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A literature review examining the effects of bilingualism in individuals who stutter

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Murray State University Honors College

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Senior Honors Thesis Prospectus - Proposed Study Abstract

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This thesis will analyze the current research involving the impact of bilingualism in individuals who stutter through a literature review. There is currently no known etiology of stuttering, however, there are multiple theories regarding the onset of stutter. This thesis will explore the Cerebral Dominance theory of stuttering and its applicability to neuroimaging and bilingualism. Furthermore, this thesis will determine the presence and extent of the impact of bilingualism on people who stutter. The cultural, gender, language and neurological influences on stuttering for those who are bilingual will also be examined. Through this analysis, the positive and negative impact of bilingualism on stuttering will be determined. The literature review will also determine more research should be completed in order to fully understand the positive and negative impacts bilingualism has on individuals who stutter.

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STUTTERING

Throughout the world, about 5% of all preschool-aged children stutter. Stuttering typically begins around 2 to 4 years of age, and the recovery rate is 80%. Therefore, about 1% of the general population has a stutter (Garnett et al., 2019). Although stuttering is not extremely common, it still affects many people throughout their entire life. Stuttering is seen in all settings of an individual's life, affecting the individual's work, school and home life. There are also accounts of stuttering around the world (Schäfer & Robb, 2012). Belyk et al. (2015) defines stuttering as "a disorder characterized by speech with involuntary repetitions, prolongations, hesitations and blocks at the levels of syllables and word" (Belyk et al., 2015, 275). The most common reported disfluencies include false starts, blocks, repetition of phrases, and multisyllabic repetition of words (Brundage & Rowe, 2018).

The research of Van Riper (1974) is still the foundation for current research. His research includes a summary of the progression of the history of stuttering. (In this work, he discusses the negative perceptions of stuttering including how it used to be looked down upon, "beaten" out of, or thought to be contagious). Currently, there are still traces of negativity involving a stutter, but overall people are a lot more understanding of those with a disability. Van Riper (1974) also includes the progression of treatment for stuttering. Initially, interventions for stuttering targeted spontaneous fluency. Current theories regarding interventions are more directed toward reducing secondary behaviors, such as physically struggling when attempting to speak. This still holds true today (ASHA, 2020). Van Riper (1974) also states it is important to try and produce controlled stuttering. ASHA, along with Van Riper (1973) states that there are strategies used to modify or control the stutter. These strategies aim to reduce physical tension in the body, and the strategies include helping individuals who stutter identify their core stuttering behaviors and

physical tension and aim to reduce this tension. These strategies can be used in order to help an individual to have controlled stuttering. Many of these strategies are still used today in order to help an individual limit the tension in their body and manage their stuttering (ASHA, 2020).

Incident and Prevalence

Approximately 5% of people will stutter during some part of their lives (Mansson, 2000). ASHA (2020) states that the incident of stuttering refers to the amount of new cases of stuttering that had been identified at a certain time. According to Reilly et al. (2013), preschool aged children have a higher incidence rate of stuttering. At 3 years of age, the incident of a stutter reaches a cumulative rate of 8.5%, and at 4 years of age the incident of a stutter reaches a cumulative rate of 11%.

ASHA (2020) states that prevalence refers to the amount of people who are living with a fluency disorder over a certain period of time. Overall, the rate of prevalence for those with a stutter is 0.72% for all ages. In children there is a higher prevalence, usually ranging from 0.9% to 5.6%. This depends on the age of the child. For children ages 3 to 17 there is a prevalence rate of 1.6%. However, for children between the ages of 3 to 10 the prevalence rate is much higher, depending on the age of the child (Craig et al., 2002 & McLeod & Harrison, 2009 & Boyle et al., 2011).

An individual's stutter is either developmental or persistent. A developmental stutter is a temporary stutter occurring when a child is still growing and developing. Guitar (2014) states that a developmental stutter is the most common form of stuttering, and that it develops during childhood during the time when children are learning speech and language at a very fast rate. He states that a stutter could also develop because of a neurological event, trauma or emotional

stress. This kind of stutter is a permanent stutter that one has for their entire life. This literature review will determine the effects bilingualism has on children and adults with a persistent stutter.

There is a lot of research that shows boys have a higher risk factor of stuttering than girls. Yairi and Ambrose (1992) found the ratio of stuttering between males and females to be 2.1 to 1. Craig et al. (2002) states that by school age, the number of boys with a stutter is three or four times more than the number of girls with a stutter. The research of Bloodstein and Ratner (2008) shows a 3 to 1 ratio of male to female stutterers in the third grade and a 5 to 1 ratio of male to female stutterers in the fifth grade. Therefore, Bloodstein and Ratner (2008) concluded the sex ratio increases as children grow older.

Characteristics

Coleman (2013) states that stuttering is characterized by primary and secondary behaviors. Primary behaviors refer to the actual stutter. This can include sound, syllable or word repetition, prolongations of sounds and/or a blockage of airflow in the oral or laryngeal cavities. Secondary behaviors refer to learned involuntary reactions to the stutter. These can include physically struggling or tense facial features, avoidance behaviors, eye blinking or facial grimacing. The combination of the behaviors results in the presentation of stuttering.

ASHA (2020) states that certain disfluencies are typical for adults and children to make. These disfluencies include hesitations, filler words, whole word repetitions, revisions, phrase repetitions or pauses when speaking. It is typical to have these types of disfluencies every so often in speech (Ambrose & Yairi, 1999; Tumanova, Conture, Lambert, & Walden, 2014). ASHA (2020) states that atypical disfluencies include repeating part of a word, prolonging a

speech sound, and blocking, or the inability to initiate sounds. Disfluencies from stuttering also typically are produced more often, for a longer amount of time, with a greater effort taken, or even with tension or struggling.

Etiology

There are many theories as to what causes a stutter, but no one knows exactly what the etiology is. Throughout history, some theories have indicated a stutter is due to anxiety, culture, neurological deficits, or home environment. When addressing the causes of stuttering, most researchers now say that it cannot be explained by just one theory.

One predominant theory of stuttering is the Cerebral Dominance theory. There are two hemispheres of the brain, the right hemisphere and the left hemisphere. Typically, language and speech production are produced in the left hemisphere of the brain. The Cerebral Dominance theory states that in an individual who stutters, the area for language and speech production is not in the left nor right side of the brain, and because of this an individual may have a lack of motor control in speech production (Anderson & Shames, 2011).

This theory was first officially introduced by Lee Edward Travis in 1978. Travis's research suggested a "reduction in cortical control of speech during stuttering" (Travis, 1978, 278). He also states that there is still a large lack of evidence so we cannot determine what the causes of stuttering are. However, since then, many recent findings also supported the cerebral dominance theory.

Anderson and Shames (2011) state that stuttering could be due to a variety of different theories, including the well-known Cerebral Dominance theory. Anderson and Shames (2011) define the Cerebral Dominance theory as neither the left nor right hemisphere of the brain being

dominant in controlling speech production. This theory has recently gained more interest by researchers because of the new evidence that shows neural imaging differs in an individual who stutters and an individual who does not stutter. However, there still needs to be more research done on this theory to know for sure how the location of Broca's area affects one's speech.

MacPherson (2018) has shown that an increased cognitive load can have many effects on an individual's linguistic system. In fact, he found that within a task involving speech production, stability and timing, there were many processes that were disrupted including response inhibition, selective attention and working memory processes. It was possible, however, that the older adults' speech and motor performances could have been affected by aged cognition and motor function. MacPherson (2018) also found that cognitive load can affect different concepts such as "sound pressure level, fundamental frequency, speech rate, intensity, and fundamental frequency and intensity variability" (MacPherson, 2018, 1259). Therefore, the motor system can be affected by cognitive demands, and these deficits can result in differences in both speech and vocal performance. This study found that, especially with older adults, cognitive load did affect the performance of phonological skills.

This idea that cognitive overload contributes to stuttering is also supported with research analyzing brain imaging. Qiao et al. (2017) determined that there may be deficits in the language circuits that involve speech planning as well as initiation, timing and the motor sequencing in the people who stutter. Qiao et al. (2017) also states that there is an inverse correlation between connectivity and severeness of the stutter. He determined that connectivity in the brain is different in those with a stutter and those without. Neuroimaging is looked at to determine connectivity and matter differences in the brain. These images are a result of an fMRI. Wong et al. (2015) states an fMRI, or Functional Magnetic Resonance Imaging, "detects the magnetic

signal resulting from blood oxygenation and flow that occur in response to neural activity" (Wong et al., 2015, 2). The research of Qiao et al. (2017) found that people with a stutter typically had significantly weaker connectivity in their left inferior gyrus or Broca's area, right putamen, right caudate and right thalamus. Qiao et al. (2017) also concluded that in the left supplementary motor area and primary motor cortex that functional connectivity was significantly stronger in the people with a stutter than those without. There is evidence of this to support a theory of stuttering which states that those who stutter do so because they have a lack of connectivity between the right and left hemispheres of their brain. This theory supports the Cerebral Dominance theory of stuttering.

Qiao et al. (2017) also found there to be dysfunction of two different neural networks in individuals who stutter. The first is an outer linguistic cortical loop. This loop controls speech and language functions as well as auditory self-monitoring. The second is the inner phonatory loop. This loop contains the cortical and subcortical regions that control speech production.

The Cerebral Dominance theory of stuttering and the idea of cognitive overload are very common theories as to why one stutters. However, Smith and Weber (2017) state a newer theory that is gaining more popularity. Their theory is that when addressing the causes of stuttering, most researchers now say that it cannot be explained by just one theory. They suggest a dynamic mechanistic approach is the best strategy to understand stuttering. Smith and Weber (2017) currently understand that a complete theory of stuttering comes from the dysfunction of a variety of subsystems as well as developmental trajectories. These subsystems include motor control, auditory integration, language processing and emotional aspects. It is also important to note that there are many parallels in both language and the motor areas for early stuttering. Research indicates that atypical and/or delayed development of these neural networks and how they

interact with each other can lead to stuttering. Therefore, the most current research states that the etiology of stuttering is due to a multitude of different systems that all work together to help us speak.

Smith and Weber (2017) also determined a child's Mean Length of Utterance and a child's phonological skills are in rapid growth as a child develops, and a stutter typically occurs at this time of a child's life. Therefore, it is possible that a stutter could also be due to this rapid growth.

BILINGUALISM

According to Lee et al. (2014), the definition of bilingualism is "a continuum implying the use of two languages by an individual speaker" (Lee, et al., 2014, 723). Wong et al. (2015) states that over half of the population of the world is bilingual and/or multilingual.

Bilingualism may be a risk factor for stuttering. Anderson and Shames (2011) state that a higher amount of stuttering is found in children who are bilingual. However, Shenker (2011) states that there is currently no credible research known that can prove that bilingualism is a risk factor for stuttering. It has been proven by many researchers, however, that typically, those who are bilingual and stutter have disfluencies in both languages, although sometimes the stutter is more severe in one language over the other (Byrd et al., 2014 & Lim et al., 2015 & Shenker, 2011 & Brundage & Rowe 2018, Lee et al., 2014, Schäfer et al., 2012, Lim et al., 2008, Galatsiou et al., 2017).

Simmonds et al. (2011) states that there are two different types of bilingualism: successive bilingualism and simultaneous bilingualism. Successive bilingualism is when one

language is learned after the first was already established, and simultaneous bilingualism is when both languages are learned at the same time.

Unfortunately, there is also a potential to misdiagnose those who are bilingual to have a stutter. Byrd et al. (2015) states that those who are bilingual typically demonstrate more disfluencies in their speech than those who are monolingual. Speech-language pathologists may see these dysfluencies as a stutter and label it as such. Therefore, continuous research on those with a dysfluency is essential so we can continue to better understand the speech of those who are bilingual and those with a stutter. This will help speech-language pathologists to better understand how to help serve others to the best of their abilities.

Switching Languages

Switching and mixing are two terms used to describe the action bilinguals take when changing the language they are speaking from one language to the next. Shenker (2011) states that some bilingual individuals use switching and mixing interchangeably, and says it is okay to use the definition of them both interchangeably. Fabbro (2001) disagrees and states that switching occurs as a social disorder of communication, for it is atypical for one to, “alternate their verbal expression between two languages” (Fabbro 2011, 213). He defines mixing as the changing of linguistic elements from multiple languages in a sentence. This is common among bilingual individuals with aphasia. However, because the latter is less recently dated, and for the purpose of this literature review, the definition of switching and mixing will include both the changing of verbal expression between languages as well as changing the linguistic elements between languages.

Switching is very prevalent in bilingual speakers. Fabbro (2001) determined that bilingual individuals typically would go on producing mixed or switched speech even when asked to use only one language (Fabbro, 2001). This shows that switching languages is a very complex process for bilingual speakers.

In order to better understand how bilinguals process and produce language, it is important to understand how bilinguals switch languages. Calabria et al. (2018) states that in some bilingual communities, bilinguals will switch languages as they address different speakers without the need for a pause or hesitation.

However, Navracsics (2019) suggests that each word may process in the brain under the meaning of the word rather than the word being a word itself. In fact, children typically change the language they are speaking fluently depending on who else is in the room with them. This suggests that children have a multilingual awareness that is highly developed. Both languages are determined to be activated when processing as a bilingual, so therefore there is no "language switch" to turn languages on and off. Navracsics (2019) also concluded that bilinguals had a harder time with processing phonemes versus processing semantics. In fact, results of their studies with EEG tests and Hungarian versus English word recognition were that they did not find any significant difference between the recognition of words in the two languages. Therefore, when "switching" languages, it is possible bilinguals do not transfer their thinking from one language to another, but rather only "switch" their motor functions.

Wong et al. (2015), found evidence that there was a greater activation in neural imaging in the caudate nucleus when individuals were switching languages. Individuals who are bilingual often show higher activation in neural imaging more than individuals who are monolingual when dealing with semantic tasks, syntactic processing and procedural representation. The research

indicated when dealing with these tasks they have a greater activation in neural imaging of their dorsolateral prefrontal cortex and inferior frontal cortex than monolinguals do. Therefore, it seems as if bilingualism can lead to greater executive functioning.

Wong et al. (2015) also found that there were many differences in naming times between bilinguals and monolinguals. Typically, those that were bilingual have slower picture naming times than those who are monolingual. Monolinguals also produce a greater amount or words in verbal fluency tasks than bilinguals. Overall, Wong et al. (2015) concluded that there are some advantages for bilinguals, such as vocabulary knowledge, but there are also some disadvantages, such as skills such as morphological and phonological awareness. According to ASHA (2020), phonology is "the sound system of a language and the rules that govern the sound combinations" (ASHA, 2020). Phonological processing is an umbrella term for the processing of the sound system as well as the processing behind these sound combinations. Phonological awareness falls under this term and refers to "a metalinguistic skill, which involves the awareness of and ability to discriminate or identify phonological structure of one's language" (Wong et al., 2015, 6).

Wong et al. (2015) also found that the caudate nucleus, located in a subcortical part of the brain, was activated more when bilinguals switch languages compared to when they did not. The role of the caudate nucleus is unclear; however, the caudate nucleus does have a role in the pathway of language processing.

WORD USAGE

Word Usage and Stuttering

Language and word usage can also play a role in the presentation of a stutter. Within language, there are content words and function words. Schäfer and Robb (2012), stated that

"Function words included articles, pronouns, verbal auxiliaries, modals, deictics, expletives, particles, interjections, pro-sentences, conjunctions and prepositions. Content words contained nouns, main verbs, adjectives and adverbs" (Schäfer & Robb, 2012, 603). Schäfer and Robb (2012) have also shown that stuttering differs on content versus function words. They have found that in a group of German and English-speaking participants who stuttered, the German language participants had a greater amount of stuttering on content words in comparison to function words. This study also found that generally adults stutter a greater amount in content words when compared to function words, and children stutter more in function words than when speaking content words. Therefore, it seems as if there is evidence that within language, the structure of words, for example, functional versus content words, could play a part in the severity of the stutter.

Word Usage and Bilingualism

The research of Gkalitsiou et al. (2017) further supports the findings of Schäfer and Robb (2012), for their research discovered that bilingual children stutter more on function words than content words. This study involved Spanish and English-speaking bilinguals, and stuttering was more often found on function words than content words when speaking Spanish compared to English. This study also suggested that there are more disfluencies in Spanish than English because Spanish has more complex linguistics and motoric complexity. This idea is to be discussed further in this literature review under the section titled, "Severity of Stutter and Language Spoken".

NEUROLOGY

Neurology in Individuals Who Stutter

There are four lobes of the brain: the frontal lobe, temporal lobe, parietal lobe, and the occipital lobe. The temporal and frontal lobe are related to the formulation of speech and language. Beal (2011) found that children with a stutter had less gray matter volume in their left frontal gyrus and bilateral temporal gyrus. These areas are located in the frontal and temporal lobes of the brain and are associated with the formulation of language and production of speech. He also found that adults have an increased amount of gray matter volume in the individual's left inferior frontal gyrus and their right superior temporal gyrus. Garnett et al. (2019) also found the largest differences in gray matter volume exists in the inferior frontal gyrus and left precentral gyrus. Therefore, gray matter differences between those with a stutter and those without are found to be mostly in the left temporal lobe and the left precentral gyrus and left frontal gyrus in their left frontal lobe.

This is important to note because the left side of the brain is typically the hemisphere dominant for language production and processing. Wernicke's area is a specific area located in the left temporal lobe along the superior edge of the bilateral temporal gyrus and is the area involved with language production and processing. Broca's area is located in the left frontal lobe. Broca's area is the area of the brain that controls speech production. Therefore, these results show that those with a stutter have a difference in volume in their Broca's area as well as the temporal lobe, where Wernicke's area is located. This means that the Broca's and Wernicke's area is involved and working differently in those with a stutter.

Beal (2011) also found that white matter density also differs between those with a stutter and those without. Adults with a stutter have differences in the connectivity in the supramarginal

gyrus and left Rolandic operculum, for they have a decreased connection of white matter. These areas are associated with speech production and language processing. In children, there was also found to be a decreased connection of white matter in the similar part of the brain.

An fMRI study has also shown differences in brain activity for those with and without a stutter. Beal (2011) found that in adults that stutter, there is an increase of motor activity in the left Broca's area as well as a decreased auditory ability during speech compared to adults who have fluent speech. This could lead to the idea that those with a stutter may need to concentrate on their speech more than others, and therefore need to use a greater amount of motor activity in the brain to go toward their speech than fluent speakers. Also, Garnett et al. (2019) determined that both persistent and recovered groups had overall FA reductions in their left arcuate fasciculus in their inferior parietal lobe and in the posterior temporal lobe. The arcuate fasciculus is white matter involved with the connectivity between language production and language processing.

Centers of the brain, specifically on the left side that are activated during speech are different for those with a stutter and those without. Belyk et al. (2015), determined that there also were many differences in the right hemisphere of the brain in those with a stutter and those without. For example, the right inferior frontal gyrus had a greater activation in those with a stutter versus those with fluent speech. The pre-supplementary motor area, lateral premotor cortex, and Rolandic operculum also all differed in those who were fluent and had a stutter. They all had a greater activation in those with a stutter. Belyk et al. (2015) also cited other studies that have determined that poor timing in those with a stutter may be because of dysfunction in the basal ganglia. Many researchers found that the areas of the basal ganglia that are activated during stuttering include the caudate nucleus, putamen, globus pallidus, subthalamic nucleus, and the

substantia nigra (Braun et al., 1997; Kell et al., 2009; Ingham et al., 2004; Loucks et al., 2011; Wu et al., 1995; Belyk et al., 2015). The basal ganglia play a role in regulating all motor movements including speech. The caudate nucleus is a part of the basal ganglia, and Wong et al. (2015) had stated that this area was activated in neuroimaging when bilinguals switched languages. This area is involved in language processing.

Neurology in Bilinguals

Calabria et al. (2018) determined that those who are bilingual have multiple parts of the brain that are activated differently when they speak. Overall, those who are bilingual use parts of the brain including their right prefrontal cortex, thalamus, left putamen and their cerebellum. This research again suggests that being bilingual can affect these area's gray matter, white matter and connectivity.

The research of Calabria et al. (2018) determined that gray matter differs in the brains of bilinguals and multilinguals. He found that there was an increased amount of gray matter in bilinguals in many parts of the brain including the posterior supramarginal gyrus which links components of lexical knowledge, an anterior parietal region which activates phonology, and the angular gyrus which processes the meanings of words. Calabria et al. (2018) also found that the parts of the brain that most commonly control inhibition and conflict resolution are the inferior and superior frontal gyri. The area of the brain that activates working memory as well as task specific processing are the posterior parietal areas. Therefore, Calabria found that being bilingual can positively affect one's inhibition, conflict resolution, working memory and task-specific processing.

Wong et al. (2015) also found differences in gray matter in the brains of bilinguals, for they found that the parietal lobe had greater grey matter density in multilingual children than monolingual children. They believed that this gray matter volume increase was why bilinguals also had a greater attention span and cognitive control. Therefore, studies have shown the gray matter of the posterior and inferior parietal lobe has a greater density in bilinguals than monolinguals. Gray matter density also differs in the basal ganglia for bilinguals. Wong et al. (2015) also determined that bilingual's left caudate nucleus had a greater gray matter volume than monolinguals. They also determined that a greater gray matter volume in the left and bilateral supramarginal gyrus means that there is a larger vocabulary size. Wong et al. (2015) also found bilinguals had differences in their syntactic processing of their language, and they had a larger left inferior frontal gyrus, precentral gyrus and putamen. Therefore, there are many areas of the brain that differ in gray matter in bilingualism and monolingualism.

Wong et al. (2015) also found that bilinguals also have some differences in their white matter and connectivity of their brain compared to monolinguals. These areas are involved in phonological processing and include increased neural activity as well as a greater density of white matter in the temporal, temporoparietal and frontal areas. Therefore, the white matter has increased connectivity between the temporal, temporoparietal and frontal areas of the brain.

Bilingualism can also affect different parts of the brain depending on where the languages were learned. In fact, Fabbro (2011) found that second languages learned at school have wider representation in the cerebral cortex when compared to the first language. He also found that when the language is acquired in a more informal setting, the parts of the brain that are most likely to be activated are the subcortical structures such as the basal ganglia and the cerebellum. Therefore, there are many ways in which bilingualism positively affects the brain.

EXECUTIVE FUNCTIONING

Executive Functioning in Individuals Who Stutter

Sasisekaran and Basu (2017) found that one's executive functioning seems to differ depending on if one has a stutter or fluent speech. Executive functioning includes many functions including task performance, processing and response times. There were multiple executive functioning differences between children with a stutter and children without a stutter. For instance, children with a stutter have a weakened knowledge of phonetics and more difficulty "implementing phonemic processes in speech production" (Sasisekaran & Basu, 2017, 2794). Therefore, they have a difference in their executive functioning abilities in speech than children without a stutter, and this may affect their speech and stutter.

Sasisekaran and Basu (2017) also found that children with a stutter can be behind their peers in certain cognitive skills such as attention, inhibition control, and switching attention. Many other researchers have agreed, and have shown that children with a stutter are behind their peers in a variety of different skills involving cognition, attention and inhibitory control (Anderson et al., 2003; Anderson & Wagovich, 2010; Eggers, De Nil, & Van den Bergh, 2010, 2012; Karrass et al., 2006; Sasisekaran & Basu, 2017). Anderson and Wagovich (2010) also determined that there is a great correlation between attention measured by parents' responses to surveys and actual performance the child demonstrates in repetition in children with a stutter.

Sasisekaran and Basu (2017) have also shown that response times also differ between children with a stutter and children without a stutter. This same study had two different studies on response time. The first study concluded that there was not a significant response time difference between the children with a stutter and children without a stutter group, however, the

second study concluded that in this task the children who had a stutter had a slower response time than the children without a stutter.

Executive Functioning in Bilinguals

Executive functioning is known to differ for those who are bilingual and those who are not. Kornisch et al. (2017) have found that bilingualism seems to cancel out the deficits in executive functioning that comes with stuttering. Specifically, this research found that bilinguals show faster reaction times as well as a fewer amount of identification errors than the monolinguals. Kornisch et al. (2017) determined that bilingualism can have benefits on individuals who stutter. Therefore, it is possible that being bilingual can have a positive effect on one's executive functioning, specifically if that individual stutters.

SEVERITY OF STUTTER AND LANGUAGE SPOKEN

There have been studies that have shown that the severity of the stutter depends on the language spoken. Lee et al. (2014) found that in most instances, the language spoken impacts both the frequency and the severity of a stutter. One study by Mamdoh and Gomaa (2015) covered those who were bilingual with a stutter. Arabic was their first language, English their second. This is an example of successive bilingualism. They all were about 10-11 years old when the study was conducted and learned English around 4 years of age. Overall, this study found that these children stuttered more in English than Arabic.

There are two different theories as to why the language affects the stutter. One is that some languages may be more phonetically and motorically complex, and therefore individuals are more likely to stutter in that language because of the complexity of the structure of the

language. Another theory is that the severity of the stutter depends on the language because of the order in which languages are learned. The language that was learned first is the more fluent language, because the speaker has been using the language itself for longer.

It would seem individuals would stutter more in the language that was labeled more complex. However, there have been studies that have contradicted this idea. A study by Schäfer and Robb (2012) compared bilinguals with a stutter who spoke both German and English and concluded that although German is a more complicated language than English, individuals stuttered more in English than German. This was not what was expected. This further shows that more research needs to be completed on how certain languages can impact a stutter. It is important to note that Schäfer and Robb (2012) found that the majority of those who are bilingual and have a stutter do not speak fluently in either language, although there have been few cases in which an individual will stutter in only one language. This, however, is not common.

Second, there have been studies that have shown that bilinguals stutter less in the first language learned. A study by Lim et al. (2008) found that those who are dominant in the English language and those who are dominant in the Mandarin language typically have higher scores when tested for stuttering in their less dominant language. On a stuttering test, a higher score is correlated to a more severe stutter. The language and structure of the Mandarin language is very similar grammatically to the language structure of the English language. The study also found that those who were equally fluent in both languages had similar scores for both languages on their stuttering test. This study concluded that language dominance does impact the severity of stuttering. Also, another study by Wong et al. (2015) has shown neurologically that the "later a second language is acquired, the more the activation is required/observed" (Wong et al., 2015,

12). However, research from Jayaram (1983), Howell et al. (2004), and Lim et al. (2008) contradicted those results. They found that bilinguals had stuttered more in their first and more fluent language.

A study by Simmonds et al. (2011) demonstrated that when using the less proficient language, bilinguals need a greater activation in their brain. “Using a picture-naming task with German–French bilinguals, they found that when using the less proficient language, activation in the left caudate and anterior cingulate cortex was more extended. One interpretation is that the processes required to produce language become more automatic, requiring less domain-general executive control, as the language becomes more familiar” (Simmonds et al., 2011, 5). However, it is important to note that there are many different findings to studies, and according to Shenker et al. (2011) the language one stutters the worst in does not necessarily have to be the language they know the least or spoken the least amount of time.

CONCLUSION

Neurology

There are multiple ideas to consider when examining the research in the literature regarding the affect bilingualism has on individuals who stutter. Research has shown that bilingualism can influence the neurology of a stutter.

Speech production is linked to Broca’s area of the brain, or the left inferior gyrus. Those with a stutter have a greater activation in Broca’s area, along with a greater amount of brain activity in their primary and pre-supplementary motor areas (Belyk et al., 2015). The primary and pre-supplementary motor areas are found in the frontal lobe and play a role in movement of the body, and it is important to note the motor movements involved in speech, such as movement

of the mouth, tongue and lips. Wong, et al. (2015) found the Broca's area in bilinguals has a greater amount of gray matter than monolinguals. His research also found that bilinguals also have an increased amount of gray matter in their frontal areas of the brain. The frontal lobe of the brain includes the primary motor cortex, supplementary motor cortex, as well as executive functioning. Wong et al. (2015) believes the increased amount of gray matter in the frontal lobe was due bilingualism, which leads to bilingual's greater attention span and cognitive control. Therefore, those with a stutter typically have a different amount of gray matter in their Broca's area and a difference in brain activity in their frontal lobe. The neuroimaging of bilinguals typically shows a greater amount of gray matter in these areas. Therefore, it is possible bilingualism can affect those with a stutter by increasing the gray matter in their Broca's area. It is possible that this could decrease the effects of a stutter. Bilingualism can also affect individuals who stutter, for bilinguals have a larger portion of their brain dedicated to their attention span and cognitive control. This could help an individual with a stutter cancel out the executive function deficits that come with having a stutter (Kornisch et al., 2017).

Language processing is associated with Wernicke's area, located in the left temporal lobe. This portion of the brain also involves phonological processing. Research in the literature also suggests that in individuals who stutter, there are decreases in gray matter density within their left temporal lobe. Wong et al. (2015) has shown that those who are bilingual have an increased amount of connectivity in their temporal lobe. Bilinguals have this greater connectivity here because they have two languages they must be able to process phonologically. Therefore, individuals who stutter have a decreased amount of gray matter in their temporal lobe, whereas bilinguals have an increased connectivity in their temporal lobe. The Research of Wong et al. (2015) supports the idea that bilingualism may have a positive effect on those with a stutter.

Individuals with a stutter may have some motor movement deficits as well as a need to attend to the production of speech more, whereas bilingual individuals have a greater portion of their brain attending to lexical knowledge and phonation. More research needs to be done on this area to confirm the extent of the neurological effect that bilingualism has on individuals who stutter.

However, the research of Wong et al. (2015) also further supports some of the negative effects of bilingualism on individual's speech. Wong (2015) concluded that a disadvantage for bilinguals could be morphological and phonological awareness. Navracsics (2019) also concluded that phonological processing is a much greater task than processing semantics for bilinguals. Since these studies have shown that individuals who stutter have phonological deficits, it is possible that bilingualism can only worsen these deficits in the individual who stutters. This contradicts findings in previous studies (Wong et al., 2015).

The supramarginal gyrus is thought to play a role in the poor timing associated with stuttering (Belyk et al., 2015). The supramarginal gyrus is also found to link components of lexical knowledge, phonology, and word meaning (Calabria et al. 2018). Individuals who stutter were found to have a decrease of white matter in the supramarginal gyrus. Calabria et al. (2018) has found that bilinguals have an increased amount of gray matter in their posterior supramarginal gyrus. Bilinguals have an increased amount of gray matter in their supramarginal gyrus, which means bilinguals have to use this area of the brain often, and they need to pay more attention to their word timing, lexical knowledge, phonology and word meaning. Therefore, bilingualism possibly can help those with a stutter, for they typically have more brain matter associated with word timing, lexical knowledge, phonology and word meaning.

The left Rolandic operculum plays a role in phonological processing. Beal (2011) found that individuals who stutter have a decreased connectivity in their supramarginal gyrus and left

Rolandic operculum (Beal, 2011 & Garnett, et al., 2019). Therefore, individuals with a stutter may have some issues with phonologically processing due to the decreased activity in the left Rolandic operculum. Wong et al. (2015) also found there to be an increased amount of gray matter in the parietal lobe of the brain of individuals with a stutter. This lobe of the brain is partly involved in processing sensory information, including phonological processing, and bilinguals have a larger portion dedicated to this part of the brain. Calabria et al. (2018) found bilinguals to have an increased amount of gray matter in their posterior supramarginal gyrus. Therefore, bilingualism could have a positive effect on a stutter, because they have a greater amount of gray matter in their brain dedicated to phonological processing.

Executive Functioning

Bilingualism can also have a positive effect on a stutter when looking at executive functioning. Kornisch et al. (2017) has shown that those who are bilingual show advantages when given tasks of executive functioning. In fact, their research has shown that those who are bilingual seem to cancel out the deficits in executive functioning for individuals who stutter. Since there has been research that shows there is a greater amount of gray matter in bilingual's inferior parietal lobe and caudate nucleus, many argue that this leads to greater attention and greater cognitive control (Wong et al., 2015). Those with a stutter typically have a lesser amount of gray matter in both the inferior parietal lobe and the caudate nucleus (Beal, 2011 & Garnett et al., 2019), and this can lead to lesser attention skills and lesser cognitive control. Therefore, bilingualism can have a positive effect on a stutter, because the areas of the brain that typically contain less volume in those with a stutter have a greater volume in those who are bilingual. This may help with skills that are typically harder for those with a stutter.

Cerebral Dominance Theory of Stuttering

Neurologically, the brain of a bilingual individual who stutters is affected by both having a stutter and being bilingual. Typically, speech and language are in the left hemisphere of the brain. The Cerebral Dominance theory of stuttering states that speech and language centers are not in either hemisphere of the brain, and this discrepancy causes individuals to stutter (Anderson & Shames, 2011). Although there needs to be more research done on this specific theory, research has shown there to be gray matter differences in the left hemisphere of the brain, specifically Broca's area in individuals who stutter and individuals without a stutter (Beal, 2011 & Garnett et al., 2019). Research has also shown there to be a great difference in Broca's area and the frontal lobe of those who are bilingual and those who are monolingual (Calabria et al., 2018 & Wong et al., 2015). Bilingualism can affect the parts of the brain that involve phonological processing and cognitive control. Neurologically, a stutter can affect the parts of the brain that influence speech and language. Research has shown that bilingualism can have a positive effect on an individual who stutters (Kornisch et al., 2017). Research suggests that those who stutter do so because they do not have a specific language cortex on either hemisphere of their brain. Based on this research, a conclusion can be made that bilingualism may help an individual with their phonological processing and cognitive control despite the lack of location of their specific language cortex.

However, it is also possible that being bilingual could have a negative effect on a stutter while looking at it through the Cerebral Dominance theory. It is possible that when one's speech and language is not on either hemisphere of their brain, the individual may have cognitive overflow, and this may lead to a greater stuttering in both languages (MacPherson, 2018). Therefore, there is still much research out there that needs to be completed to determine the

accuracy of the Cerebral Dominance theory as well as how being bilingual and having a stutter can affect the brain.

Culture

An additional relevant factor to consider is how the culture of the bilingual individual may affect their stutter. Bilingualism offers a variety of different cultures that can present themselves in a variety of different ways. Therefore, because of the potential of different cultures that bilingualism has to offer, it is possible bilingualism can influence a stutter in this way. If one's culture is focused on one specific group in society, it is possible the stutter could worsen because of the pressure put on that group.

Switching Languages

Bilingualism can also have a negative effect on the motor functions of an individual who stutters. Bilinguals switch languages often when they speak, sometimes without even realizing it. This switching in languages was at first thought of as bilinguals switching over which language they are speaking in their brains, however, recent research shows that bilinguals actually do not go through this process, yet instead the act of switching is purely just for motor functions (Navracsics, 2019). Therefore, although multilingual awareness is highly developed for bilinguals, when bilinguals switch languages this can affect the cognitive demands of the language, which can affect the motor system of the individual speaking (MacPherson, 2018). Bilingualism can therefore have a negative effect on the motor functions on an individual who stutters, because those with a stutter already have deficits with physical motor functions, and cognitive overflow will only worsen the conditions (MacPherson, 2018).

Bilingualism can affect an individual's stutter, depending on which language is spoken. Studies have shown that some languages are more phonemically complex than others, and this can influence how frequent or severe the stutter is. One study has shown that the more complex the language is, the less severe and frequent the stutter was, which is an opposite result than expected (Schäfer, Robb, 2012). However, research does show the language spoken can impact the severity and frequency of a stutter, and that the stutter can also be influenced by whichever language was learned first, or the language that is considered better-known by the bilingual individual who stutters (Mamdoh & Gomaa, 2015 & Lim et al., 2008 & Wong et al., 2015 & Howell et al., 2004 & Jayaram, 1983). Typically, the language that was learned second has a higher severity and frequency of a stutter. Therefore, bilingualism can affect an individual who stutters, for they could stutter more frequently and severely when speaking one language over the other.

Overall, there is much evidence that suggests that bilingualism affects individuals who stutter both positively and negatively. Bilingualism can positively affect the neurology, phonological awareness and executive functioning of individuals who stutter based on their culture, languages they are switching between, and the language spoken. An individual who is bilingual has a greater portion of their brain dedicated to their phonological awareness and executive functioning, and this can help to improve their skills in these areas. However, bilingualism can also have a negative effect on individuals who stutter, for bilingualism can cause an individual to experience cognitive overload and cause individuals to have difficulties switching languages. Based on this literature review, there are many positive and negative effects bilingualism has on an individual with a stutter, however, the positive effects outweigh the negative effects. However, there does need to be continuous research done on both bilingualism

and stuttering in order to fully understand the positives and negatives of bilingualism. Therefore, there is a lack of cohesive research and evidence to suggest the true effects bilingualism has on an individual with a stutter.

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