Do your Eyes Help you Hear? Appropriate Visual Contexts Improve Performance in Speech in Noise Task

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Approval

The undersigned recommend the acceptance of the thesis

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Abstract

Previous hearing and auditory perceptual research as focused mainly on the older population as well as those within the hard of hearing community but little on the population of young adults. Further, previous research had suggested a positive role on semantic context when processing degraded speech. The current study explored the potential benefits of using a multimodal (ie. audiovisual) stimulus in a speech-in-noise (SIN) task under conditions with and without semantic context. A total of 51 normal hearing young adults participated in this study (M_{age} = 19.67, *SD*= 1.45), one Genderfluid, 35 females (M_{age}= 19.49, SD=1.31) and 15 males (M_{age}= 20.13, SD=1.73). Results suggested that SIN tasks completed with audiovisual stimuli led to a higher number of correct\ target words than the standard audio only SIN task. Further, SIN task conditions which included both a visual talker and both visual and semantic context led to a significant positive impact on performance compared to both the audiovisual (no context) and audio alone SIN conditions. This suggested that visual and contextual aids were beneficial speech recognition under less than ideal conditions. Future research should examine similar audiovisual and contextual SIN tasks on hard of hearing participants or those with cochlear implants to determine if these visual and contextual aids are beneficial to these populations.

Do your Eyes Help you Hear? Appropriate Visual Contexts Improve Performance in Speech in Noise Task

The study of speech intelligibility and perception is important to the understanding of the development of language acquisition and language perception. Psychological phenomenon such as the cocktail party effect are one such avenue of research in which the exploration of speech intelligibly in degraded speech tasks occur. In terms of the processing of degraded speech, Peelle (2017) suggested in his literature review that the cognitive processes involved in the processing of degraded speech are most likely verbal working memory and a high level of attention monitoring. Along with this, he suggested that the challenges of perceiving acoustic changes in speech are not solely an issue with auditory perception and are also affected by cognitive processes in both non-linguistic and linguistic realms (Peelle, 2017). Koelewijn et al., (2015) found that it was difficult for participants to hone in on the correct auditory stimuli in situations where there is degraded speech. For example, the cocktail party effect, the perceptual ability to pay attention to one target conversation while in the presence of other competing conversations (Sinnett, Smiliek and Kingstone, 2016) leads to an increase in overall effort when the listener is hesitant about what sounds distinguish the target sentence from the distractor sentence(s) (Koelewijn et al., 2015). Other similar avenues of research have explored how speech perception can be altered by the direction the sound is coming from (Giulani and Brayda, 2019), the age of the individual (Newman, 2005 and Kim, Frisina and Frisina (2006), audiovisual presentation of stimuli (Rudner, Mishra, Stenfelt Lunner and Rönnberg, 2015) as well as the potential benefit of the semantic context surrounding the speech (Aydelott, Leech and Crinion (2010), and Winn, 2016). The current study explores the effects of background noise and semantic context in both auditory alone and audiovisual combined modalities on speech perception and performance using a modified speech in noise task [modelled on QUICKSIN (2006)].

There is a notable gap in the literature surrounding the age of participants within SIN research, specifically within the normal hearing young adult population since previous studies have focused on both younger and older populations. For example, a study by Newman (2005) found that infants five months of age can decipher, and separate speech sounds from multiple talkers, and in fact if the words audibly presented were masked, infants at 5 months of age were able to recognize words that were familiar to them. However, when it came to the recognizing their names, infants under the age of one could successfully do this if the target words were10 dB more intense than the background babble (Newman, 2005). At the age of 13 months, infants were able to recognize their own name within a harder signal-to-noise ratio, something they were unable to do just four months prior (Newman, 2005). Although this study focused on infant hearing, it is evident that there are issues when deciphering speech within background babble at a young age.

On the other hand, as humans age, hearing loss is a prominent issue. Kim, Frisina and Frisina (2006), suggested that as people age their abilities to perceive pure tones declines, and this seems to start in early adulthood. Specifically, these difficulties are due to a decline in the abilities of the medial olivocochlear auditory efferent system (MOC) located within the brain stem (Kim et al., 2006). Kim et al., (2006) findings suggested that there was a possibility that the MOC is an auditory filter that may function in the processing and separation of target speech sounds from the background babble involved within the cocktail party effect or other speech in noise tasks. The decline in hearing abilities over time plays a role in the understanding of age-related abilities in the processing and comprehension of degraded speech (Kim et al., 2006). Additionally, Winn (2016), found that older adults with normal hearing have poor speech intelligibility when it came to the processing of degraded speech, specifically speech presented amidst background noise. In terms of other cognitive factors, executive functioning and working memory can play into the processing of speech, especially in old age (Schneider, Pichora-Fuller and Daneman (2010). In their review, Scheider et al., (2010) suggested that as demands on working memory increase- via increased background noise, semantic difficulty or multitasking- the perceptual processes involved in separating and understanding speech can lead to a decrease in performance on various speech tasks. Along with this, executive functioning controls often determine which stimuli to attend to and whether or not this information will be stored within Long Term Memory (Scheider et al., 2010) . Other research by Gates and Mills (2005) suggested that presbycusis –a term used to describe hearing loss within the older adult population- could be contributed to a number of other factors such as trauma to the auditory system and aging. In terms of the central auditory system, frequent insults upon the auditory system could affect the processing of speech perception within competing noise as well as on a neuronal level (Gates et al., 2005). If there are other underlying issues in age related disfunction, Gates et al., (2005) suggested that the loss or decrease in function of other processing systems could impact the patient's ability to hear. In saying this, Gates et al., (2005) state that many people suffering from central presbycusis have outer hair-cell loss within the cochlea, rather than issues with processing due to brain lesions. In this case, focusing on a younger population may help avoid other biological issues caused by aging or excessive damage to hearing structures. Although the current study will not be directly examining neurological function, this information is critical to the current study's decision to focus on a younger age group. If the MOC's abilities decline with age, then selecting a younger age population would be best to avoid other cognitive factors which could impact the performance on these SIN tasks. Along with this, by using a younger adult sample with normal hearing, this study will be able to accurately describe the hearing capabilities of this population, without having to worry about the degradation of various auditory processing structures.

Studies such as those by Moradi et al., (2017) have explored audiovisual speech training and the benefits it may have on individuals with hearing loss. Results suggested that training in audiovisual gated speech tasks can improve the overall ability to identify target speech in background noise. While looking at the effects of eye movements on audiovisual speech perception Mitterer and Reinisch (2017) found that critical facial movement changes in a visual stimuli video can alter the speech perceived. For example, much like the McGurk effect, changes to the labial (lips) closure can alter the perceived speech. That is, if participants viewed a video where the individual closed their lips, the participant would be more likely to assume that the target speech contained a labial articulation (Mitterer et al., 2017). Similarly, a review by Peelle and Sommers (2015) suggested that visual speech cues such as manner of articulation can aid in later intergradation of speech. For example, in tasks such as the McGurk task, the input of visual and auditory information is integrated and perceived based upon the visual cues viewed at the mouth.

Peelle and Sommers (2015) suggested that at a biological level, the integration of audiovisual stimuli can enhance the perception of speech. Specifically, Peelle et al., (2015) suggested that the lower frequency brain waves produced in the auditory cortex during crossmodal integration aids in the perception of the acoustic features of speech. This in turn is theorized to reduce the amount of lexical competition the brain undergoes while deciphering speech, in a similar way that a decrease in background noise would (Peele et al., 2015). Unlike a typical SIN task which presents sentences solely in the auditory domain and similar to Moradi et al (2017), the current study will explore the effects of a modified SIN task unitizing both auditory and visual stimulus modalities to determine if the presence of a visual component will improve speech perception.

A study by Mishra, Lunner, Stenfelt, Rönnberg and Runder (2013) suggested that background noise effected the overall perception of the target speech, due attention and stimulus processing issues. In quiet conditions (ie. no background noise), it was found that the auditory stimuli provided to normal hearing young adults, was enough to aid the individual in executive functioning tasks, as there was minimal competition (Mishra et al., 2013). For the audiovisual trial it was found that seeing the speaker in any level of background distractor noise, benefited the participants' executive processing of speech (Mishra et al., 2013). These findings suggested that seeing the talkers face when it is difficult to hear and comprehend the target speech aided the processing of auditory stimuli (Mishra et al., 2013). The current study explored whether these beneficial effects of audiovisual stimuli extend outside the usual populations of young children and older adults to also benefit young adults' perception of degraded speech.

In a later study by Rudner et al., (2016) it was found that free recall performance in young adults was higher when they were presented with the speakers face along with the speech and background babble. However, in older adults who experienced hearing loss, this improvement was not statistically significant when speech was presented alone (ie. only the target words/sentences) or embedded into background babble (Rudner et al., 2016). On a Cognitive Spare Capacity Test, it was found that viewing the speakers face when trying to comprehend target speech in background noise improved scores for the older participants in the study, whereas this was only true for young adults when the target sentences were presented alone (Runder et al., 2016). Runder et al., (2016) suggested that although these findings seemed to contradict themselves; the nature of the task and the demands it placed on the participant (ie. working memory, executive function task, hearing and recall task) seemed to have an impact on whether or not the participant (young or old) performed better or worse on the specific task. Since the current study examined the performance of normal hearing young adults, these results are important to take note of, as they suggest that young adults will perform better on speech comprehension and free recall in background babble when they are presented with the face of the speaker (Runder et al., 2016). The current study aims to determine if the presence of the talkers' face will have an impact on performance of a SIN task, something which involves both the auditory system as well as recall from working memory. Rudner et al., (2016) results suggest that seeing the talkers face in a free recall speech task will in fact improve the performance for those within the current studies population.

Semantic context has been deemed to be beneficial in terms of improving speech intelligibility in background babble. One of the earliest studies of speech intelligibility was completed by Pichora-Fuller, Schneider and Daneman (1995). As expected, Pichora-fuller et al., (1995) found that younger adults performed well on low context SIN tasks in a +8 dB difficulty, whereas participants in the older adult category found this task difficult, followed by those in the presbycusis group (those with hearing loss) found this task even more difficult. These findings suggested that although context aids in the perception of speech, for those in the older adult population or those experiencing hearing loss, SIN tasks with low context are not enough to improve their perception of speech (Pichora-Fuller et al., 1995). Pichora-Fuller et al., (1995) suggested that individuals in the older population as well as those with presbycusis rely on context to ease their listening effort, thus making it easier to process the spoken words within background noise. Along with this, young adults perform better on both low and high contextual conditions, suggesting that for a young adult population, context aids in the perception of speech within competing babble (Pichora-Fuller et al., 1995). Aydelott, Leech and Crinion (2010) examined the hearing abilities of both younger and older adults (age ranged from 18- 70+) and their results suggested that priming the semantic context is beneficial in aiding an older population in quiet environments. However, this benefit was not observed in noisy environments in the same older adult population Aydelott et al., 2010). The researchers suggested that this could be related to the reliance on speech cues such as meaningful sound and contextual cues given to decipher speech (Aydelott et al., 2010), However, due to fact that contextual information involves the integration between both top-down and bottom- up processing, other auditory issues associated with ageing such as central auditory processing can potentially impact the implication of the top-down processing (Aydelott et al., 2010). Overall, their findings suggested that in quiet environments, semantic context is more important to speech recognition in older adults, as other cognitive processes could be impacted by aging (Aydelott et al., 2010). When compared to younger adults, semantic context for the older population does aid in speech perception but is not used in noisy background environments for older adults (Aydelott et al., 2010). Although this study viewed adult hearing perception (18-70+), their findings suggest that as individuals age (even as young adults), there is a semantic context benefit when processing and comprehending speech (Aydelott et al., 2010).

Additional support for the importance of semantic context is presented by Winn in (2016). Here it was reported that there was an 11% error rate of responses from the normal hearing older adult participants in in the high-context condition -where the target word at the end of each of the twenty-five sentences where highly semantically linked to the rest of the words in the sentence- (ie. “stir your coffee with a spoon”) had reported at least one wrong word. Whereas a 38% error rate from the low-context condition (ie, “Jane thought about a spoon”) (Winn, 2016). Out of the errors made in the high-context conditions, there was only a 9% error rate of the target word errors that were recorded which also had an error in the context word preceding it (Winn, 2016). Similar results were seen in individuals with cochlear implants, where a 5% error rate was reported for the high-context sentences along with a failure to correctly identify the context of the sentence (Winn, 2016). These findings suggest that words presented in sentences with appropriate semantic context in background babble are easier to understand and results in fewer errors than low-context sentences with background babble (Winn, 2016). Although there are other elements effecting the perception of the sentences, the addition of context within the sentence helped in the correct identification of the words which followed (Winn, 2016). The main purpose of the current study was to examine the benefits of the presentation of visual and auditory semantic context in a speech recognition task, where in the context condition the sentences heard by each participant will match the visual environment in which the speaker is speaking, and the participant is imagining (ie. restaurant and doctor's office).

Individual differences can also impact speech recognition performance. The main variables impacting performance would be hearing ability and visual perception (audiovisual speech perception) but other, learned, variables have also been shown to be important modifiers of performance. Relevant to the current study, research has shown that formally trained musicians perform better in speech in noise tasks (Slater, Skoe, Strait, O'Connell, Thompson and Kraus (2015). Other studies by Parbery-Clark, Tierney, Strait and Kraus, (2012) found that musicians have a stronger neural advantage when deciphering speech syllables presented in noise. One possible suggestion for these connections has to do with extensive practice effecting the encoding of a variety of frequencies (Parbery- Clark et al., 2012). Parbery-Clark et al., (2012) suggested that the processing of higher and lower frequency pitches can cross over to the encoding of the perceptual properties of speech, thus enhancing musicians' abilities in SNR (Signal to Noise Ratio) tasks. Similarly, Zendel, Tremblay, Belleville and Pertez (2015) suggested that French speaking musicians performed better on speech in noise tasks which included a higher SNR than did those who were not musically trained. This meant that musicians were able to recall and report a higher number of correct words in the most difficult SIN task than those who were non-musicians (Zendel et al., 2015). Slater et al., (2015) found that children who were formally trained in music had improved performances in hearing in noise tasks, suggesting that there is a link between some aspect of musicianship and improved auditory perception. They suggested that since musicians often have to decipher specific sounds and pitches from each other, it was likely that these abilities transfer to speech perception in noisy environments (Slater et al., 2015). Similar results were also seen in expert listeners where it was shown that individuals who were highly skilled listeners, such as musicians, performed similarly in terms of their neural processing of speech (Mankel and Bidelman , 2018). However, using QuickSIN, it was found that musicians performed better and showed behavioral enhancements in the speech-in-noise tasks (Mankel et al., 2018). This suggested that formal music training can affect the performance and perception of speech within a QuickSIN speech in noise task (Mankel et al., 2018). The current study also examined the benefits of musicianship in three SIN tasks, audio alone, audiovisual and audiovisual context.

The current study examined the performance of a sample of normal hearing young adults (musicians and non-musicians) on Speech in Noise Tasks across three separate presentation conditions (audio alone, audiovisual without context, audiovisual in context). Based on previous research with older adults (65+ yrs.), the current study hypothesized that young adult participants (18-25 yrs.) would perform better in audiovisual conditions compared to audio alone conditions and better still in the audiovisual condition with a congruent semantic context. Additionally, it was hypothesized that individuals with experience in formal music training would have higher overall scores in speech perception performance than individuals with no music training, irrespective of presentation condition.

Method

Participants

A total of 51 normal hearing participants (M_{age} = 19.67, SD= 1.45) from Memorial University of Newfoundland's Grenfell Campus participated in this study. Participants were asked to self-report their own hearing abilities and were asked to report any hearing difficulties as well as rating their comprehension of the English Language on a scale of one (being completely unable to comprehend) to ten (completely able to comprehend). Of these 51, one identified as Genderfluid, while 35 identified as female (M_{age}= 19.49, SD=1.31) and 15 identified as male (M_{age}= 20.13, SD=1.73). Out of these 51, 28 self-reported musicianship with a range from formally trained (5+ years of school banding or formal lessons) to self- taught- those who taught themselves or completed less than 5 years of formal training, and 23 reported non-musicianship. All participants underwent an informed consent process.

Materials

Before beginning the study, each participant read and signed the informed consent form (Appendix A). The informed consent form outlines important information about the current study. Participants were informed about the purpose of the study, as well as any possible risks and benefits from the study. Although there were no obvious risks associated with this study, participants were made aware that they will have to spend around one hour in a sound proof booth. If someone felt as if they were not able to stay within the booth, the option for them to discontinue the study was available. Participants were made aware of ways they could contact the researchers about the results of the study as well as any other questions or concerns they could have regarding the study.

Stimuli and Experimental Design

Each participant watched a series of three videos. The practice videos, audio alone trial and audiovisual trials used sentence lists from QuickSIN created and tested by Killion (2004) to be formally used and published by Etymotic Research (2006). The SIN lists from the audiovisual context condition were created for the use of this study by the researcher of this study based upon the principles outlined in the QuickSIN guide (Etymotic Research, 2006). Each condition contained a total of twelve sentences, with 6 sentences in each video, and two videos per condition. Each of the sentences were approximately equal in length both in regard to word count and pronunciation time and contained 5 target words (Appendix C). Overall, there were 36 unique sentences. For a maximum score, participants needed to successfully report all 60 target words in each condition. In order for a word to be counted as a correct report, the word recalled and reported needed to be exactly the same as those stated in the sentences. For example, if a participant stated the word makes for made, this would be an incorrect response and would not be counted. All incorrect responses were also recorded including incorrect words that were reported. These videos were created on an iPhone 7 as well as on a Cannon Rebel T1i Camera. To ensure the audio files would match from each device, the files were adapted in iMovie. In doing this, the recordings from the Cannon Rebel T1i Camera were normalized and set to present at an average of 25dB per sentence (outside of talkers rise and fall of voice). For the iPhone 7, the audio was normalized and was played at around 25-30dB. This was due to the fact that the iPhone 7's presentation of the sentences was initially louder than that of the Cannon Camera and was brought down to as close of a dB level as possible. All videos were presented in iMovie on a 13-inch MacBook Air (model number: A1466). In all videos there was background babble overlayed with the spoken target sentences and the volume of the babble increased across the six sentences (ie. sentence 1: 25% babble (30 db babble), sentence 2: 50% babble (40 dB), sentence

3: 100% babble (43dB), sentence 4: 126% babble (46dB), sentence 5: 158% babble (55B), sentence 6: 200% babble (60dB) in each set while the speaker volume was kept constant. The background babble was recorded from a babbled audio file on an iPhone 7 and was clipped to use the first 15 seconds of the audio file (10 Hours of People Talking, July16, 2015). The background babble was normalized within iMovie and was added in 5 second increments into each of the audio files for the lists. Along with the babble, each audio file for each list was normalized insuring each sentence within each video was presented at the same volume, from here, as stated before, each babble clip was adjusted to give the illusion of the SIN task, making each sentence harder than the one before. This background babble had no distinct words spoken, thus the only speech that could be heard came from the speakers spoken target sentences. Due to the fact that the videos were created and edited on iMovie, the sound levels are presented in percentiles rather than a dB number. To ensure that each video had started and ended at the same dB, each video was tested via Decibelmeter-measure dB level (professional sounds app version 1.8.1) altered to present sentence one at 51-53 dB, working up to the final sentence to be presented around 75 dB. This led to having six different levels of trial difficulty (ie. sentences 1 through 6) which is consistent with a standard SIN task (see babble dB levels and audio db levels above). The main manipulation in the currently study was the amount of visual information provided to the participant via the videos during these speech recognition trials. All sentences were spoken by the same female speaker and approximately the same speed and volume leading to 36 unique sentences, twelve per condition with two of each difficulty level.

Video 1: Audio Alone Condition

In the audio alone condition, a white/black screen was presented as the video background (see figure 1. In this condition, the sentences were presented in auditory format only with each sentence (in order least to most difficult) presented following a 15 second interatrial interval

(ITI) which allowed the participant time to repeat the sentence and for the research to record the response.

Figure 1: Visual Stimuli for Audio Alone Condition

<u>Video 2: Audiovisual Condition</u>

In the audiovisual condition, the sentences were presented with the speaker visible with a white background behind her (see figure 2). As with the previous condition, sentences were presented with a 15 second interatrial interval (ITI).

Figure 2: Visual Stimuli for Audiovisual Condition

Video 3: Audiovisual (Context) Condition

In the audiovisual (context) condition, the speaker was again presented on the screen, but recording was done with a green screen in the background of the speaker and later replaced to make the background either a doctor's office (list 1) or a restaurant (list 2) (see Figure 3 and 4). Further the sentences spoken were semantically related to a doctor's office (list 1) and a restaurant (list 2). All sentences can be seen in Appendix C. Sentences were presented with the same ITI as previously mentioned.

Figure 3: Visual Stimuli for Audiovisual Context Condition (list 1)

Figure 4: Visual Stimuli for Audiovisual Context Condition (list 2)

Procedure

This study was advertised in classes as well as with posters (Appendix B) posted around Grenfell Campus of Memorial University of Newfoundland. A testing time was arranged with interested participants based on a first come first serve basis.

Upon entering the testing room and after signing the Informed Consent form, the participant entered the booth. Prior to the beginning of the experimental trials, each participant was given instructions to look at the screen and listen to the audio through the speakers. They were told there were six videos and six sentences per video and to state what they had heard after each sentence. Each participant then completed two practice audio alone trials which results were not included within the current study. All 51 participants completed all three conditions. Although, each condition was presented in a different order for each participant, to avoid practice effects (ie. effects (ie. order A: audio alone, audiovisual, audiovisual context, order B: audiovisual, audiovisual context and audio alone, order C: audiovisual context, audiovisual, audio alone). The data collected from these trials were graded on the SIN Grade form (Appendix

C), which kept track of the total number of target words per sentence and per list. Each underlined word is a target word and the participant would be scored for all successfully recalled word(s) provided in the correct order and tense.

Upon completion of the experimental trials, each participant completed a demographic form including their age, identified gender, level of self-reported hearing impairment, comprehension of the English Language, as well as musicianship (Appendix D). After filling out this form, each participant was given the opportunity to ask questions. Along with this they were informed the nature of the task they had just completed as well as some basic information such as what a SIN task is often used for.

Results

A repeated measures ANOVA examined the total number of words which were repeated correctly from an overall score of 60 per condition, across all three conditions with the descriptive statistics presented in Table 1. Mauchly's test of indicated that the assumption of sphericity was violated $X^2(2) = 10.38$, p=.006. There was a significant effect of condition video type, $F(1.58, 83.97) = 149.23$, p <.001, $\eta_p{}^2$=.75.

Table 1 *Descriptive Statistics for Type of Video Displayed*

Condition Type	*M*	*SD*	*N*
Audio Alone	38.08	5.60	51
95% CI	[36.506, 39.651]		
Audiovisual	41.55	9.24	51
95%CI	[38.950, 44.148]		
Audiovisual Context	53.29	4.15	51
95%CI	[52.126, 54.462]		
Total	44.31	0.77	51

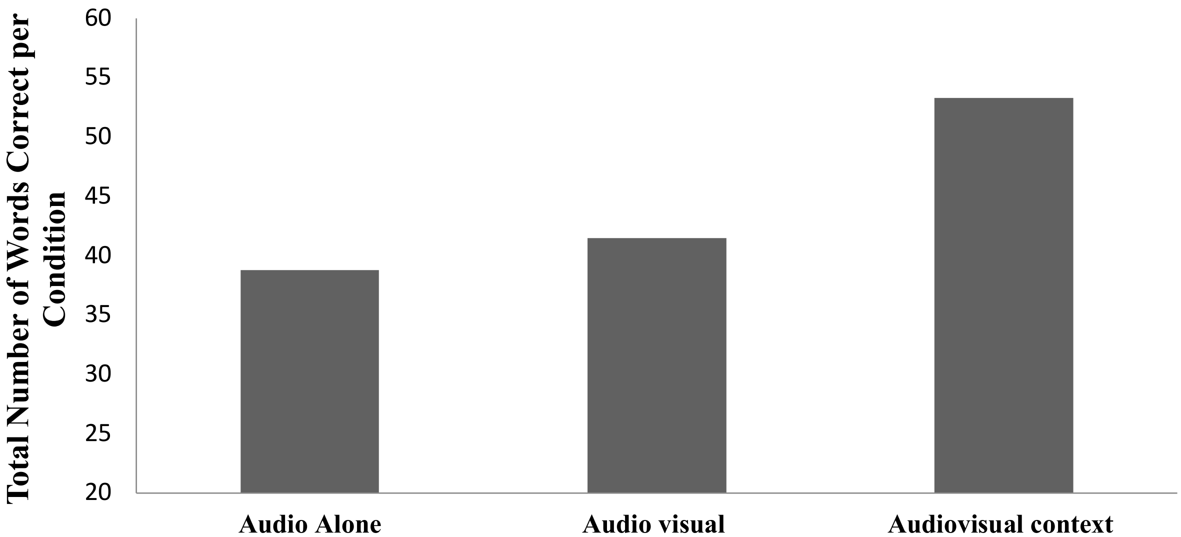

Figure 5. Mean Performance Scores Accross Three Adapted SIN Tasks.

Pairwise comparisons revealed that participants performed better on the audiovisual condition (*M*=41.55, *SE*=.98, *p*=.001, mean difference = -3.47, 95%CI [5.453,-1.488]) than they did in the audio alone condition (*M*=38.08). Similarly, the scores in the audiovisual context condition (*M*=53.29, *SE*=.70, *p*<.001, mean difference= 15.22, 95%CI [13.815, 16.671]) were significantatly higher than the audio alone trials. Further, the results indicated that participants performed better on the audiovisual context tasks than they did on the audiovisual tasks (*p*< .001, *SE*= 1.05, mean difference= 11.75, 95% CI [9.643,13.847]. These findings suggest that participants performed better on the adapted SIN task when the visual stimuli (ie. restaurant or doctor's office) was semantically linked with the auditory stimuli.

To examine the hypothesis that musicianship may positively impact SIN performance, a 2 (musician) x 3 (condition) mixed factorial ANOVA revealed that musicians performed better than non-musicians in all three conditions There was a significant effect of musicianship in all three conditions; F(1,49)=5.95, *p*= .018, $\eta_p{}^2$= .108. However, there was no significant interaction

F(1.60, 83.078)= 1.145, p= 3.16, $\eta_p{}^2$= 0.23, thus further testing was not completed to examine interactions. The descriptive statistics are outlined in table 2 and are graphically displayed in figure 6.

Table 2 *Descriptive Statistics for Musicianship Performance Scores and Non-musician performance scores on three adapted Speech In Noise Tasks.*

Condition Type	*M*	*SD*	*N*
Audio Alone			
Musician	39.43	4.26	28
Non-Musician	36.43	6.61	23
Audiovisual			
Musician	43.89	8.89	28
Non-Musician	38.70	9.03	23
Audiovisual Context			
Musician	54.46	2.82	28
Non-Musician	51.87	5.05	23

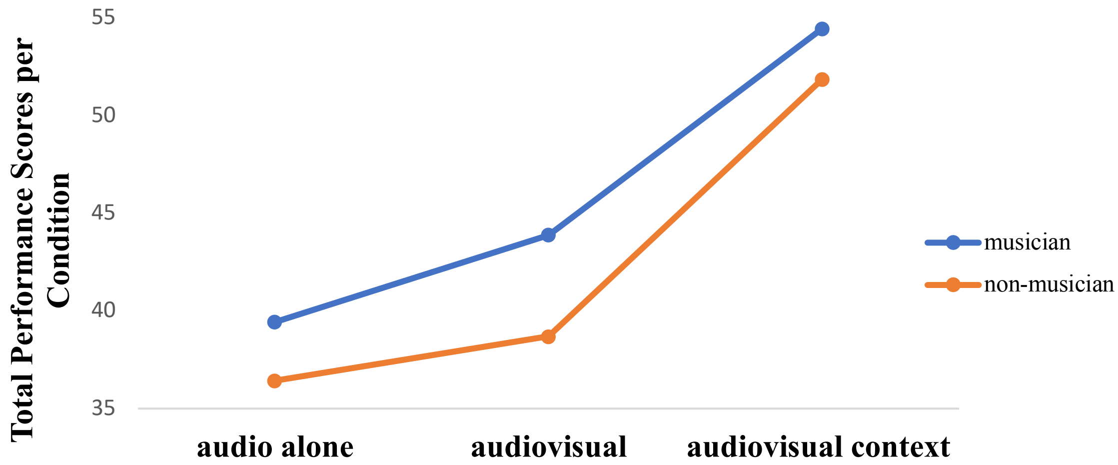

Figure 6. SIN Performance Scores Of Musicians verses Non-Musicians

The results in table 4 and figure 6 reveal that participants who had reported musicianship had significantly higher performance scores in all three conditions when compared to those who did not report musicianship.

To examine performance accuracy within each condition across the six increasing levels of SIN trial difficulty, a 3 (condition) x 6 (trial difficulty) repeated measures ANOVA was completed. As previously noted, there was a significant main effect of condition, F (2, 100) = 157.93, p<.001, $\eta_p{}^2$= .76, and as expected, there was a significant main effect of trial type, F (5, 250) = 235.36, p<.001, $\eta_p{}^2$= .83. Importantly, the analysis revealed a significant interaction between condition and trial difficulty, F (10, 500) = 56.52, p<.001, $\eta_p{}^2$= .53. This is graphically displayed in figure 7.

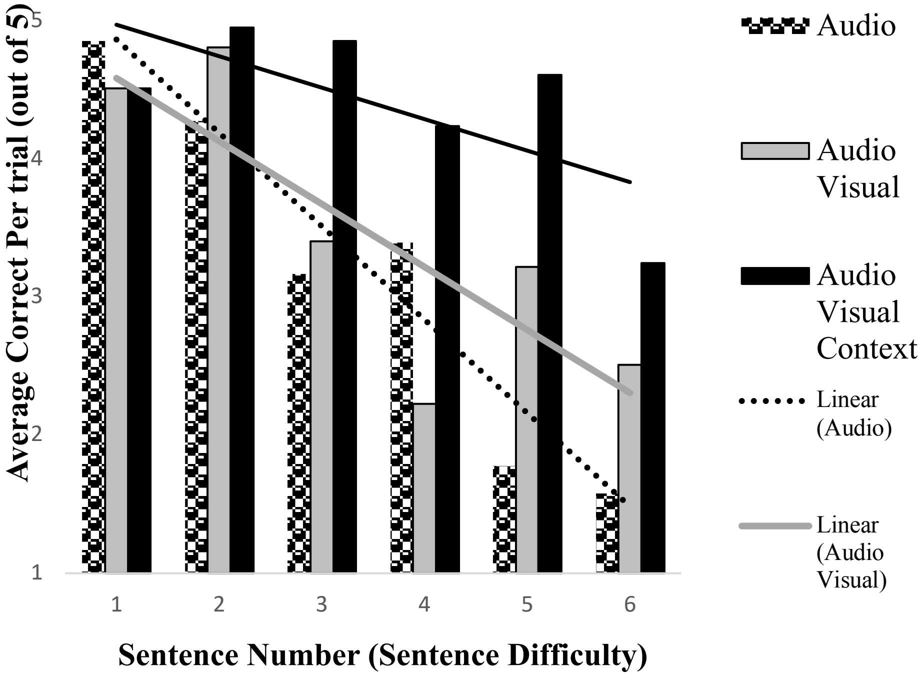

Figure 7. Interaction between Condition Type and Trial in Inital Six Sentence SIN Task

However, upon a re-examination of the stimuli, it became apparent that two videos used (one audiovisual and one audiovisual context) did not function as intended due to a volume discrepancy in the last two sentences. To account for this, we focused on the first four sentences of the first list presented to the participants, in which all of the videos functioned according to the expected parameters.

After removing trials 5 and 6 from the analysis, a 3 (condition) x 4 (trials difficulty) repeated measures ANOVA examined performance accuracy. In line with the previous analysis, significant main effects of condition type F (2, 100) = 99.05, p<.001, $\eta_p{}^2$=.665 and trial difficulty, F (3, 150) =153.08, p<.001, $\eta_p{}^2$=.754 were found. Additionally, a significant interaction between the condition type and trial difficulty was obtained, F (6, 300) = 58.99, p<.001, $\eta_p{}^2$=. 541.Descriptive statistics can be seen in Table 3 and Figure 8 graphically depicts this interaction. Participants had higher performance scores in both audiovisual and audiovisual context conditions than in the audio alone condition. However, scores in the audiovisual context condition were significantly higher suggesting that the context helped preserve speech accuracy even when faced with increasing background babble.

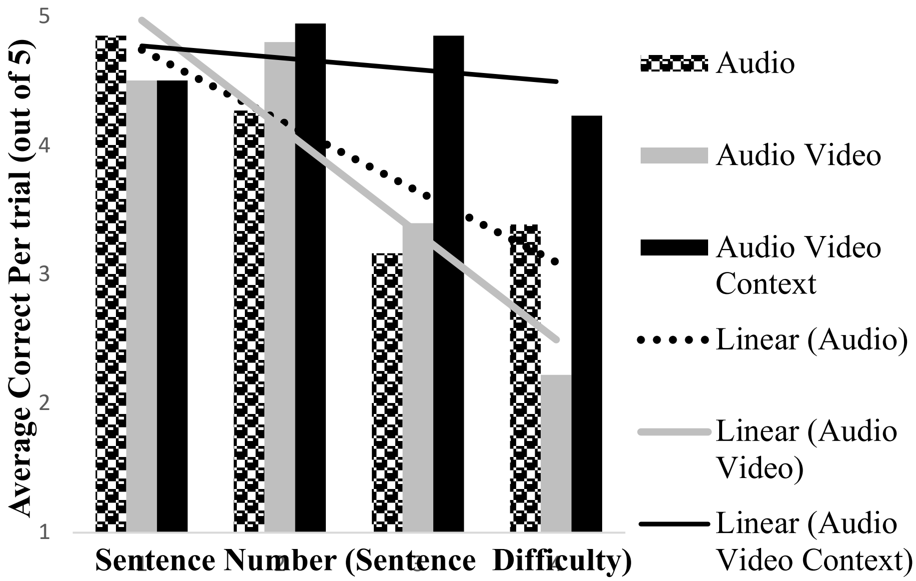

Figure 8. Interaction Between Condition Type and Trial with Sentences Five and Six excluded

As displayed in Table 3, results revealed that there was no significant difference in participants performance accuracy scores in the audio alone condition (*M*=3.922, *SE*=0.06, 95% CI [3.78, 4.05]) and the audiovisual condition (*M*=3.75, *SE*=0.09, 95% CI [3.54, 3.92] *p*=.02, mean difference=0.18, 95% CI [.0.3, .0.34]), suggesting that a visual aid alone does not aid in the perception of speech in background noise. However, there was a significant difference in performance accuracy scores between the audio alone condition and the audiovisual context condition (*M*=4.63, *SE*=.05, 95% CI [4.25, 2.75]), where participants scored higher in the audiovisual context condition than in the audio alone condition (*p*<.001, mean difference, -0.71, 95% CI [-0.82, -0.61]). There was also a significant difference in performance accuracy scores between the audiovisual condition and the audiovisual context condition, where participants scored higher with the audiovisual context stimuli than with the audiovisual stimuli (*p*<.001, mean difference= - 0.90, 95% CI [-1.04, -0.76]).

Table 3 *Descriptive statistics of average performance accuracy scores across all trials*[n]

Condition and Sentence	*M*	*SD*	*N*
Audio Alone			
1	4.85	0.51	51
2	4.27	0.58	51
3	3.16	0.77	51
4	3.39	0.77	51
Audiovisual			
1	4.51	0.61	51
2	4.80	0.33	51
3	3.40	1.07	51
4	2.22	1.40	51
Audiovisual Context			
1	4.50	0.61	51
2	4.95	0.28	51
3	4.85	0.40	51
4	4.23	0.79	51

n= each trail is a sentence within the first list of stimuli per condition.

As seen in Table 4, there was a significant difference in the scores beginning at sentence three, suggesting that the volume level of background babble was high enough to impact the perception of speech. This can also be seen in Table 3 where mean performance scores began to drop in sentence three and four when compared to sentence two.

Table 4 *Pairwise Comparisons of Averaged Sentence Scores for Sentences 1 Through 4 in each SIN Task*

Sentence	1	2	3	4
1				
p		.337	.000*	.000*
MD		-.052	.817	1.34
95% CI		[-.161, .056]	[.675, .959]	[1.15, 1.53]
2				
p	.337		.000*	.000*
MD	-.052		.869	1.39
95% CI.	[-.161, .056]		[.734, 1.01]	[1.21, 1.57]
3				
p	.000*	.000*		.000*
MD	.817	.869		-.523
95% CI	[.675, .959]	[.734, 1.01]		[-.676, -.370]
4				
p	.000*	.000*	.000*	
MD	1.34	1.39	-.523	
95% CI	[1.15, 1.53]	[1.21, 1.57]	[-.676, -.370]	

Discussion

The current study explored the effects of background babble on the perception of spoken sentences in normal hearing young adults. This study explored three main hypotheses, each of which were supported by the findings of this study. Most importantly, this study found that visual talkers aids in the ability to accurately perceive speech in noise. The first hypothesis that participants would have higher accuracy scores on the audiovisual SIN task than the audio alone SIN task, was confirmed by our results. This study found that participants performed better (+3.47 words out of 60 per trial) on the speech in noise task when they were provided with the visual aid of the talker. The results of the current study support a larger body of literature which suggests that visual stimuli can aid in speech perception in noisy environments, for example, a study from Rudner et al., (2016) suggested that a visual aid within a speech free recall task (CSCT) improved the scores for normal hearing young adults (19-35 years of age). However, these benefits were only seen when there was a presentation of steady state noise behind the speech presented (Rudner et al., 2016). Similar findings were seen by Mishra et al., (2013) who found that viewing the talkers face within a (CSCT) speech related task counteracted some of the effects of the background noise presented. These findings along, with the findings of the current study, suggest that visual aids within a speech task aids in higher performances in speech related tasks.

The second hypothesis was also supported as participants performed significantly better on the audiovisual context condition, which suggests that the added semantic and visual context aids in the perception of speech within competing background noise. Using a visual speaker stimulus, a visual context, and sentences with semantic contexts that matched the visual, this study may be the first to manipulate semantic context in a speech-in-noise-task on such a high scale. A previous study by Winn (2016) found that for normal hearing older adults, semantic context within a sentence or list of sentences is helpful in speech intelligibility tasks. Similar results were found by Holmes, Folkeard, Johnstrude and Scollie (2018) who found that those who are hard of hearing are able to identify a higher number of key words when each sentence presented was of the same topic. In fact, Holmes et al., (2018) suggested that the continuation of this semantic context from sentence to sentence aids in the comprehension of speech presented with background babble for those who are hard of hearing. Much like the findings from the current study, these findings suggested that congruent semantic context aids in the perception of speech as well as increasing performance on degraded speech tasks. Not only does semantic context aid in these tasks for normal hearing people, as the current study shows, but these abilities are also beneficial to those in the hard of hearing population. These findings suggest that future research should investigate if a semantically linked SIN task is adequate for testing those in the hard of hearing population. Further, these results suggest that for people listening under non-optimum conditions, a visual aid significantly improves hearing. Previous research has shown this to be true for older adults who are hard of hearing and the current study suggests it is true of normal hearing young adults. If a situation requires a high level of comprehension, a discussion with a physician perhaps, a visual aid would be very helpful, rather than a conversation over the phone. Perhaps future research should explore the use of visual conferencing in different populations and how this may improve the delivery and comprehension of speech on the part of the patient and improve healthcare outcomes.

Lastly, this study found that musicians consistently performed better on the SIN tasks than non-musicians across all three conditions. For those who were musicians, the results showed higher speech accuracy scores than those who are not musicians. In fact, participants who reported musicianship had reported + 4.46 (out of 60 per trial) correct words from the audio alone trial to the audiovisual trial and an average of +10.57 (out of 60) from the audiovisual to audiovisual context, displaying that musicianship is a possible factor in the increase of these scores. Although non-musicians did have an increase in SIN performance scores, this increase was much smaller with an average increase of + 2.27 (out of 60 per trial) from the audio alone to the audiovisual and +13.17 (out of 60 per trial) in the audiovisual context condition. Although non-musicians did see a higher increase in scores within the audiovisual context condition, musicians scores were still higher with an overall average of M=54.46 correct target words out of 60. In other words, participants reported a higher number of correct words within the SIN task when the sentences heard matched the visual environment they were placed in. These findings suggest that although the addition of semantic context is critical in the performance of a SIN task, those who have musical experience seem to have an increased ability to decipher unknown target words from embedded speech within increased background babble.

This study, like many others supports the notion that musicians excel on speech in noise tasks. A study by Parbery-Clark, Skoe, Lam and Kraus (2009), was one of the first of these studies which found that musicians performed better on speech in noise tasks than those who are non-musicians. In fact, higher SIN scores were highly correlated with working memory in musicians, suggesting that working memory resources are critical to the increased SIN abilities for musicians. Along with this, it was found that musicians performed just as well on SIN tasks which included longer and more challenging sentences, suggesting that not only does working memory effect the processing, but a history of musicianship plays a role in the processing and recall of the sentences in the SIN task. Similar findings from Zendel et al., (2015) found that musicians performed better than non-musicians on the most difficult SIN tasks. These current studies results are also supported by Mankel et al., (2018) who found that musicians experience behavioural enhancements in their abilities of SIN tasks, thus suggesting that scores are in fact higher for those with musical training, rather than those of musical sleepers, non-musicians with proficient listening skills. According to Mankel et al., (2018), the neural enhancements to speech processing are linked to musical experience in such a way that individuals with higher musicality scores have stronger neural responses to the timbre and pitch of the presented speech, even if it is imbedded within interfering background babble (Mankel et al., 2018).

The results of the current study assessed the performance scores on three SIN tasks of normal hearing university students, as well as the impact of musicianship on the performance of these tasks. It is important to note that 28 out of the 51 participants were musicians who scored significantly higher than the non-musician sample, these results could have impacted the overall performance scores. Although these scores would not change the significant findings of the study- as there was a significant difference in the scores of the three SIN tasks of the non-musician population- it could potentially make an impact on the steep increase of ability on each condition. Although there would still be a significant difference between the audiovisual SIN task and the audiovisual context condition, this difference may not be as drastic.

Secondly, due to the fact that some of the audio files within this study were later found to be louder in the later sentences, as well as filmed on two separate devices, future research should utilize one singular form of technology to film and record the files as the current study had issues with exact dB readings. Along with this, future research could utilize the use of headphones rather than speakers to examine the effect of a direct hearing source.

Lastly, due to the fact that this sample had normal hearing, these findings may not extend to a hard of hearing population. Although it is evident that the addition of a visual stimuli and semantic context aids in the perception of speech within increased background babble, in order to accurately apply this information, future research should replicate this study within various hard of hearing populations. In doing this, researchers could determine if visual and contextual aids are not only helpful in the perception of speech as previous research as already determined (Winn et al., 2016, Mishra et al., 2013 and Holmes et al., 2018), but if these aids can benefit the applied fields of audiology and other hearing researchers in their hearing assessments.

The current study explored the benefits of using a video talker in SIN tasks as well as how combining visual and semantic context can help combat the negative effects of the increased background babble and therefore aid in speech perception. By using three SIN tasks -audio alone, audiovisual and audiovisual context-the results suggested that there was a benefit of utilizing cross modal perception within these tests to better understand speech perception. Much like previous research, this study showed that participants who have a history of musicianship perform better on speech task and the encoding of speech (Mankel et al., 2018, Patel, 2011). Future research should explore the benefits of music training and SIN tasks on an older adult population to determine if the benefits of musicianship will aid in their perception of speech. Along with this, future research could explore video options of SIN tasks, as often the audio alone versions may not cover all environmental situations a person may encounter. If these findings can be replicated within a hard of hearing population- suggesting that individuals with hearing loss see improvements in their speech perception when there are visual and contextual aids- other technologies and tests can be developed, helping those in the hard of hearing community adapt to their changing world.

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Appendix A

Informed Consent Form

The purpose of this Informed Consent Form is to ensure you understand the nature of this study as well as your involvement in it. This consent form will provide information about the study, giving you the opportunity to decide if you would like to participate.

Researchers: This study is conducted by Gillian Ash as part of the requirements for the Honours Project in Psychology (Psychology 4959). This study is under the supervision by Dr. Peter Stewart.

Purpose: This study is designed to investigate whether the level of background noise and contextual cues have an effect on auditory perception and performance levels in a variety of speech- in-noise tasks. This study may also investigate eye tracking patterns in speech tasks.

Task Requirements: You will be asked to complete a number of Speech-in-Noise Tasks. This involves listening and remembering spoken sentences. While completing the Speech-in-Noise Tasks, your eye movements may be tracked. Only the movements of your eyes are recorded and not images of you or your face. You may decide to discontinue this study at any point.

Duration: This in lab study will take approximately 1 hour complete.

Risks and Benefits: This study will take place within a sound proof room. If you feel anxious about being in smaller spaces, you can choose to either complete the study with the door open or choose to not participate. If you are a psychology student here at Grenfell Campus, you may receive course credit for your participation (1%) as specified by your instructor. There are no other obvious risks or benefits involved with your participation in this study.

Anonymity: Please do not put any identifying information on the in-study questionnaire. All responses will be analyzed and reported on a group basis. Thus, individual responses cannot be identified by the researchers. All participant information will be kept on a password protected computer or locked in a locked cabinet (AS 335).

Right to Withdraw: Your participation in this in lab study is completely voluntary and you are free to withdrawal at any time.

Contact Information: If you have any questions or concerns about the study, please feel free to contact Gillian Ash at gmash@grenfell.mun.ca or Dr. Peter Stewart at pstewart@grenfell.mun.ca

If you have ethical concerns about the research such as the way you have been treated or your rights as a participant, you may contact the Chairperson of the GC-REB at gcethics@grenfell.mun.ca. This study has been approved by an ethics review process in the psychology program at Grenfell Campus, Memorial University of Newfoundland and has been found to be in compliance with Memorial University's ethics policy.

By completing this study, I acknowledge that I am at least 19 years old or a college/university student and I have been informed of, and understand, the nature and purpose of the study, and I freely consent to participate.

Signed____

Date____

Appendix B

Do your eyes help you hear?

WILL YOUR EYES HELP YOU LISTEN WHEN YOU CAN'T HEAR SOMEONE TALK?

BACKGROUND BABBLE AND SEMANTIC CONTEXT IN AUDITORY PERCEPTION.

For more information, or if you would like to participate in this study, please contact Gillian Ash at gmash@grenfell.mun.ca.

Requirements: Must be between 18-25 years of age and a student of Grenfell Campus of Memorial University.

Appendix C

Participant Number: _____
Order: A (1,2,3)
Order: B (2,3,1)
Order: C (3,2,1)

Grade Form

Practice A

1. The lake sparkled in the red hot sun
   Score: (babble: 25%)____________

2. Tend the sheep while the dog wanders
   Score: (babble: 50%)____________

3. Take two shares as a fair profit
   Score: (babble: 100%) __________

4. North winds bring colds and fevers
   Score: (babble: 126%)___________

5. A sash of gold silk will trim her dress
   Score: (babble: 158%) ___________

6. Fake stones shine but cost little
   Score: (babble: 200%) ____________

   Total: __________

Practice B

1. Wake and rise and step into the green outdoors
   Score: (babble: 25%)____________

2. Next Sunday is the twelfth of the month
   Score: (babble: 50%)____________

3. Every word and phrase he speaks is true
   Score: (babble: 100%) __________

4. Help the weak to preserve their strength
   Score: (babble: 126%)___________

5. Get the trust fund to the bank early
   Score: (babble: 158%) ___________

6. A six comes up more often than a ten
   Score: (babble:200%) ____________

   Total: ___________

Condition 1

List 1

1. To have is better than to wait and hope
   Score: (babble: 25%)____________

2. The screen before the fire kept in the sparks
   Score: (babble: 50%)____________

3. Thick glasses helped him read the print
   Score: (babble: 100%) __________

4. The chair looked strong but had no bottom
   Score: (babble: 126%)___________

5. They told wild tales to frighten him
   Score: (babble: 158%) ___________

6. A force equal to that would move the earth
   Score: (babble:200%) ____________

   Total: __________

List 2

1. Take shelter in this tent, but keep still
   Score: (babble: 25%)____________

2. The little tales they tell are false
   Score: (babble: 50%)____________

3. Press the pedal with your left foot
   Score: (babble: 100%) __________

4. The black trunk fell from the landing
   Score: (babble: 126%)___________

5. Cheap clothes are flashy but don't last
   Score: (babble: 158%) ___________

6. At night the alarm roused him from a deep sleep
   Score: (babble: 200%) ____________

   Total:_____________

Condition 2

List 1

1. Dots of light betrayed the black cat
   Score: (babble: 25%)____________

2. Put the chart on the mantel and tack it down
   Score: (babble: 50%)____________

3. The steady drip is worse than a drenching rain
   Score: (babble: 100%) __________

4. A flat pack takes less luggage space
   Score: (babble: 126%)___________

5. The gloss on top made it unfit to read

Score: (babble: 158%) ___________

6. Seven seals were stamped on great sheets
   Score: (babble: 200%) ____________

   Total:______________

List 2

1. The leaf drifts along with a slow spin
   Score: (babble: 25%)____________

2. The pencil was cut to be sharp at both ends
   Score: (babble: 50%)____________

3. Down that road is the way to the grain farmer
   Score: (babble: 100%) __________

4. The best method is to fix it in place with clips
   Score: (babble: 126%)___________

5. If you mumble your speech will be lost
   Score: (babble: 158%) ___________

6. A toad and a frog are hard to tell apart
   Score: (babble: 200%) ____________

   Total:__________

Condition 3

List 1

1. Welcome to the Doctors office take a seat.

   Score: (babble: 25%) ____________

2. Make sure you have an Insurance Card for the Doctor.

   Score: (babble: 50%)___________

3. Please provide the Doctor with a list of your medications.

Score: (babble: 100%) _____________

4. <u>When</u> you are <u>finished</u>, <u>please</u> make your <u>next</u> <u>appointment.</u>

   Score: (babble: 126%) _____________

5. <u>Your appointment</u> will be <u>on</u> the <u>18th</u> of <u>February.</u>

   Score: (babble: 158%)___________

6. <u>When</u> you <u>arrive</u> for your <u>appointment</u>, <u>notify</u> the <u>secretary</u>.

   Score: (babble: 200%)___________

   Total:______________

List 2

1. Take a <u>seat</u> at <u>either</u> a <u>booth</u> or a <u>table</u> for <u>four</u>.

   Score: (babble: 25%)___________

2. Make <u>sure</u> to <u>order extra</u> <u>water</u> for the <u>table</u>.

   Score: (babble: 50%)___________

3. <u>After</u> you <u>order</u> you are <u>welcome</u> to ask for <u>more bread</u>.

   Score: (babble: 100%) __________

4. <u>When</u> you <u>finish</u> the <u>meal</u> <u>please</u> order <u>cheesecake.</u>

   Score: (babble: 126%)____________

5. Do not <u>forget</u> the take <u>home boxes</u> with your <u>left-over</u> <u>food</u>.

   Score: (babble: 158%)_____________

6. <u>Please</u> <u>pay</u> for your <u>meal</u> with either <u>cash</u> or <u>debit</u>.

   Score: (babble: 200%)____________

   Total:_________

Appendix D

Demographic Form

Please fill out the following demographic information. All information on this form will be used for demographic purposes. Please do not place any identifying information on this form as all participant identities are anonymous.

1. Age: ________

2. I have normal or corrected to normal hearing

   Yes: __________
   No: ___________

3. Place an (X) for the Gender you identify as:

   Male: _______
   Female: _______
   Another Gender
   (Feel free to specify) ________________________

4. Please rate your ability to understand spoken English on a scale of 1-10 (1 being "Completely Unable to Comprehend" and 10 being "Completely able to Comprehend")

   1 2 3 4 5 6 7 8 9 10

5. Do you play a musical instrument?

   YES NO

   If yes, please answer the following questions:

   a) How many years have you been playing a musical instrument (if more than one instrument, please list the longest amount of time) ________________

   b) What is the primary instrument you play? ____________

   c) Are you a formally trained musician (private lessons and/or more than 5 years of Jr high and high school music training) or a self-taught musician?

   Formally trained: ______ Self-taught: _____

   d) How many hours do you currently spend per week practicing/ playing your instrument? _______

Thank you for participating in this study!