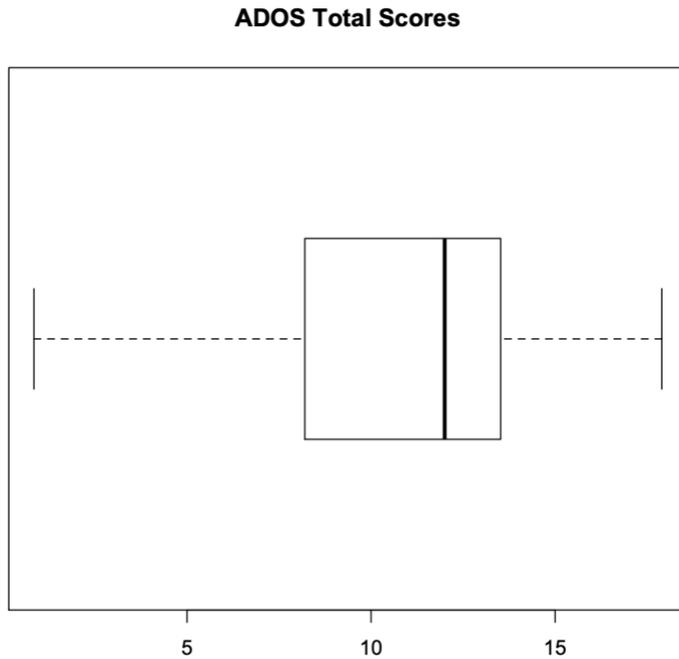


Figure 6. Box plot of Total scores.

Finally, Tables 3 and 4 show the mean CSS scores across age and group and mean Total scores across age and group for studies using the ADOS. Similar to the stuttering data, control participants did not produce data for some age groups, including preschool-age and adult age groups. Viewing Table 3, it is clear that the ASD participants produce CSS scores in the range of 6 to 7, which does indicate a diagnosis of ASD. Viewing Table 4, it is clear that ASD participants produced Total scores in the range of 8 to 13, indicating a diagnosis of ASD.

Table 3. Mean (count) CSS scores across age and group.

	Control	ASD
Preschool	NA	6.76 (11)
School-age	1.1 (1)	7.37 (11)
Adult	NA	6.18 (8)

Note: ASD refers to autism spectrum disorder

Table 4. Mean (count) Total scores across age and group.

	Control	ASD
Preschool	2.2 (1)	13.01 (9)
School-age	17.2 (1)	11.51 (10)
Adult	NA	8.2 (9)

Note: ASD refers to autism spectrum disorder

In summary, results indicate three main findings. First, for the SSI and the ADOS Total score, distributions resemble a normal distribution. This suggests that these scores acquired from these populations do appear to be consistent with many other measures obtained from nature that also adhere to a normal distribution. However, because these samples were not drawn randomly from a larger population, but rather from participants who were already known or suspected of having each disorder, this normal distribution appears to be specific to these populations based on data from these selected studies. The ADOS CSS scores, however, do not appear to be as good a fit to a normal distribution. The primary reason for this might be that the manner in which this score is calculated results in a fit to something other than a normal distribution.

The second finding is that distributions do show a clear difference between people who are diagnosed with a disorder versus those to serve as “control” participants. This suggests that the obtained scores reflect precisely what was specified by the study designs, or in other words, categorizing participants according to whether they had the disorder or not. This would suggest that both the SSI and the ADOS indicate a clear diagnostic threshold within selected populations and fulfill the intended purposes of the assessments.

The third finding is that, when comparing distributions from the SSI and the ADOS Total, there appears to be much in common. This might suggest that if autism is suspected of being on a spectrum, this might be the same for stuttering. However, it is important to note that the present notion of a “spectrum” is based on the notion that scores are continuous from some baseline to some ceiling, with most of the scores falling near a mean. As will be discussed, this is different from conventional definitions of the spectrum view, which typically entail that a trait or disorder is continuous across an entire population, whether diagnosed with a disorder or not, with no clear distinction between those who “have” the disorder and those who do not.

Part VIII: Discussion:

The main findings will be discussed first. Next, implication of findings for a spectrum view of autism versus stuttering is discussed. Finally, general clinical conclusions are drawn with an eye toward learning more about one disorder from what the other has to offer.

Main Findings

First, it should be noted that there were differences in reporting of scores for SSI and ADOS studies. As it was noted previously, ADOS score reporting varied between studies and included RRB (Restrictive and repetitive behaviors), SA (social affect), Total, and CSS (calibrated severity score), while SSI score reporting primarily included a total score. The varied manner in which studies reported ADOS scores combined with the differing structure and design between these studies contributed to some difficulty of the process of reviewing the articles pertaining to ADOS scores. While the reasons for the lack of cohesion of reporting in ADOS articles are unclear, it can be inferred that reporting varied in relation to the overall purpose of each study, or what each study aimed to measure. It should also be noted that while the ADOS includes various means by which data may be quantified in the forms of differing scores which reflect certain behaviors within the modules administered, proper scoring of the SSI includes 3 elements of disfluencies produced within the administration: number of disfluencies within a given number of syllables, duration of disfluency, and any physical concomitants which may accompany the disfluency. In contrast to ADOS studies, although the SSI does include data pertaining to several dimensions of disfluency (e.g., duration of disfluency, number of disfluencies, physical concomitants) there appeared to be consensus in reporting only one type of

score or numerical value from SSI participants regardless of aims or intended purposes of the study.

Secondly, there were significantly more studies pertaining to the SSI which utilized control participants, or individuals who did not stutter, than those pertaining to the ADOS. This is indicated in the tables which portray the data extracted from the studies. There is a notable gap in the data between scores of participants who, by definition, seemingly do not present with the corresponding disorder and those whose scores reflect the criteria outlined by the assessments as eligible for a diagnosis. It was hypothesized in the prospectus of this study that, given the variability in behaviors and presentation of phenotypes associated with either disorder, there would be significant display of data surrounding the threshold scores indicated in the assessments. This shows that each of the assessments are designed to indicate a distinct diagnosis and studies are not specifically designed to demonstrate the overall variability of behaviors and phenotypes in a given population, but that individuals are typically carefully selected to participate in studies based on diagnosis or lack thereof.

One reason for this difference might have to do with the underlying assumptions for each disorder. For stuttering, control participants are often used as the “normal” criterion by which to evaluate people who stutter. This does not seem to be the usual assumption for ASD. In other words, it is not assumed that one can learn about autism, by and large, from people who do not have autism, other than the diagnosis of autism itself, though behaviors associated with autism are considered to deviate from those of typically developing individuals.

Third, there were several studies within the ADOS articles which included individuals with a diagnosis of PDD or language delay, while no SSI article included an individual with a comorbid diagnosis, meaning individuals were either diagnosed as stuttering or non-stuttering only. It is assumed in stuttering research that behavioral or cognitive measures are confounding if a participant exhibits any other speech, language, or hearing difficulty. In other words, they must be within normal limits on a battery of other standardized tests and pass a hearing screening. On the other hand, it is not assumed that other co-morbidities might present as confounding for children with ASD. Rather, it appears to be the common assumption that any measure within the scope of the ASD does pertain to ASD.

Additionally, within the scope of participants for each corresponding assessment, there were significant differences in categorization. Many SSI articles included participants which were designated as stuttering, non-stuttering, persistent, and recovered. “Persistent” refers to older school-age children or adults who continue to stutter, while “recovered” indicates school-age children or adults who no longer stutter. These categories are absent in studies related to the ADOS, as behaviors associated with Autism Spectrum Disorders typically persist into adulthood and there is little evidence to show that individuals with an autism diagnosis spontaneously recover, as those with a stuttering diagnosis often do. This also suggests something about the nature of the spectrum view in ASD. Although both stuttering and ASD are considered to be developmental disorders, stuttering can appear years after the acquisition of language and speech. Stuttering can also exhibit spontaneous recovery in adulthood for reasons that are not well understood. In other words, if stuttering should be considered a spectrum disorder, one

might expect the underlying causes of stuttering onset and/or persistence to be on a spectrum as well.

The Spectrum View

A “spectrum” view of autism is a perspective which has evolved over the years (Evans, 2013). One of the secondary aims of this study was to examine stuttering and autism through the same lens and to determine if the same criteria which is considered in classifying a diagnosis of autism on a spectrum may be applied to stuttering. In the articles which were included for the purposes of this study, it was noted that studies which include ADOS and SSI scores are not designed to portray quantitative data or behaviors across the general population but across a specified population chosen for specific studies. Although individuals without a diagnosis of stuttering or autism do exhibit certain behaviors associated with each disorder, it would require a significantly large number of participants to assess whether the idea of a spectrum may be applied to a general population, as mentioned previously. As such, it can be inferred that, based on the data presented in these studies, a spectrum view of autism may refer to the population possessing an autism diagnosis rather than an overall given population. In contrast to the spectrum view with people with autism, as indicated by the ADOS, within a larger population of people, the spectrum might reveal itself in terms of the distribution of physical, social, or cognitive behaviors. In other words, the ADOS is designed to diagnose autism within the population of people suspected of having autism. The same can be said for the SSI, which is designed to measure the severity of people who stutter, whereas all people in a general population produce speech disfluencies.

Finally, it is worth noting that it was more challenging gleaning relevant data from ADOS studies versus SSI studies. Most notable is that about half the ADOS studies used in this study reported scores as either CSS or Total. This would seem to create a problem of how to compare scores from one study to another. In contrast, all SSI studies reported a single score, the raw score, which could also be translated into a standard score. Because the SSI has been scored consistently from its inception in the 1970s (SSI-1), scores are not only comparable across studies but across time.

It is also worth noting that, as discussed earlier, that the SSI-4 is comprised of three different measures, namely, frequency of stuttering 100 words, duration of 3 longest disfluencies, and secondary behaviors. None of these measures are used separately but are designed to contribute to the overall SSI score as a single variable. Similarly, the ADOS takes into account both behavioral (i.e., repetitive behaviors) as well as cognitive (social deficits) characteristics to contribute to a single overall score (Goldstein & Nagieri, 2009). Presumably, this means that it requires both characteristics, at the very least, to successfully diagnose a child with autism. In other words, it is assumed by researchers and clinicians that both sets of characteristics, and not merely one, are necessary to make an appropriate diagnosis. If so, this would suggest that only one characteristic should not be used independently to diagnose autism, although a study of course could use any measure, whether behavior or cognitive, as a dependent measure in a research study.

Diagnosing autism within the scope of the ADOS allows room for clinical intuition and subjectivity. For example, thresholds of human behavior may be difficult to quantify, such as

identifying atypical behaviors which may be “less different” than that of typical individuals. This is an aspect of the diagnosis which has been argued to have contributed to an overall heterogeneity in the field of autism (Motttron & Bzdok, 2020). However, for clinicians or researchers who are appropriately trained in administering the ADOS, there should be some degree of reliability across test administrators in reaching a common outcome. The same is true for stuttering, as it requires some subjectivity in identifying a stuttering behavior and perhaps rating its overall noticeability. However, to the extent that clinicians and researchers gain some experience, and perhaps compare their ratings with others, some level of objectivity can be obtained.

Interestingly, the SSI has now in its 4th version and has not changed much in terms of its design or scoring. This means that SSI scores acquired from the first edition can easily be compared to the fourth edition. It is also worth pointing out that the overall incidence and prevalence of stuttering do not appear to have changed since the 1960s (e.g., Andrews and Harris, 1964), when such studies were first conducted on a large scale. It is also the case there is little or no evidence that incidence or prevalence differs across different parts of the world (Bloodstein & Ratner, 2008). On the other hand, there seems to be some evidence that the incidence of autism is increasing. One report shows that the incidence of Autism in 8-year old children to be 1 in 44, a .4% increase from another recent estimate (Maenner et al., 2021).

Although the possible reasons for this presumed increase are beyond the scope of this thesis project, this does have implications for the spectrum view of stuttering. For example, if the autism spectrum associated with a random sample of a population is a function of the

neurodiversity of that population, one might not expect aspects of that neurodiversity to be changing, as such change would likely only occur at an evolutionary timescale. On the other hand, if additional individuals within that population are being identified as sub-clinical cases of autism, the incidence rate would certainly increase. This has been referred to as the “broader autism phenotype,” meaning that clinicians with much experience capture a “gestalt” of the disorder that might not align with the “tick box” approach inherent in standardized tests (Fitzgerald, 2018). This means that the diagnostic boundary for what counts as autism might be different between the clinical and the research communities. Another element which may be a significant factor in the overall increase in incidence is a greater awareness of autistic behaviors as they are exhibited in females. The idea of “camouflaging” refers to a covert set of behaviors which may deviate from typical behavior yet present differently in females than in males, or perhaps females present with atypical behaviors which do not at this moment fit the diagnostic criteria (Hull et al., 2020). This is also in contrast with stuttering, where audible or overt stuttering behaviors are not assumed to differ between males and females, even though more males than females stutter overall.

Thus, there is clearly a spectrum within each population of people with stuttering or autism, ranging from some floor of “mild” to some ceiling of “severe.” This is likely the case for many, if not most, developmental disorders, as whatever the underlying genetic etiology of the disorder, that etiology manifests over the course of development in ways that are unique to a single person’s unique developmental experience. Indeed, every person is different, and likewise, each client presents a different set of challenges and demands some degree of creativity in

establishing or implementing a treatment approach. In addition, for people with autism or stuttering, the ability to manage each disorder into adulthood can depend on a host of other factors associated with the person, including the social environment, the age at which the disorder was first diagnosed, and the quality of treatment early after diagnosis.

One should also consider the quality of the clinician working with any client. It is imperative for each disorder to not solely examine the behaviors and phenotypical traits, but also the manner in which these behaviors impact a person's life. Understanding similarities and differences between stuttering and autism can contribute to the willingness of professionals in the field of psychology and communicative disorders to take a holistic approach in treating those diagnosed with either, assisting individuals in managing the behaviors with these disorders while promoting acceptance of those who fall within the spectrum.

From a clinical standpoint, one should also consider the perspective of the person with the disorder versus the person helping to treat the disorder. For stuttering in particular, Perkins (1991) noted that "Stuttering is a problem of *involuntary* disruption of a word the speaker is otherwise attempting to utter, rather than of the resulting acoustic event, which is what the listener perceives." He goes on to say that "...from the observer's vantage point, the continuity hypothesis (that stuttering develops along a *continuum* from perceptually normal to abnormal disfluency) is credible... From the stutterer's vantage point, however, the judgment is *categorical*: Either involuntary blockage has or has not occurred to some degree." This suggests that stuttering might be on a continuum in terms of how it's measured, but is categorical, and

thus not on a continuum or a spectrum, based on the subjective perspective of the person who stutters. It is interesting to consider whether the same might be true of autism.

Conclusions

Stuttering and autism spectrum disorder are two developmental disorders with high heritability, and with many areas of divergence and convergence. The current study was undertaken to evaluate to what extent ADOS scores and SSI scores, acquired from published studies, would fit a normal distribution, and whether these distributions would appear similar between the two types of scores. Findings indicate that for the SSI score and the ADOS Total score, distributions both appear to be consistent with a normal distribution, meaning that, as far as research studies are concerned, there is an expected continuum (i.e., spectrum) of scores for each. This indicates that both stuttering and autism are two developmental disorders in which those who fit the criteria for the disorder are subject to much variability across a range of characteristics.

However, the spectrum view of autism can also mean that those traits associated with autism fall within a continuum across a population of people, whether they are diagnosed with autism or not. This spectrum view would assume that such characteristics are part of the human condition, perhaps within the continuum of neurodiversity (e.g, Silberman, 2015). To this end, current findings have little to say about whether stuttering fits within a neurodiversity perspective. Although both stuttering and autism have a high heritability, and the characteristic of each are variable within each population, this is might not be sufficient to consider stuttering from a neurodiversity perspective, as the areas of divergence between the two disorders point to

them being qualitatively different disorders. In other words, despite the strong genetic influence on both disorders and their impact on the lives of those with the diagnoses, how each manifest in behavior over the course of development (e.g., onset and recovery) appear to be qualitatively different.

Finally, a future study with similar aims as this study should acquire far more studies than what was acquired for this study, to more fully flesh out the distributions of both the ADOS and the SSI. A future study could also acquire data from a large random sample of a population to see whether a normal distribution applies to everyone. In other words, do characteristics associated with autism exist to some to some degree in all people, and if so, how much? The same applies to stuttering. Although all people produce some speech disfluency, at least in some social contexts, this does not mean that all people experience the feeling of loss of control, the feeling from which many stuttering behaviors follow. Because there does not appear to be a corresponding behavior in autism like the feeling of loss of control in stuttering, a defining characteristic that can come and go with little warning or explanation, the areas of divergence between stuttering and autism would appear to be more remarkable than the areas of convergence.

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Appendix 1: SSI

Author	Year	Journal	Group	Number	Males	Age	SSI	SD
Garnett	2018	Brain	Persistent	25	17	6.5	22.7	7.4
Garnett	2018	Brain	Recovered	11	5	5.8	16.1	4.1
Chang	2018	HHS	Persistent	24	16	6.6	21.2	5.9
Chang	2018	HHS	Recovered	15	9	6.8	16.4	5.3
Mock	2012	HHS	Stuttering	13	13	10.1	22.3	7.5
Choi	2013	NIH	Stuttering	26	22	48.89	20.31	5.09
Chang	2009	NIH	Stuttering	20	11	35.75	24.5	6.35
Zengin-Bolatkale	2018	HHS	Stuttering	39	29	5.5	14.94	3.73
Singer	2020	AJSLP	Persistent	10	9	46.6	19.3	6.8
Singer	2020	AJSLP	Recovered	32	23	45	18.4	5.4
Singer	2020	AJSLP	Nonstuttering	28	19	46.1	6.8	1.3
Singer	2020	JCD	Nonstuttering	24	18	45.31	6.9	1
Singer	2020	JCD	Recovered	26	21	43.2	18.8	5.8
Singer	2020	JCD	Persistent	10	9	46.6	19.3	6.8
Ntourou	2020	JFD	Stuttering	75	52	49.16	16.49	3.56
Chow	2019	Neuro Lang.	Persistent	26	18	6.5	21	8.3
Chow	2019	Neuro Lang.	Recovered	17	9	5.4	13	2.9
Johnson	2010	JSLH	CWS	16	11	46.69	16.69	4.19
Schwenk	2007	JCD	CWS	18	10	47.1	20.5	5.3
Anderson	2006	JFD	Stuttering	24	9	47.9	19.4	5.2
Wieland	2015	Brain Language	Stuttering	17	17	8.7	16.76	6.06
Zengin-Bolatkale	2018	Dev. Neuro	Persistent	9	8	45.11	16.56	7.65
Zengin-Bolatkale	2018	Dev. Neuro	Recovered	23	17	47.11	15.3	4.43
Zengin-Bolatkale	2018	Dev. Neuro	Nonstuttering	17	11	53.06	6.71	2.08
Chang	2015	Brain	Stuttering	37	21	6.35	21.05	8.02
Chow	2017	HBM	Persistent	23	16	7.8	22.5	8
Chow	2017	HBM	Recovered	12	6	7.2	17.5	5.4
Misaghi	2018	Neuro. Letters	Stuttering	11	NR	114.18	22.09	8.39
Means:				22.43	15.78	31.82	17.63	5.43

Appendix 2: ADOS Total

Author	Group	Number	Age Range	Gender	Score	SD
Benedetto	Exp	50	18-24 mo	Mixed	16.1	4.51
Benedetto	Exp	86	25-36 mo	Mixed	15.53	5.5
Benedetto	Exp	11	37-48 mo	Mixed	13.45	5.47
Eyler	Exp	40	1-4 y	Mixed	17.7	3.7
Eyler	Ctrl	40	1-4 y	Mixed	2.2	1.7
Aman	Placebo	61	6-12 y	Male	17.2	4.5
Aman	Exp	60	6-12 y	Male	16.7	4.2
Glatt	Autistic Disorder	37	13-46 mo	Mixed	17.9	5.8
Glatt	PDD	23	12-41 mo	Mixed	13	3.2
Glatt	Dev Delay	17	13-43 mo	Mixed	8.2	5.4
Glatt	Language Delay	34	12-32 m	Mixed	4.9	3.8
Karaminis	Exp	35	7.42-16.83 m	Mixed	10.33	4.31
Kleinhans	Exp	20	23.57 y	Mixed	12.45	4.06
Kohl	Exp	15	9-18 y	Male	12.4	4.3
Lai	Exp Male	29	18-41 y	Mixed	7.86	4.6
Lai	Exp Female	28	18-45 y	Mixed	3.93	3.28
Lawrence	Exp	13	29-60 y	Male	9.02	2.9
Manning	Exp	33	5.95-12.97 y	Mixed	11.03	5.75
Marchena	ASD	21	20-46 y	Mixed	13.52	4.29
Marchena	TD	21	20-48 y	Mixed	0.84	0.84
Moessnang	Exp	205	7.1-30.6 y	Mixed	2.6	2.6
Ratto	Exp Male	228	6-16.25 y	Mixed	13.4	5.51
Ratto	Exp Female	228	6-16.25 y	Mixed	12.6	4.97
Palser	Exp	49	6-19 y	Mixed	6.469	2.337
Qi	Exp	229	10 y	Mixed	14	4.7
Rubido	Exp	38	18-45 y	Male	12	3.8
Rynkiewicz	Exp Male	35	5-10 y	Mixed	9.71	2.95
Rynkiewicz	Exp Female	35	5-10 y	Mixed	8.94	2.46
Samms-Vaugh	Exp	149	25-115 mo	Mixed	9.86	3.18

Umbricht	Exp ASD	19	23.4 y	Males	12	4.8
				Means:	10.86	3.98

Appendix 3: ADOS CSS

Author	Group	Number	Age Range	Gender	Score	SD
Bartov	Exp	89	2-3.5 y	Male	7.37	1.72
Bartov	Exp	36	2-3.5 y	Female	7.14	1.69
Lai	Exp	29	18-41 y	Male	7.86	4.6
Lai	Exp	28	18-45 y	Female	3.93	3.28
Lawrence	Exp	43	8-17 y	Male	7.33	2.07
Lawrence	Exp	39	8-17 y	Female	6.61	1.88
Dawson	Exp (A/M)	24	18-30 mo	Mixed	6.9	1.7
Dawson	Exp (ESDM)	24	18-30 mo	Mixed	7.2	1.7
Moulton	Exp	190	1-4 y	Mixed	6.53	2.15
Anvi	ASD	68	6 y, 10 mo	Mixed	8.41	1.68
Anvi	ASD+ADHD	76	7 y, 4 mo	Mixed	7.4	2.13
Anvi	ASD+Anxiety	29	7 y, 10 mo	Mixed	8	2.26
Anvi	ASD+ADHD+Anxiey	87	7 y, 7 mo	Mixed	8.11	1.76
Barzy	Exp	50	33 y	Mixed	8	5.35
Billeci	Exp	16	18-72 mo	Unknown	6.4	1.3
Herbricht	Exp	32	25-60 m	Mixed	7	1.43
Lawrence	Exp Male	43	8-17 y	Mixed	7.33	2.07
Lawrence	Exp Female	39	8-17 y	Mixed	6.61	1.88
Morrier	Exp	40	18-40 y	Male	7.68	1.639
Moulton	Exp	282	16.89-31.97 m	Mixed	6.31	2.19
Muratori	Exp	70	24-48 mo	Mixed	7.1	2
Muratori	Exp	989	16-75.15 mo	Mixed	6.26	0.06
Pan	Exp ASD	344	8-31 y	Mixed	6.27	2.35
Pan	Exp ASD TWIN	344	8-31 y	Mixed	5.28	2.27
Rogers	Exp	7	6-15 mo	Mixed	4.43	2.44
Rosario	Exp	54	6-36 mo	Mixed	6.1	2
Schauder	Exp	42	12-16 y	Mixed	6.48	1.66
Schauder	Ctrl	42	12-16 y	Mixed	1.1	0.3
Shumway	Exp ASD	157	2-12 y	Mixed	7.64	1.39
Tilford	Exp ASD	146	4-17 y	Mixed	7.2	1.8

Tillman	Exp ASD	2684	1-65 y	Mixed	6	2
				Means:	6.64	2.02