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An Analysis on the Perception and Production of Deaf Accented Speech

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ABSTRACT

Hearing loss negatively affects human beings and sometimes does this by decreasing speech intelligibility and voice quality. People often identify these differences in what is known as a deaf accent. This study evaluates the characteristics, factors, effects and adaptations all in regards to deaf accents within individuals who experience hearing loss. A comprehensive literature review of journal articles was conducted using multiple databases in order to collect evidence. The findings showed that not every deaf accent is alike. Different factors affect the speech intelligibility of deaf accents, which, in effect, impacts communication with others and one's quality of life. However, there may be strategies, such as hearing devices like cochlear implants or voice training, that could overall effectively improve deaf speech and its related health and wellbeing. In conclusion, more research needs to be conducted to further understand what impacts deaf accents and discover ways to improving technology and corresponding intervention.

Keywords: hearing loss, deaf accent, deaf speech, auditory feedback, speech perception, speech production, quality of life, rehabilitation

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Finally, here's to those with hearing loss. May we possess the courage to self-advocate. May we prove the others wrong. May we continue to inspire change. "I am only one, but still I am one. I cannot do everything, but still I can do something; And because I cannot do everything, I will not refuse to do the something that I can do" (Grover, 1909, p. 28).

Chapter 1

Introduction

Ranked as the third most common physical disability in the world, those who personally experience hearing loss understand the significance of its long-lasting effects (Masterson et al., 2016). An estimated 1.5 billion people worldwide face some form of hearing loss (*World Report on Hearing*, 2021). The term "hearing loss" or "hearing impairment" refers to an inability to perceive sound and its severity ranges from mild to profound depending on the individual affected. Typically, a hearing impairment begins at a threshold of 20dB or greater. It is also important to note that those with a mild to severe hearing loss are referred to as "hard of hearing" and a severe to profound hearing loss classifies one as "deaf". For the purposes of this literature review, I will use the expression, "deaf", as an overarching term that applies to any individual with a form of hearing loss whose speech has been affected as a result. Approximately 430 million of the 1.5 billion with hearing loss experience a moderate or greater hearing loss and 30 million classify as profound. In addition to seeing different numbers in terms of severity of hearing loss, there is also a noticeable difference in regards to age of hearing loss onset. One survey found that 1.7 per 1,000 infants screened for hearing loss were identified as individuals with hearing loss (CDC, 2020). Infants born with hearing loss never have full access to sound. On the contrary, 25% of adults older than the age of 60 are found to experience hearing loss after having lived a life full of sound ("Deafness and Hearing Loss", n.d.). Essentially, hearing loss is more prevalent in those who are older. These are the individuals who encounter the negative ramifications from a lack of sound. When one cannot hear their surrounding world, it becomes

extremely difficult to facilitate language development and replicate typical speech, therefore resulting in what is known as deaf accented speech. A deaf accent can be found in individuals with hearing loss who create distinct sounds and pronunciations that are not similar to typical speech. As a result, there is a noticeable decrease in speech accuracy and intelligibility. The consequences of not being able to communicate with others may lead to a lack of social interaction, a decrease in quality of life as well as deprivation of an education.

Fortunately, with the help of scientific research and improvements in technology, some individuals with hearing loss may benefit from instruments such as hearing aids or cochlear implants. It is important to note that these treatment options do not restore hearing, but rather help amplify sounds for the patient. Typically, those with a mild to severe hearing loss may gain access to sounds with hearing aids, a non-invasive treatment option. Utilizing a microphone, hearing aids pick up and adjust the sound to fit the personalized programming of the patient with hearing loss. Research has found positive correlations between increased listening ability and increased speech and language outcomes in children with hearing loss (Tomblin et al., 2014). Additionally, those with severe to profound hearing loss are considered candidates to undergo surgery for cochlear implants. Cochlear implants use electrical signals to stimulate the auditory nerve which can then be interpreted as speech. Similar to the increased speech intelligibility attributable to hearing aid treatment, cochlear implants show benefits for its users as well (Freeman & Pisoni, 2017). However, in comparison to hearing peers, speech delays can still be found in cochlear implant users (Niparko, 2010). Altogether, hearing devices have the potential to improve the speech intelligibility of individuals with hearing loss, but just like they cannot restore hearing loss, they cannot always restore typical speech.

Technology such as hearing aids and cochlear implants play a major role in what is known as auditory feedback, which is crucial to voice control and speech production (Tejeda-Franco et al., 2020; Ubrig et al., 2019). Auditory feedback occurs when a human being detects an error in their communication and uses this realization to correct themselves and improve the exchange of information. Auditory feedback plays a critical part in how humans acquire speech, but when deafness occurs, voice control is cut off and the individual with hearing loss is unable to self-correct since they are unable to recognize mistakes in their communication. As a result, deaf individuals experience changes in the rate, fundamental frequency, and volume of their speech (Schenk et al., 2003). It is significant to emphasize that most of the time, early hearing loss is extremely detrimental to speech acquisition in children with congenital hearing loss because the relationship between hearing loss age of onset and language disruption is somewhat continuous (Korver et al., 2017). This is due to the fact that the critical language development period occurs during the first few years of life and may extend all the way to puberty (Friedmann & Rusou, 2015). According to Wang et al. (2014), humans reap the most benefits in regards to speech development from ages 3 to 5 years old. After this time, the brain experiences a loss of plasticity and left lateralization and it becomes much more difficult to acquire speech and language (Friedmann & Rusou, 2015). Prelingual deafness prevents children with hearing loss from acquiring and refining their speech. However, studies also show that post lingually deafened adults experience speech production degradation as well (Brudzynski, 2010). While hearing technology assists in improving auditory feedback, it still is not enough since individuals with hearing loss still experience delays in speech compared to that of normal hearing peers. Although anyone with hearing loss can experience debilitating speech effects due to lack of auditory feedback, the repercussions still tend to be more noticeable in children. As a result, most

studies in this review focus on participants who are younger since the impact on speech is greater.

Purpose of Study

Born with a severe bilateral sensorineural hearing loss, I grew up in a household with extremely proactive parents who were determined in fitting me with the appropriate hearing aids and taking the necessary means to make sure I could communicate with a hearing society by speaking orally. The first 18 years of my life, I grew up surrounded by numerous individuals who raised me, taught me, and provided me with speech language therapy and rehabilitation. My experiences as an undergraduate at Penn State University allowed me to meet hundreds of new people. In doing so, I found myself in disbelief on account of how many noticed a deaf accent in my voice. It made me question how exactly my speech sounded different since I considered it normal. I became even more curious when I discussed this with friends and family back home who stated that they understood my speech just fine. I began to wonder if and why it was harder for my new acquaintances at Penn State University to handle conversations with me.

Now more than ever, diversity is a crucial topic to discuss in this ever-changing environment of individuals emerging from different cultures and linguistically different backgrounds. Just as location plays a major role in identifying and connecting distinct styles of speech to certain populations, my time at Penn State University spent studying under my Communication Sciences and Disorders major taught me that some communication disorders affect speech the same way. Similar to the way that humans might change their accented speech

due to geography by using voice training, this paper will discuss how this process occurs with speech affected by hearing loss.

In this analysis, I will examine studies about hearing loss and how hearing loss affects speech and its development. Furthermore, I will investigate the effects of deaf accented speech and the strategies individuals can use to adapt to a deaf accent. To conclude, I will discuss the limitations of these studies as well as what can be done next in the field of research to help advance the speech intelligibility of the deaf. By investigating previous existing literature on the topic, I can raise awareness about the topic of deaf speech and promote further research on ways to improve speech acquisition and intelligibility in individuals with hearing loss through improvements in treatments.

Method

The data and results interpreted in this study were obtained through an extensive literature review search. I used a variety of databases and search terms which I recorded during the process of my search. Such databases included Penn State University Libraries, Google Scholar, PubMed, ProQuest, Wiley, ScienceDirect, and the National Center for Biotechnology Information (NCBI). I conducted multiple searches using these phrases:

1. Deaf accent
2. How does hearing loss affect voice
3. Hearing aids affect voice
4. Cochlear implants affect voice
5. Deaf speech production

6. Hard of hearing speech production
7. Deaf speech quality
8. How do accents affect deafness
9. Hearing aids and accents
10. How auditory feedback affects deaf people
11. How deafness affects auditory feedback
12. How to communicate with deaf individuals
13. Cochlear implant speech acquisition outcome
14. Hearing aid speech acquisition outcome
15. Auditory feedback

A major criterion put into effect for these journal articles was that they only go back as far as 2015. Only a select number of papers date prior to 2015 so all of the results in this literature review are as current as possible and only presented the newest and most relevant discoveries and best practices.

Chapter 2

An Overview of Deaf Accented Speech

As indicated, the individuals identified as having lower speech intelligibility due to deaf accented speech are those with some varying degree of a hearing loss. Ertmer (2010) mentions that children with severe to profound hearing loss were discovered to only be 20% intelligible. This does not bode well in regards to a listener's understanding. Decreased speech intelligibility results from a lack of auditory feedback and the ability to self-correct and adapt their articulation (Schenk et al., 2003). In addition, the onset of hearing loss and the type of treatment factor into the prominence of a deaf accent (Coelho et al., 2015). For that reason, the characteristics of deaf accented speech in this literature review are generalized, but not all of them apply to every deaf individual. Characteristics of speech differ in many aspects. Studies have found that hearing loss affects the phonology, suprasegmental speech and overall voice quality of deaf individuals (Ubrig et al., 2019). It is important to procure a better understanding of deaf speech so as to improve intervention methods and strategies as well as lead to successful communication interactions amongst deaf and normal hearing individuals.

Children's' speech will be affected due to hearing loss, especially if there is a lack in early intervention ("Effects of Hearing Loss on Development", n.d.; CDC, 2019). Unlike older adults who might acquire hearing loss post lingually, some deaf children are born without ever hearing what standard speech sounds like. Therefore, they lack the chance to compare and contrast the differences in their own speech compared to typical speech. Multiple studies have been conducted in order to uncover how speech may be altered as a direct result of hearing loss.

One such study focused on how children often miss out on consonants such as /s/, /ʃ/, /f/, /t/, and /k/ when conversing with others ("Effects of Hearing Loss on Development", n.d.). Ergo, they frequently omit these sounds from their speech, leading to decreased speech accuracy (Warner-Czyz et al., 2010). Not only are consonant sounds left unheard during conversation, but other aspects of oral communication in general are lacking. One of these problems include nasality, which also helps contribute towards the idea of a deaf accent (Baudonck et al., 2015).

In one study, researchers initiated an investigation on nasalance and nasality in prelingually deaf children fitted with either cochlear implants or hearing aids compared to that of normal hearing peers (Baudonck et al., 2015). Measuring nasalance determines the degree of the velopharyngeal opening during speech whereas nasality refers to how nasal resonators impact the quality of voice. Typically, deaf individuals are found to exhibit some form of nasality like hyper- or hyponasality. Researchers assessed children all around the age of nine. They first measured nasalance via the Nasometer. Each child then sustained the vowels /a/, /i/, and /u/ and the consonant /m/ as well as read a Dutch passage aloud. Then, they employed two speech therapists to observe nasality via a nominal rating scale from numbers 0 to 3 using speech recordings of the children.

Baudonck and her colleagues uncovered two major points. First, both children with hearing aids or cochlear implants displayed lower nasalance values compared to their normal hearing peers. Secondly, the children with just hearing aids appeared to speak with significantly high nasality, otherwise known as hypernasality, in relation to the normal hearing children. These results are important for several reasons. It shows that in some cases, normal resonance is displayed in those with hearing loss. This can be attributed to the idea that the children were fitted with hearing aids or cochlear implants. However, the study also confirms that children with hearing loss are more likely at risk to experience disturbances to the resonance. Consequently, these disturbances will affect the intelligibility of their speech. Therefore, it qualifies as an important characteristic for researchers and professionals to study some more and treat as best as possible in order to improve the way others perceive deaf speech.

A supplementary study compared the voice analysis between pediatric cochlear implant and hearing aid users and normal hearing peers aged approximately six-years old. Researchers measured the perturbation and mean fundamental frequency (F0) of a sustained vowel /a/ (Jafari et al., 2017). Furthermore, they extracted vowel duration of the vowel sounds /i/, /e/, /æ/, /u/, /o/, and /a/ “from the six following words: bid, bed, bæd, bud, bod, [and] bad…”. They recorded the children three times by having them repeat what was said and then chose the best recording to be analyzed. Together, the results of these measurements allowed the researchers to come to some interesting conclusions.

The phonation quality parameters were higher in values for cochlear implant and hearing aids users than for the normal hearing children. This included values of fundamental frequency, harmonic-to-noise ratio and different variations of jitter and shimmer. Jitter can be defined as

variations in cycles and shimmer is defined as the amplitude variation in sound waves. It should be pointed out this proved only to be significantly different for hearing aid users versus the control group. Similar to the previous study, results like this one suggest that individuals who undergo cochlear implantation end up with better voice quality than hearing aid users. In the context of vowel duration, cochlear implant and hearing aid users possessed greater values than the control group. The combination of these results led the researchers to the conclusion that improvements in speech are possible with the proper treatment and intervention.

From the perspective of older adults, post lingual deafness tends to be a more common theme in contrast to the prelingual theme in children. This makes for a unique viewpoint because these individuals have already acquired proper speech and allows for researchers to gain a better understanding of how post lingual hearing loss affects auditory feedback and its corresponding speech control. That being said, one must keep in mind that there are still deaf adults with a prelingual hearing loss, and they also provide fresh perspective in terms of how hearing loss affects deaf accented speech. Much like deaf children, adults with hearing loss also face impairment in terms of phonological sounds, suprasegmental speech, and voice quality.

In one particular study, researchers studied four different groups of people. Group 1 was comprised of prelingual deaf speakers fitted with cochlear implant(s) before language acquisition (Neumeyer et al., n.d.). Group 2 consisted of a second set of prelingual deaf speakers who were equipped with cochlear implant(s) after language acquisition. Group 3 was made up of post lingual deaf individuals resourced with cochlear implant(s) less than two years after hearing loss began to occur. Finally, Group 4 was formed of post lingual deaf individuals fitted with cochlear implant(s) more than two years after hearing loss began to occur. Ages varied from

approximately 11-years old to about 59-years old. For this reason, four control groups were formed that matched in age as well as sex and the number of speakers. These groups were analyzed based on sibilant production, or more specifically, measured in the first spectral moment of /s/ and /ʃ/. Generally, high frequencies above 8500Hz prove difficult for cochlear implant users to identify. Unfortunately, sibilants are known for being higher in frequency. Due to this matter, cochlear implant users are subject "to a very restricted frequency range in the perception of /s/ and to a poor frequency resolution in the spectra of /ʃ/".

Thus, Neumeyer and colleagues hypothesized that the mean values of the first spectral moment of the sibilants would be lower in cochlear implants users than in their normal hearing counterparts and that those mean values would not differ as much. Not only that, they predicted large differences between the prelingually deaf speakers implanted after language acquisition and normal hearing speakers. Their research resulted in significantly lower first spectral moment values for /s/ in the cochlear implant speaker groups compared to the control groups. While /ʃ/ had lower values in all of the cochlear implant groups, it only proved to be significant for post lingually deaf speakers. Ultimately, differences will vary amongst all of the cochlear implant groups depending on whether or not they classify as prelingual or post lingual and not how soon they were treated. As previously mentioned, deaf individuals often have a difficult time producing sounds they cannot hear themselves and those sounds typically end up distorted (Schenk et al., 2003). Groups 1-4 reflect this in their lower values for sibilants because of the way their auditory feedback system works. They compensate by using an adaptive strategy known as "downshifting behavior" by shifting characteristic frequencies downwards.

The first study focused on adults honed in on how hearing loss affects segmental aspects of speech, but this second study highlights intelligibility, phonation quality characteristics like fundamental frequency, and nasality. An intriguing aspect of this study focuses on the short-term effects to speech when turning a cochlear implant on and off (Zamani et al., 2021). After recruiting forty-eight post lingually deafened adults wearing a cochlear implant, a control group of normal hearing individuals was also formed as well. Each deaf adult underwent speech recordings three different times. The first sample was collected on arrival with the cochlear implant on, and the second sample was collected after the cochlear implant had been shut off for five hours. Lastly, the third sample was gathered after the cochlear implant was turned back on again.

Ultimately, the off condition does contribute to what may sound like to some like a deaf accent. The results showed significant differences between the on and off conditions in fundamental frequency, jitter, shimmer, harmonic-to-noise ratio (HNR), and hypernasality. HNR calculates the periodic and non-periodic parts of sounds (Fernandes et al., 2018). Fortunately, there were no significant differences in jitter and speech intelligibility percentage between the cochlear implant speakers and normal hearing speakers (Zamani et al., 2021). One of the key takeaways is that once the cochlear implants were turned back on, the deaf adults' speech went back to normal. Interestingly enough, in the previous children's study, significant differences in regards to phonation quality were only visible between hearing aid users and the normal hearing group but not the cochlear implant group (Jafari et al., 2017). However, this study does show a significant difference between cochlear implant users and normal hearing speakers.

Perhaps one of the most fascinating studies, a researcher took hearing subjects and simulated cochlear implant acoustic processing in real-time to see its effects on speech production (Casserly, 2015). There were 18 total English-speaking normal hearing participants, including controls, who were between 18 to 35-years old and studied three separate times: "baseline, initial simulation exposure, [and] production following learning period". They read aloud 114 isolated words as well as a short passage and some prosodic structures. Casserly had the experimental participants read aloud using a vocoder during the initial simulation exposure and the production following learning period. She analyzed the acoustic-phonetic characteristics of sibilant fricatives, aspirated stops, and F1/F2 vowel qualities and how the affected auditory feedback would impact the participants' speech. In doing so, there were significant changes to the F1 formant frequency and low vowels like /æ/ were raised and high vowels, such as /i/ lowered. There were no significant changes to sibilant fricatives which was interesting because the Neumeyer et al. (n.d.) article speaks of sibilant fricative difficulties amongst deaf individuals who are fitted with cochlear implants. If Casserly's study suggests that this real-time cochlear implant simulation on normal hearing individuals is successful at creating similar effects, then why do her results differ from Neumeyer et al. (n.d.)? Perhaps there are multiple other factors contributing to the outcomes of this study.

Together, these studies show that hearing loss affects the speech production of individuals with hearing loss in numerous ways. These characteristics collectively make up what may be known as a "deaf accent" to some. Some of these characteristics include deletion of consonants, hypernasality, low speech intelligibility percentages, high values in fundamental frequency, harmonics-to-noise ratio, jitter and shimmer as well as low first spectral moment values for sibilants. Coelho et al. (2015) mentions other characteristics identified from previous

studies. For example, deaf individuals may exhibit absences of rhythm, show strain or breathiness or even present a monotone voice due to a lack of auditory feedback. All in all, a vital takeaway from this review of deaf accented speech is that there are many factors in play here that affect the severity of speech intelligibility and that there are some viable treatment options that reduce the risk of an accent but do not eliminate it completely.

Chapter 3

Factors Affecting Deaf Accented Speech

It is now necessary to discuss what factors affect an individual's deaf accent and how these factors may affect characteristics of deaf speech. Alas, it is impossible to pinpoint a specific combination of factors towards what will cause a deaf accent (Coelho et al., 2015). Despite that, there are certain elements that can contribute towards what could either be a weak or strong deaf accent. More research is still needed in this area because if an individual with hearing loss exhibits multiple factors related to deaf speech, those conditions have the potential to interfere with results in studies investigating other topics related to hearing loss and speech production. It is important to obtain a better understanding as to what conditions may shape deaf speech because identifying factors that directly affect deaf speech have the potential to create positive speech production outcomes for those with hearing loss. That in of itself could make a world of difference and bridge the gap when it comes to communicating with individuals with hearing loss.

To begin, a group of researchers decided to explore the idea that age of treatment could play a substantial part in affecting the speech production of deaf children. Using assessment data from three centers, researchers enlisted 403 children with congenital bilateral severe to profound hearing loss who received cochlear implants by the age of six (Dettman et al., 2016). They split the children up into four separate groups. Group 1 was implanted before the age of 12 months, Group 2 was implanted before the age of 18 months, and Group 3 was implanted before the age of 24 months. Group 4 was fitted with cochlear implants in between 25 to 42 months. The researchers collected data from speech perception, speech production, and language assessments, but for the purpose of this literature review, the areas regarding speech production will be

highlighted. Using the Diagnostic Evaluation of Articulation and Phonology (DEAP) assessment and percentage word-intelligibility, researchers hypothesized that deaf children who received cochlear implantation before the age of 12 months would develop similarly to their normal hearing peers.

The speech production assessment data did not disappoint. Group 1 indicated significantly more accuracy as opposed to Groups 2, 3, and 4. They achieved 95% vowel, 83% consonant, 89% phoneme, and 64% cluster accuracy. Furthermore, they also achieved 63% word-intelligibility accuracy. The findings support the idea that cochlear implantation in children 12 months or younger optimize speech production outcomes. Taking these results and applying them to what was learned in the studies for children with cochlear implants in Chapter 2, these are promising results in regards to improving speech intelligibility in children with a deaf accent (Baudonck et al., 2015; Jafari et al., 2017). For instance, omitting consonants is a common characteristic found in prelingually deafened children with cochlear implants, but 83% consonant accuracy with implantation before the age of 12 months shows positive results (Dettman et al., 2016). However, these findings contradict the results found in the study by Neumeyer et al. (n.d.). Although findings were pulled from individuals ten years or older, it is interesting that the study concluded that differences amongst speech production would not be due to how soon the participants had been fitted with cochlear implants.

Of interest in regards to factors affecting deaf speech characteristics, Coelho et al. (2015) conducted a thorough literature review and created a table describing hearing loss factors and their effects on speech. As previously discussed so far, the onset of hearing loss (i.e. prelingual or post-lingual) and treatment options (i.e. hearing aid(s) or cochlear implant(s), or both) have effects on deaf individuals and their speech production (Jafari et al., 2017; Neumeyer et al., n.d.).

Another factor to consider includes the type of hearing loss (Coelho, et al. 2015). There are three types: conductive, sensorineural, and mixed. According to the CDC (2020), conductive hearing loss occurs with blockage of sound in either the outer or middle ear and is associated with reduced loudness. Sensorineural hearing loss takes place in the inner ear and is closely linked with both normal, unstable and high fundamental frequency as well as normal jitter and shimmer, and high amplitude variation (Coelho et al., 2015). Regrettably, there has not been enough research done to link mixed hearing loss to any specific speech production characteristics. Moreover, the severity of hearing loss plays a role in deaf speech. A mild to moderate hearing loss gives rise to resonance issues, and a severe to profound hearing loss induces high fundamental frequency and instability.

There are other factors including environmental influences, intervention, age of hearing loss onset, and gender. A study done on elementary and high-school aged cochlear implant users evaluated some of those factors that affected the speech intelligibility in individuals with a profound sensorineural hearing loss (Tobey et al., 2011). Multiple assessments were utilized in this study with reference to speech intelligibility accuracy, a questionnaire, samples of sign language, aided threshold averages, and several others. The results revealed that elementary school-aged cochlear implant users with better speech correlated with smaller families, higher socioeconomic status and the female gender. Additionally, the high-school aged user results demonstrated more accurate speech production in females and those who rely less on sign language. Those who immerse themselves in oral communication and do not rely on sign language are associated with better speech intelligibility. This is because they are compelled to speak orally since everyone surrounding them does as well. Overall, this illustrates the notion that there are lots of factors that impact deaf speech production and its corresponding speech

intelligibility. In brief, depending on the number of factors and other circumstances, speech production outcomes will end up varying anywhere from a mild divergence to a severe voice disorder.

Chapter 4

Effects of Deaf Accented Speech

Lamentably, deaf accented speech gives rise to negative effects in regards to quality of life and how an individual with hearing loss functions in society. Hearing loss is sometimes looked upon as being an invisible disability because it is not something that is clearly visible unless a patient is wearing hearing aids or cochlear implants. This can be dangerous because the people who surround that individual might be completely oblivious as to what they are going through. On the other hand, hearing loss can be extremely noticeable, especially when it effects the voice of a deaf individual and creates speech limitations. This deaf accent may then cause decreased quality of life, educational limitations, social isolation and much more.

One research study examined chosen modes of communication and its relationship to perceived quality of life (Kushalnagar et al., 2011). The researchers surveyed their participants based on communication method, perceived quality of life and depression. They discovered that the deaf high school-aged children who used oral speech as their main form of communication reported greater stigma associated with being deaf. In addition to that, they also correlated mode of communication with severity of hearing loss. Those who experience mild to moderate hearing loss are more likely to speak orally and those with severe to profound hearing loss typically use sign language. Disappointingly, there were no significant correlations for participation, self-acceptance, or advocacy. These are vital attributes for someone with a disability as they can be used to their advantage to help ensure that they are receiving proper accommodations and building new skills as they partake in activities with their normal hearing peers.

Additionally, the Most (2007) study explored speech intelligibility, coherence, and loneliness amongst deaf children in both academic group and individual settings. Most

investigated 19 children between the ages of 12 to 14 who had severe to profound hearing loss. The group setting took place in special classes at a regular school and the individual setting meant that the participant was mainstreamed in a regular classroom. The subjects filled out a Loneliness Questionnaire and Sense of Coherence Scale and their speech intelligibility was measured as well. Results showed a significantly lower average speech intelligibility score for children in a group inclusion setting rather than the individual inclusion setting. Plus, there were significant correlations for children in individual inclusion related to coherence, loneliness, and speech intelligibility.

In essence, this study recognized that good speech intelligibility is not only necessary to communicate with others, but is necessary in order to regulate good social and emotional feelings. This also suggests that speech intelligibility affects children in school settings as well. Something to note is that the study mentions that children in the group inclusion setting communicate through speech as well as speech and sign. In the Tobey et al. (2011) study, they mention that children who rely less on sign language will experience better speech intelligibility because they are compelled to speak rather than sign. If the students in the group inclusion setting are given the opportunity to be mainstreamed, their speech intelligibility might reap the benefits.

A third study focused on the relationship between speech intelligibility and psychosocial functioning in deaf children with cochlear implants (Freeman et al., 2017). The researchers investigated whether or not delayed speech may cause the risk for psychosocial issues in deaf children. In the first part of the study, researchers explore the effects of speech intelligibility on psychosocial functioning in deaf preschoolers with cochlear implants. Using the Beginner's Intelligibility Test and the Behavior Assessment System for Children, Second Edition, they

concluded that while there were significant differences amongst deaf children and normal hearing children in speech intelligibility, there were no significant differences in regards to psychosocial development, suggesting that the deaf children were still on track with their normal hearing peers in the specific category. Moreover, the results show that better speech intelligibility is related to better psychosocial behavior.

In the second half of the study, researchers studied deaf teens with cochlear implants aged 7 to 20 years. Using the McGarr Sentences and the Behavior Assessment System for Children, Second Edition, they concluded that there was a significant difference between the deaf teens and normal hearing teens in terms of speech intelligibility. However, it is important to note that the deaf teens who relied more on oral communication exhibited better speech intelligibility than their peers who used speech and sign. This falls in line with the Tobey et al. (2011) study as mentioned before which showed that children who rely less on sign language experience improved their speaking skills, therefore possibly limiting the risk of a deaf accent. Additionally, the deaf teens scored significantly worse than their normal hearing peers in the context of psychosocial development (Freeman et al., 2017). Finally, results indicated that better speech intelligibility in deaf teens meant better psychosocial behavior. This study shows that not only should assessment of psychosocial functioning be in evaluations, but that more research and therapy regarding speech production is necessary for school-aged children who wear cochlear implants.

Chapter 5

Strategies to Improve Speech Intelligibility of Deaf Accented Speech

Taking into consideration how a deaf accent comes to be and how it harms individuals with hearing loss, it is vital that I review strategies that have been suggested in studies in order to increase speech intelligibility, which as I mentioned in the previous chapter, will improve quality of life. One of the more obvious suggestions includes treatment regarding hearing technology like hearing aids and cochlear implants. While there are plenty of studies showing their effectiveness, this chapter will shine a spotlight on other treatment options that might work just as well in helping to facilitate conversations.

Another major treatment option includes different forms of therapy that individuals should take advantage of. A necessary form of therapy in terms of improving voice quality and speech production, voice training benefits anyone experiencing some form of hearing loss and a resulting voice disorder (Coelho et al., 2015). The authors pointed out specific voice quality issues and ways that voice training can be of assistance. For instance, someone with high fundamental frequency might try a yawn-sigh exercise. In another case, if someone presents a monotone voice, musical scales and cards with arrows pointing up and down on certain words will add some intonation and stress back to the voice.

A second option suggested by the study involves the “multisensory method” during rehabilitation. Not only do patients use auditory cues, but visual and tactile cues as well. One of the most talked about solutions that deaf individuals utilize is the concept of lip reading. By observing tongue placement or even open or closed mouth shapes. One study observed improved frequency and intensity after patients viewed computerized visual feedback. As for tactile and

kinesthetic monitoring, patients emit a sound and touch their head, face, nose, mouth, and neck to try and identify abnormalities in the way they produce sounds.

In a study conducted by researchers, both a treatment and control group ranging from 17 to 48 years old with a severe to profound prelingual bilateral sensorineural hearing loss demonstrated the positive effects of voice therapy intervention and its influence on speech (Ubrig et al., 2019). Vocal recordings were obtained both before and after training for the treatment group and twice for the control group but without the training. The recordings consisted of a sustained vowel /a/ and sentence reading, which then underwent acoustical analysis and a subjective evaluation. Results showed significant improvement in overall voice level and reductions in instability and degree of resonance as a direct consequence of voice therapy intervention. Group 2 failed to make any significant improvements in their production of speech. A key takeaway from this study is researchers recommend increased voice therapy time and adding a focus onto the suprasegmental side of speech production.

In terms of young children, the American Speech-Language-Hearing Association (ASHA) suggests family-centered intervention as early as possible to promote speech and cognitive development (“Effects of Hearing Loss on Development”, n.d.). Additionally, newborn hearing screenings are highly recommended for infants and babies. The sooner intervention begins, there is less of a risk for a voice disorder.

Chapter 6

Discussion

Ultimately, all of these studies combined indicate that individuals with hearing loss are at risk for a loss of speech intelligibility in their speech production. This creates what is otherwise known as a deaf accent. Interestingly enough, the speech production of any individual with hearing loss of any age can affect their speech intelligibility. A deaf accent is not limited to a certain set of characteristics to define it. However, studies have found that individuals with hearing loss experience deletion of consonants, hypernasality and higher values in fundamental frequency, HNR, jitter, and shimmer (Baudonck et al., 2015; "Effects of Hearing Loss on Development, n.d.; Jafari et al., 2017). A deaf accent can include, but is not limited to, all of these identifying characteristics. Many factors play into the concept of compromised voice quality and how prominent the accent may be to others who perceive it. Such factors include, but again, are not limited to: onset of hearing loss, age of treatment and intervention, gender, type of treatment, type of hearing loss, severity of hearing loss, as well as surrounding environmental influences.

Unfortunately, hearing loss bears negative ramifications, especially if left untreated. It can lead to a sense of decreased quality of life, feelings of isolation and loneliness, adverse psychosocial functioning, lack of participation, and can even harm both teachers' and classmates' opinions on how a deaf child is portrayed. Thankfully, there have been several studies discussing treatments, interventions and adaptation strategies. These solutions help to

improve the speech intelligibility of individuals with hearing loss. As a result, the negative ramifications mentioned just above will begin to see positive changes.

Notably, the Tobey et al. (2011) study results demonstrated that individuals with hearing loss who utilized oral communication, spoke more fluently compared to their peers who used both speech and sign. This was a notion that was brought up several times in this literature, especially when it came to determining classroom options in an educational setting. I believe this would make for an intriguing research idea in which children with hearing loss are placed in a group inclusion setting, an individual inclusion setting, and a mixed setting of the both of them. It would be interesting to see the results of whose speech production would end up benefitting the most.

Additionally, there was not a sufficient amount of literature to include this in the literature review, but studies regarding Automated Speech Recognition technology have begun to surface. In today's society, a Google Alexa or Siri on an iPhone rely on good quality of speech in order to understand what the consumer is asking for. Deaf individuals struggle with this due to their accents and low speech intelligibility scores. Using technology like this might not only open society's eyes to finding ways to help accommodate individuals with hearing loss, but also might help uncover information about the speech intelligibility of those with hearing loss and how to improve it.

Clearly, extensive research that needs to be accomplished in order to have a full understanding of what it means to perceive deaf accented speech. As a human race, we need to ask ourselves questions such as: what solutions could possibly eliminate the sound of a deaf accent? Would improving technology such as cochlear implants prove more beneficial rather than placing a focus on rehabilitation? If deaf individuals are okay with how they sound, how

can society adapt to their accent, and what are some strategies to create a greater sense of listener's ease? It might also question those who wear hearing aids and what can be done to get them to the same level as their normal hearing peers and cochlear implant users.

Chapter 7

Conclusion

In summary, the lack of auditory feedback affects speech production in all areas of speech: segmentally, suprasegmentally, and voice quality (Ubrig et al., 2019). As a direct result, speech intelligibility decreases and it becomes harder for individuals with hearing loss to communicate with others leading to feelings like loneliness (Most, 2007). However, this paper discusses the idea that with voice training and assistive listening technology like hearing aids or cochlear implants, auditory feedback improves which then leads to improvement in speech production and perception (Coelho et al., 2015). Other factors also play into deaf accents such as age, gender, mode of communication, and severity of hearing loss. Additionally, this literature review uncovers the consequences deaf speech has on a deaf individual's quality of life. While previous studies have taught us much about deaf accented speech and have helped to improve speech production, it has also educated us on the fact that individuals with hearing loss are still very much at risk for a deaf accent. Further research is necessary in order to understand why characteristics of deaf speech occur and to discover improvements in treatment and intervention to mitigate this risk.

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The Pennsylvania State University | Schreyer Honors College — **University Park, PA**

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LEADERSHIP AND INVOLVEMENT

Audiology Club — **University Park, PA**

President — *Aug 2017 – Present*

- Presided over all club operations and planned numerous events to promote ideas such as hearing protection and treatments
- Instrumental in the formation of collaborations with other organizations to make a larger impact on the student body
- Facilitated lectures on a monthly basis to educate members on the field of audiology and to provide advice for graduate school

Penn State Sign Language Organization — **University Park, PA**

THON™ Performance Chair (2020) — *Aug 2017 – Present*

- Instructed and mentored community members on using American Sign Language (ASL) to communicate with deaf individuals
- Contributed to collaborative club fundraising of over $6,000 towards a university-wide total of more than $11M donated to benefit the lives of those impacted by childhood cancer by designing a performance in ASL and leading fundraisers

Alpha Kappa Psi Professional Business Fraternity — **University Park, PA**

Secretary (2018) | Merchandise Chair (2019) | Rush Committee (2019) — *Feb 2018 – Present*

- Developed professional and networking skills through resume workshops, professional presentations, and informational sessions with members of the fraternity
- Participated with an inductee class of 16 to orchestrate and host professional, philanthropic, social and fundraising events for 115 fraternity members to enhance brotherhood unity

Penn State THON™ Dancer Relations Committee — **University Park, PA**

Icebreaker Chair (2020) — *Oct 2019 – Feb 2020*

- Encouraged and motivated dancers to continue standing for all 46 hours by providing them with motivational stories, food, and other activities like scavenger hunts to keep them occupied
- Supported dancers by suggesting exercises and stretches to avoid strain and injury as well as maintain healthy well-being
- Boosted work productivity amongst 37 other committee members by creating meeting activities to improve energy levels

WORK EXPERIENCE

St. Luke's Hospital Audiology and Hearing Aid Center — **Phillipsburg, NJ**

Observer (Student Engagement Network Grant) — *May 2018 – Aug 2018*

- Awarded a $1,500 grant to shadow and assist local audiologist, Dr. Jennifer Titus, by interacting and communicating with patients and participating in administrative activities such as filing medical reports for the patient record system
- Assisted in conducting hearing evaluations for patients of all ages, offering advice on treatment options, and cleaning hearing aids to ensure each individual obtained a better quality of life by being able to properly hear their surrounding environment

Federal Taphouse — **State College, PA**

Hostess — *Sep 2020 – Present*

- Welcomed and escorted patrons to assigned tables and offered information on menu items and corresponding specials
- Organized and controlled all tables, waitlists and takeout orders through five applications each on their respective technological devices
- Communicated with kitchen staff, management, serving staff and customers to achieve a high level of customer satisfaction

B&B North Department Stores — **Lavallette, NJ**

Sales Associate — *May 2019 – Aug 2020*

- Assisted customers daily by answering questions about products and services, thereby ensuring consumer satisfaction
- Stocked, managed, and organized inventory both on the floor and in the dressing room for easy customer access
- Rotated merchandise displays for the strategic placement of new merchandise to attract shoppers and encourage purchases

HONORS, SKILLS, AND INTERESTS

Honors: NJ Grace's Law Advocate, Hear Strong Foundation Champion (2013-Present), Dean's List 5 semesters, Schreyer Honors College Academic Excellence Scholarship, College of HHD Academic Scholarship, AG Bell College Scholarship

Skills: Working Knowledge of Microsoft Office PowerPoint and Word, Basic Knowledge in American Sign Language, RAMP Certification

Interests: Camping, Cheerleading, Deauville Beach, *Harry Potter*, Mac n' Cheese, Rollercoasters, RV trips, Pinterest, *The Bachelor*