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Asymmetrical speech in noise assessment for children with (Central) Auditory Processing Disorders

Jessica Vaughn

ASYMMETRICAL SPEECH IN NOISE ASSESSMENT FOR CHILDREN WITH (CENTRAL) AUDITORY PROCESSING DISORDERS

by

Jessica Vaughn, B.A.

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Abstract

The primary purpose of this investigation was to determine if children with (Central) Auditory Processing Disorder have better word recognition abilities for monosyllabic words under monaural speech-in-noise conditions than binaural speech-in-noise conditions. Fifteen participants, five females and ten males, ages 8-10 years, were included in this study. There were 7 children placed in the experimental group with a diagnosis of (C) APD identified from the Louisiana Tech University Speech and Hearing Center. There were 8 typically developing children placed in the control group. Each participant had pure-tone thresholds of 0-20 dB HL for 250-8000 Hz bilaterally. The SCAN-3 for children, the SSW, and the SAAT tests were used to confirm or deny the presence of an auditory processing disorder. Each participant received fifteen word lists in all three test conditions (right, left, and binaural) and all SNRs (+8 dB, +6 dB, +4 dB, +2 dB, and 0 dB) in each test condition. It was hypothesized that children with (C) APD would have better word recognition abilities for monosyllabic words under monaural speech-in-noise conditions than binaural speech-in-noise conditions. It was also hypothesized that children with normal auditory processing abilities would perform significantly better in all conditions compared to (C) APD children. The results revealed that the mean percentage correct was higher for the control group at each SNR (+8 dB, +6 dB, +4 dB, +2 dB, and 0 dB) in each condition (right, left, and binaural). Overall, the control and experimental groups did best in the binaural condition at all SNRs; however, the control group performed significantly better than the experimental group in all

conditions. The control and experimental groups did better in the right monaural condition than the left monaural condition at all SNRs. The control group performed better in the right monaural condition than the experimental group in the binaural condition at all SNRs.

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CHAPTER I

Introduction

According to the American Speech Language Hearing Association's (ASHA; 2005) technical report, (Central) Auditory Processing Disorder includes difficulties such as auditory discrimination, temporal ordering, localization and lateralization, auditory pattern recognition, temporal masking, temporal discrimination, or auditory performance with degraded acoustic signals. Chermak, Somers, and Seikel (1998) surveyed audiologists and found that difficulty hearing in background noise was the most frequently reported symptom of (C) APD. Individuals diagnosed with (C) APD typically have normal hearing acuity; however, some still have trouble understanding speech in less than favorable conditions (Keith, 1999). Common characteristics also associated with (C) APD include difficulty following oral instructions, poor listening skills, academic difficulties, and poor auditory association skills (Chermak et al., 1998). According to ASHA (2005), (C) APD is due to a problem with the processing of auditory stimuli and cannot be the result of higher order cognitive or language issues. Keith (1999) stated that potential patients for (C) APD testing often demonstrate similar behaviors such as normal hearing thresholds, problems with auditory discrimination, problems understanding speech in background noise, poor listening skills, an inability to follow auditory instructions, difficulty with the manipulation of phonemes, an inability to understand dialects or rapid speech, and requests that speech be repeated often. These individuals may also have handwriting, reading, and spelling problems or language and articulation disorders (Keith, 1999). It is often recommended that children with (C) APD use a personal FM system in the classroom to improve their speech in noise performance (Bellis, 2002); however, there is a lack of research involving speech in noise performance of children diagnosed with (C) APD and the benefit of this type of device on their overall performance. Research has been done with speech in noise performance for patients with auditory lesions (Olsen, Noffsinger & Kurdziel, 1975), hearing loss (Stuart & Phillips, 1996), and normal hearing (Danhauer & Leppler, 1979); however, additional research is needed to determine if children with (C) APD have better word recognition abilities under monaural or binaural speech in noise conditions. Therefore, the primary purpose of this investigation is to determine if children with (C) APD have better word recognition abilities for monosyllabic words under monaural speech in noise conditions compared to binaural speech in noise conditions. It is hypothesized that children with (C) APD will have better word recognition abilities for monosyllabic words under monaural speech in noise conditions than binaural speech in noise conditions. Furthermore, some children with (C) APD exhibit significant left ear deficits possibly as a result of an immature auditory system. Therefore, if children with (C) APD have better word recognition abilities in the monaural condition, their speech in noise performance in the classroom could be improved without the use of amplification by simply eliminating the contribution of one ear (i.e., the "weaker ear"). It is also hypothesized that children with normal auditory processing abilities will perform significantly better in all conditions compared to children in the (C) APD group.

CHAPTER II

Review of Literature

In noisy environments, understanding speech can be difficult for listeners with normal hearing and normal auditory processing skills. For individuals diagnosed with (C) APD, trouble understanding speech in less than favorable conditions can be even more difficult (Keith, 1999). Chermak et al. (1998) found that difficulty hearing in background noise was the most frequently observed behavior of individuals with (C) APD. Because of this difficulty, speech testing in the presence of background noise is an important component of a (C) APD test battery. The type of background noise used in (C) APD testing often includes stimuli with either energetic or informational masking. According to Brungart (2005), an energetic masker is a signal which contains energy in the same critical bands at the same time and portion of the speech signal. Brungart (2005) defines informational masking as occurring when the speech signal and the masker are both audible speech; however, the listener may have difficulty separating the target speech from the masker.

Speech in Noise Studies with Normal Listeners

To understand the impact of background noise in the disordered population, insight must first be gained from how informational and energetic masking affects normal hearing listeners. Danhauer and Leppler (1979) investigated the effects of different background noise competitors on performance of normal hearing subjects using the California Consonant Test (CCT). The subjects were 35 normal hearing listeners ranging from 19 to 23 years of age. All subjects had normal hearing as determined by pure-tone thresholds of 15 dBHL or better from 250 to 8000 Hz. The subjects were presented with the CCT list 1 in the presence of one of four noise competitors at varying signal-to-noise ratios (SNR). The four noise competitors included the following: white noise, cocktail party noise, multi-talker noise, and four-talker noise. Each subject was presented with the CCT and background noise monaurally directed to the right ear. Variable SNR were used for each of the four noise competitors. For white noise, SNRs of -3, 0, +10, +15, +20, +25, and +30 dB were used. For cocktail party noise, SNRs of -3, 0, +5, +10, +20, +25, and +30 dB were used. For multi-talker noise, SNRs of 0, +5, +10, +15, +20, +30, and +40 dB were used. For four-talker noise, SNRs of 0, +5, +10, +15, +20, +25, and +30 dB were used. The subjects were separated into seven groups of five listeners each. The subjects in each group heard the CCT stimuli in all four background noise conditions, but only at one SNR. The CCT stimuli was presented in all conditions at 45 dB Sensation Level (SL), while the noise was varied according to each condition.

The researchers found that white noise, cocktail party noise, multi-talker noise, and four-talker noise had similar effects on the CCT results of normal-hearing listeners at +10 to +30 dB SNRs. However, at SNRs of 0 and +5 dB, the four-talker noise and multi-talker noise were found to be more difficult than the cocktail party noise and white noise. The researchers concluded that the CCT may be complex enough to evaluate speech discrimination without the presence of a competing signal. This also indicates that if a competing signal is present, the type will have little effect on the results for most of the SNRs.

Sperry, Wiley, and Chial (1997) also studied the effects of background noise on word recognition abilities of normal hearing listeners. The purpose of this study was to compare the effects of three types of background competing noise on word recognition abilities. In this study, the background noise conditions included a meaningful speech competitor, an amplitude-modulated competitor, and a non-meaningful speech competitor. The meaningful speech competitor consisted of three women and three men talking at the same time about different subjects. The amplitude-modulated competitor had the same long-term average speech spectrum and amplitude as the multitalker competitor. The non-meaningful speech competitor consisted of a digitally reversed version of the multitalker competing message which had the same spectral and temporal characteristics but lacked meaningful information. The subjects were 11 women and 7 men between 18 and 30 years of age. All subjects had normal hearing as indicated by pure-tone thresholds of 10 dB HL or better from 500 to 4000 Hz, tympanometry within normal limits, and present ipsilateral acoustic reflexes for 1000 Hz at 95 dB HL. The subject's better ear was selected for testing during the study based on pure-tone average (PTA). Testing was completed for each subject during a 1.5 hour test session and breaks were given as needed. Each subject was presented with a practice test at 40 dB SL, which consisted of 7 words in quiet and 7 words in the presence of each background noise condition at +8 dB SNR. Next, each subject was presented Northwestern University Auditory Test No. 6 (NU-6) word lists at 40 dB SL in the presence of each of the three background noise conditions at varying SNRs. The SNRs used for the three background noise conditions were -8, -4, 0, +4, and +8 dB for 15 total test conditions. The SNRs and presentation order of the NU-6 word lists were varied among subjects.

For all conditions, the subjects were asked to write their responses instead of repeating them to eliminate experimenter bias. At the end of each test session, each subject was presented with a NU-6 word list at 40 dB SL in quiet. The researchers found that the meaningful multitalker competing message had the greatest impact on word recognition. The amplitude-modulated competitor had the least significant effect on word recognition performance.

Wightman and Kistler (2005) studied the effects of ipsilateral and contralateral distracters of informational masking of speech in children. The subjects included 38 children ranging from 4 to 16 years of age and eight adults ranging from 20 to 30 years of age. The children were grouped by age: 4.6-5.7 years; 6.6-8.5 years; 9.6-11.5 years; 11.6-13.5 years; and 13-16 years. All subjects were found to have normal hearing sensitivity as indicated by pure-tone thresholds of 20 dB HL or better. The subjects were presented with a monaural stimuli and an ipsilateral distracter message at the same time. In other conditions, an additional distracter message was presented to the contralateral ear. The target stimuli presented a call sign, color, and number that the listener had to use a mouse to click on a computer screen. Three distracter conditions were included in this study, with all conditions including a target stimuli and distracter stimuli presented to the right ear. First, the monaural condition presented no distracter message to the contralateral ear. The second condition presented noise that had a speech-shape to the contralateral ear. The third condition presented speech stimuli to the contralateral ear. Each condition was presented with both male and female talkers. The researchers found that children performed worse in the presence of informational masking than adults. The addition of a distracter message in the contralateral ear resulted in reduced performance, especially when the distracter message was of the same sex as the target message.

Johnstone and Litovsky (2006) studied the effects of masker type and age on speech intelligibility and spatial release from masking in children and adults. The subjects included 20 children ranging from 5 to 7 years of age and 20 adults ranging from 18 to 42 years of age. All subjects were found to have normal hearing sensitivity as indicated by pure-tone thresholds of 20 dB HL or better from 250 to 8000 Hz. Each subject was presented with two-syllable spondees spoken by a male voice (i.e., target stimuli). Interfering stimuli included modulated white noise, forward speech of a female speaker with little high frequency energy, reversed speech of a female speaker, and forward speech of a female speaker with a great amount of high frequency energy. Each subject was instructed to ignore the interfering stimuli and pay attention to the male speaker. The target stimuli was presented in three conditions: quiet, the target and interfering stimuli from the front speaker, and the target stimuli from the front speaker and the interfering stimuli from the right speaker at 90 degrees. Subjects in the child group were asked to select a picture matching the target stimuli from a group of four pictures. Subjects in the adult group were asked to select the word matching the target stimuli from a list of 25 words. A speech reception threshold (SRT) was estimated for each subject in each listening condition.

The authors found that children had greater decreased speech intelligibility than adults in the presence of interfering stimuli. Children generally experienced greater masking and had higher SRTs than adults in each condition. For adults, the modulated white noise condition resulted in the greatest masking compared to any other condition.

Adults were able to identify and understand the target stimuli even when an interfering stimulus was present. Children experienced the greatest masking for the time-reversed speech condition. Overall, children experienced decreased speech intelligibility and greater masking in the presence of interfering stimuli compared to adults.

Speech in Noise Studies with Disorders of the Auditory System

In addition to speech in noise studies with normal hearing listeners, research has also been completed with patients with auditory lesions. Olsen, et al. (1975) studied the effects of white noise on the speech discrimination abilities of patients with peripheral and central lesions. Subjects included a group of 75 patients with normal hearing and no peripheral or central lesions. The other groups included patients diagnosed with hearing loss due to Meniere's disease, noise trauma, Multiple Sclerosis, 8^{th} nerve tumors, and temporal lobe lesions. Air and bone conduction thresholds, speech reception threshold, and speech discrimination testing were completed for each subject. The 75 normal hearing subjects were tested in order to supply normative data for the study and all had hearing thresholds of 25 dB HL or better from 125 to 8000 Hz and speech discrimination scores of 90% at 40 dB SL in quiet. Twenty five subjects had a history of noise induced trauma with pure-tone averages and speech reception thresholds within normal limits, but had a high frequency notch at 3000, 4000, or 6000 Hz. At 40 dB HL in quiet, speech discrimination scores were 90% or better for all subjects in the noise induced trauma group. Twenty-five subjects had a diagnosis of Meniere's disease and had hearing thresholds that varied from 27 to 62 dB HL for this group. Speech discrimination scores in quiet varied from 60 to 100%. Twenty-one subjects with unilateral 8^{th} nerve tumors were included in the study where hearing acuity varied from normal to mild and speech discrimination ranged from 56 to 100% in quiet. Twenty-one subjects had a diagnosis of Multiple Sclerosis and had hearing thresholds of 25 dB HL or better from 125 to 8000 Hz, a speech reception threshold of 25 dB HL or better, and speech discrimination of 90% or better. Twenty-four subjects had temporal-lobe lesions: 11 with partial temporal lobectomies, 3 had with hemispherectomies, 10 with cerebrovascular accidents. The ears opposite the damaged hemisphere were used in this study. This group was found to have normal speech reception thresholds and word recognition scores of 84 to 100%. NU-6 words were presented to all subjects at 40 dB SL in quiet and then in white noise with a 0 dB SNR. Sixty percent of the normal hearing group was found to have scores from 20 to 28% poorer in noise than in quiet. A difference of 40% or more from quiet-to-noise was determined to be abnormal for this study. A difference of 40% or more was found for 8% of the noise trauma subjects, 48% of the Meniere's disease subjects, 62% of the 8^{th} nerve tumor subjects, 14% of the Multiple Sclerosis subjects, and 42% of the temporal lobe damage subjects. Overall, the researchers found that even in the presence of hearing thresholds within normal limits, lesions could be identified within the auditory system. Speech in the presence of energetic noise testing could be used to determine the presence of an abnormality, although it could not localize it.

Speech in Noise Studies with Hearing Impaired Listeners

In addition to speech in noise studies with normal hearing listeners and patients with auditory lesions, research has also been performed with patients with peripheral hearing loss. Stuart and Phillips (1996) studied the effects of continuous and interrupted noise on word recognition performance of normal hearing young adults, normal hearing older adults, and hearing impaired older adults. The subjects were divided into three groups based on age and hearing acuity. The first group included 12 normal hearing adults with a mean age of 24.9 years. The second group included 12 normal hearing adults with a mean age of 61 years. The third group included 12 hearing impaired adults with a mean age of 62.8 years. The normal hearing subjects were found to have normal hearing sensitivity as indicated by pure-tone thresholds of 25 dB HL or better from 250 to 4000 Hz. The hearing impaired subjects were found to have high frequency sensorineural hearing loss as indicated by pure-tone thresholds of 25 dB HL or better from 250 to 1000 Hz and thresholds of 35, 60, and 60 dB HL or better from 2000 to 4000 Hz. All participants had a negative history of neurological disorders, otological disease, head trauma, or noise exposure. Therefore, it was assumed the hearing loss of the hearing impaired subjects was due to presbyacusis, (i.e., hearing loss due to the aging process). Each subject was presented with 50 identical monosyllabic words from NU-6 lists 1 through 4 at 30 dB SL in quiet, continuous noise, and interrupted background noise. The SNRs used were +10, +5, 0, -5, -10, -15, and -20 dB and were varied across subjects. All stimuli and competing noise was presented to each subject's right ear.

The researchers found that for all groups, performance was greatest in the quiet condition followed by the interrupted background noise. There were considerable differences between the groups for the three listening conditions. In quiet, both normal hearing groups had better word recognition performance than the hearing impaired group. All groups performed better in the interrupted noise condition than the continuous noise condition. This was presumed to be the result of an anticipated release of masking compared to the continuous noise. The two older groups of subjects had reduced performance in interrupted noise than the younger group, which was thought to be the result of a temporal processing deficit due to aging.

Wilson, Abrams, and Pillion (2003) studied word recognition abilities of listeners with normal hearing and with sensorineural hearing loss in quiet and in multitalker babble. The subjects were 24 normal hearing listeners (M = 21.1 years of age) and 24 listeners with a sensorineural hearing loss (M = 58.5 years of age). The normal hearing subjects were found to have normal hearing sensitivity as indicated by pure-tone testing. The subjects with a sensorineural hearing loss had symmetrical mild to moderate pure-tone thresholds, word recognition scores of 76% or better at 50 dB HL in quiet, and present ipsilateral acoustic reflexes from 500-2000 Hz. Each subject was presented NU 6 list 1 and 2 at 60 and 80 dB HL in quiet. This was counterbalanced with list 1 presented at 80 dB HL and list 2 presented at 60 dB HL for half of the subjects; and list 1 presented at 60 dB HL and list 2 presented at 80 dB HL for the other half of the subjects. Each subject was then presented two trials of words with multitalker background noise. For both trials, the multitalker babble was presented at 60 dB HL and the signal was presented at different levels varying from 60 dB to 84 dB HL.

Both groups of subjects had comparable word recognition abilities at 60 dB and 80 dB HL in quiet. In multitalker babble, the subjects with hearing loss needed an average of 5.5 dB higher signal-to-babble ratio to perform as well as normal hearing subjects. The researchers concluded that listeners with hearing loss often have more difficulty in the presence of background noise than normal hearing listeners.

Speech in Noise Studies with (C) APD Listeners

According to ASHA's (2005) technical report, (C) APD includes difficulties such as auditory discrimination, temporal ordering, localization and lateralization, auditory pattern recognition, temporal masking, temporal discrimination, or auditory performance with degraded acoustic signals. In addition this document states that (C) APD is due to a problem with the processing of auditory stimuli and cannot be the result of higher order cognitive or language issues. For children diagnosed with (C) APD, the classroom can be one of the most difficult environments for speech understanding. Smoski, Brunt, and Tannahill (1992) studied the listening characteristics of children diagnosed with (C) APD by collecting information from teachers. The subjects were 64 children diagnosed with (C) APD; 48 of the children were male and 16 were female, ranging in age from 7 years, 1 month to 11 years, 8 months. Each child had normal hearing sensitivity as indicated by pure-tone testing, tympanometry, acoustic reflexes, and word recognition scores of 90% or better at 40 dB SL. In addition, each child involved in the study had failed two or more of the (C) APD tests used in the study (i.e., The Staggered Spondaic Word test [SSW], the Dichotic Digit test, the Competing Sentence test, Pitch Pattern Sequence test).

The Children's Auditory Processing Performance Scale (CHAPPS) (Smoski, Brunt, &Tannahill, 1992) was used to collect information about the subjects' listening behavior from their teachers. The teachers were instructed to rate the level of difficulty that each child exhibited in comparison to other children in each listening condition. The ratings ranged from least difficult (+1) to cannot function at all (-5) for each listening environment. Social, behavioral, and educational information was also completed by the teachers by means of an Educator's Case History form (Smoski, Brunt, &Tannahill,

1992). The CHAPPS and the Educator's Case History form was completed by each teacher one or two weeks before the (C) APD testing. Each subject received a complete audiological evaluation during one two hour test session, and the (C) APD evaluation was completed during a subsequent two hour test session.

The researchers concluded that the listening performance of children diagnosed with (C) APD differed among listening conditions (e.g., quiet and multiple inputs) and showed difficulty in more than one listening environment. The researchers also found that children diagnosed with (C) APD varied greatly in academic performance with some children failing several academic areas and others performing at grade level. For half of the subjects involved in this study, reading was an academic area in which they were having the greatest difficulties. The social and behavioral information collected revealed children diagnosed with (C) APD were judged by their teachers to have similar social and behavioral skills when compared to children of the same age and background without (C) APD.

Elliott, Bhagat, and Lynn (2006) studied the ability of children diagnosed with (C) APD to sequentially recall digits in the presence of irrelevant sounds (i.e., tones and spoken words). The subjects consisted of 11 children diagnosed with (C) APD and 22 children without (C) APD. All of the subjects were 11 years of age and had normal hearing sensitivity as indicated by pure-tone testing and speech reception thresholds at 10 dB HL bilaterally. Each subject had to complete two tasks of recalling digits in the presence of background noise. In each task, lists of digits from 1 to 9 (except 7) were randomly put on a computer screen and the subject was asked to type their response on a keyboard. For the first task, each subject completed a practice trial with the experimenter and then completed three trials without the help of the experimenter. Next, four trials were presented with each list adding additional digits until the subject failed to respond to two of the four trials accurately. The longest list length with two trials answered accurately was used as the participant's memory span to be used in the next task. The subject's length of memory span varied from three to nine items. For the second task, the subject's memory span length was entered into the database and determined the length of the list of digits (memory span length=x, x=length of list). Each subject was asked to focus on the numbers on the screen and to type their response, disregarding the background noise. The background noise used was irrelevant tones for some trials and spoken words for others. Each subject completed a practice trial in quiet and then completed a total of 33 trials randomly presented with tones or speech as the background noise. The background noise ranged from 62-68 dB (A) in intensity as measured by a Quest sound-level meter and EC-9A Earphone Coupler (6cc) and were all judged subjectively to be of equal intensity.

Children in both the (C) APD and the control groups had decreased recall of digits in the presence of the irrelevant background noise. Children in the control group were disrupted more by speech than tones. Children diagnosed with (C) APD were disrupted by speech and tones to the same degree. Elliot et. al (2006) suggested that children diagnosed with (C) APD may process speech and tones in the same way and that these children may not be able to separate a target speech signal from speech or non-speech background noise. This provides further information that children diagnosed with (C) APD process speech differently and are not able to separate speech from other sounds as their normally developing peers do, making it difficult to process speech in multiple input environments.

It is often recommended that children with (C) APD use a personal FM system in the classroom to improve their speech in noise performance (Bellis, 2002). In an article by Rosenberg (2002), support was provided for the use of an FM system for children with (C) APD. According to Rosenberg (2002), a personal FM system may possibly be recommended as a portion of the management strategy of (C) APD. According to Rosenberg (2002), (C) APD management includes the listening environment, compensatory strategies, and direct therapy. To modify the listening environment, Rosenberg suggests that a personal FM system would help children with (C) APD who have difficulty understanding speech in background noise. A personal FM system could be used along with direct therapy and compensatory strategies. Rosenberg (2002) suggests a trial period of at least six weeks to determine if the management strategy and the use of the FM system is effective.

Frequency-modulated (FM) systems are often recommended for children with (C) APD (Bellis, 2002); however, more portable options of amplification to improve SNR have not been studied. Kuk, Jackson, Keenan, and Lau (2008) studied the benefits of personal amplification on performance and daily tasks of children diagnosed with (C) APD. In this study, bilateral behind-the-ear hearing aids were used instead of FM systems for children diagnosed with (C) APD. The subjects were 14 normal hearing children diagnosed with (C) APD between 7 and 11 years of age. Each subject was fit with bilateral, behind-the-ear, wide dynamic range compression, open-fit hearing aids. The gain of the hearing aids was set to provide 10 dB of insertion gain for conversational speech. Noise reduction and directional microphones were programmed to the hearing aids. The subjects were asked to wear the hearing aids in all of their daily environments as much as possible. Each subject was seen for a hearing aid fitting, a two week follow up, a three month follow up, and a six month follow up. The participants were tested during the follow up visits with the NU-6 word list and the Auditory Continuous Performance Test (ACPT; Keith, 1994) in noise. For the NU-6 word list, the word list was presented at 68 dB SPL. The noise level was modified for each participant during the initial visit so that their word recognition score was between 20% and 60%. Once the word recognition score was beyond the range of 20% to 60%, the noise was adjusted in 5 dB steps until the participant's word recognition score was within this range. This individual SNR was used for testing word recognition during the follow up visits to estimate a noise level where ceiling and floor effects could be avoided. For three participants, a SNR of -10 dB (noise at 78 dB SPL) was used, for nine participants, a SNR of – 5 dB (noise at 73 dB SPL) was used, and for two participants, and SNR of 0 dB (noise at 68 dB SPL) was used. The ACPT was used to assess auditory attention ability. For the ACPT, speech was presented at 46 dB HL and noise was presented at 53 dB HL. The CHAPPS (Smoski et al, 1998) questionnaire was used before and following the study to quantify listening behaviors of the children in six listening categories. For each listening category, the performance of each participant was compared by their parents and teachers to the difficulty reported by children of the same age and background. At the end of the study, each participant was asked five questions to assess their opinion of the amplification system. The five questions included: "Do you like to wear your aids, or does your mom make you?" "Do you wear your hearing aid on program 1 or 2?" "Do you wear your aids at school/home?" "When you wore your aids, did you hear your teacher 'the same', 'a little better', or 'a lot better?" "When you wore your hearing aids, did you hear your mom or dad 'the same', 'a little better', or 'a lot better?"

The researchers found that wearing hearing aids in the omnidirectional microphone program did not improve speech in noise performance when compared to the unaided condition. Noise reduction and directional microphone programs were found to improve the subjects' speech in noise performance. The researchers also found that amplification reduced the number of errors on the ACPT. However, it was stated that the improvement in ACPT scores could have been the result of a possible learning effect of the test and that more subjects were needed to successfully evaluate the effect of hearing aids on ACPT scores. Several areas of the CHAPPS questionnaire were found to have improved following the study; though, the improved results were not statistically significant. The lack of statistically significant findings of this study led the authors to conclude that the use of mild-gain directional BTE hearing aids with noise reduction may be attempted on some children with (C) APD on a trial basis, depending on the child's motivation and listening environments.

It is often recommended that children with (C) APD use a personal FM system in the classroom to improve their speech in noise performance (Bellis, 2002); however, there is a lack of research supporting the benefit of amplification on speech in noise performance of children diagnosed with (C) APD. In addition, there is a lack of research available in how children with (C) APD perform in noisy situations. Due to the results of the previously discussed research, additional research is first needed to determine if children with (C) APD have better word recognition abilities under monaural or binaural speech in noise conditions. It is hypothesized that children with (C) APD will have better word recognition abilities for monosyllabic words under monaural speech in noise conditions than binaural speech in noise conditions. If children with (C) APD have better word recognition abilities in the monaural condition, their speech in noise performance in the classroom could be improved without the use of amplification by simply eliminating the contribution of one ear. It is also hypothesized that children with normal auditory processing abilities will perform significantly better in all conditions compared to children identified with (C) APD.

CHAPTER III

Methods and Procedures

The primary purpose of this investigation was to determine if children with (C) APD had better word recognition abilities using monosyllabic words under monaural speech in noise conditions versus binaural speech in noise conditions. The hypotheses were that children with (C) APD would perform better in speech in noise under monaural listening conditions compared to binaural listening conditions (i.e., the right ear advantage would prevail), and children with normal auditory processing abilities would perform significantly better in all conditions compared to (C) APD children.

Methods

Participants

Prior to initiation of this study, the Institutional Review Board (IRB) at Louisiana Tech University approved this project (Appendix A). Fifteen participants, five females and ten males, ages 8-10 years, were included in this study. There were 7 children placed in the experimental group (mean age = 8.71 years; range = 8-10 years) with a diagnosis of (C) APD identified from the Louisiana Tech University Speech and Hearing Center. There were 8 typically developing children placed in the control group (mean age = 9.00 years; range = 8-10 years). All participants in the control group performed at or above grade level academically as reported by their teachers through a questionnaire (Appendix B).

All participants had normal hearing as determined by pure-tone thresholds being between 0-20 dB HL at octave frequencies from 250 – 8000 Hz. All participants had normal middle ear function as determined by peak middle ear pressure of no less than -100 da Pa and compliance of no less than .2 mm or patent pressure equalizing tubes. All participants were right handed as determined by the Edinburgh Handedness Inventory (Oldfield, 1971; Appendix C), had unremarkable otologic and neurologic history, and were native English speakers as reported by parents in a written case history (Appendix D). Each participant in the experimental group had an initial diagnosis of (C) APD as identified by the Louisiana Tech University Speech and Hearing Center. Diagnosis of (C) APD was determined by results of the *Staggered Spondaic Word Test* (SSW; Katz, 1962, 1968), the *Selective Auditory Attention Test* (SAAT; Cherry, 1980), and the *SCAN-3* (Keith, 2009; See Tables 1and 2).

To be included in this study, each participant in the experimental group scored at least two standard deviations below the mean on the Auditory Figure Ground subtest of the *SCAN-3*, had a decrease of 40% or more from the quiet-to-noise on the *SAAT*, or had tolerance-fading memory classification on the *SSW*. Each participant in the typically developing group scored within the normal limits for their age on the Auditory Figure Ground test of the *SCAN-3*, the *SAAT*, the *SSW*, and did not fall more than two standard deviations below the mean on more than one subtest of any test used (See Table 2).

Table 1: SSW, SAAT, and SCAN-3 results for the experimental group

Participant	Age	Tymp Results	Puretone Results	APD Diagnosis	SCAN-3 Results	SSW Results	SAAT Results
1E	9	A,AU	WNL	YES	WNL	REV (ORG), ORDER H/L (TFM)	ABN 32% DIFF
2E	8	A,AU	WNL	YES	WNL	RC (DEC), LC (TFM), TOTAL, TYPE A (INT)	ABN 32% DIFF
3E	8	A,AU	WNL	YES	WNL	RNC, RC (DEC), LC (TFM), LNC (DEC), TOTAL, ORDER H/L (TFM)	ABN 32 % DIFF
4E	8	A,AU	WNL	YES	WNL/BORDERLINE	RC (DEC), LC (TFM), TOTAL	ABN 40% DIFF
5E	9	A,AU	WNL	YES	WNL	LC (TFM), LNC (DEC), TOTAL, REV (ORG), L/H EAR, ORDER H/L (TFM), TYPE A (INT)	ABN 32% DIFF
6E	10	A,AU	WNL	YES	DISORDERED (CW-DE)	LC (TFM), LNC (DEC), TOTAL, EAR L/H, ORDER H/L (TFM)	ABN 24% DIFF
7E	9	A,AU	WNL	YES	WNL	LC (TFM), EAR L/H, TYPE A (INT)	ABN 28% DIFF

Table 2: SSW, SAAT, and SCAN-3 results for the control group

Participant	Age	Tymp Results	Puretone Results	APD Diagnosis	SCAN-3 Results	SSW Results	SAAT Results
1C	8	A,AU	WNL	NO	WNL	WNL	WNL
2C	8	A,AS; Ad, AD	WNL	NO	WNL	WNL	WNL
3C	8	A,AU	WNL	NO	WNL	WNL	WNL
4C	10	A,AU	WNL	NO	WNL	WNL	WNL
5C	10	A,AU	WNL	NO	WNL	WNL	WNL
6C	9	A,AU	WNL	NO	WNL	WNL	WNL
7C	9	A,AU	WNL	NO	WNL	WNL	WNL
8C	10	A,AU	WNL	NO	WNL	WNL	WNL

Legend:

LC =left competing
LNC = left non-competing
RC = right competing
RNC = right non-competing
REV = reversals
Order H/L = order high low
Order L/H = order low high
Total = total number of errors
Type A = Integration
TFM = Tolerance Fading Memory
DEC = Decoding
ORG = Organization
Decoding – the inability to quickly and accurately process speech
Tolerance Fading Memory – difficulty with speech and noise and short term memory
Integration – the inability to bring together information
Organization – difficulty organizing and sequencing auditory and other information

Instrumentation

A Welch Allen Otoscope was used to perform otoscopy. A Grason-Stadler Tympstar Version 2 Middle-Ear Analyzer (Med-Acoustics, Stone Mountain, GA; ANSI S3.39, 2002) was used to perform tympanometry. A Grason-Stadler GSI 61 audiometer (Med-Acoustics, Stone Mountain, GA; ANSI S3.6-1969, R-1973, R-2004) was used to perform pure-tone testing. All equipment received an annual electroacoustic calibration and daily biological checks to ensure consistency in performance. The SCAN-3 for children, the SSW, and the SAAT tests were used to confirm or deny the presence of an auditory processing disorder. All tests were played through a Tascam CD-160 CD player coupled to the GSI 61 audiometer. Tests were delivered and scored according to test manuals.

Standardized Tests. The SCAN-3 (Keith, 2009) is a valid and reliable test battery which is used to help identify children from 5 to 12 years of age with auditory processing disorders and describe the impact on their daily life. Each participant is presented the test battery in the booth with inserts used as transducers. The SCAN-3 test includes the following screening subtests: Random Gap Detection, Auditory Figure Ground at +8 dB SNR, and Competing Words Free Recall. Also included are four diagnostic tests: Auditory Figure Ground at +8 dB SNR, Filtered Words, Competing Words, and Competing Sentences. Additional supplementary subtests given as part of the SCAN-3 are: Competing Words Free-Recall, Auditory Figure Ground at 0 dB SNR, Auditory Figure Ground at + 12 dB SNR, and Time Compressed Sentences. The SCAN-3 results are scored according to the SCAN-3 test manual. Ear advantage scores are given for all tests excluding the Gap Detection subtest.

The SSW test (Katz, 1962, 1968) is a valid and reliable test which evaluates central auditory function by presenting staggered spondaic words dichotically. Each participant is presented the test battery in the booth with inserts used as transducers. The spondaic words are presented with their onsets and endings varying between the ears. The participants must repeat the words in the order they are presented. The four conditions tested include: Left Non-Competing, Left Competing, Right Non-Competing, Right Competing. The SSW results are scored according to the SSW test manual.

The SAAT test (Cherry, 1980) is a speech-in-competing-message test. Each participant is presented with a list of 25 words in quiet and a list of 25 words with a competing message. The words are first presented in quiet through a single speaker in the booth. The subject is asked to point to a picture of the word in the Word Intelligibility by Picture Identification (WIPI) book that is said. In the competing condition, the words and competing message are presented through a single speaker in the booth. The subject is asked to point to a picture of the word in the WIPI book while ignoring the competing message. All lists are scored based on the percentage of words that are identified correctly. The competing message condition is given only if a score of at least 88% was obtained in the quiet condition. If a score of at least 88% is not obtained in the quiet condition, the results are considered to be unreliable.

Experimental Procedure. Recorded NU-6 word lists were presented as experimental stimuli to the participants using the GSI-61 audiometer coupled to a Tascam CD-160 CD player. Professionally recorded NU-6 word lists (1A, 2A, 3A, 4A, 1B, 2B, 3B, 4B, 1C, 2C, 3C, 4C) provided by Auditec of St. Louis were used as the primary stimuli for the study. Recorded four-talker babble from Auditec of St. Louis was used as a masker in the speech in noise condition. Prior to testing, a packet was created for each participant that included: the SCAN-3 protocol for children, the SSW protocol, the SAAT test form, and a copy of fifteen NU-6 word lists presented at various SNRs (Appendix E). For each packet, the order of the presentations (right ear, left ear, binaural) for the NU-6 word lists varied and the order of the other tests (SCAN-3 C, SSW, and SAAT) remained unchanged. If the packet said the order was right ear first, left ear second, binaural third, the test order would be: the SCAN-3, then right ear NU-6 lists (+8 dB, +6 dB, +4 dB, +2 dB, 0 dB), followed by the SSW, then left ear NU-6 lists (+8 dB, +6 dB, +4 dB, +2 dB, 0 dB), followed by the SAAT, and lastly binaural NU-6 lists (+8 dB, +6 dB, +4 dB, +2 dB, 0 dB).

Procedures

Testing

Letters were mailed to the parents of potential participants who were originally diagnosed as having (C) APD at Louisiana Tech University (Appendix F). Potential participants for the experimental group were evaluated to determine if they met the inclusion criteria. To be included in the study, each participant in the experimental group scored at least two standard deviations below the mean on the Auditory Figure Ground subtest of the SCAN-3, had a decrease of 40% or more from the quiet-to-noise on the SAAT, or had tolerance-fading memory classification on the SSW (Left Competing, Order H/L). If the children met the inclusion criteria listed above, they were asked to participate in the study. However, if they did not meet the inclusion criteria and still had (C) APD they were to be dismissed from the study. All children tested as potential participants for the experimental group met the (C) APD inclusion criteria. If children originally were diagnosed as having (C) APD but fell within normal limits during testing and were reported as performing at or above grade level by their teacher, the participants were asked to participate and were to be placed in the control group. No participants were recruited in this manner. The control group was recruited via word of mouth and flyers placed in the Louisiana Tech Speech and Hearing Center (Appendix G).

Informed consent was received from each participant's parent or guardian prior to the initiation of testing (see Appendix H). Each participant's parent or guardian completed a child case history form (see Appendix D). The case history was evaluated to ensure that children of either group had unremarkable otologic and neurologic history. All participants in the control group performed within normal limits academically as reported by their teachers through a questionnaire. Participants were placed in control and experimental groups based on the inclusion criteria.

Each participant was scheduled for a 2 hour test session and breaks were given as needed. Both groups received the same test battery which included: otoscopy, tympanometry, pure-tone testing, SCAN-3, SSW, SAAT, and the fifteen word lists presented at various SNRs (+8, +6, +4, +2, 0). All participants met the otoscopy and tympanometry requirements to be included in the study (See Tables 1 and 2).

The participant was then placed in the double walled, double suite, sound proof booth where ER-3A inserts and EAR LINK foam inserts were placed in each ear. Pure-tone thresholds were obtained at octave frequencies from 250-8000 Hz bilaterally. To be included in the study, pure-tone thresholds had to be 0-20 dB HL for all frequencies tested (See Tables 1 and 2).

Following pure tone testing, the SCAN-3 test was administered according to the SCAN-3 manual. Inserts were used as transducers and the SCAN-3 for Children compact disc was used. Channel 1 was set to external B and channel 2 was set to external A. Both channel 1 and 2 on the audiometer were set to 50 dB HL for the duration of the test. The SCAN-3 screening was completed as part of the SCAN-3 test. The screening includes the Random Gap Detection, Auditory Figure Ground at +8 dB SNR, and Competing Words Free Recall tests. Next, diagnostic and supplementary tests were given which included Auditory Figure Ground at +8 dB SNR, Filtered Words, Competing Words, Competing Sentences, Auditory Figure Ground at 0 dB SNR, Auditory Figure Ground at + 12 dB SNR, and Time Compressed Sentences subtests. The SCAN-3 results were documented for each participant on the protocol and are provided in summary form on Tables 1and 2.

The audiometer was then arranged for the first five lists of the experimental procedure NU-6 and four-talker babble. Inserts were used as transducers and the recorded NU-6 words and four-talker babble CD was used as the stimulus. On the audiometer, channel 1 was set to external A and channel 2 was set to external B. External A was set at 50 dB HL for the speech stimulus (recorded NU-6 words) and external B was set at varying SNRs beginning with 42 dB HL (+8 dB SNR) for the background noise (four-talker babble). The participant was then given these instructions:

> *You are going to hear words in one or both of your ears. You will hear 'Say the word' before each word. You only need to tell me the last word. You will hear people talking in the background. These people will be loud at times and soft at others. Ignore the people talking in the background and say the word. Do you have any questions?*

The participant was presented with the first list of 50 words in the first test condition (i.e., either right, left, or binaural depending on the packet order) at +8 dB SNR. For each packet, the order of the presentations (right ear, left ear, binaural) for the NU-6 word lists was predetermined and written on the packet. Four additional lists were given at decreasing SNRs (+6 dB, +4 dB, +2 dB, and 0 dB) for the same test condition (right, left, or binaural).The second list in the first condition was presented at +6 dB SNR with external A set at 50 dB HL and external B set at 44 dB HL. The third list in the first condition was presented at +4 dB SNR with external A set at 50 dB HL and external B set at 46 dB HL. The fourth list in the first condition was presented at +2 dB SNR with external A set at 50 dB HL and external B set at 48 dB HL. The fifth list in the first condition was presented at 0 dB SNR with external A and B set at 50 dB HL. Percentages correct for each word list in the first condition at each SNR were documented and put into a table for comparison between the experimental and control groups.

The audiometer was then prepared for the SSW test. Inserts were used as transducers and the SSW compact disc was placed into the compact disc player. Channel 1 was set to external B and channel 2 was set to external A. External B and external A were set to 50 dB HL for the duration of the test. The SSW test was then completed per the test manual; the participant repeated the words in the order presented. Scoring was completed according to the SSW manual. The SSW results were documented for each participant and placed in a table for comparison between the experimental and control groups.

The audiometer was then arranged for the second five lists of the recorded NU-6 words and four-talker babble. The next 5 lists were given at the next condition in the packet (i.e., right, left, or binaural) at decreasing SNRs (+8 dB, followed by +6 dB, +4 dB, +2 dB, and 0 dB). Using inserts as transducers and the NU-6 and four-talker babble compact disc as the stimulus, channel 1 was set to external A and channel 2 was set to external B. External A was set at 50 dB HL for the speech stimulus (recorded NU-6 words) and external B was set at varying SNRs beginning with 42 dB HL (+8 dB SNR) for the background noise (four-talker babble). The participant was then again given these instructions:

> *You are going to hear words in one or both of your ears. You will hear 'Say the word' before each word. You only need to tell me the last word. You will hear people talking in the background. These people will be loud at times and soft at others. Ignore the people talking in the background and say the word. Do you have any questions?*

The participant was presented with the first list in the second test condition (right, left, or binaural, depending on the packet order) at +8 dB SNR. The following four lists were given at decreasing SNRs (+6 dB, +4 dB, +2 dB, 0 dB) for the same test condition (right, left, or binaural). The second list in the second condition was presented at +6 dB SNR with external A set at 50 dB HL and external B set at 44 dB HL. The third list in the second condition was presented at +4 dB SNR with external A set at 50 dB HL and external B set at 46 dB HL. The fourth list in the second condition was presented at +2 dB SNR with external A set at 50 dB HL and external B set at 48 dB HL. The fifth list in the second condition was presented at 0 dB SNR with external A and B set at 50 dB HL. Percentages correct for each word list at each SNR for the second condition were documented and put into a table for comparison between the experimental and control groups.

The audiometer was then prepared for the SAAT test. The left speaker was used as the transducer and the SAAT compact disc was placed in the compact disc player. Channel 1 was set to external B. External B was set to 50 dB HL for the duration of the test. The SAAT test was then completed. According to the test manual, each participant was presented with a list of 25 words in quiet and a list of 25 words with a competing message. The words and competing message were presented through a single speaker in the booth. The participant's inserts were taken out and their chair was turned to face the stimulus speaker. The researcher was seated in a chair next to the participant for the duration of the SAAT test. The words were first presented in quiet through a single speaker in the booth. The subject was asked to point to a picture of the word in the Word Intelligibility by Picture Identification (WIPI) book that was said. In the competing noise condition, the participant pointed to a picture in the WIPI book of the word said while ignoring the competing message. All lists were scored based on the percentage of words that were identified correctly. The competing message condition was given only if a score of at least 88% was obtained in the quiet condition. The SAAT results were documented for each participant and placed into a table for comparison between the experimental and control groups.

The audiometer was then arranged for the third five lists of the recorded NU-6 words and four-talker babble. The next 5 lists were given at the third condition in the packet (i.e., right, left, or binaural) at decreasing SNRs (+8 dB, followed by +6 dB, +4 dB, +2 dB, and 0 dB). Using inserts as transducers and the NU-6 and four-talker babble compact disc as the stimulus, channel 1 was set to external A and channel 2 was set to external B. External A was set at 50 dB HL for the speech stimulus (recorded NU-6 words) and external B was set at varying SNRs beginning with 42 dB HL (+8 SNR) for the background noise. The participant was then again given these instructions:

> *You are going to hear words in one or both of your ears. You will hear 'Say the word' before each word. You only need to tell me the last word. You will hear people talking in the background. These people will be loud at times and soft at others. Ignore the people talking in the background and say the word. Do you have any questions?*

The participant was then presented with the first list in the third test condition (right, left, or binaural, depending on the packet order) at +8 dB SNR. The following four lists were given at decreasing SNRs (+6 dB, +4 dB, +2 dB, 0 dB) for the same test condition (right, left, or binaural). The second list in the third condition was presented at +6 dB SNR with external A set at 50 dB HL and external B set at 44 dB HL. The third list in the third condition was presented at +4 dB SNR with external A set at 50 dB HL and external B set at 46 dB HL. The fourth list in the third condition was presented at +2 dB SNR with external A set at 50 dB HL and external B set at 48 dB HL. The fifth list in the third condition was presented at 0 dB SNR with external A and B set at 50 dB HL. Percentages correct for each word list at each SNR for the third condition were documented and put into a table for comparison between the experimental and control groups.

CHAPTER IV

Results

As mentioned before, the primary purpose of this investigation was to determine if children with (C) APD have better word recognition abilities for monosyllabic words under monaural speech in noise conditions than binaural speech in noise conditions. Each participant received three test conditions (right, left, and binaural) and five SNRs (+8 dB, +6 dB, +4 dB, +2 dB, and 0 dB) in each test condition. The percent correct for each SNR and test condition (right, left, binaural) was compared between the control group and the experimental group. The hypotheses were that children with (C) APD would perform better in speech in noise under monaural listening conditions than binaural listening conditions, and children with normal auditory processing abilities would perform significantly better in all conditions compared to children with (C) APD.

Data from fifteen child participants with normal peripheral hearing was used to determine the percentage correct for each SNR and test condition. Data from seven participants in the experimental group was compared to the data from eight participants in the control group. A 2-way repeated measures analysis of variance (RM-ANOVA) was used to compare the two groups (between subjects factor) on one within subject factor: ear conditions (right, left, binaural). The grouping variable was SNR with five levels (+8 dB, +6 dB, +4 dB, +2 dB, and 0 dB). A Bonferroni correction was used within SPSS 17 to adjust for the numerous comparisons.

The means and standard deviations for each condition at each SNR are in Table 3 for the Control Group and Table 4 for the Experimental Group. The main effect for the ear conditions (right, left, binaural) was found to be significant, $F\,(10, 46) = 7.23, p <$ .000, *partial* $\eta^2 = .611$. However, there was not an interaction between the SNR and which group a child was placed in, $F\,(10, 46) = 0.944, p = 0.503$, *partial* $\eta^2 = .170$. The main effect for the grouping variable of SNR was significant (see Table 5). There were no significant interactions for SNR and ear conditions (see Table 6).

Table 3

Means and Standard Deviations of Control Group

	Mean	SD
Right Ear + 8 dB	88.25	3.62
Left Ear + 8 dB	83.75	3.92
Binaural +8 dB	90.75	3.85
Right Ear +6 dB	84.00	4.78
Left Ear +6 dB	81.00	5.76
Binaural +6 dB	87.75	3.92
Right Ear +4 dB	75.75	5.39
Left Ear +4 dB	72.50	5.93
Binaural +4 dB	84.75	6.04
Right Ear +2 dB	68.50	2.98
Left Ear +2 dB	64.50	4.50
Binaural +2 dB	78.75	5.45
Right Ear 0 dB	67.50	5.10
Left Ear 0 dB	56.75	5.01
Binaural 0 dB	70.25	6.54

Table 4

Means and Standard Deviations of Experimental Group

	Mean	SD
Right Ear + 8 dB	83.14	4.14
Left Ear + 8 dB	80.29	8.12
Binaural +8 dB	86.00	3.46
Right Ear +6 dB	78.00	2.83
Left Ear +6 dB	71.71	7.95
Binaural +6 dB	81.71	7.61
Right Ear +4 dB	66.57	4.72
Left Ear +4 dB	63.14	9.92
Binaural +4 dB	74.57	9.07
Right Ear +2 dB	60.86	3.98
Left Ear +2 dB	56.57	7.55
Binaural +2 dB	63.71	6.78
Right Ear 0 dB	60.00	3.65
Left Ear 0 dB	44.29	8.83
Binaural 0 dB	60.57	6.50

Table 5
Main Effect for SNR

	F	Sign.	Parital η2
+ 8 dB	9.470	0.001*	0.421
+ 6 dB	11.970	<.000*	0.479
+ 4 dB	16.650	<.000*	0.562
+ 2 dB	17.940	<.000*	0.580
0 dB	53.52	<.000*	0.805

*Sign. at .05 ; df = 2,26

Table 6
Interaction for SNR and Conditions

	F	Sign.	Parital η2
+ 8 dB	0.173	0.842	0.013
+ 6 dB	0.605	0.554	0.044
+ 4 dB	0.032	0.969	0.002
+ 2 dB	2.705	0.086	0.172
0 dB	1.244	0.305	0.087

*Sign. at .05 ; df = 2,26

The main effect of groups at each SNR was found to be significant (see Table 7). This suggested that the Control and Experimental Group were significantly different at each SNR level.

Table 7
Test of Between-Subjects Effects for SNR

		Mean	Sign.
+ 8 dB			
	Control	87.58	0.026*
	Experimental	83.14	
+ 6 dB			
	Control	84.25	0.007*
	Experimental	77.14	
+ 4 dB			
	Control	77.67	0.004*
	Experimental	68.1	
+ 2 dB			
	Control	70.58	<.000*
	Experimental	60.38	
0 dB			
	Control	64.83	0.002*
	Experimental	54.95	

*Sign. At .05 with a Bonferroni correction.

In addition, a pairwise comparison was performed to identify which conditions were significantly different for each SNR (See Table 8). The following were found to be statistically significant: +8 dB SNR, the left compared to binaural conditions; +6 dB SNR, the left compared to binaural condition; +4 dB SNR, the right compared to binaural conditions, the left compared to binaural condition; +2 dB SNR, the right compared to left condition, the right compared to binaural condition, the left compared to binaural condition; and 0 dB SNR, the right compared to left condition, the left compared to binaural.

Table 8
RMANOVA: Pairwise Comparison of Conditions

SNR	Cond. 1	Cond. 2	Sign.
8 dB	RIGHT	LEFT	0.087
	RIGHT	BINAURAL	0.137
	LEFT	BINAURAL	0.006*
6 dB	RIGHT	LEFT	0.115
	RIGHT	BINAURAL	0.194
	LEFT	BINAURAL	<.000*
4 dB	RIGHT	LEFT	0.639
	RIGHT	BINAURAL	0.001*
	LEFT	BINAURAL	<.000*
2 dB	RIGHT	LEFT	0.037*
	RIGHT	BINAURAL	0.008*
	LEFT	BINAURAL	0.001*
0 dB	RIGHT	LEFT	<.000*
	RIGHT	BINAURAL	0.772
	LEFT	BINAURAL	<.000*

*Sign. = .05

As displayed in Figure 1, at +8 dB SNR the Control and Experimental group performed best in the binaural condition. The Control group performed better in the right monaural condition than the left monaural condition. The Control group performed better in the right monaural condition than the Experimental group did in the binaural, right monaural, and left monaural conditions.

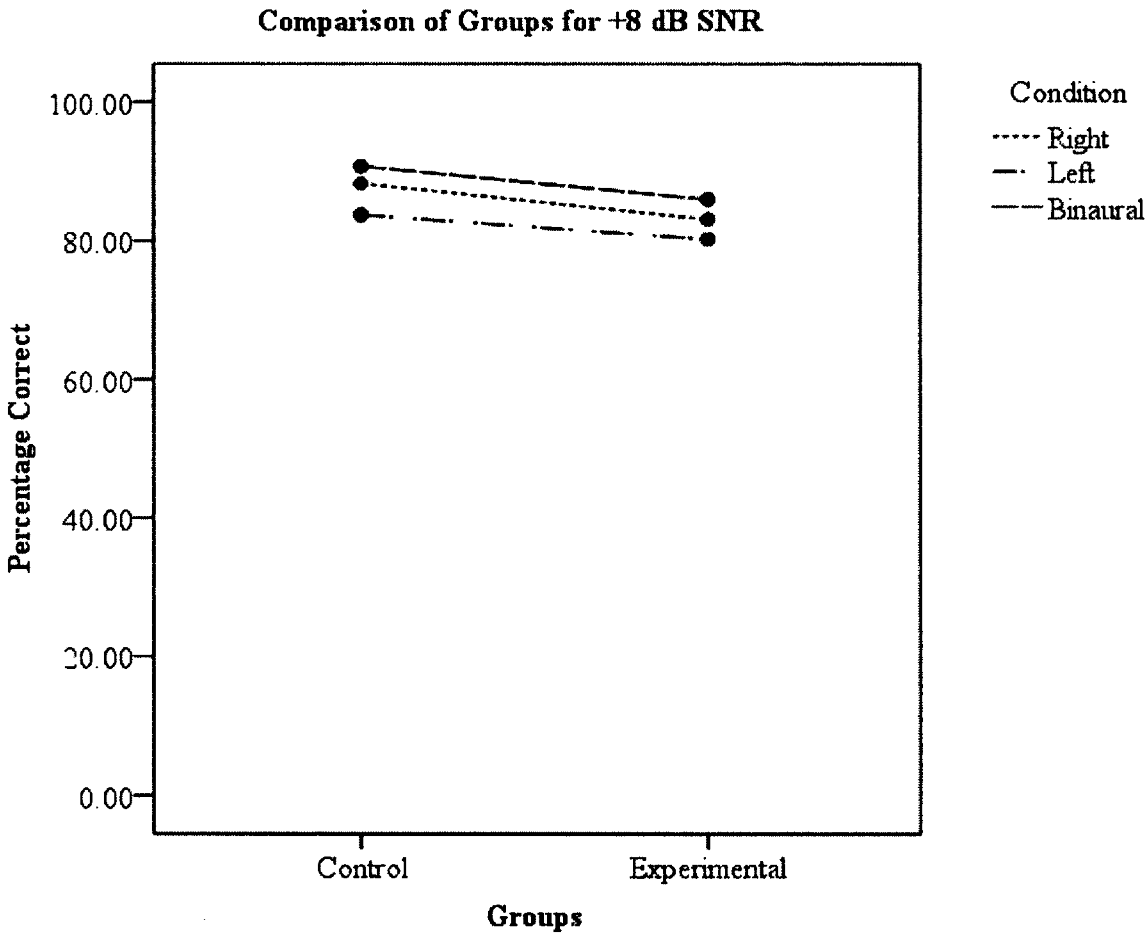

*Figure 1.*Comparison of Groups for +8 dB SNR.

As displayed in Figure 2, at +6 dB SNR the Control and Experimental group performed best in the binaural condition. The Control group performed better in the right monaural condition than the left monaural condition. The Control group performed better in the right monaural condition than the Experimental group did in the binaural condition. The Control group performed better in the left monaural condition than the Experimental group did in both the right and left monaural conditions.

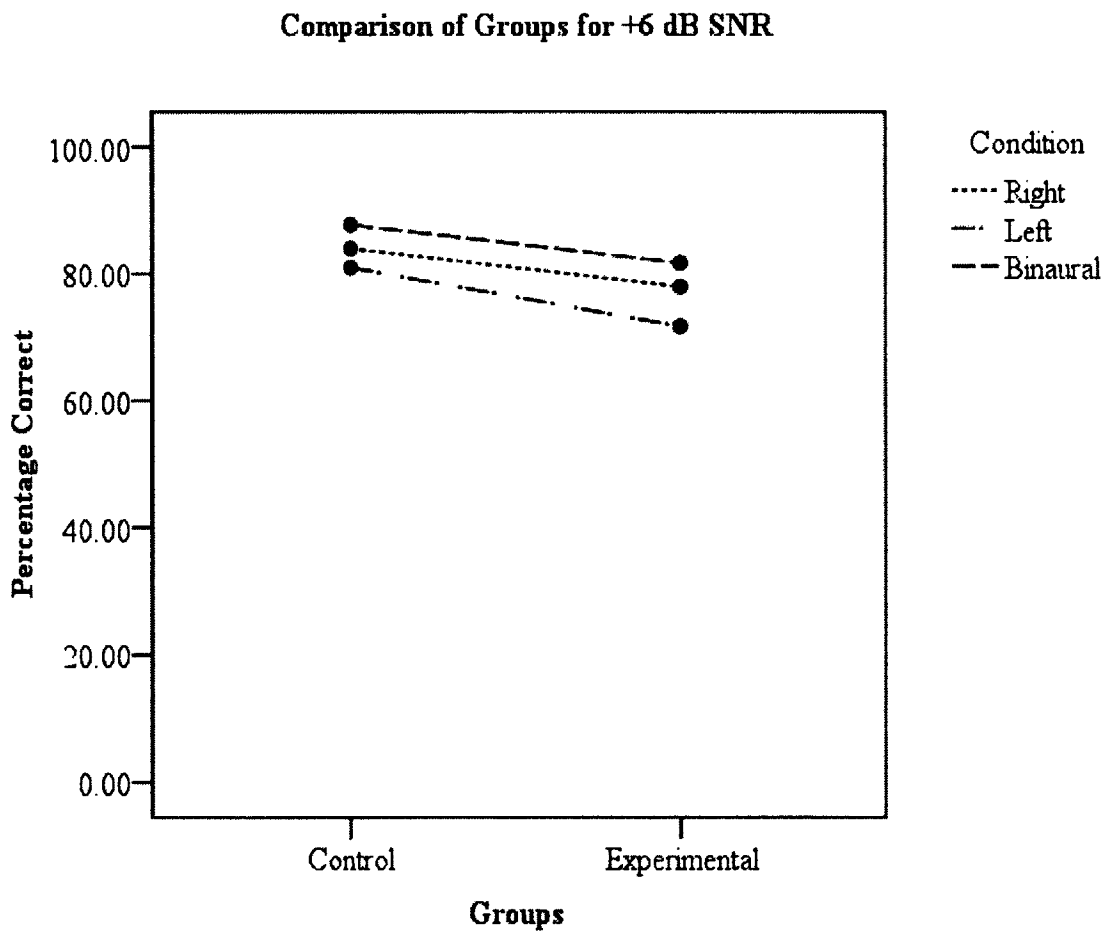

*Figure 2.*Comparison of Groups for +6 dB SNR.

As displayed in Figure 3, at +4 dB SNR the Control and Experimental group again performed best in the binaural condition. The Control group performed better in the right monaural condition than the left monaural condition. The Control group performed better in the right monaural condition than the Experimental group did in the binaural condition. The Control group performed better in the left monaural condition than the Experimental group did in both the right and left monaural conditions.

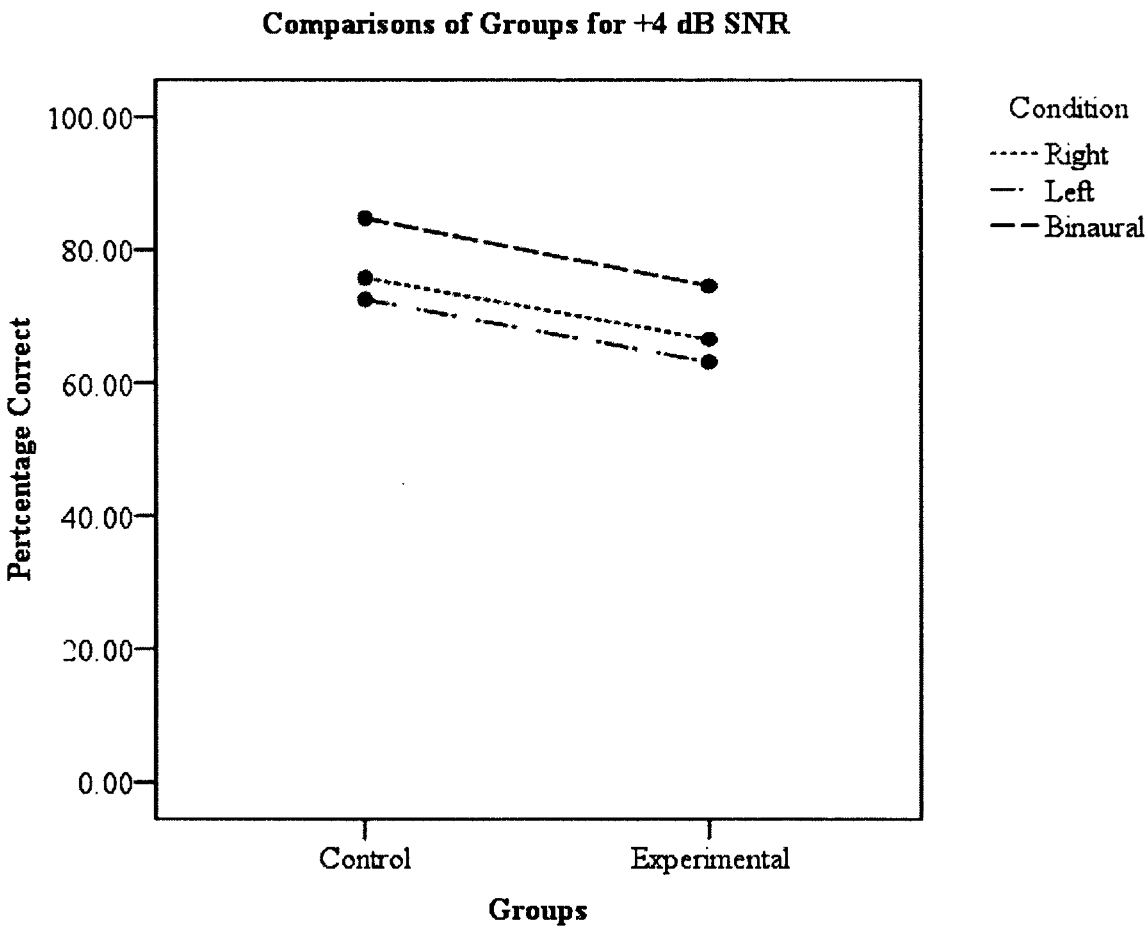

Figure 3. Comparison of Groups for +4 dB SNR.

As shown in Figure 4, at +2 dB SNR, the Control and Experimental groups performed best in the binaural conditions. The Control group performed better in the right monaural condition than the left monaural condition. The Control group performed better in the right monaural condition than the Experimental group in the binaural condition. The Control group performed better in the left monaural condition than the Experimental group in the binaural, right monaural and left monaural conditions.

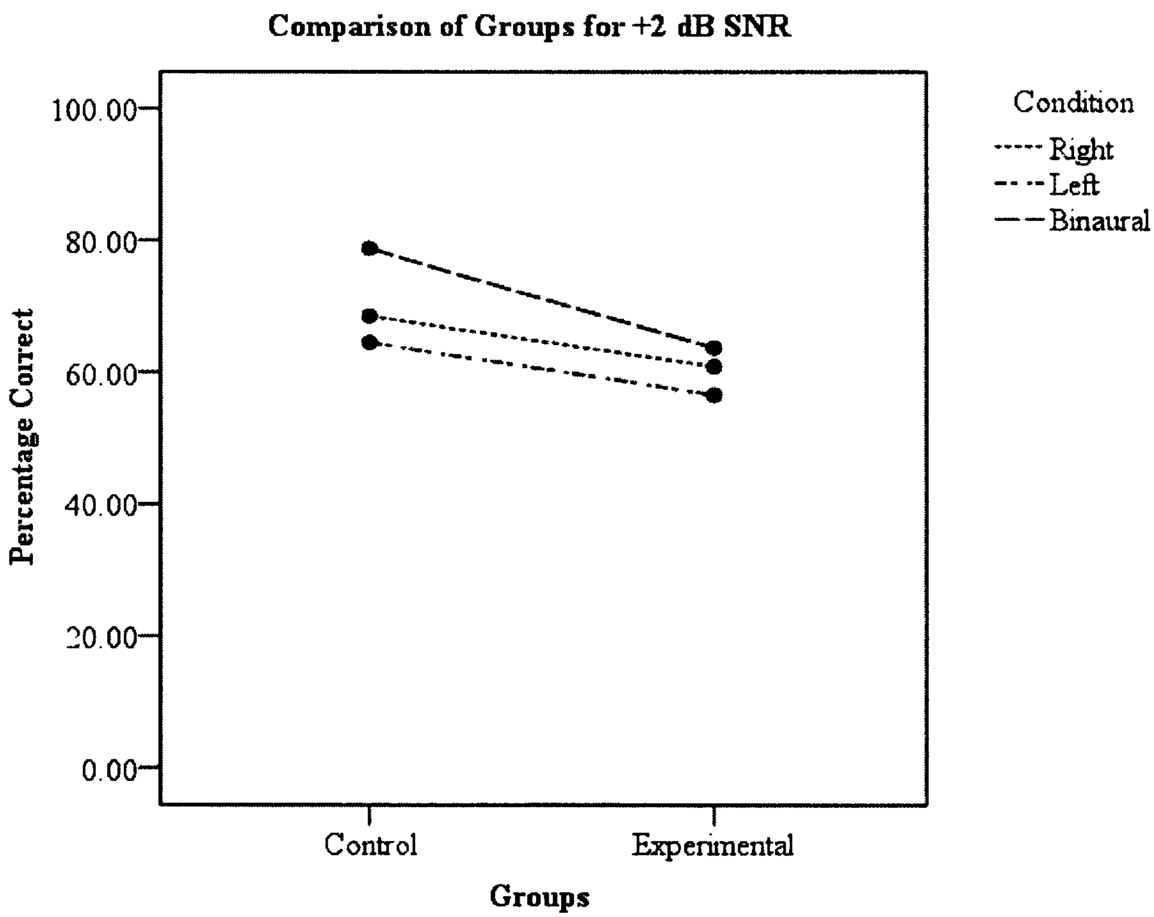

*Figure 4.*Comparison of Groups for +2 dB SNR.

As shown in Figure 5, at 0 dB SNR the Control and Experimental group performed best in the binaural conditions. The Control group performed better in the right monaural condition than the left monaural condition. The Control group performed better in the right monaural condition than the Experimental group in the binaural, right monaural, and left monaural conditions. The Experimental group performed equally in the binaural and right monaural conditions, both of which fell below the mean of the right monaural condition of the Control group.

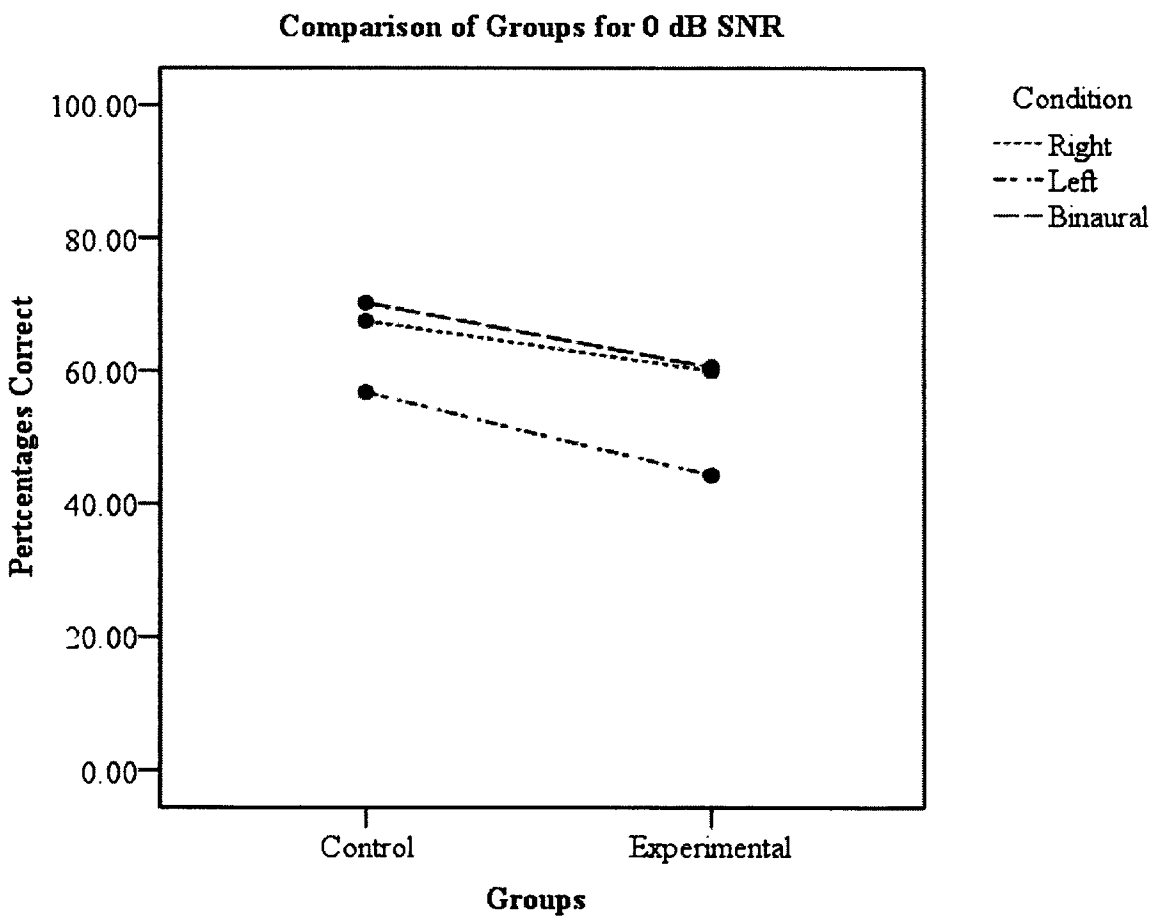

*Figure 5.*Comparison of Groups for 0 dB SNR.

Overall, the Control and Experimental groups did best in the binaural condition at all SNRs (see Figures 1-5); however, the Control group performed significantly better than the Experimental group in all conditions. The Control and Experimental groups did better in the right monaural condition than the left monaural condition at all SNRs. The Control group performed better in the right monaural condition than the Experimental group in the binaural condition at all SNRs.

CHAPTER V

Discussion

The primary purpose of this investigation was to determine if children with (C) APD have better word recognition abilities for monosyllabic words under monaural speech in noise conditions than binaural speech in noise conditions. The hypotheses were that children with (C) APD would perform better in speech in noise under monaural listening conditions than binaural listening conditions (i.e., the right ear advantage would prevail), and children with normal auditory processing abilities would perform significantly better in all conditions compared to (C) APD children. These hypotheses were made due to young children (less than 12 years of age) with normal auditory processing abilities having a stronger right ear response (i.e., a significantly weaker left ear response) to dichotic stimuli.

It was thought that if the results of this study found that children with (C) APD had better word recognition abilities in the monaural condition, their speech in noise performance in the classroom could be improved without the use of amplification by simply eliminating the contribution of the weaker ear (i.e., left ear). The hypothesis that children with (C) APD would have better word recognition abilities for speech in noise under monaural listening conditions was not supported. The results of this study found that children with (C) APD performed better in speech in noise under binaural listening conditions than monaural listening conditions. Therefore, speech in noise performance in the classroom would not be improved by eliminating the contribution of one ear. The hypothesis that children with normal auditory processing abilities would perform significantly better compared to (C) APD children was supported.

Based on the overall findings, the control and experimental groups did best in the binaural condition at all SNRs; however, the control group performed significantly better than the experimental group in all conditions. The control and experimental groups did better in the right monaural condition than the left monaural condition at all SNRs. The control group performed better in the right monaural condition than the experimental group in the binaural condition at all SNRs. This means that children with (C) APD can understand better with both ears versus their right ear alone, and better in their right ear alone versus their left ear alone.

The experimental group performed worse in the binaural condition than the control group in the right monaural condition. The experimental group performed worse in the right monaural condition than the control group in the left monaural condition. At 0 dB SNR, the experimental group performed equally in the binaural and right monaural conditions, both which fell below the mean scores of the control group.

The results of this study support the hypothesis that children with (C) APD would perform significantly worse in speech in noise conditions than children with normal auditory processing skills. It was found that binaural listening is best for children diagnosed with (C) APD as well as children with normal processing skills. The results revealed that children diagnosed with (C) APD listening binaurally are performing worse than children with normal auditory processing skills listening with only their right ear. It was also found that children with (C) APD listening with only their right ear are performing worse than children with normal processing skills using only their left ear.

These results reveal that even when listening binaurally, children with (C) APD are already at a disadvantage when compared to children with normal auditory processing skills.

FM Systems

For all children in this study, an increase in the noise level (four-talker babble) caused a decrease in the percent correct of the target speech signal (NU-6 words). It is often recommended that children with (C) APD use a personal FM system in the classroom to improve their speech in noise performance (Bellis, 2002). According to Rosenberg (2002), (C) APD management includes the listening environment, compensatory strategies, and direct therapy. To modify the listening environment, Rosenberg (2002) suggests that a personal FM system would help children with (C) APD who have difficulty understanding speech in background noise. The results of this study support the recommendation of an FM system for children with (C) APD with deficits in speech in noise.

For children with (C) APD, binaural listening with an increased SNR is best for speech in noise conditions such as the classroom. For that reason, children with (C) APD with deficits in speech in noise could benefit from the use of an FM system in the classroom by improving the SNR by means of increasing the target speech signal while decreasing the effects of noise, reverberation, and distance from the speaker.

NU-6 words in noise as a diagnostic (C) APD test

In noisy environments, understanding speech can be difficult for listeners with normal hearing and normal auditory processing skills. For individuals diagnosed with (C) APD, trouble understanding speech in less than favorable conditions can be even more difficult (Keith, 1999). Chermak et al. (1998) found that difficulty hearing in background noise was the most frequently observed behavior of individuals with (C) APD. The results of this study confirm that children with (C) APD consistently have poorer performance in speech in noise conditions than children with normal auditory processing skills.

Because of this difficulty, speech testing in the presence of background noise is an important component of a (C) APD test battery. Background noise used in (C) APD testing often includes the use of both energetic and informational masking. According to Brungart (2005), an energetic masker is a signal which contains energy in the same critical bands at the same time and portion of the speech signal. Brungart (2005) defines informational masking occurring when the speech signal and the masker are both audible speech; however, the listener may have difficulty separating the target speech from the masker. The results of this study reveal that ordinary NU-6 words combined with an informational masker such as four-talker babble could be used diagnostically as part of the (C) APD test battery. An informational masker such as four-talker or multi-talker babble would be best for this type of testing. The results of this study found that the control group performed significantly better than the experimental group at all SNRs. Additional normative data needs to be collected to determine which SNR would be the best to use diagnostically.

A limitation of this study was found to be that the NU-6 word lists were always given at decreasing SNRs (+8 dB, +6 dB, +4 dB, +2 dB, 0 dB) for each test condition (right, left, or binaural). For each test condition, 0 dB was found to be the most difficult SNR. Although fatigue could have been a factor, this was thought to have minimal impact on the results of the study. A possible recommendation for future studies is to randomize the presentation order of the SNRs.

APPENDIX A

IRB Approval Memorandum

LOUISIANA TECH
UNIVERSITY

MEMORANDUM

OFFICE OF UNIVERSITY RESEARCH

TO: Dr. Sheryl Shoemaker and Ms. Jessica Vaughn

FROM: Barbara Talbot, University Research

SUBJECT: HUMAN USE COMMITTEE REVIEW

DATE: February 16, 2012

In order to facilitate your project, an EXPEDITED REVIEW has been done for your proposed study entitled:

"Asymmetrical Speech-in-Noise Assessment for Children with (Central) Auditory Processing Disorders"

HUC 923

The proposed study's revised procedures were found to provide reasonable and adequate safeguards against possible risks involving human subjects. The information to be collected may be personal in nature or implication. Therefore, diligent care needs to be taken to protect the privacy of the participants and to assure that the data are kept confidential. Informed consent is a critical part of the research process. The subjects must be informed that their participation is voluntary. It is important that consent materials be presented in a language understandable to every participant. If you have participants in your study whose first language is not English, be sure that informed consent materials are adequately explained or translated. Since your reviewed project appears to do no damage to the participants, the Human Use Committee grants approval of the involvement of human subjects as outlined.

Projects should be renewed annually. ***This approval was finalized on February 16, 2012 and this project will need to receive a continuation review by the IRB if the project, including data analysis, continues beyond February 16, 2013.*** Any discrepancies in procedure or changes that have been made including approved changes should be noted in the review application. Projects involving NIH funds require annual education training to be documented. For more information regarding this, contact the Office of University Research.

You are requested to maintain written records of your procedures, data collected, and subjects involved. These records will need to be available upon request during the conduct of the study and retained by the university for three years after the conclusion of the study. If changes occur in recruiting of subjects, informed consent process or in your research protocol, or if unanticipated problems should arise it is the Researchers responsibility to notify the Office of Research or IRB in writing. The project should be discontinued until modifications can be reviewed and approved.

If you have any questions, please contact Dr. Mary Livingston at 257-4315.

A MEMBER OF THE UNIVERSITY OF LOUISIANA SYSTEM

P.O. BOX 3092 • RUSTON, LA 71272 • TELEPHONE (318) 257-5075 • FAX (318) 257-5079
AN EQUAL OPPORTUNITY UNIVERSITY

APPENDIX B

Teacher Questionnaire

Teacher's Name: ____________________Child's Name:______________________

Read each item carefully and decide how much you think this child exhibits the following behaviors. Put your check in the box that is true of this child at the present time.

	Not At All	Just a Little	Pretty Much	Very Much
1. Restless in the "squirmy" sense				
2. Demands must be met immediately				
3. Temper outbursts/unpredictable behavior				
4. Distractibility/attention span is a problem.				
5. Disturbs other children				
6. Pouts and sulks				
7. Mood changes quickly and drastically				
8. Restless; always on the go				
9. Excitable, impulsive				
10. Fails to finish things he starts				

How much of a problem do you think this child has at the present time (compared to others of the same age)? NONE MINOR MODERATE SEVERE

Is this child performing at or above grade level academically? YES NO

APPENDIX C

Edinburgh Handedness Inventory

Developed by R.C. Oldfield, Edinburgh University,

Edinburgh, Scotland (1971)

Last Name/First Name/M.I.____

Date of Birth________________________

Sex______________________________

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent put + in both columns.Some of the activities require both hands. In these cases the part of the task, or object, for which hand preference is wanted in brackets.Please try to answer all the questions, and only leave a blank if you have no experience at all of the object or task.

	LEFT	RIGHT	
1. WRITING			
2. DRAWING			
3. THROWING			
4. SCISSORS			
5. TOOTHBRUSH			
6. KNIFE (without fork)			
7. SPOON			
8. BROOM (upper hand)			
9. STRIKING MATCH (match)			
10. OPENING BOX (lid)			

TOTAL number in each column L______ R______

Laterality quotient (LQ) is defined as (R-L) / (R+L) x 100 = ______.
McMeekan&Lishman (1975) defines right-handed as +30 to +100 and left-handed as -30 to -100. Handedness of -29 to +29 is indifference (or ambidexterity).

APPENDIX D

(C) APD Case History Form

LOUISIANA TECH UNIVERSITY
SPEECH AND HEARING CENTER
P.O. BOX 3165
120 ROBINSON HALL
RUSTON, LA 71272
Phone: (318) 257-4766
Fax: (318) 257-4492
Auditory Processing Case History

Date: ____________________

We are pleased that you have chosen to have your child evaluated at the Louisiana Tech University Speech and Hearing Center. In order to give us as much information as possible, we request that you complete this questionnaire and return it to as soon as possible to the address shown on above. An appointment for your child will be scheduled at that time. If you have additional test results, school papers, personal observations that you wish to share with us, please enclose them with this questionnaire on page

GENERAL HISTORY

Child's Name: ________________________________ Age: _______ D.O.B.

Address: ____ Phone:

City: ___________________________ State: ____________ Zip Code:

Name of person answering questionnaire:

Does your child live with both parents? Yes No. If no, which parent is the primary custodial guardian? _________________________

Relationship to child: ____________ Has your child been seen in this Center before?

If yes, when?

Father's Name: __________________________________ Age:_________________

Occupation: ________________________________Education:_________________

Mother's Name: ________________________________ Age:__________________

Occupation: _________________________________ Education:________________

Referred by:

____

Other children in the family?

NAME	AGE	GENDER	ANY PROBLEMS?

List other adults in the home:

____

What is the primary language spoken in your home? ______________ Other? ________

STATEMENT OF THE PROBLEM

Describe as completely as you can, your child's Speech/Language/Auditory problem(s).

____

____

____

____

____

____

____

____

When were the problems first noticed and by whom?

____

____

____

Please describe what has been done to address the problem(s).

____
____
____
____

What specific questions would you liked answered about your child's problem?

____
____
____
____
____

BIRTH INFORMATION

Age of parents at child's birth: Mother: ____________________ Father: ______________

Is this an adopted child? ______________________ Child's age at adoption:__________

Mother's general health during pregnancy: Normal? ______________________________

Amount of weight: Gain: ___________________ Loss: ______________ Diet:________

Medications taken during pregnancy:

____
____

Any unusual conditions during pregnancy?

____

___________ Chicken Pox ________ Asthma _________ Flu
___________ German Measles ________ Pneumonia _________ Mumps
___________ Urinary Infections ________ Sinusitis _________ Toxemia
___________ High Blood Pressure ________ Bronchitis _________ Anemia
Other:

____

Full-term child? ______________________________ Birth weight:____________________

Labor and delivery: Spontaneous__________ Induced ____________ Length of labor____

Type of delivery: Head first _______ Feet first ________ Breech _______ Caesarian ___

Check all that apply to your child as a newborn:
______Alert _______ Oxygen _______ Slow to breathe
______ Bruised _______ Poor sucking _______ Slow weight gain

______ Jaundiced ______ Swallow
Other:

____

Were there any feeding problems or formula changes?

____

Is there a Rh factor in your family? ______ Other blood incompatibilities: __________

Health of baby during first few months:

____

Describe your child's personality as an infant:

____
____
____
____

DEVELOPMENTAL HISTORY

Identify the age at which your child completed the following (approximate ages are fine):
Turned from stomach to back: _______________ Sat alone: ____________________
Crawled: ___________________________ Walked alone: ____________________
Dressed self: _________________________ Fed Self ________________________
Tied shoes: __________________________ Cut with scissors: __________________
Skipped:____________________________ Rode a bike: _____________________
Bowel trained: ________________________ Bladder trained: ___________________

Established hand preference:

____

Used single words (e.g., no, mom, doggie, etc.)

____

Combined words (e.g., me go, daddy shoe, etc.)

____

Named simple objects (e.g., where's doggie?, etc.)

____

Engaged in conversation

____

Does your child have difficulty walking, running, or participating in other activities, which require small or large muscle coordination? If so, please describe

____
____
____

Are there, or have there ever been, any feeding problems (e.g., problems with sucking, swallowing, drooling, chewing, etc.). If yes, please describe

____

____

____

What leisure activities does your child like to engage in alone?

____

____

What activities does your child like to do with his parent(s) or others?

____

____

At what age did your child begin to play organized sports? Which sports?

____

____

What is your child's reaction to organized sports?

____

____

____

Were there any factors that you considered may have interrupted your child's "normal" development? If so, please describe

____

____

____

MEDICAL HISTORY

Is your child generally healthy?

____

Which of the following medical conditions has your child experienced?
Age/Severity Age/Severity

Tonsillitis Head injuries________	Pneumonia Frequent Colds________
Earaches ________	Allergies________
Seizures Rubella ________	Scarlet Fever________
Tonsillitis ________	High Fever ________
Encephalitis ________	Mastoiditis ________
Headaches ________	Meningitis________
RSV ________	Pneumonia ________
Sinusitis ________	Asthma ________
Tinnitus (ringing ears) ________	Croup ________
Convulsions ________	Mumps ________
Measles ________	Digestive upsets________

Chicken pox______________________ Other____________________________

Surgeries: Age Age
Tonsillectomy___________________ Adenoidectomy_____________________

Ear Surgery (tubes) (number of tubes placed)______________________________

Does anyone in the family (parents, siblings, uncles, grandparents, etc.) have similar problems?

Has your child ever been tested for allergies? When? Results?

____

____

Describe any major accidents or hospitalizations of your child.

____

____

____

Is your child taking any medications? Please list and identify and note any negative reactions that may have occurred with each medication.

____

____

____

Are your child's immunizations up-to-date?

____

PERSONALITY TRAITS/PHYSICAL CHARACTERISTICS
Which of the following descriptors best identify your child? Circle as many as are appropriate:

hyperactive	self-sufficient	tires
circles under eyes	puffiness around eyes	nasal voice
bed wetting	joint aches	easy to anger
dependent	independent	aggressive
underactive	distractible	impulsive
short attention span	calm	too happy
itchy rashes	doesn't try	too controlled
difficulty sleeping	has few friends	depressed
easily frustrated	frequently nauseated	irritable
cries easily	bruises easily	helps others
lacks confidence	temper tantrums	sulks
fast worker	dawdles	hard to love
fearful	disorganized	takes turns
follows directions	responsible	good memory
good social skills	poor social skills	competitive

Check all that apply
______Appears to have a hearing loss
______Has difficulty comprehending speech in the presence of background noise
______Has difficulty processing distorted or rapid speech
______Has an expressive and/or receptive language problem
______Has poor auditory memory
______Has difficulty following multi-step commands
______Frequently says "huh" or "what"
______Distractible
______Inattentive
______Restless
______Has poor phonic skills
______Has poor reading, writing, and spelling abilities
______Has a history of chronic otitis media
______Inconsistently responds to auditory stimuli
______Frequently requests that auditory information to be repeated
______Needs for increased time to respond
______Is sensitive to loud sounds
______Has difficulty with localization (finding a sound source)

Does your child prefer to be a leader or a follower?________________________________

Does your child have any unnatural fears?____

What additional information would you like to tell us about your child's personality and physical characteristics?____

SPEECH AND LANGUAGE HISTORY

When did your child use his/her first word?____

When did your child begin to use-two word sentences?______________________________

Does your child use speech: Frequently ________Occasionally _______Never

Does your child prefer to use speech (e.g, single words, short phrases) or gestures? (Give examples)

Which does your child prefer to use? Complete sentences:__________Phrases ________
One or two words _________ Sounds_________________

Check all that apply
______Responds to greetings
______Makes requests
______Attends to tasks

______Takes turns
______Describes events
______Maintains topics
______Sequences actions
______Defines words
______Imitates activities or conversation
______Interacts with same age peers
______Volunteers for activities
______Follows multi-step commands

How well can your child's speech be understood by: Parents__________ ____________
Strangers______________________Brothers and sisters ________________________
Friends and playmates____

If your child has difficulty with speech and/or language, what do you think may have caused the problem(s)?

____
____
____

Has the problem changed since it was first noticed?

____

If yes, please describe changes.

____
____

HEARING HISTORY

Describe your child's auditory behavior

____
____
____

Is noise a factor in your child's ability to understand information? Please describe:

____
____
____

Describe your child's response to sound (e.g., responds to all sounds, responds to loud sounds only, inconsistently responds to sounds, etc.)

____
____
____

Are there any other speech, language, learning or hearing problems in your family? If yes, please describe.

____
____
____

READING HISTORY

How does your child feel about reading?

____

Has your child changed schools recently? What was the effect on his reading ability? ____
____

What comments do you get from the school about your child's reading ability? ________
____

At what age did your child begin to recognize letters by sight?________________

At what age did your child begin to identify the sounds of letters? ____________

Does your child like to read to himself?________________________________

How do you rate your child's reading problem(s)? Mild, Moderate, or Severe
___________________ Does not know letters and sounds
___________________ Cannot decode words (sound-out word)
___________________ Poor comprehension of what he/she reads
___________________ Inattentive to instruction
___________________ Inadequate reading vocabulary

How often do you read to your child?
___________ frequently ___________ often
___________ occasionally _________ seldom

Does your child reverse numbers or letters when reading or writing?___________

Does your child learn best by seeing _________ hearing_________doing_______

EDUCATIONAL INFORMATION
Name of
School(PreSchool)____

Address:____

Principal's Name:

____

Teacher's Name:

____

Grade:____________

Has he/she ever failed a grade? ________________
Which grade(s)?__________________________________

Does he/she excel in any subjects?______________________________

Does he/she have any serious difficulty in any subjects?________________

How does he/she feel about school and his/her teachers?

____

Has he/she ever had any psychological tests? ________ When ____________
Where: ______________________________________
By Whom: ____________________________________
Were the results interpreted to
you?____

____

Have any other speech-language specialists or audiologists seen your child? Who and when? What were their conclusions or suggestions?

____

____

____

Have any other specialists (e.g., physicians, psychologists, special education teachers, etc.) seen the child? If yes, indicate the type of specialist, when the child was seen, and the specialist's conclusions or suggestions.

____

____

____

Does the child now receive special services? If yes, where? Describe.

____

____

____

How does your child interact with others (e.g., shy, aggressive, uncooperative, etc.)?

____

If enrolled for special education services, has an Individualized Educational Plan (IEP) been developed? If yes, describe the most important goals as discussed with you. If you have a copy of this IEP, please attach it to this form.

Provide any additional information that might be helpful for providing services to your child.

Please send copies or attach reports, finding, IEPs, etc. that would be helpful in the evaluation and remediation of the client to:

Coordinator, Speech, Language, and Hearing Services
Louisiana Tech University
Department of Speech
P.O. Box 3165
Ruston, LA 71272

Person completing this form____
Relationship to child____
Signed____ Date ____________

Parents please complete this form and return with case history.

Parent's Name:

Child's Name:

Read each item carefully and decide how much you think this child exhibits the following behaviors. Put your check in the box that is true of this child at the present time.

	Not At All	Just a Little	Pretty Much	Very Much
1. Restless in the "squirmy" sense				
2. Demands must be met immediately				
3. Temper outbursts/unpredictable behavior				
4. Distractibility/attention span is a problem.				
5. Disturbs other children				
6. Pouts and sulks				
7. Mood changes quickly and drastically				
8. Restless; always on the go				
9. Excitable, impulsive				
10. Fails to finish things that he starts				

How much of a problem do you think this child has at the present time (compared to others of the same age)?

NONE MINOR MODERATE SEVERE

APPENDIX E

NU-6 Word List 1A

1.	LAUD	26.	LOVE
2.	BOAT	27.	SURE
3.	POOL	28.	KNOCK
4.	NAG	29.	CHOICE
5.	LIMB	30.	HASH
6.	SHOUT	31.	LOT
7.	SUB	32.	RAID
8.	VINE	33.	HURL
9.	DIME	34.	MOON
10.	GOOSE	35.	PAGE
11.	WHIP	36.	YES
12.	TOUGH	37.	REACH
13.	PUFF	38.	KING
14.	KEEN	39.	HOME
15.	DEATH	40.	RAG
16.	SELL	41.	WHICH
17.	TAKE	42.	WEEK
18.	FALL	43.	SIZE
19.	RAISE	44.	MODE
20.	THIRD	45.	BEAN
21.	GAP	46.	TIP
22.	FAT	47.	CHALK
23.	MET	48.	JAIL
24.	JAR	49.	BURN
25.	DOOR	50.	KITE

APPENDIX F

(C) APD Letter

Dear Parent or Guardian: Date

In review of our records, it has come to our attention that it is time to schedule Child's name follow-up auditory processing evaluation. Currently, we are offering free auditory processing follow-up testing ($225.00 value) at Louisiana Tech University Speech and Hearing Center as part of a research study. Your child meets the criteria to be included in this study. To schedule the evaluation, please call Jessica Vaughn at (337) 375-5234.

Dr. Sheryl Shoemaker, Ph.D., Au.D., CCC-A
Director, Louisiana Tech University Speech and Hearing Center
112 Robinson Hall
Ruston, LA 71272
(318) 257-4766

APPENDIX G

Research Participants Needed

Requirements:

- 8-10 years of age
- Normal hearing
- Right-handed
- Normal academic performance

Participants will:

- Receive a free hearing test
- Receive 3 auditory processing tests
- Listen to word lists in various levels of background noise at comfortable listening levels

Time Required:

- 3-4 hours

Please call Jessica Vaughn for more information.
(337) 375-5234
jva005@latech.edu

Purpose of Study:
The purpose of this research study is to determine if children with (C) APD have better word recognition abilities for monosyllabic words under monaural or binaural speech-in-noise conditions. The study will be conducted at Louisiana Tech University.

APPENDIX H

HUMAN SUBJECTS CONSENT FORM

The following is a brief summary of the project in which you are asked to participate. Please read this information before signing the statement below.

TITLE OF PROJECT: Asymmetrical Speech-in-Noise Assessment for Children with

(Central) Auditory Processing Disorders

PURPOSE OF STUDY/PROJECT:

To determine if children with (C) APD have better word recognition abilities for monosyllabic words under monaural or binaural speech-in-noise conditions.

PROCEDURE:

All participants will have normal hearing which will be determined by pure-tone testing. All participants will have normal middle ear function as determined by Tympanometry. All participants must be right handed, have unremarkable otologic and neurologic history, and be native English speakers. Each participant in the (C) APD group must have an initial diagnosis of (C) APD at Louisiana Tech University. The participants that meet the criteria will be included in the study. Each participant will be presented with 15 word lists, right, left, or binaurally, and a SNR will be randomly chosen for each child.

INSTRUMENTS:

A Welch Allen Otoscope will be used to perform Otoscopy. A Grason-Stadler Tympstar Verson 2 Middle-Ear Analyzer will be used to perform Tympanometry. A Grason-Stadler GSI 61 audiometer will be used to perform pure-tone testing. Word lists will be presented to the participants using the GSI 61 audiometer coupled to a Tascam CD-160 CD player. Northwestern NU-6 word lists will be used as the primary stimuli for the study.

RISKS/ALTERNATIVE TREATMENTS: The participant understands that Louisiana Tech is not able to offer financial compensation nor to absorb the costs of medical treatment should you be injured as a result of participating in this research.

BENEFITS/COMPENSATION: None

I, ___________________, attest with my signature that I have read and understood the following description of the study,"Asymmetrical Speech-in-Noise Assessment for Children with (Central) Auditory Processing Disorders", and its purposes and methods. I understand that my participation in this research is strictly voluntary and my participation or refusal to participate in this study will not affect my relationship with Louisiana Tech University or my grades in any way. Further, I understand that I may withdraw at any time or refuse to answer any questions without penalty. Upon completion of the study, I understand that the results will be freely available to me upon request. I understand that the results of my survey will be confidential, accessible only to the principal investigators, myself, or a legally appointed representative. I have not been requested to waive nor do I waive any of my rights related to participating in this study.

_________________________________ _______________

Signature of Participant or Guardian Date

CONTACT INFORMATION: The principal experimenters listed below may be reached to

answer questions about the research, subjects' rights, or related matters.

Researcher: Jessica Vaughn

Director: Sheryl Shoemaker

Email: jva005@latech.edu

Members of the Human Use Committee of Louisiana Tech University may also be contacted if a problem cannot be discussed with the experimenters:

Dr. Les Guice (257-3056) Dr. Mary M. Livingston (257-2292 or 257-4315

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