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Sound pressure levels within the ear canal of iPod users

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SOUND PRESSURE LEVELS WITHIN

THE EAR CANAL OF

iPOD USERS

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ABSTRACT

Portable listening devices, specifically iPods are becoming more and more popular among teens and young adults. According to Apple's quarterly financial results in March 2008, total iPod sales reached close to 152,000,000 since their release in January 2001 (Apple, 2008). Because nearly 15 million individuals suffer from noise induced hearing loss, listening levels of individuals using iPods are of main concern to audiologists. The purpose of this dissertation is to determine (1) average listening levels of males and females, as well as experienced and inexperienced iPod users and (2) if a certain groups of individuals are at more of a risk for hearing loss.

Forty listeners with normal hearing (20 males and 20 females aged 18-25) were asked to set an iPod to their preferred listening level for a predetermined song (called the music stimulus). Then, 8 probe microphone measurements were obtained in a sound treated booth for the music stimulus and a white noise stimulus. Specifically, 4 measurements were obtained for each stimulus (music and noise) to determine the sound pressure levels produced in individuals' ear canal. The results indicated that when listeners set their iPods to their preferred listening levels, sound pressure levels of males and females were similar. Additionally, experienced and inexperienced iPod users listened at similar levels. Furthermore, 7 of the 40 participants listened at levels that could be harmful to their hearing.

APPROVAL FOR SCHOLARLY DISSEMINATION

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TABLE OF CONTENTS

ABSTRACT....................iii

LIST OF FIGURES....................vii

LIST OF TABLES....................viii

ACKNOWLEDGEMENTS....................ix

CHAPTER I: INTRODUCTION....................1

CHAPTER II: REVIEW OF LITERATURE AND STATEMENT OF THE PROBLEM....................3

Review of Literature....................3

iPods....................3

Noise Induced Hearing Loss....................6

Use Patterns and Personal Listening Devices....................7

Effect of Personal Listening Device Use on Hearing Sensitivity....................10

Probe Microphone Systems....................19

The Audioscan Series....................20

Statement of the Problem....................22

CHAPTER III: METHODS AND PROCEDURES....................24

Participants....................24

Qualification Procedures....................25

Probe Microphone Measurements....................27

CHAPTER IV: RESULTS 29

Secondary Analysis 35

CHAPTER V: DISCUSSION 36

APPENDIX A PICTORIAL REPRESENTATION OF iPOD AND ITS EARBUDS 42

APPENDIX B HUMAN SUBJECTS PERMISSION FORM 44

APPENDIX C PARTICIPANT QUESTIONNAIRE 46

APPENDIX D DIRECTIONS FOR CALIBRATION AND PROBE MICROPHONE MEASURES 48

REFERENCES 50

LIST OF TABLES

Table 1: Total Mean Time (and Standard Deviation) of iPod Use in Months, Days, and Hours..........25

LIST OF FIGURES

Figure 1: SPL as a function of frequency for peak averages for music and noise stimuli 5

Figure 2: SPL as a function of frequency for experienced versus inexperienced iPod users for the music stimulus 30

Figure 3: SPL as a function of frequency for experienced versus inexperienced iPod users for the white noise stimulus 31

Figure 4: SPL as a function of frequency for males versus female iPod users for the music stimulus 31

Figure 5: SPL as a function of frequency for males versus female iPod users for the white noise stimulus 32

Figure 6: Peak, average, and valley values for music and white noise 34

Figure 7: Intensity as a function of measurement condition (peak, average, and valley values) for music compared to white noise stimuli 39

Figure 8: Graphic representation of iPod and standard iPod earbuds....................43

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CHAPTER I

INTRODUCTION

Portable listening devices can be described as any portable device that runs on batteries and plays music over an extended period of time. Throughout the years, personal listening devices have become more advanced and have moved from the bulky tape and compact disc (CD) players to smaller mp3 players. Today, the most popular portable listening device is the Apple® iPod. It is estimated that over 50% of all portable listening devices owned in the United States are iPods (Apple, 2007). In fact, according to Apple's quarterly financial results from March 2008, total iPod sales reached 152 million since their release over 6 years ago (Apple, 2008).

An iPod is a portable, digital media player that allows users to listen to music, watch music videos and television shows, look at photos, and play games. In addition, the iPod can be used as a personal address book, calendar and telephone. The iPod can hold from 250 - 20,000 songs depending on the size of the memory, and the battery can last up to 20 hours (Serwer, 2005; Kahney, 2005). For these reasons, iPods are becoming more popular than CD players, tape players, and other portable listening devices on the market today.

Research has shown that listening to personal listening devices at elevated levels or for lengthy amounts of time may cause damage to individuals' hearing (Catalano and Levin, 1985; Hellstrom and Axelson, 1988; Airo, Pekkarinen, and Olkinuora, 1996; Mostafapour, Lahargoue, and Gates, 1998). For example, Catalano and Levin (1985) found both males and females to be at risk for noise-induced hearing loss (NIHL) when using personal listening devices. Williams (2005) also found that males listen to their personal listening devices louder than females and that the average sound pressure levels (SPL) ranged from 73.7 dB to 110.2 dB, which may be harmful to an individual's hearing. In addition, Hellstrom and Axelson (1988) indicated that listening to music at a person's most comfortable level for an hour has the ability to cause a temporary threshold shift (TTS) and/or hearing impairment.

To date, no known data has been collected to investigate sound SPLs of iPod/mp3 players at preferred listening levels. Therefore, the purpose of this study is to measure SPLs in the ear canal of iPod users at their preferred listening level with the Audioscan® RM500SL. The following research questions were addressed:

1. What are the preferred listening levels (in SPL) of the following groups of listeners while using an iPod
    a. males and females, and
    b. experienced and inexperienced iPod users; and
2. Are the SPL differences within the ear canals of listeners in the above two groups significantly different than one another when listening at their preferred listening levels?

CHAPTER II

REVIEW OF LITERATURE AND STATEMENT OF THE PROBLEM

Review of Literature

In this review of literature, especially in the sections on "iPods" and the "Effects of Personal Listening Device use on Hearing Sensitivity," I worked closely with my classmate and colleague, Ahmad Brandelle Alexander. During the process of literature review and assembling our joint findings, we shared both our research and writing. Similarities between these sections of our dissertations should be noted and understood as by us as intentional. Since our basic research subject matter was similar, we worked together closely on our final texts to draw comparisons, and make fundamental distinctions.

iPods

In 2001, the computer based software company, Apple, introduced a new portable listening device called the iPod (see Appendix A for pictorial representation of the iPods and its earbuds). The iPod is a digital, portable media player that can store between 250 and 20,000 songs and operates on a rechargeable battery that lasts up to 20 hours (Serwer, 2005; Kahney, 2005).

The iPod's small size and ability to store a large number of songs makes it desirable to many individuals. It connects directly to any computer via a firewall cable, which allows listeners to transfer songs or videos directly to the device through a free jukebox application called Apple iTunes (Kahney, 2005). In addition to playing music and videos, the iPod works as a notepad (i.e., similar to a palm pilot), calendar, address book database, photo and game center, and can also be used to transfer files the same way as a floppy disc (Darlin, 2006). The iPod has six easy to use controls, which include menu (i.e., a screen that displays the main iPod menu to select functions), a play button, a select button (i.e., to allow for selecting a song), a skip forward button, a skip backward button, and a hold switch. The "hold" switch exists on top of the iPod, and when activated, the iPod's buttons and scroll wheel become unresponsive so that the individual using the iPod cannot change anything on the device. Additionally, iPods typically come with white earbud headphones that match the design of the device. These earbud headphones have the ability to produce an average output peak volume of 97 dB SPL for music and 92.7 dB SPL for white noise (see Figure 1).

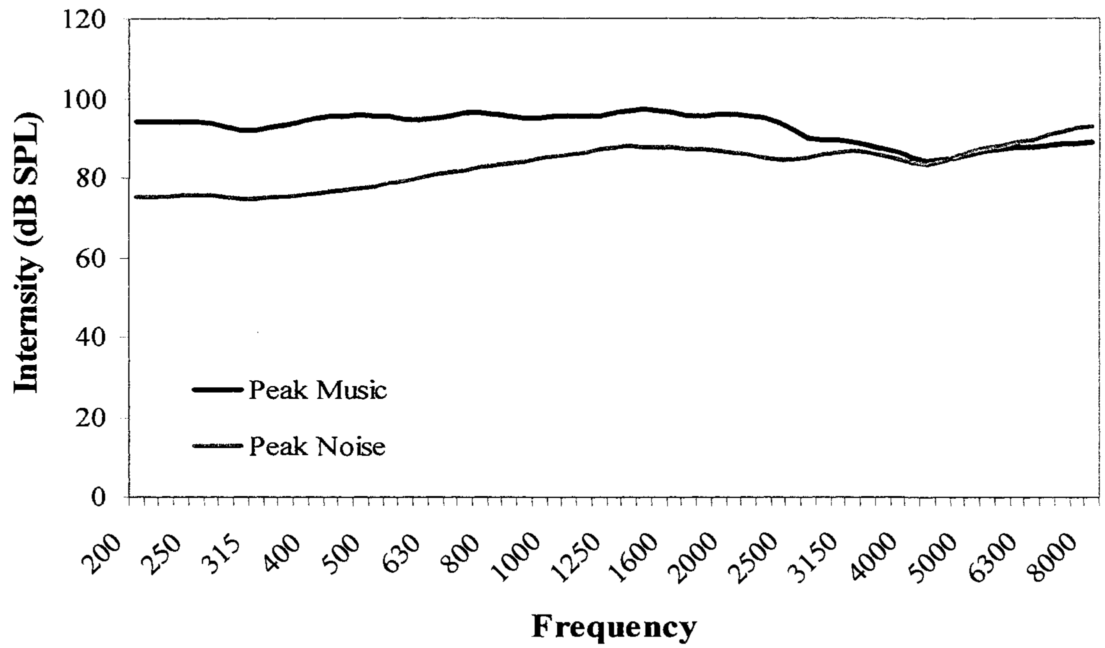

Figure 1: SPL as a function of frequency for peak averages for music and noise stimuli.

Since the introduction of the iPod, the Apple Company has released five generations of devices. All generations vary in device size, hardware size, design, color, and price; however, all generations of iPods have generally the same capabilities. Because of the continuous updates in software, yearly iPod sales have increased from 125,000 in 2001 to over 52 million in 2007 (Apple, 2008). According to Apple's quarterly financial results in March 2008, total iPod sales reached 151,957,000 since their release in January of 2001 (Apple, 2008). On January 21, 2009, Apple posted record revenues of over 10 billion dollars from iPod sales and accessories (Apple, 2009). This was a 7 billion dollar increase from their fiscal report of 3.4 billion at the end of 2006 (Apple, 2009).

Noise Induced Hearing Loss

Hearing loss affects nearly 30 million individuals in the United States. Nearly 15 million of these individuals suffer from hearing loss attributed to noise exposure, and more than 20 million individuals are exposed to hazardous noise levels daily (NIH, 1990). Noise induced hearing loss (NIHL) can be described as any hearing impairment that is a direct result of constant noise exposure, whether it be from occupational, recreational, intermittent or impulse noise (Suter, 2007). According to the Occupational Safety and Health Administration (OSHA), any individual who is exposed to noise levels of 85 dB(A) for eight and a half hours or more in a single day, without hearing protection, is at risk for hearing impairment (OSHA, 2002). As these individuals are exposed to louder noise levels, the amount of time they can spend in noise decreases significantly.

NIHL can occur at any age, from infancy to adulthood, and will vary in degree from mild to severe. It will also have different effects on each individual depending on the duration and the intensity of the noise exposure. A person with NIHL typically begins to lose sensitivity in the higher frequency region at the base of the cochlea, where much of the information that allows us to differentiate between speech sounds is contained (NIH, 1990). Therefore, a loss in this region can reduce patients' ability to distinguish between different speech sounds, as well as cause them to have trouble in background noise or in reverberant rooms. Other common side effects are a decreased dynamic range, decreased sensitivity to sounds, decreased environmental awareness to sounds, difficulty understanding speech, and tinnitus (NIH, 1990).

Different types of NIHL loss could occur from occupational or recreational noise exposure; one type is called an acoustic trauma. An acoustic trauma is a permanent hearing loss occurring from a single, extremely loud event (Suter, 2007). An example of an acoustic trauma is an explosion or gunshot. Depending on the loudness and duration of the trauma, hearing loss can range from a mild to profound loss, as well as perforate the ear drum or disarticulate the middle ear ossicles (Suter, 2007). Another type of hearing loss that can occur from noise exposure is a temporary threshold shift (TTS). A TTS is described as a brief decrease in hearing sensitivity that may occur when an individual is exposed to excessive noise (Suter, 2007). Most TTS last for a brief period of time before hearing is restored to normal. Structural changes associated with a TTS include damage to the outer hair cells in the cochlea and swelling of the auditory nerve endings (NIH, 1990). In more extreme cases, repeated exposure to TTS may gradually cause a more permanent NIHL. This is called a permanent threshold shift (PTS), and occurs when individuals are exposed to very loud noise over longer periods of time (Suter, 2007). With continued exposure to noise, the damaged number of outer hair cells increases significantly, the cochlea becomes more vulnerable noise trauma, and degeneration of the cochlear nerve fibers may occur (NIH, 1990).

NIHL may occur when listening to iPods for a long period of time. Specifically, elevated levels of music can cause TTSs. Over time these temporary shifts in hearing may become permanent shifts, which may adversely affect hearing permanently.

Use Patterns and Personal Listening Devices

The following section describes research regarding listeners' use of personal listening devices. Specifically, patterns of personal cassette players (PCPs) use, patient age, location of use, and leisurely activities are discussed. Generally, the results showed that individuals listen to PCPs at various listening levels, which range from soft to harmful. Furthermore, time of PCP use varied from around 15 to 20 minutes per day to 10 or more hours per day. Results further indicated that PCP use may be dependent on age of the user with younger individuals listening for longer periods of time. Lastly, no shifts in hearing thresholds were noted; however, the authors stated that NIHL is a progressive disorder that many times can only be detected after years of exposure.

First, Wong, Van Hasselt, Tang, and Yiu (1990) examined typical use patterns of personal cassette players (PCPs) in young adults and the effects of PCP use on hearing thresholds. Four hundred and eighty seven individuals, aged 15 to 24 years, were interviewed to determine the duration and frequency of PCP usage, the place of use, the type of music played, and personal and environmental information.

Results of the questionnaire concluded that 73% of PCP users and 81% non-PCP users believed that PCPs could affect their hearing sensitivity. Sixty-five percent of the subjects were female, and 73.7% of all listeners were 15 to 19 years old. Results further indicated that the mean duration of PCP use was 2.8 years with an average listening time of 4.5 hours per week. No significant differences were found between education level, occupation, type of living quarter, and PCP use.

In addition to the questionnaire, hearing thresholds were measured for 103 listeners. Among the 103 individuals, 78 were classified as a PCP user. A PCP user was classified as a listener that uses a PCP three or more days a week for at least six months. Results showed no significant difference in the hearing thresholds of PCP users and non-users. Furthermore, the mean SPLs obtained in the artificial ear at the listener's preferred listening level were 71.2 dB(A) [range = 58.6 – 115 dB(A)] and 69.5 dB(A) [range = 56 – 113 dB(A)] for rock and light music, respectively. The results indicate that the PCP users in this study were exposed to music at low levels for short periods of time, which were not harmful to the listeners' hearing. However, the researches noted that the SPLs obtained in the present study were measured in a quiet environment, and that these levels would be more likely to be detrimental to hearing if measured in a noisy environment. The researchers also noted that NIHL is a progressive disorder that can only be detected after years of exposure; therefore, the experimenters caution that listening to music at elevated levels for extended periods of time can be detrimental to a person's hearing (Wong et al., 1990).

In a similar experiment, Ising, Babisch, and Hanee (1997) investigated the music listening habits of 569 individuals between the ages of 10 and 17 years. The purpose of the study was to measure the music level at which individuals listen to PCPs and determine the average exposure time and intensity levels of PCPs and discotheques. Participants provided their own cassettes, placed them into a predetermined cassette player with earphones, and changed the volume to their preferred listening level. The music was then measured for one minute using a dosimeter. To determine SPLs in the free field, the level of the music heard through PCPs was also measured in an anechoic chamber.

Results of the experiment conclude that 50% of the participants listened to PCPs for less than an hour per day; however, chronic listeners listened between eight and ten hours per day. In addition, 10% of the participants between the ages of 12 and 16 years listened to PCPs at 110 dB(A); however, 17 year olds listened at a lower level.

Researchers indicated that music levels greater than 90 dB(A) could lead to a steady increase in volume level due to TTS. Researchers further indicated that listening to music at levels greater than 90 dB(A) for ten years can lead to approximately 40% of young people having a NIHL.

In summary, PCP users were defined as those individuals who had listened to PCPs at least 3 days per week for a six-month time period. These studies revealed that while some PCP users listened at low levels for short durations, others listened at elevated levels [levels greater than 90 dB(A)] for longer time periods. These listeners were at greater risks for TTS and NIHL.

Effect of Personal Listening Device Use on Hearing Sensitivity

The following section describes potential risks associated ith the use of personal listening devices. The results reveal mixed opinions as to whether personal listening devices cause potential risks to an individuals hearing sensitivity. On one hand, some experimenters have found that individuals using PCPs are at risk for decreased hearing sensitivity, NIHL, tinnitus, and temporary and permanent threshold shifts. Conversely, other experimenters have concluded that individuals are not at risk when using PCPs unless they are listening at elevated levels for extended periods of time.

First, Rice, Breslin, and Roper (1987) measured unobstructed field levels (i.e., continuous A-weighted SPLs) for 61 individuals using PCPs in a two-part experiment. Part 1 included 20 listeners who were asked to adjust the level of two predetermined songs to their preferred listening level using a Sony Walkman PCP in a laboratory setting. Then, 70 dB (A) of traffic noise was added, and the subjects were asked to reset their preferred listening level for each song in the laboratory. Part 2 included 41 individuals who were listening to their PCPs in typical daily listening environments. These individuals were asked if measurements could be made with their personal PCP at the listeners preferred level and at the listeners preferred level using the Sony Walkman PCP. Lastly, all participants were asked to complete a questionnaire detailing an average hours per week they listened to their PCPs. A-weighted SPLs were measured in the following manner: (1) listeners were asked to set the PCPs at their preferred listening levels, (2) PCP were placed on Knowles Manikin for Acoustic Research (KEMAR), and SPL were measured, (3) transfer functions were applied as conversion factors from KEMAR to A-weighted SPLs.

Results of Part 1 of this study showed no A-weighted SPL differences between the two songs when they were set at the listener's preferred listening levels. Results of Part 1 further showed an increase (about 4 dB) when listening in the presence of background noise compared to listening in a quiet environment. Results further showed no correlation between the amount of background noise and user listening level when listeners were evaluated in typical daily listening environments. Lastly, data from all 61 listeners was pooled, and each listener's A-weighted SPL was compared to number of listening hours per week. The results showed that five percent of participants were exposed to volume levels that could be harmful to their hearing [i.e. >90 dB (A)]. These results indicated that the presence of background noise may increase the SPL individuals set their PCPs, independent of the song used. These results further indicated that some listeners may be listening at levels that exceed the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) recommendations, which could be detrimental to hearing.

Secondly, Hellstrom and Axelson (1988) performed a related study on the maximum output (in SPL) of three portable cassette players (the Sony WM-DD, Sony MDR-E282, and the Sony MDR-51) with headphones. White noise, one-third octave band filtered noise, modern pop music, and synthetic music were recorded to determine typical characteristics of portable cassette players (PCP). The SPLs were analyzed using KEMAR and in real ears with mini-microphones. Fifteen normal hearing individuals, age 14 to 23 years, were asked to adjust the level of the music to the highest volume level they considered enjoyable. Probe tube measurements were taken to determine the SPLs in their ear canals for the different types of stimuli. Additionally, ten participants, aged 13 to 20 years, listened to music for one hour at their most comfortable listening level after which the researchers measured TTS. Furthermore, the experimenters also interviewed 154 individuals, aged 14 to 15, to determine listening habits.

Three interesting findings were discovered. Results of the experiment revealed that SPLs varied between the portable cassette players and headphones, with the maximum outputs ranging from 104 dB to 126 dB. First, when the subjects were told to listen at their highest comfortable volume level, mean SPLs corresponded to 112 dB SPL in free field. Additionally, when the individuals were told to take one of the earphones off, they wanted to decrease the volume level significantly. Second, when testing for TTS, four individuals complained of tinnitus after listening to the music. The mean threshold shift was 5 to 10 dB at 1000 Hz and 8000 Hz and the threshold shift recovery time varied from 30 minutes to 30 hours. Third, results of the 154 interviews revealed that most individuals reported used personal listening devices during leisurely activities and holidays, and five percent listened for more that seven hours per week. In addition, the estimated equivalent SPL (i.e., how loud the experimenters expected the participants listen to their PCPs based on their interview answers) varied from 87 to 99 dB with a mean of 92 dB, and 64% of listeners experienced tinnitus after exposure to elevated music levels. The results indicated that different personal listening devices and different earphones have varying SPLs. Also, subjects listening at their highest comfortable level without pain are at risk for hearing impairment. The results further indicated that listening to music at a person's most comfortable level for an hour has the ability to cause a TTS and/or hearing impairment.

Thirdly, Fligor and Cox (2004) investigated the output levels from six different portable CD players to determine if output levels could cause NIHL. In addition, the researchers measured different headphone styles to determine if headphone style influenced output levels of the CD player. KEMAR was used to measure output levels recorded from headphones at different volume settings. White noise and eight different types of music were used to measure the output levels of the devices. White noise was used to measure the output levels because it provided equal energy across the entire frequency spectrum and did not fluctuate like the different genres of music. The white noise and music were played through a CD player with the standard headphone and measured at volume control settings 5 to 10. Next, each CD player was measured at the maximum level (10) with each additional headphone to determine the difference in maximum output.

Results of the experiment revealed that output levels varied among manufacturer and type of headphone used, with the smallest headphone producing the highest output level. The peak SPL was the lowest for classical music (109 dB SPL) and the highest for rock music (139 dB SPL). The results indicate that different types of CD players and headphones produce varying output SPLs. Results further indicate that the maximum output levels produced can propose a significant risk for hearing impairment.

Fourthly, Williams (2005) recently performed a study on the normal everyday listening levels by individuals using personal stereo players (PSP) and the approximate time that these individuals use PSPs. Fifty-five persons aged 15 to 48 years, who were using PSPs at the time, were approached at random on the street and asked to participate in the experiment. Individuals were approached at two different locations that were chosen to represent typical background noise levels. When the individuals agreed to participate, the volume setting of their PSP at that time was measured on a KEMAR fitted with a Zwislocki artificial ear simulator. The participants were then asked to fill out a questionnaire concerning the amount of hours per day of PSP use, years of PSP use, incidence of tinnitus, history of hearing loss, conversational difficulty in background noise, and their occupation.

Results of the experiment revealed that the average SPLs ranged from 73.7 dB to 110.2 dB. Also, personal PSP listening times ranged from 40 minutes to 13 hours per day with the number of years of PSP usage ranging from one month to around 15 years. Results further revealed that males listened to PSPs at a significantly higher level than females (80.6 dB compared to 75.3 dB). There were no significant correlations between hearing loss or tinnitus caused by PSPs. The results indicate that males listen to PSPs at higher intensity levels, but there is not a significant risk to hearing sensitivity from PSP use alone.

Fifthly, Rice, Rossi, and Olina (1987) investigated the possible risks to an individual's hearing from PCPs using data from six sources, three of which were unpublished. The data from the six studies revealed that the majority of individuals using PCP's are younger than 30 years, and that on average, men listen to their PCP's one hour more per week than females. It was also reported that most all of the users were aware that listening to PCP's at elevated levels can cause hearing damage.

Of the 750 plus users that participated in the six studies, 20% described symptoms of tinnitus or of degraded hearing after using their PCP. Additionally, 25% of participants were exposed to their PCP's at levels exceeding 90 dB (A), which is harmful to individuals hearing. The researchers estimate that if the participants in the study keep up their current listening habits, more that six percent will be at a high risk for hearing impairment. They further estimated that about 1 in 1500 individuals (of the entire PCP user population) that listen to music through headphones will also be at risk for hearing impairment. Results of this study indicate that most PCP users are younger than 30 years and many describe symptoms that are consistent with elevated noise levels. These results may be similar to individuals who listen to iPods since the target populations are high school and college students (i.e., younger than 30 years).

In addition, Pugsley, Stuart, Kalinowski, and Armson (1993) investigated the effect of portable stereo system (PSS) use on hearing sensitivity. Thirty individuals with normal hearing sensitivity, normal middle ear function, and no PSS use for one day served as the participants for this study. Immediately after testing, each participant listened to the PSS for one hour at their preferred listening level in a quiet room. The results revealed that, on average, one hour of PSS use at preferred listening levels does not contribute to decreases in hearing sensitivity. The researchers, however, cautioned that although hearing sensitivity was not affected by PSS use in the current study, the following factors could decrease hearing sensitivity in PSS users: the presence of background noise, the style of earphones, the type of PSS device, the type of music stimulus presented, exposure time, and the preferred listening level. These results indicate that one hour of PSS use at the individuals preferred listening level does not cause a significant decrease in an individuals hearing sensitivity.

Seventhly, Airo, Pekkarinen, and Olkinuora (1996) performed a three-part noise exposure assessment on individuals using PCPs with earphones. Fourteen individuals participated in the Part 1 of the experiment. Probe tube measurements were taken on the participants in a quiet environment after listening to four music samples. Results of Part 1 study revealed that the average listening level in quiet was 69 dB SPL and ranged from 52 to 80 dB SPL. Listening levels varied between the four music samples and were also judged to be higher with supra-aural earphones than with semi-aural earphones. Results further indicated that the average listening level in the presence of background noise was 82 dB SPL and ranged from 61 to 104 dB SPL (the mean background noise levels were 65 dB SPL and 73 dB SPL).

In Part 2, probe microphone measurements were taken after listening to music samples in the presence of background noise on three of the original 14 participants. Results concluded that the average listening time was 11 hours per week with an average listening level of 82 dB SPL. The mean exposure level ranged from 55 to 101 dB SPL. Additionally, 50 individuals using PCPs on the street were asked to participate in Part 3 of the experiment. These individuals were asked not to change their volume setting so that measurements could be taken through an acoustic coupler, SPL meter and a calibrated DAT recorder at that time. Additionally, subjects were questioned about PCP exposure time and typical listening situations. Results indicated that individuals listen to music significantly louder in the presence of background noise and may be at risk for hearing impairment at levels that exceed 85 dB SPL.

Eighthly, Catalano and Levin (1985) distributed a questionnaire to 190 college students to determine the mean volume setting at which these individuals listen to music, as well as the number of hours they were exposed to portable radios each week. One hundred and fifty four students, aged 18 to 21 years, qualified and participated in the study. Next, the three most popular walkman radios from the questionnaire (Sony Walkman, Toshiba KT-VS1, and Sanyo M-G1) were used for sound intensity testing. The earphones were coupled to an artificial ear and the song *Flashdance* was played at each volume setting from 1 to 10. The researchers then established their own Auditory Risk Criteria (ARC) with a ten-year exposure to noise. This criterion was based on the American Academy of Ophthalmology and Otolaryngology and the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA) noise recommendations.

Result of this study showed that the mean intensity level for males and females was 97.06 dB(A) [range = 77 to 110 dB(A)] and 94.67 dB(A) [range = 75 to 110 dB(A)], respectively. Additionally, mean exposure time for males was 13.97 hours per week (range = 4 to 75 hours per week), and mean exposure time for females was 8.04 hours per week (range 30 minutes per week to 75 hours per week). In addition, results of the study indicated that approximately 31% of all radio users exceeded the ARC. Results further indicated that 57.8% of the participants were radio users. Of these, 41.2% of male users and 29.2% of females users were found to be at risk for NIHL. No significant difference in intensity level was found between males and females, but the length of exposure was found to be significantly different. Therefore, the difference between the 41.2% for males and 29.2% for females was attributed to exposure time.

In a similar experiment, Turunen-Rise, Flottorp, and Tvete (1991) investigated the effects of PCP use on NIHL. A-weighted equivalent and maximum SPLs for five types of PCPs were measured on KEMAR in an anechoic room. Eleven tapes, containing pop music, classical music, or light classical music, were played at the maximum gain setting (ten) for 15 minutes on KEMAR, and the average output level was recorded. In addition, six individuals with normal hearing were tested while listening to music at the level eight gain setting. TTS were measured for each participant two minutes after listening to two of the pop music cassettes for a total of one hour. Recovery of the TTS was measured after 20, 40, and 120 minutes of listening to the music.

Results of this study showed that the PCPs A-weighted field equivalent SPLs, measured on KEMAR, ranged from 55 to 99 dB(A), depending on the gain setting. Likewise, different types of music also produced different A-weighted equivalent and maximum SPLs when evaluated on the same PCP at the same volume control setting. The pop music with percussion instruments was noted to produce the highest SPL and greatest TTS. No significant SPL differences were measured between the semi-aural and supra-aural headphones on KEMAR. In addition, three individuals reported tinnitus after listening to the music at 95 dB(A).

Based on these results, the researchers concluded that hearing loss is possible from listening to PCPs at extreme levels; however, most PCPs were at low risk for hearing loss due to the fact that these most individuals listen at low intensity levels for short periods of time. Furthermore, it should be noted that music containing percussion instruments may be more damaging to an individual's hearing than music without percussion instruments.

Lastly, Mostafapour, Lahargoue, and Gates (1998) researched the potential dangers of hearing loss associated with personal listening devices and other sources of leisurely noise including: firearms, motorcycles, lawnmowers, chainsaws, and snowmobiles. Fifty college students, aged 18 to 30, who passed a comprehensive audiological examination served as subjects. Subjects were then placed into three groups (low, medium, or high) depending on their preferred listening level.

Results revealed that all subjects also had exposure to personal listening devices for at least one hour per day, with an estimated lifetime exposure of 2394 hours, and an average lifetime exposure to home stereo systems of 4221 hours. Results further revealed that there was not a significant difference in the pure tone thresholds, speech reception thresholds, or word recognition abilities of individuals based on their preferred listening level. These results indicate that individuals using personal listening devices are at low risk for NIHL. In addition, those exposed to random leisurely noise are also at low risk.

Probe Microphone Systems

In the early 1980s, Steen Rasmussen of Denmark developed the first computerized probe microphone system, the Rastronics CCI-10. By 1985, four more computerized models had been developed (Mueller, 2005). Today, some of the most common probe microphone systems are the Med RX Avant® REM/HIT, Fonix® 6500, Madsen IGO-HAT series, Maico System 2400, Madsen Aurical® Plus, and the Audioscan Series which includes the RM500SL® and the Verifit®.

Early probe microphone systems, such as the Rastronics CCI-10 were used to measure the output of hearing aids to ensure that they met ANSI standards. Today's probe microphone systems, however, provide many other services. Specifically, measures obtained from completing probe microphone testing include an estimate of the maximum and reference SPL delivered to a patient's ear. This allows audiologists to make adjustments to patients' hearing aids (while measuring SPLs) so that they can match appropriate targets of recommended amplification. By doing this, the audiologist can ensure that speech and other important environmental sounds are audible, comfortable, and tolerable. In addition, probe microphone systems can also measure the directionality of the hearing aid, the hearing aids telecoil function, the occlusion factor, and how well the hearing aid will reduce background noise (Mueller, 2005). Overall, these systems provide an efficient and objective means of verifying hearing aid fittings before the hearing aid patient leaves the office (Mueller, Hawkins, and Northern, 1992).

The Audioscan Series

Audioscan is a manufacturer that makes a series of probe microphone systems. Their first system, the RM500, was developed in 1988. The RM500 was also the first portable real ear/hearing aid analyzer developed in the world (Mueller et al., 1992). The Audioscan RM500 was similar to the early probe microphone systems which allowed users to verify the calibration of hearing aids (i.e., verify that the hearing aids met ANSI standards) as well as measure the SPLs in the ear canal of hearing aid wears. In 1992, Audioscan introduced Speechmap® to this system. Speechmap used simulated speech sounds to create a map of the amplified speech region within the patient's residual auditory area (RM500: http://www.audioscan.com/webpages/library.htm). This gave audiologists a reliable way to verify the hearing aid fitting using a speech-like signal.

In 2001, Audioscan introduced the Verifit. This was Audioscan's first desktop probe microphone/real ear analyzer. The Verifit enhanced the Speechmap software from the original RM500 and replaced the tones used in previous probe microphone analyzers with digital real speech samples. The Verifit also added in new fitting formulas (i.e. DSL i/o and NAL-NL1), which were designed to be used to measure the function of wide dynamic range compression (WDRC) hearing aids. Furthermore, the Verifit allowed users to make a number of more advanced probe microphone measurements such as: simulate battery drain and usage, test for occlusion, and test the strength of the hearing aids telecoil (Verifit: http://www.audioscan.com/webpages/library.htm). In addition, the Verifit was the first hearing aid analyzer with dual speakers that allowed audiologists to test for directionality of a hearing aid in real time.

Furthermore, Audioscan released the RM500SL in 2005 to replace the RM500. This probe microphone system is very similar to the Verifit except that it is a portable probe microphone device. It can perform almost every measurement as the Verifit with exception the measurement of directionality. This is mainly due to the size of the RM500SL and the fact that it only has one main speaker. The RM500SL is almost half the size of the original RM500 and the Verifit. In addition, both the RM500SL and the

Verifit have target appropriate gain for digital and WDRC hearing aids, something the early RM500 system did not account for (RM500SL: http://www.audioscan.com/ webpages/library.htm).

Statement of the Problem

Hearing loss is one of the most debilitating diseases in the United States today, affecting over 30 million individuals. Of these 30 million, over 10 million have suffered hearing loss from noise exposure (NIH, 1990). As the usage of portable listening devices continues to grow daily, the number of individuals at risk for NIHL also rises. OSHA states that an individual exposed to noise at a level of 85 dB(A) or greater for eight and a half hours or more in a single day is at a great risk for hearing impairment (OSHA, 2002). As individuals are exposed to louder and louder noise levels [over 85 dB(A)], the amount of exposure time before a possible hearing problem occurs decreases substantially.

Everyday there are also more individuals purchasing portable listening devices, specifically iPods. In 2007 alone, Apple sold over 42 million iPods in the United States (Apple, 2008). This is of large concern to audiologists and other hearing professionals because many of the individuals who purchased these devices know little about the effects that loud music can have on their hearing sensitivity. Research has shown that elevated volume levels from personal listening devices can be extremely harmful to an individual's hearing (Rice, Breslin, and Roper, 1987; Catalano and Levin, 1985; Hellstrom and Axelson, 1988; and Suter 2007). Therefore, the purpose of this dissertation is (1) to determine the average listening levels of males and females, as well as experienced and inexperienced iPods users, and (2) to determine if a certain group of individuals are at more of a risk for hearing loss than another group.

CHAPTER III

METHODS AND PROCEDURES

Participants

Forty young adults (20 men and 20 women) with normal hearing sensitivity participated in the study. Participants were recruited from undergraduate and graduate classes in the Department of Speech at Louisiana Tech University (Ruston, LA). The inclusion criteria were as follows: (1) normal hearing (defined as 20 dB HL at all octave frequencies from 250 to 8000 Hz); and (2) age 18 to 25 years (M = 21.500, SD = 1.432, range = 18 to 24 years). Furthermore, the participants were divided into the following two groups: inexperienced iPod users and experienced iPod users. It should be noted that experienced iPod users were defined as listeners who listened to an iPod or other personal listening devices at least three times weekly for at least three months.

Table 1

Total Mean Time (and Standard Deviation) of iPod Use in Months, Days, and Hours.

Listening Length	Inexperienced Users		Experienced Users	
	Mean	SD	Mean	SD
Months	1.789	4.482	14.850	13.600
Days (per week)	0.850	1.268	5.250	1.610
Hours (per week)	0.600	0.771	1.775	1.775

Qualification Procedures

Upon arrival, each participant was given an overview of the experiment and signed an informed consent form (see Appendix B). In addition, the following demographic information was collected for each participant: age, gender, if the participant owns an iPod, number of hours of daily iPod usage, number of days per week of iPod usage, personal preference of the song used for testing, and history of otologic pathology (see Appendix C).

Otoscopy was completed bilaterally on each participant with a Welch Allen otoscope in order to view the ear canal and tympanic membrane. If otoscopy revealed an ear that was not healthy or if there was occluding cerumen, the individual was excluded from the study and appropriate recommendations were made. Following the otoscopic examination, tympanometry was completed bilaterally using a Grason Stadler (GSI)

Tympstar Middle-Ear Analyzer (serial #AL051305). Tympanometry was administered to ensure that each patient had normal middle ear function bilaterally. The criterion for normal tympanometry was as follows: ear canal volume between 0.5 and 2.0 cc, static compliance between 0.3 and 1.7 cc, ambient air pressure between +/-100 daPa.

Pure-tone auditory thresholds were then screened with a clinical audiometer (GSI 61, serial #AA063067) and supra-aural headphones (TDH-50P) in a sound-treated booth (IAC-30; dimensions: 9′4″ by 9′8″) with acceptable ambient noise levels (ANSI, S3. 1-1991). The audiometer was calibrated to the American National Standards Institute (ANSI, S3. 6-1996) standards. Normal hearing was defined as thresholds of 20 dB HL at octave frequencies from 250 to 8000 Hz for each ear. If any threshold exceeded 20 dB HL, the participant was excluded from the study and recommended to the Louisiana Tech Speech and Hearing Center for a complete audiological evaluation.

Each participant then walked outside with the tester on the Louisiana Tech University (Ruston, Louisiana) campus. During this walk, each participant was asked to listen to the song *I Still Remember* by the Bloc Party through a 60 GB Apple iPod (serial #:JQ447CWVRSR). This song was chosen for the following reasons: (1) it contains an upbeat melody; (2) it simulated a real world stimulus, and (3) music is what is commonly listened to on iPods. Each participant was asked to adjust the level of the song to their preferred listening level while walking to Woodard Hall (Note: The entire song was listened to while the participant was outside between Robinson and Woodard Halls). The purpose of the walk was to allow the participant to adjust the iPod volume, in a real world situation, to their preferred listening level. Once the volume level was set, it was locked onto the iPod by activating the "hold" feature on the top to ensure that the volume level could not be manipulated during the experimental testing.

Probe Microphone Measurements

To determine typical SPLs at listener's preferred listening level using an iPod, monaural probe microphone measurements using the Audioscan RM 500SL were conducted for each participant while seated in a sound-treated booth (IAC-30; dimensions: 9′4″ by 9′8″). First, the black marker on the probe tube was measured with a ruler at 30 mm for males and 28 mm for females. The probe tube was then placed in the participant's right ear, with the black marker seated at the intertragal notch. Next, the iPod earbud was placed in each participant's ear. For each participant, the earbud was placed inside the concha bowl between the tragus and anti-tragus. The cord from the earbud extended out of the ear at the intertragal notch. The loudspeaker on the probe microphone system was deactivated, and the song *I Still Remember* was played at the listeners preferred listening level (i.e., the locked volume control setting).

A series of probe microphone measurements were then performed for two different noise types (the song *I Still Remember* and a white noise stimulus). The song was used in the experiment because it had a relatively flat frequency response over the entire course of the song. Additionally, white noise was used in the experiment because it provided a constant stimulus across all frequencies (Note: Prior to testing, a spectral analysis of the song was conducted to ensure that the root mean squared (RMS) of the song and the RMS of the white noise were similar). The following measurements were obtained using the probe microphone system: four 10 second averages for music and four 10 second averages for white noise. Therefore, a total of eight measurements were made for the two conditions (the song *I Still Remember* and the white noise; see Appendix D for specific directions in obtaining probe tube measurements). All probe microphone measurements consisted of 65 data points measured in 1/12th octave steps over a frequency range of 200 to 8000 Hz. Data for output levels recorded at the tympanic membrane were stored in the probe microphone system and downloaded to a personal computer for subsequent data analysis.

CHAPTER IV

RESULTS

One purpose of the present study was to obtain probe microphone measurements at listeners' preferred listening levels while listening to an iPod and the song *I Still Remember* by the band Bloc Party. Individuals set the iPod to their preferred listening level while walking outside. Then, probe microphone measurements were obtained in a sound-treated booth using the Audioscan RM500SL. Four probe tube measures were made while the individual listened to both the music and white noise stimulus for a total of eight probe microphone measures. Each of the eight frequency curves was comprised of 65 data points at 1/12 octave frequencies from 200 to 8000 Hz. These data points were extracted from the Audioscan and placed into a Microsoft Excel file for subsequent data analysis.

As previously stated, four probe microphone measures were obtained for both stimuli (music and white noise), and each probe microphone measurement consisted of 65 data points from 200 to 8000 Hz. Each probe microphone measurement also consisted of three frequency response curves: one representing the peaks of speech (called peak measurement); one representing the average speech signal (called average measurement); and one representing the valleys of speech (called valley measurement). Each data point (i.e., SPL at 200 Hz) on the four frequency curves for the peak, average, and valley measurements were then averaged together so that there was one curve for the peak, average, and valley for music and white noise per individual (i.e., a total of six curves per individual). After each individual's SPLs were averaged into three curves for music (i.e., peak, average, and valley curves) and three for noise (i.e., peak, average, and valley curves), they were assigned to different groups for analysis purposes. The groups were as follows: experienced listeners versus inexperienced listeners and males versus females. The graphs below show the peak, average, and valley frequency response curve for each group and stimuli (music and white noise) (see Figures 2-5). For Figures 2-5, please note that the solid line is the average measurement while the dotted lines are the peaks and valley measurements.

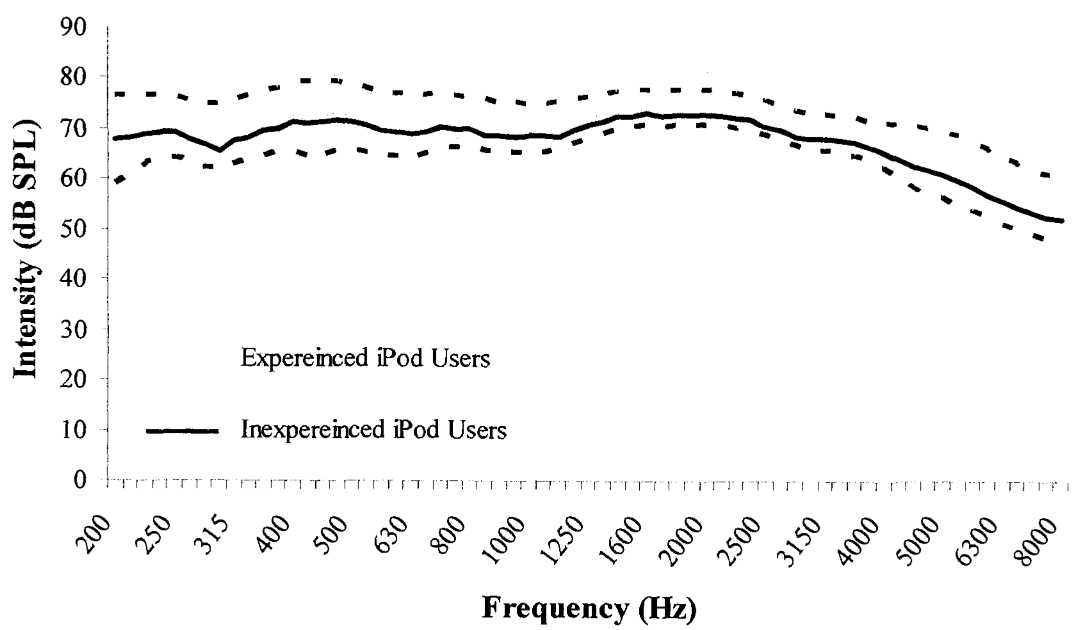

Figure 2: SPL as a function of frequency for experienced versus inexperienced iPod users for the music stimulus.

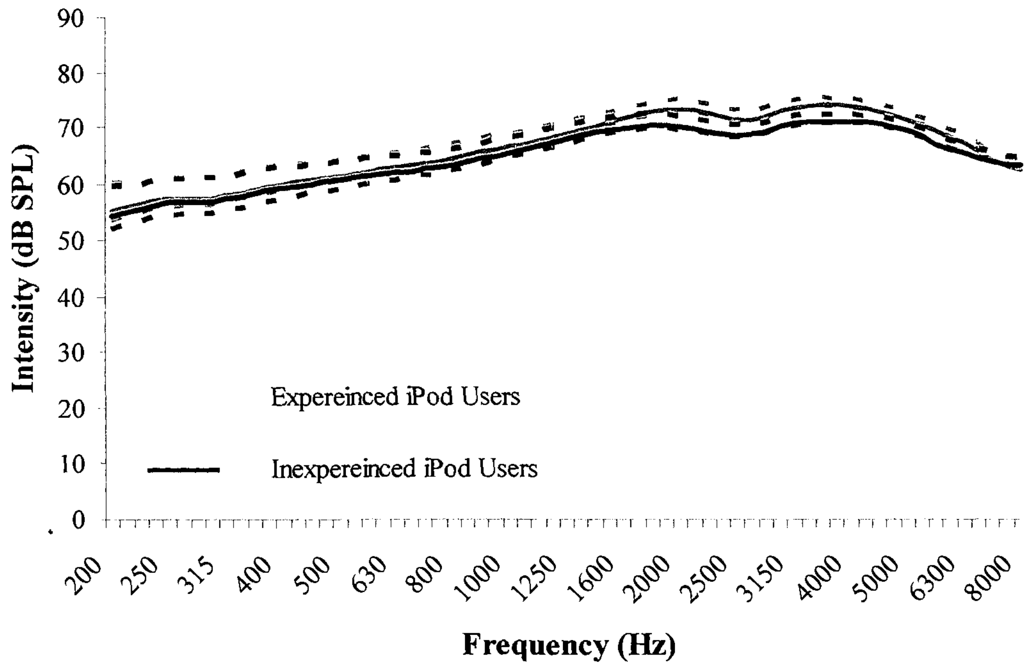

Figure 3: SPL as a function of frequency for experienced versus inexperienced iPod users for the white noise stimulus.

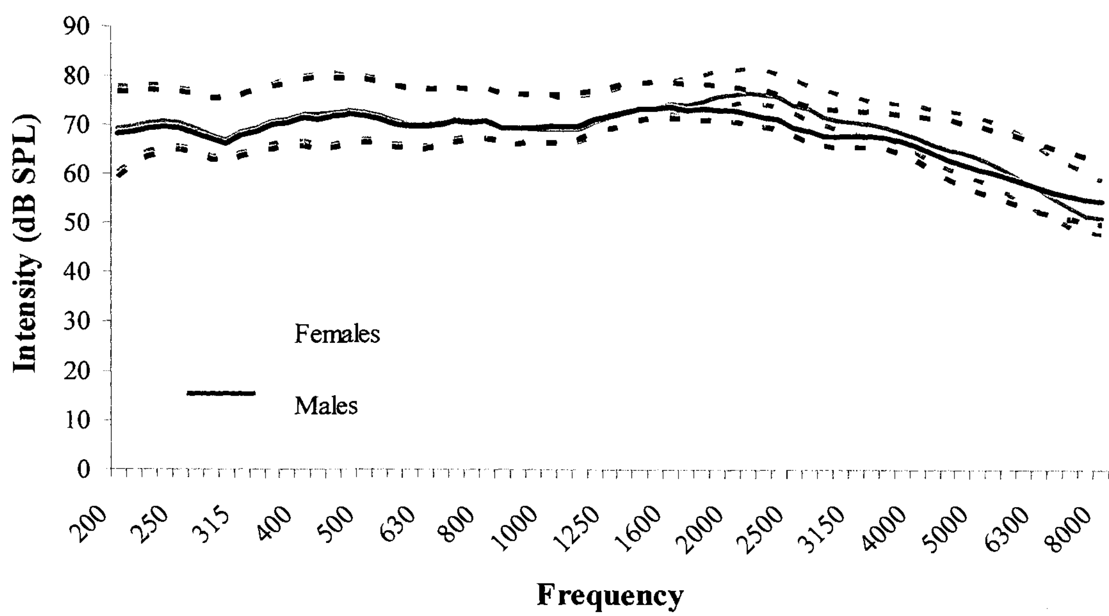

Figure 4: SPL as a function of frequency for males versus female iPod users for the music stimulus.

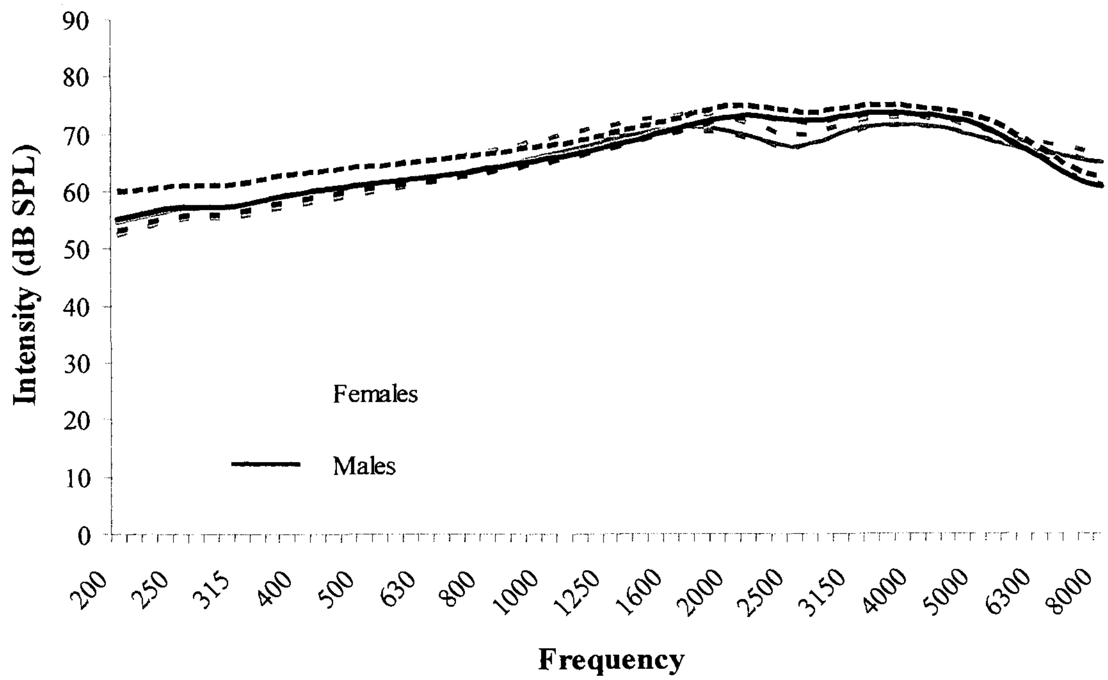

Figure 5: SPL as a function of frequency for males versus female iPod users for the white noise stimulus.

For statistical analysis, data points from the six frequency response curves (i.e. three for white noise and three for music) were averaged so that a single number represented the frequency range between 200 to 8000 Hz for every individual's peak, average, and valley curves. These numbers were then placed into an SPSS file for data analysis purposes. A four-way repeated measures analysis of variance (ANOVA) was performed to evaluate the effects of gender, experience level, stimulus, and measurement condition on SPL values at listeners' preferred listing level. The dependent variable was SPL value. The within-subject factors were stimulus with two levels (music and white noise) and measurement condition with three levels (peak, average, and valley). The between-subject factors were gender with two levels (male and female) and experience level with two levels (experienced and inexperienced). It should be noted that experienced listeners were defined as those who listened to an iPod or personal listening device at least three days per week for more than six months. The analysis revealed significant main effects for stimulus ($F_{1,36} = 162.745$, $p < 0.001$), measurement condition ($F_{1,35} = 1282.983$, $p < 0.001$), and the stimulus by measurement interaction ($F_{2,35} = 738.956$, $p < 0.001$). Furthermore, post hoc analyses using pairwise comparisons revealed that all measurement conditions were significantly different from one another. Specifically, peak measures (M = 71.397) were significantly larger than average measures (M = 66.892), which were significantly larger than valley measures (M = 64.527). Additionally, secondary analysis of the interaction data revealed that the peak SPL curve for the white noise stimulus decreased more than the peak SPL curve for the music stimulus when compared to the valley and average curves. This is due to the fact that noise is more constant than music (see Figure 6).

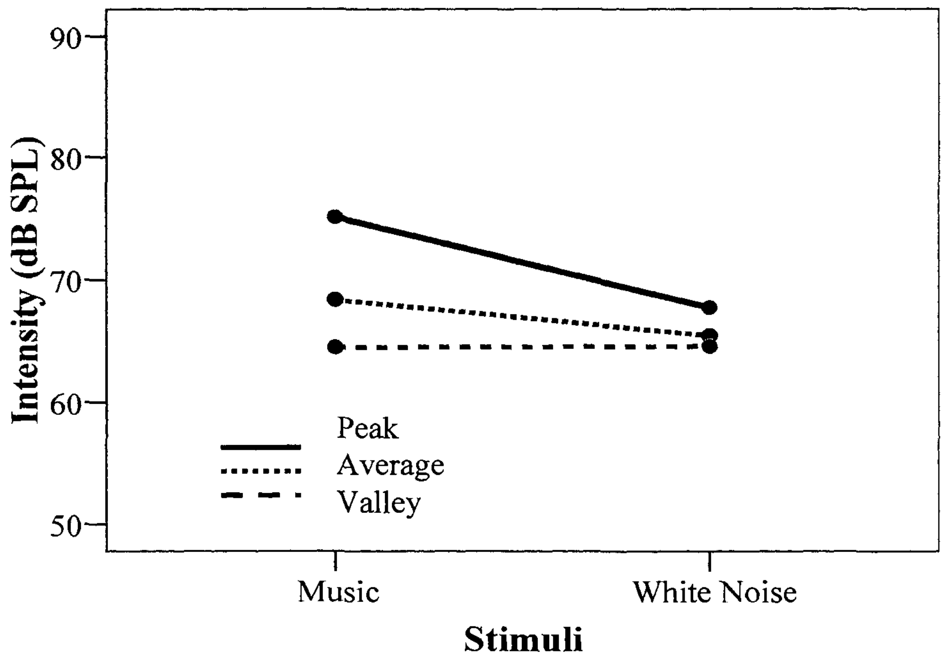

Figure 6: Peak, average, and valley values for music and white noise.

Furthermore, there were no significant main effects for gender ($F_{1.36} = 0.077$, $p = 0.783$), experience level ($F_{1.36} = 0.370$, $p = 0.547$), or for the following interactions: stimuli by gender ($F_{1.36} = 0.510$, $p = 0.480$); stimuli by experience ($F_{1.36} = 0.345$, $p = 0.561$); stimuli by gender by experience ($F_{1.36} = 0.166$, $p = 0.686$); measures by gender ($F_{2.35} = 0.638$, $p = 0.531$); measures by experience ($F_{2.35} = 0.740$, $p = 0.481$); measures by gender by experience ($F_{1.36} = 0.321$, $p = 0.726$); stimuli by measures by gender ($F_{2.35} = 0.031$, $p = 0.969$); stimuli by measures by experience ($F_{2.35} = 0.590$, $p = 0.557$); or stimuli by measures by gender by experience ($F_{2.35} = 0.634$, $p = 0.533$). These results indicate that when individuals set their iPod to their preferred listening level, average SPL values for males ($M = 67.875$) and females ($M = 68.849$) are not significantly different, indicating that both males and females listen to their iPods at similar volume levels. These results further indicate that, on average, experienced listeners ($M = 68.478$) did not listen to their iPods significantly louder than inexperienced listeners (M = 66.733). However, there were SPL average differences between the white noise (M = 65.896) and music (M = 69.314) stimuli, as well as between the three measurement conditions: peak (M = 71.39), average (M = 66.892), and valley (M = 64.527). Specifically, the music stimulus was listened to at louder levels than the white noise stimulus, and the three measurement conditions obtained significantly different SPL values.

Secondary Analysis

Peak data was also observed for each individual for the music and white noise stimuli to possibility determine which individuals, if any, were listening to their iPods at harmful listening levels. The analysis revealed a mean of 82.247 dB SPL (SD = 8.909) for music and a mean of 76.853 dB SPL (SD = 8.206) for white noise. Results further showed that seven individuals listened to music above 90 dB SPL. Of those seven individuals, two listened between 90 and 94.9 dB SPL, four between 95 and 99.9 dB SPL, and one above 105 dB SPL. For noise, there were only two individuals that listened above 90 dB SPL; one individual listened between 90 and 94.9 and one between 95 and 99.5. These results suggest that although, on average, listeners do not listen at levels that are harmful to their hearing based on OSHA standards, some of the peaks of speech may be above the acceptable value of 90 dB SPL.

CHAPTER V

DISCUSSION

The purpose of this study was to measure SPLs in individuals' ear canals (N=40) while they were listening to music and white noise at their preferred listening levels. After each listener set an iPod to their preferred listening level while walking outside, they were seated in a sound treated booth and probe microphone measurements were obtained using the Audioscan RM500SL. Eight frequency response curves (four for music and four for white noise) were obtained from each participant. Furthermore, frequency response curves obtained for the music and white noise included values (i.e., frequency response curves) for the peaks, averages, and valleys of speech. The 4 curves for each noise stimulus (each containing a peak, average, and valley curve) were averaged, so each individual had a total of 6 curves (i.e., three for music and three for noise). The 6 curves were then averaged across the frequency range so that there was a single number representation for each peak, average, and valley curve for music and white noise for all participants. A four-way repeated measures ANOVA was then performed to evaluate the effects of gender, experience level, stimulus, and measurement condition on SPL values at listeners' preferred listing level.

Results of the experiment indicated that the stimuli (i.e., music and noise) were significantly different from one another. Specifically, the mean of the music (M = 69.314) stimulus was higher than the mean for the white noise stimulus (M = 65.896). This most probably occurred for two reasons. One, the music stimulus fluctuated in decibels more than the white noise stimulus. Specifically, variations in the singer's voice, as well as decibel differences in the musical instruments used, caused the SPLs to constantly vary across the frequency range. The white noise stimulus, however, had no fluctuation in frequency or loudness because it consisted of a constant steady state stimulus. Two, the white noise cut out most of the low frequency noise that was present in the music stimulus. Specifically, the three white noise curves varied between 55 – 70 dB from 200 – 1000 Hz whereas the average music curves varied between 60 – 80 dB across the same frequencies.

Secondly, the results revealed a significant difference for measurement condition. Specifically, the SPLs of the peak, average, and valley curves for both stimuli differed from each other. These differences were expected because the measurement conditions were evaluating the peaks, averages, and valleys of speech, and the average dynamic range of speech is approximately 30 dB (Dunn and White, 1940). Therefore, one would expect that the output of the peak (highest SPL) would be significantly louder than the average (mean SPL), which would be significant louder than the valley (lowest SPL) measures.

Thirdly, there was a significant difference for the stimulus by measurement condition interaction. The main reason for this interaction was that the peaks of the music stimuli were constantly louder when compared to the steady state white noise stimulus. This was mainly due to the fact that the singer's voice and the instruments used in the music stimulus constantly varied during the entirety of the song. The white noise, however, did not ous fluctuations as much; it simply measured a constant steady state stimulus with no variability whatsoever throughout the measurement. For this reason, the peaks of the music stimulus were larger that the peaks of the white noise stimulus. Furthermore, average measurements showed a difference between the music and white noise stimuli, with the music again being louder than the white noise. This, again, was due to the overall range in decibels of the music stimulus when compared to the noise. As stated above, the music stimulus had higher decibel fluctuations when compared to the steady state white noise stimulus; therefore, the averages between the two types of noisediffered significantly. However, no significant differences were noted between the valley measurements of the two stimuli. This was due to the fact that the valley curves were measuring the minimum outputs of the stimuli. Although the singer's voice and the instruments used in the music stimulus vary in pitch and intensity, the valleys of the music and noise stimuli were very close to the averages, thus producing no differences between the two valley measurements (see Figure 7 for mean peak, average, and valley measurement for the two stimuli).

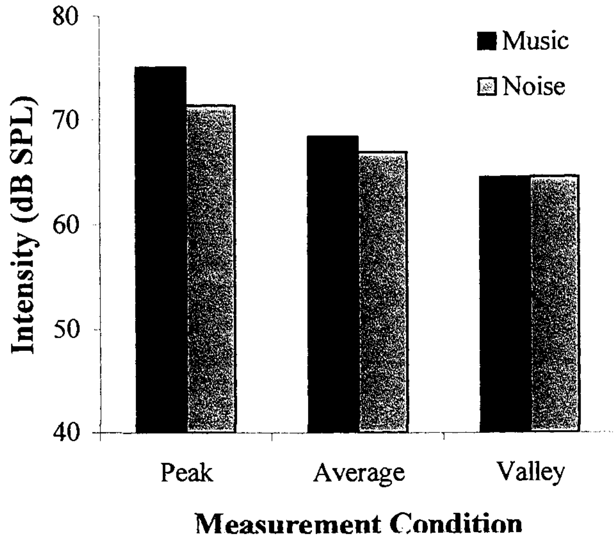

Figure 7: Intensity as a function of measurement condition (peak, average, and valley values) for music compared to white noise stimuli.

Differences between the listening levels of males and females and experienced and inexperienced users were also investigated. The results revealed no significant main effects for gender, indicating males (music: M = 67.875, noise: M = 65.148) and females (music: M = 68.849, noise: M = 65.691) listened to their iPods at similar volume levels. Based on previous research, these results were somewhat expected. Williams (2005) tested participants at their most comfortable listening levels in and out of background noise. Results indicated that males (M = 80.6 dB HL) listened to their personal listening devices much louder the females (M = 75.3 dB HL); however, neither group was at risk for NIHL or TTS. A similar research experiment performed by Catalano and Levin (1985), however, produced different results. Catalano and Levin (1985) concluded that males and females listened to music at similar volume levels; however, males listened to their personal listening devices for longer periods of time than females, possibly putting them at a greater risk for a TTS or NIHL.

Furthermore, average listening levels of experienced (M = 68.478) and inexperienced (M = 66.733) iPod users were not different. It should be noted that experienced users listened to their iPod or personal listening device for approximately 2 hours per day, 5 days per week, and inexperienced users listened for about 0.5 hours per day, 1 day per week. The results indicated that individuals who listen to iPods or other personal listening devices for extended periods of time (i.e., at least three times weekly for more than six months) do not listen to music at levels louder than individuals that do not listen to personal listening devices frequently. These results were expected based on previous research. Wong et al. (1990) examined use patterns of individuals that used PSPs. Their results indicated no SPL differences or hearing threshold differences of PSP users verses nonusers (Wong et al., 1990). Furthermore, research also states that SPLs at preferred listening levels may be related to age (Ising et al., 1997). Ising and colleagues (1997) investigated the music listening habits of individuals between the ages of 10 and 17 years and found that a percentage of younger individuals listened to PCPs at 110 dB(A). In addition, it was noted that 17 year olds listened at lower levels. Consequently, younger individuals have been known to listen to music at louder levels and for longer durations. However, in the present study, preferred listening levels were measured in college-aged students between the ages of 18 to 25 years, and the results showed no difference in preferred listening levels for experienced and inexperienced users. Based on previous research it should, however, be noted that differences may be seen between experienced and inexperienced listeners for younger generations.

Lastly, it was initially hypothesized that most individuals would listen to their iPods at listening levels that could be harmful to their hearing. Results of the present study indicated that, on average, individuals did not listen at levels that were harmful to their hearing. However, seven of the 40 individuals tested listened to their iPods at levels over 90 dB SPL, which may put them at risk for NIHL. Specifically, depending on the length of time that individuals listened to their iPod at these levels, they could experience either temporary changes in their hearing or more permanent changes that could eventually lead to a NIHL. Previous research has been at odds on weather PCPs at preferred listening levels are harmful to an individuals hearing. Turunen-Rise et al. (1991) concluded that there is a possibility that individuals listening to PCPs at elevated levels are at risk for a TTS or NIHL; however, most PCPs users were at low risk for hearing impairment due to the fact that they listened to their devices at low intensity levels for short periods of time. Furthermore, Rice et al. (1987) found that only five percent of the individuals tested were exposed to noise levels above 90 dB(A). Conversely, Hellstrom and Axelson (1988) concluded that listening to music at an individual's most comfortable level for one hour at a time has the ability to cause a TTS and eventually a NIHL. Additionally, Catalano and Levin (1985) findings indicated that both men and women are at high risk for hearing loss when listening to PCPs at their preferred listening level.

In summary, results of the present study indicated that when listeners set their iPod to their preferred listening level, SPLs in the ear canals of males and females were similar. In addition, experienced and inexperienced iPod users also listened to the device at similar listening levels. Seven of the 40 individuals, however, tested in the present experiment listened to their iPod at levels that could be harmful to their hearing. Listening at these levels puts the user at risk for a TTS, PTS, NIHL, and possibly tinnitus.

APPENDIX A

PICTORAL REPRESENTATION OF iPOD AND ITS EARBUDS

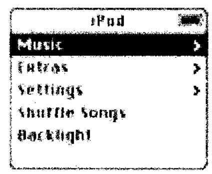

Figure 8: Graphic representation of iPod and standard iPod earbuds.

APPENDIX B

HUMAN SUBJECTS PERMISSION FORM

HUMAN SUBJECTS PERMISSION FORM

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

TITLE: Sound pressure levels within the ear canal of iPod users.

PURPOSE OF STUDY/PROJECT: The purpose of this experiment is to determine sound pressure levels (SPL) in the ear canals of iPod users when the volume is set to the individual's preferred listening level.

PROCEDURES:

Each participant will be asked to listen to a song through a 60 GB Apple iPod. The participant will be instructed to set the volume level to their preferred listening level. After completion of the song, the volume level will be locked into place. Monaural probe microphone measurements (Audioscan RM500SL) will be conducted for the two types of stimuli ("I Still Remember" and white noise) on each participant to determine typical sound pressure levels. Data for output levels recorded at the tympanic membrane will be stored in the probe microphone system and downloaded to a personal computer for subsequent data analysis.

INSTRUMENTS: The subject's identity will not be used in any form in the analysis or representation of the data. Only numerical data such as sound pressure levels in the ear canal will be used in the presentation of the results.

RISKS/ALTERNATIVE TREATMENTS: There are no known risks to subjects. All procedures will be conducted at listeners preferred listening levels.

BENEFITS/COMPENSATION: Each participant will receive a free hearing screening provided by Louisiana Tech Speech and Hearing Center.

I, ______________________________, attest with my signature that I have read and understood the above description of the study, "Sound pressure levels within the ear canal of iPod users," 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 and/or Louisiana Tech Speech and Hearing Center. Furthermore, I understand that I may withdraw from the study 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 will be confidential, accessible only to the project director, principal experimenters, 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 Date

CONTACT INFORMATION: The principal experimenter listed below may be reached to answer questions about the research, subject's rights, or related matters.

Matthew Bryan, Au.D., CCC-A	Department of Speech (318) 257-3102
Melinda Bryan, Ph.D., CCC-A	Department of Speech (318) 257-2146

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	(318)257-4647
Dr. Mary Livingston	(318)257-2292
Nancy Fuller	(318)257-5075

APPENDIX C

PARTICIPANT QUESTIONNAIRE

Participant Questionnaire **DATE:** ___________

Demographics

- Name: ______________________________ Subject #: ____________________

- Gender: M / F

- Birthday: ____________ Age: ________

- Phone Number: ____________ Email: ________________________

- Do you currently own an iPod? YES / NO

- If no, do you use any other kind of personal listening device, such as a portable CD player or an mp3 player (please specify the kind of device)?

____

- How many days per week do you listen to your iPod?

a. one	f. five
b. two	g. six
c. three	h. seven
e. four	i. does not apply

- How many hours per day do you listen to your iPod / mp3 (circle one)?

a. less than one hour	g. six - seven hours
b. one - two hours	h. seven - eight hours
c. two - three hours	i. eight - nine hours
d. three - four hours	j. nine - ten hours
e. four - five hours	k. ten or more hours
f. five - six hours	l. does not apply

- On a scale from 1 - 5, with five (5) being very high preference for the song and one (1) being extreme dislike, rate your preference of the song you listened to.

Circle your rating:

Extreme Dislike	Dislike	Neutral	Prefer	High Preference
1	2	3	4	5

APPENDIX D

DIRECTIONS FOR CALIBRATION AND PROBE MICROPHONE MEASURES

Calibration

1) Hit *Tests* and go to *REM Calibration.* Hold the microphone one meter from the test box. Hit enter button.
2) Calibration curve should be a flat response.

Directions for Probe Tube Measurements on Participants

1) Pre-measure the probe tube and set at 30 mm for men and 28 mm for women. The black indicator should be visible at the intra-trageal notch in the participant's ear
2) Place earbud headphone over probe tube so black marker can still be seen
3) Turn the iPod on with the hold button set so the song is ready to play
4) Power on the Audioscan. Hit *Test* and then hit *Real Ear Measurements-Speechmap*
5) Go to left ear *REAR 1* and hit *Enter*
   - stimulus should be set to live speech
   - start the song
6) Hit *continue* so that the Audioscan averages the music in the left ear for 10 seconds
   - repeat this step three more times: *REAR* 2, *REAR* 3, and *REAR* 4
7) Go to right ear *REAR 1* and hit enter
   - stimulus should still be set to live speech
   - start the white noise
8) Hit *continue* so that the Audioscan averages the white noise for 10 seconds
   - repeat this step four times: *REAR* 1, *REAR* 2, *REAR* 3, and *REAR* 4
9) Dump the data
   - hit *session* and then hit *export data to file on USB stick*
   - hit the enter button to continue

Directions for Probe Tube Measurements on KEMAR

1) Put earphone on the left ear of KEMAR
2) Click Short cut to channel SLM
3) Under "physical channel" select browse
4) Select AI DAL?
5) Sample Rate = 50,000 and the number of samples = 500
6) Weighting should be linear, the low band in 20 Hz and the high band is 20,000 Hz
7) Mode = fast, time count =125
8) Select the box that says "write octave data to file?"
9) Hit play on the iPod
10) Click *start acquisition*
11) When the song is over, hit stop/pause on the iPod
12) Click *stop and close* on the software
13) Name the file using the participants name and click *ok*
14) The file will go into the folder on the desktop named "measures from KEMAR"

The data will be named Session D

1) Highlight the row of frequencies and copy them. Paste into an Excel document
2) Highlight *data* and hit *text to columns*
3) Choose *fixed width* and hit *next* to break the data up into columns.
4) Hit *next* again and then hit *finish*

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