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Influence of Music and Music Preference on Acceptable Noise Levels in Listeners with Normal Hearing

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Abstract

Acceptable noise level (ANL) is defined as the maximum level of background noise that an individual is willing to accept while listening to speech. The type of background noise does not affect ANL results with the possible exception of music. The purpose of this study was to determine if ANL for music was different from ANL for twelve-talker babble and investigate if there was a correlation between ANL for music samples and preference for those music samples. Results demonstrated that ANL for music tended to be better than ANL for twelve-talker babble, indicating listeners were more willing to accept music as a background noise than speech babble. The results further demonstrated that ANL for the music samples were not correlated with preference for the music samples, indicating that ANL for music was not related to music preference. Therefore, music appeared to be processed differently as a background noise than twelve-talker babble.

Key Words: Acceptable noise level, background noise, music, music preference

Abbreviations: ANL = acceptable noise level; BNL = background noise level; MCL = most comfortable level; MS = music sample; SPIN = Speech Perception in Noise test; TTB = twelve-talker babble

Sumario

Un nivel aceptable de ruido (ANL) esta definido como el máximo nivel de ruido de fondo que un individuo esta dispuesto a aceptar mientras escucha el lenguaje. El tipo de ruido de fondo no afecta el ANL, con la posible excepción de la música (Nabelek y col., 1991). El propósito de este estudio fue determinar si el ANL para la música era diferente del ANL ante un balbuceo de doce hablantes, e investigar si existía una correlación entre los ANL para muestras de música, y para la preferencia con respecto a estas muestras de música. Los resultados demostraron que el ANL para la música tendió a ser mejor que el ANL para el balbuceo de doce hablantes, indicando que los sujetos estaban más dispuestos a aceptar la música como ruido de fondo que el lenguaje en balbuceo. Los resultados además demostraron que el ANL para las muestras de música no correlacionaba con la preferencia para las muestras de música, indicando que los ANL para la música no tenía que ver con la preferencia musical. Por lo tanto, la música parece procesarse diferente como ruido de fondo que el balbuceo de doce hablantes.

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Palabras Clave: Nivel aceptable de ruido, ruido de fondo, música, preferencia musical

Abreviaturas: ANL = nivel acceptable de ruido; BNL = nivel de ruido de fondo; MCL = nivel mas confortable; MS = muestra de música; SPIN = Prueba de Percepción del Lenguaje en Ruido; TTB = balbuceo de doce hablantes

Individuals with hearing loss often complain that noise greatly disturbs their ability to hear and understand speech. Researchers have attempted to address this issue with measures of speech understanding in noise (Kalikow et al, 1977; Bilger et al, 1984; Beattie, 1989; Nilsson et al, 1993; Bentler, 2000; Stockley and Green, 2000; Stuart, 2004). These tests have been developed to reflect real-world listening environments using various male and female speakers as the primary signal with different types of background noise (e.g., speech babble and speech spectrum noise). Speech in noise tests are often used pre– and post–hearing aid fitting to show improved word understanding in noise with the use of hearing aids. At this time, there is no evidence that these tests are accurate predictors of hearing aid success.

Nabelek et al (1991) developed a test of background noise acceptance rather than word recognition in noise. These researchers reasoned that willingness to listen to background noise might be a contributing factor to hearing aid success. This procedure was initially described as "tolerated S/N" by Nabelek et al (1991). More recently, researchers have adopted the term "acceptable noise level" (ANL) in order to differentiate this measure from loudness tolerance measurements (e.g., Rogers et al, 2003; Nabelek, Tampas, et al, 2004). In order to measure ANL, a primary stimulus of running discourse was introduced at the listener's most comfortable listening level (MCL). Then, a competing noise was added to the background. The listener was asked to adjust the level of the background noise to the "most noise that you would be willing to put up with and still follow the story for a long period of time without becoming tense or tired." This level was called the "background noise level" (BNL) and was subtracted from the MCL (ANL = MCL - BNL). For the Nabelek et al (1991) study, the primary discourse was an Auditec recording of a female talker, and the secondary stimuli were twelve-talker babble, speech spectrum noise, traffic noise, light music, and a pneumatic drill. Seventy-five listeners participated and were grouped by age, hearing sensitivity, and self-described hearing aid use. The five groups were as follows: young with normal hearing, older with normal hearing, older hearing-impaired full-time hearing aid users, older hearing-impaired part-time hearing aid users, and older hearing-impaired rejectors of hearing aids. Nabelek et al (1991) found that success with hearing aids was related to acceptance of background noise. On average, full-time hearing aid users accepted a background noise level 7.5 dB less than the primary stimulus (ANL = 7.5 dB). The other groups required a greater signal-to-noise ratio, preferring on average a 10 dB difference between signal and noise (ANL =10 dB).

Nabelek et al (1991) additionally evaluated the effect of background noise type on ANL. The mean ANLs for each background noise collapsed across groups were 12.35 dB for twelve-taker babble, 13.03 dB for speech spectrum noise, 10.92 dB for traffic noise, 15.47 dB for music, and 11.83 dB for the pneumatic drill. A significant difference was found only for music. The researchers suggested that the variability of the music sample, the frequency spectrum of the music sample, and/or the listener's preference for the music sample might explain their findings. Nabelek et al (1991) further suggested that the use of music as a background noise in entertainment such as television, radio, or public places might actually reduce a person's willingness to listen to speech.

Since the initial investigation into acceptance of background noise, subsequent research has focused on hearing aid success and has utilized a male primary discourse (Arizona Travelogue) and twelve-talker babble. These researchers have shown that ANL to twelve-talker babble is variable across listeners with an average of about 10 dB (Nabelek, Burchfield, et al, 2004; Nabelek et al, 2006); ANL is not related to age, hearing sensitivity, or the listener's gender (Nabelek et al, 1991; Rogers et al, 2003); ANL is an accurate predictor of hearing aid success (Nabelek, Burchfield, et al, 2004; Nabelek et al, 2006); ANL is stable over a three-month time period and is not related to the speech perception in noise (SPIN) test results (Nabelek, Tampas, et al, 2004).

Music has rarely been the subject of research in hearing science. Researchers have studied the use of hearing aid technology (Franks, 1982; Balfour and Hawkins, 1992) and cochlear implant technology (Gfeller et al, 2000; Leal et al, 2003; Kong et al, 2004) for providing musical enjoyment to the hearing impaired. The majority of music listening research has come from the field of psychology. Researchers have evaluated the effect of music as background noise and have found that it has more complex influences than other types of background noise. Music appears to affect our decisions (North et al, 1997); impede cognitive task performance on the Stroop task (Stroop, 1935), immediate object memory recall tasks, memory for prose, and reading comprehension tasks (Parente, 1976; Furnham and Bradley, 1997; Furnham and Strbac, 2002); and at low levels serves to relax individuals (Staum and Brotons, 2000). These studies have illustrated that music has effects other than that of common background noise (e.g., computer noise, office noise, people talking). Rentfrow and Gosling (2003) found that music preference is influenced by self-views, cognitive ability, and personality.

Studies of music provide evidence of the complexity of our reaction to music as a background noise; however, they provide little information concerning our acceptance of music as a background noise in speech communication. ANL studies have primarily focused on hearing aid success; however, the psychoacoustic aspects of individual acceptance of background noise needs further investigation. As suggested by Nabelek et al (1991), one possible factor in the acceptance of music as a background noise is music preference. Additional factors that may affect ANL measured using music as the background noise include musical attributes such as tempo, familiarity, musical aptitude, personality, and genre. Therefore, the primary goals of this study were to (1) determine if ANLs to twelve-talker babble and music samples differ and (2) determine if ANL for an individual music sample is related to preference for that music sample. It was hypothesized that ANL measurements for the twelve-talker babble would be different than those for music and that ANL for music would be related to music preference. This study will increase our knowledge of music as background noise as it pertains to ANL.

METHODS

Listeners

Twenty-four female adults with normal hearing, ranging in age from 20 to 29 (mean = 23.54 years), participated in the study. Prior to inclusion, participants completed a history form. The criteria for inclusion were as follows: (1) 18–29 years of age; (2) pass audiometric screening (thresholds of 25 dB HL or less at 500, 1000, 2000, and 4000 Hz); (3) native speakers of American English; (4) no history of tinnitus, middle ear problems, neurologic disorder, or speech-language disorder; and (5) not taking central nervous system suppressing medications.

Apparatus and Test Materials

Audiometric screening, ANL to twelve-talker babble, ANL to music, and music preference tasks were completed in an Industrial Acoustics Company double-walled sound-treated room meeting American National Standards Institute specifications for maximum allowable ambient noise levels for audiometric rooms (ANSI [American National Standards Institute], 1991). Audiometric screening results were obtained with an audiometer (Grason-Stadler Incorporated GSI-16) calibrated in accordance with ANSI (1996) specifications for a Type 2 audiometer. Pure tones were presented through TDH 50P earphones mounted in supra-aural cushions.

The primary stimulus for all ANL tasks was the same male running discourse (Arizona Travelogue, Cosmos, Inc.) used previously in other ANL studies (Nabelek, Tampas, et al, 2004; Freyaldenhoven, Nabelek, et al, 2005; Freyaldenhoven, Thelin, et al, 2005). Seven secondary stimuli were used to measure BNL. The secondary stimuli were twelve-talker babble and six music samples (MS) created for the study. The twelve-talker babble was originally recorded for the SPIN test (Kalikow et al, 1977) and later used in the Revised SPIN (R-SPIN) (Bilger et al, 1984). All music sample recordings were developed using compact disc files edited using computer software (Adobe Audition, version 1.5). Due to the relationship between personality and music preference (Rentfrow and Gosling, 2003), music genre was not crossed. The music stimuli were selected from the rock music genre. Research has shown that rock music is moderate in tempo, moderate in lyrical content, and is one of the genres that young adults prefer (Rentfrow and Gosling, 2003; Weisskirch and Murphy, 2004). The body of music samples was created by isolating a 15 sec instrumental portion from various songs recorded on compact disc. Nabelek et al (1991) used a music sample that was 30 sec in length and stated that the short-term variability of the music sample may have influenced their findings. In order to reduce the short-term variability of the music, music samples of 15 sec were utilized. Amplitude values and frequency spectra were digitally analyzed. The six music samples with the most similar frequency spectra to the twelve-talker babble were chosen for the study. The average root-mean square (rms) amplitude value was adjusted so that each music sample had the same average rms amplitude as the twelve-talker babble. Each of the 15 sec instrumental music samples was digitally concatenated to provide a 4 min music stimulus. The musical artist and song title for each of the music samples can be found in Table 1.

Stimuli for the ANL tasks were delivered via a Sony (Model CDP-CD345) compact disc player through a two-channel audiometer (Grason Stadler GSI-16) and a Lifeline speaker. For measures of music preference, experimental tasks were measured using a Hewlett-Packard personal computer with the same audiometer and speaker used in the ANL tasks. The stimuli for the music preference task were the same music samples as used in the ANL procedures. However, only the original 15 sec music samples were used in this portion of the study.

Procedures

All testing was accomplished in one 90 min session. The order of ANL tasks and the music preference tasks were counterbalanced. Each participant was provided verbal and written instructions prior to each experimental task (Appendix A). After completion of both experimental tasks, the participants completed an exit questionnaire regarding their familiarity with the music samples used, their overall enjoyment of the type of music used, and how often they listen to music (Appendix B).

ANL Procedures

ANL procedures for this study were the same procedures used in previous ANL studies (Nabelek et al, 1991; Rogers et al, 2003; Nabelek, Burchfield, et al, 2004; Freyaldenhoven, Nabelek, et al, 2005;

Table 1. Musical Artist and Song Title for Each of the Music Samples

	Musical Artist	Song Title
1	The Flaming Lips	The Spark That Bled
2	Weezer	Say It Ain’t So
3	Rush	Leave That Thing Alone
4	Smashing Pumpkins	Siva
5	The Marshall Tucker Band	This Ol’ Cowboy
6	The Allman Brothers Band	Jessica
7*	Rage Against the Machine	Revolver

*This sample was only used in the music preference-rating task to find a comfortable listening level.

Freyaldenhoven, Thelin, et al, 2005; Nabelek et al, 2006). Participants were seated 1.5 m from the loudspeaker at 0 degrees azimuth. Participants were instructed to signal intensity adjustments of the primary stimulus or background noises by using thumbs-up, thumbs-down, and flat-palm signals. The thumbs-up signal was used to signal an increase in the intensity, thumbs-down to signal a decrease in the intensity, and flat-palm to stop adjustments. Measures of MCL and BNL were obtained in order to calculate ANL.

In order to obtain MCL for each participant, the primary stimulus was presented at 30 dB HL and adjusted in 5 dB steps as indicated by the participant. For each signal by the participant, the signal was adjusted one step by the investigator. Participants were first instructed to adjust the level of the speech to an intensity louder than their MCL, then to an intensity softer than their MCL. Last, the participant was instructed to adjust the level of the stimulus back up to their MCL (i.e., "a level where you would want to listen to the radio"). During this final adjustment, the investigator refined the measurement by decreasing the step size to 2 dB. Once the participant was satisfied with the level of the stimulus, the investigator recorded the intensity of the speech stimulus as the participant's MCL. This MCL was used for all subsequent BNL measures.

In order to measure BNL, the primary stimulus remained at MCL, and the secondary stimulus was added as a competing signal. The secondary stimulus was introduced at 30 dB HL and adjusted in 5 dB HL steps using the same hand signals utilized in the MCL task. Participants were first instructed to adjust the level of the secondary stimulus to an intensity level where the primary stimulus could not be heard clearly, then to an intensity where the primary stimulus could be heard clearly. Last, the participant was instructed to turn the level of the secondary stimulus "back up to the most noise that you would be willing to put up with and still follow the story for a long period of time without becoming tense or tired." During this final adjustment, the step size was reduced to 2 dB. Once the participant was satisfied with this level, the investigator recorded this intensity as the BNL. BNL was measured three times, and the results were averaged. During this procedure all measures were recorded for the twelve-talker babble and the six music samples. All background noise selections were randomized with the use of a table of random digits (De Veaux et al, 2006) to control for order effect. ANL was then calculated with the use of MCL and BNL (ANL = MCL - BNL).

Music Preference Procedures

Listeners rated their preference for each music piece relative to all other musical samples used in the ANL portion of the study. The original 15 sec music samples used to generate the stimulus for the ANL task were used in this portion of the study. From the six music samples, 15 pairs were generated so that each sample was paired with every other sample. Next, the order of the pairing was reversed to generate 15 more pairings. All 30 pairings were performed twice for reliability.

A music sample not used in the experiment was presented through the loudspeaker to the participant and adjusted to their MCL using the same procedure as used in the MCL portion of the ANL task. The 60 music sample pairings were presented at MCL via the loudspeaker. The order of presentation of the pairs was randomized for each participant using ECos/Win Controller for Windows computer software (Avaaz Innovations). The participant was informed that they would hear two music samples, and they were instructed to indicate which of the two they preferred. Each music sample was labeled on the computer screen as icons, 1 or 2, based on the order of presentation. The participant indicated their preference by using the mouse to select the appropriate icon. The participants' responses were recorded by the ECos/Win Controller program. For scoring purposes, the preferred sample received a score of one point, and the unselected sample received a score of zero points. The participant's numerical responses for the music samples were totaled for each sample. For each participant the music ratings were ordered from the music sample or samples with the highest numerical score (most preferred) to the music sample or samples with the lowest numerical score (least preferred).

RESULTS

Reliability of BNL measures for each background noise was evaluated with the use of Pearson product-moment correlations. All correlation coefficients were significant ($p < .001$), and r-values ranged from 0.822 to 0.964, indicating strong reliability of BNL measures. A table of the correlation coefficients for BNL measures can be found in Table 2. The three BNLs for each background noise were averaged for calculation of ANL. The means and standard errors for all background stimuli types are shown in Figure 1.

The assumptions for a one-factor repeated measures analysis of variance (ANOVA) were tested. The Shapiro-Wilk test of normality was not significant for any of the background noises, which indicated normality of the data. Mauchly's test of sphericity was significant ($p = .014$), so the Huynh-Feldt correction factor was utilized for interpreting the ANOVA. The effect of background noise type was assessed with a one-factor repeated measures ANOVA. Results of this ANOVA revealed a significant main effect ($F[6,18] = 9.048$, $p < 0.001$) for background noise type. Since the omnibus ANOVA was significant, post hoc testing was necessary to compare ANLs to twelve-talker babble and each music sample. Results of the one-way ANOVA Bonferroni post hoc comparisons revealed that five of the six music samples were significantly different from the twelve-talker babble; however, MS6 was not significantly different. MS6 was significantly different from music samples 1, 4, and 5. The results of the post hoc comparisons of the twelve-talker babble and each music sample are found in Table 3.

For the music preference task, performance on the first presentation of the 30 music pairings was compared to the second presentation of the same 30 music pairings. A test-retest coefficient of stability was calculated ($r = .74$) and indicated strong reliability of participant performance on this task. For each music sample pairing, the music sample selected by the participant as their most preferred was given one point, and the sample not chosen was given zero points. Points were tallied across participants. The order of music sample preference from most preferred to least preferred was MS6, MS1, MS2, MS3, MS5, and MS4. Participants reported a wide range of number of hours of music per week spent listening to music, 3.5 to 84 hours (mean = 20.63).

In order to compare the possible relationship between ANL and music sample preference, Pearson product-moment correlations were completed between ANL for each music sample and music preference score total for that music sample. Correlation coefficients ranged from -0.325 to 0.015. No significant correlation was found between ANL for

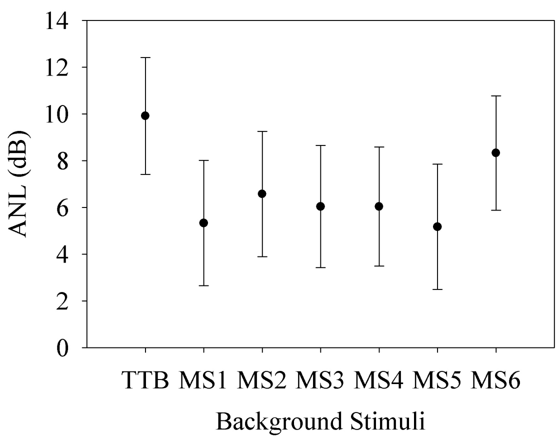

Figure 1. The means and standard errors for ANLs using twelve-talker babble (TTB) and music samples (MS) 1–6.

Table 2. Correlation Coefficients for Background Noise Level (BNL) Measures to Twelve-Talker Babble (TTB) and the Six Music Samples (MS1–MS6)

	BNL 1-BNL 2	BNL 1-BNL 3	BNL2-BNL3
TTB	.897	.861	.913
MS1	.938	.953	.953
MS2	.945	.900	.925
MS3	.934	.919	.961
MS4	.879	.822	.941
MS5	.926	.926	.964
MS6	.862	.856	.871

music and music sample preference. A Pearson product-moment correlation was performed to compare ANL to twelve-talker babble and mean ANL across music samples for each participant. This correlation was significant ($p < .001$) with a correlation coefficient of $r = .872$. The coefficient of determination suggested that the shared variance accounted for was 76% ($r^2 = 0.76$).

Based on ANL to twelve-talker babble, individuals were grouped into a low-ANL group and a high-ANL group, a posteriori. These groups were created in order to examine possible differences between individuals with low ANLs and those with high ANLs. The cutoffs for inclusion in ANL groups were based on the Nabelek, Burchfield, et al (2004) and Nabelek et al (2006) logistic regression curve. Individuals in the low ANL group (n = 6) had ANLs to twelve-talker babble of 6 dB or lower. Individuals in the high ANL group (n = 7) had ANLs to twelve-talker babble of 14 dB or higher. Standard deviations for the two groups were compared. The low ANL group showed consistent variability across background noises. ANL variability was similar between groups for twelve-talker babble. However, variability for ANL to music was greater for the high ANL group. Mean ANL for each background noise and standard deviations for each group are shown in Table 4.

Table 3. One-Way ANOVA Pairwise Comparisons for Twelve-Talker Babble and All Music Samples

Paired Comparisons	p
TTB-MS1	.000*
TTB-MS2	.044*
TTB-MS3	.001*
TTB-MS4	.000*
TTB-MS5	.001*
TTB-MS6	.958

Note: TTB = twelve-talker babble.
*Statistical significance based on Holm's sequential Bonferroni procedure.

DISCUSSION

The mean ANL for twelve-talker babble was 9.92 dB in the present study. This is similar to previous findings for young listeners with normal hearing (Rogers et al, 2003). That study found a mean ANL to twelve-talker babble of 10.9 dB for a similar group of listeners. The results of this study also revealed that ANL to music tended to differ from ANL to twelve-talker babble. The mean ANL for each of the music samples was better than that to twelve-talker babble (Figure 1), illustrating that participants were able to accept music as a background noise at a higher level than twelve-talker babble while listening to speech. An additional purpose of this study was to investigate the relationship of ANL for music and music preference. Because ANL research has shown that a difference might exist between ANL to music and ANL to other types of background noises, and because music and music preference studies indicate that music as a background noise influences listeners differently than other background noises, it was predicted that music preference would influence ANL and that the ANL to music would correlate with music preference. The results of this study showed that music sample preference was not correlated with ANL to the music samples.

As noted previously, ANL to music was better than that to twelve-talker babble in the present study. The mean ANL averaged across all music samples for the young adult listeners was 6.25 dB. In contrast, Nabelek et al (1991) found that ANL to music was

Table 4. Mean ANL and Standard Deviation for Each Background Noise Type by Low ANL (ANL 6 dB or better) and High ANL (ANL 14 dB or worse) Grouping

	Low-ANL Group	High-ANL Group
TTB	1.67 (2.34)	17.29 (1.70)
MS1	-1.67 (3.24)	13.29 (5.79)
MS2	-0.83 (4.26)	13.29 (7.09)
MS3	1.50 (3.32)	12.29 (5.47)
MS4	-1.67 (3.13)	13.57 (4.08)
MS5	-2.00 (4.47)	11.43 (7.11)
MS6	1.17 (3.65)	14.86 (3.08)
Music Mean	-0.58 (3.68)	13.20 (5.44)

Note: TTB = twelve-talker babble.

worse ANL to all other background noises, which indicated that lower intensities of music were accepted while listening to speech than while listening to the other background noises. The young adults with normal hearing in their study had a mean ANL to music of 20.80 dB. The mean ANL collapsed across all age groups with differing hearing sensitivity was 15.47 dB. These differences may indicate that ANL differs across music genre or that ANL to music is affected by musical attributes. The different findings between these two studies may be due, in part, to the different primary stimuli used. The present study utilized the male talker Arizona Travelogue used in more recent ANL studies, whereas the Nabelek et al (1991) study used an Auditec recording of a female talker as the primary discourse. It is possible that music has a greater effect on female primary discourse than male primary discourse. Future research should investigate the effect of music as a background noise with both male and female primary discourse.

The music sample used for the Nabelek et al (1991) study was described as "light music, such as that used in waiting rooms." It was 30 sec in length, and frequency spectral analysis revealed that it had more high-frequency energy than the other background noises used in that study. Nabelek et al (1991) suggested three factors that may have contributed to the ANL difference found between music and other types of noise. These factors were short-term variability of the 30 sec of music, frequency spectra of the music sample, and participant preference for the music sample. Because ANL appears to be mediated at the level of the central processes (Freyaldenhoven, Thelin, et al, 2005; Harkrider and Smith, 2005; Tampas and Harkrider, 2006), it is unlikely that short-term variability and frequency spectra are factors in ANL differences. However, for the present study, efforts were made to control for these factors by reducing the music sample length from 30 sec to 15 sec and by matching the frequency spectra of the music samples to the twelve-talker babble. After controlling for these factors, all six of the music samples resulted in ANLs at lower intensity levels than ANL to twelve-talker babble. Five of the six music samples differed significantly from twelve-talker babble as a background stimulus.

The musical instrument used or the participant's familiarity with the music sample may have influenced the ANL. MS6 was the only music sample including a piano performance and was most familiar to participants. Five participants correctly identified the musical artist for at least one of the music samples. Four participants correctly identified the musical artist for MS6. Two participants identified the musical artist for MS4; however, it was significantly different from the twelve-talker babble. In an effort to examine the effect of familiarity, the participants who identified the musical artists were removed from the data set and an ANOVA was completed. The results of this ANOVA were the same, suggesting that familiarity may not influence ANL to music. The data regarding familiarity was not conclusive since it was not a focus of this study and only five participants were able to correctly identify musical artists.

The results of the present study might have been influenced in part by the selected music samples. The present study attempted to control factors influencing music genre preference by selecting music samples from only one musical genre. The genre selected was rock music because young adults typically like rock music (Weisskirch and Murphy, 2004) and because all rock music is similar in tempo (Rentfrow and Gosling, 2003). While controlling for these factors, limiting the music samples to one genre may have influenced preference selection based on each participant's personal enjoyment of rock music. Since young adults were participants in the present study, it is possible that they are more likely to encounter music as a background noise than the general population. This group may be less distracted by and more accepting of background noise composed of music. Future research should address acceptance of music as background noise across different age groups.

Additionally, the design of the music preference task may have influenced the results of the present study. An individual who enjoys rock music may prefer all samples equally, while an individual who does not like rock music may not prefer any of the samples. These instances would have made it difficult for participants to make a selection based on two samples they either liked or disliked. When asked in the exit interview, "Do you like this type of music?" 8 (33%) participants stated that they did like this type of music, 12 (50%) participants stated that it was "okay," and 4 (17%) said they did not like this type of music. The rationale for utilizing the two-alternative forced-choice music preference task and for selecting music samples was intended to increase internal validity. In actuality this may have created excessive control, possibly influencing the correlation of the ANL to music and music preference results. The only music sample that did not produce significantly different ANLs from twelve-talker babble was MS6. While the present study found no significant relationship between music preference and ANL for music, MS6 was the most preferred music sample across participants. This could indicate that one aspect of ANL may be how much the listener enjoys listening to the background noise. The use of music samples from various genres of music may be necessary in order to fully evaluate the relationship of music preference and ANL to music. Additionally, the use of a rating scale or standardized music genre preference form may be more representative of a participant's musical preference than the two-alternative forced choice.

As noted previously, mean ANLs for music tend to be lower than those for twelve-talker babble. However, it should be noted that the correlation between ANL to twelve-talker babble and average ANL across music samples is significant. This indicates that individuals with low ANLs for twelve-talker babble will tend to have low ANLs for music, and those individuals with high ANLs for twelve-talker babble will tend to have high ANLs for music. Background noise type may affect ANL results, but the trend appears to remain the same, at least for twelve-talker babble and music. This suggests that while the noise background type may change the measured ANL, it may not alter the accuracy of hearing aid success predictions.

In order to compare possible differences between individuals with low ANLs and those with high ANLs, two groups were formed based on their ANL to twelve-talker babble. Individuals in the low-ANL group had ANLs of 6 dB or lower ($n = 6$), and the high-ANL group had ANLs of 14 dB or higher ($n = 7$). The low-ANL group had a mean ANL to twelve-talker babble of 1.67 dB with a standard deviation of 2.34 dB. The high-ANL group had a mean ANL to twelve-talker babble of 17 dB with a standard deviation of 1.7. The low-ANL group had a mean ANL across all music samples of -0.58 dB with a standard deviation of 3.68 dB. The high-ANL group had a mean ANL across all music samples of 13.2 dB with a standard deviation of 5.44. For ANL to twelve-talker babble, the standard deviations indicated that the variability in the two groups was similar. However, for ANL to music, the low-ANL group had much lower variability than the high-ANL group. This might indicate that individuals with high ANLs to twelve-talker babble respond differently to music as a background noise. In order to evaluate these results, characteristics of individuals with high ANLs and those with low ANLs should be further evaluated in future studies.

It appears that there are other factors that may play a role in the differing acceptance of music as a background noise while listening to speech as compared to twelve-talker babble. These factors possibly include musical attributes or an individual's attributes. The musical attributes that may affect ANL to music might include tempo, instrumental composition, and instrumental versus lyrical content. An individual's attributes might include musical aptitude, familiarity with the music, and aspects of personality. Cognitively the two different signals (speech and music) might be easier to process simultaneously than simultaneous speech signals. This may be related to auditory stream segregation (Bregman, 2001). Auditory signals of dissimilar timbre are easier to segregate than those of similar timbre. Since music is often present as a background noise, it might be that we are more able to process music as a background noise. Music is an intelligible background signal while twelve-talker babble is not. Further studies should address the questions that remain regarding music as a background noise. These studies may provide us with greater knowledge of music as a background noise and its influences on a person's willingness to listen.

In summary, the findings of this study revealed that overall ANL to music is smaller than ANL to twelve-talker babble. The ANL for each music sample does not appear to be related to preference for that music sample. The later result may be due to the use of a single music genre. Future studies should address ANL to music across various music genres and explore additional factors that may explain an individual's willingness to listen to speech with music as the background noise.

REFERENCES

American National Standards Institute. (1991) *Maximum Ambient Noise Levels for Audiometric Test Room* (ANSI S3. 1-1991). New York: American National Standards Institute.

American National Standards Institute. (1996) *American National Standards Specification for Audiometers* (ANSI S3. 6-1996). New York: American National Standards Institute.

Balfour PB, Hawkins DB. (1992) A comparison of sound quality judgments for monaural and binaural hearing aid processed stimuli. *Ear Hear* 13:331–339.

Beattie RC. (1989) Word recognition functions for the CID W-22 test in multitalker noise for normally hearing and hearing-impaired subjects. *J Speech Hear Disord* 54:20–32.

Bentler RA. (2000) List Equivalency and Test-Retest Reliability of the Speech in Noise Test. *Am J Audiol* 9:84–100.

Bilger RC, Nuetzel JM, Rabinowitz WM, Rzeczkowski C. (1984) Standardization of a test of speech perception in noise. *J Speech Hear Res* 27:32–48.

Bregman AS. (2001) *Auditory Scene Analysis: The Perceptual Organization of Sound.* Cambridge, MA: MIT Press.

De Veaux RD, Velleman PF, Bock DE. (2006) *Intro Stats.* 2nd ed. New York: Pearson Education.

Franks JR. (1982) Judgements of hearing aid processed music. *Ear Hear* 3:18–23.

Freyaldenhoven MC, Nabelek AK, Burchfield SB, Thelin JW. (2005) Acceptable noise level (ANL) as a measure of directional benefit. *J Am Acad Audiol* 15:228–236.

Freyaldenhoven MC, Thelin JW, Plyler PN, Nabelek AK, Burchfield SB. (2005) Effect of stimulant medication on the acceptance of background noise in individuals with attention deficit/hyperactivity disorder. *J Am Acad Audiol* 16:677–686.

Furnham A, Bradley A. (1997) Music while you work: the differential distraction of background music on the cognitive test performance of introverts and extraverts. *Appl Cogn Psychol* 11:445–455.

Furnham A, Strbac L. (2002) Music is as distracting as noise: the differential distraction of background music and noise on the cognitive test performance of introverts and extraverts. *Ergonomics* 45:203–217.

Gfeller K, Christ A, Knutson JF, Witt S, Murray KT, Tyler RS. (2000) Musical backgrounds, listening habits, and aesthetic enjoyment of adult cochlear implant recipients. *J Am Acad Audiol* 7:390–406.

Harkrider AW, Smith SB. (2005) Acceptable noise level, phoneme recognition in noise and measures of auditory efferent activity. *J Am Acad Audiol* 16:530–545.

Kalikow DN, Stevens KN, Elliott LL. (1977) Development of a test of speech intelligibility in noise using sentence materials with controlled word predictability. *J Acoust Soc Am* 61:1337–1351.

Kong YY, Cruz R, Jones JA, Zeng F. (2004) Music perception with temporal cues in acoustic and electric hearing. *Ear Hear* 25:173–185.

Leal MC, Shin YJ, Laborde M, Calmels M, Verges S, Lugardon S, Deguine O, Fraysse B. (2003) Music perception in adult cochlear implant recipients. *Acta Otolaryngol* 123:826–835.

Nabelek AK, Burchfield SB, Tampas JW, Freyaldenhoven MC. (2004) Relationship between acceptance of background noise and hearing aid use. Podium presentation at the 2004 International Hearing Aid Research Conference, Lake Tahoe, CA.

Nabelek AK, Freyaldenhoven MC, Tampas JW, Burchfield SB, Muenchen RA. (2006) Acceptable noise level as a predictor of hearing aid use. *J Am Acad Audiol* 17(9):626–639.

Nabelek AK, Tampas JW, Burchfield SB. (2004) Comparison of speech perception in background noise with acceptance of background in aided and unaided conditions. *J Speech Hear Res* 47:1001–1011.

Nabelek AK, Tucker FM, Letowski TR. (1991) Toleration of background noises: relationship with patterns of hearing aid use by elderly persons. *J Speech Hear Res* 34:679–685.

Nilsson M, Soli SD, Sullivan JA. (1993) Development of the Hearing In Noise Test for the measurement of speech reception thresholds in quiet and in noise. *J Acoust Soc Am* 95:1085–1099.

North AC, Hargreaves DJ, McKendrick J. (1997) In-store music affects produce choice. *Nature* 390:132.

Parente JA. (1976) Music preferences as a factor of music distraction. *Percept Mot Skills* 43:337–338.

Rentfrow PJ, Gosling S. (2003) The do re mi's of everyday life: the structure and personality correlates of music preferences. *J Pers Soc Psychol* 84:1236–1256.

Rogers DS, Harkrider AW, Burchfield SB, Nabelek AK. (2003) The influence of listener's gender on the acceptance of background noise. *J Am Acad Audiol* 14:372–382.

Staum MJ, Brotons M. (2000) The effect of music amplitude on the relaxation response. *J Music Ther* 37:22–39.

Stockley KB, Green WB. (2000) Interlist equivalency of the Northwestern University Auditory Test No. 6 in Quiet and Noise with adult hearing-impaired individuals. *J Am Acad Audiol* 11:91–96.

Stroop JR. (1935) Studies of interference in serial verbal reactions. *J Exp Psychol* 18:643–662.

Stuart A. (2004) An investigation of list equivalency of the Northwestern University Auditory Test No. 6 in interrupted broadband noise. *Am J Audiol* 13:23–28.

Tampas JW, Harkrider AW. (2006) Auditory evoked potentials in females with high and low acceptance of background noise when listening to speech. *J Acoust Soc Am* 119:1548–1561.

Weisskirch RS, Murphy LC. (2004) Friends, porn and punk: sensation seeking in personal relationships, internet activities, and music preference among college students. *Adolescence* 39:189–201.

Appendix A. Instructions for ANL Tasks

Instructions for Establishing Your Most Comfortable Listening Level:

You will listen to a story through a loudspeaker. After a few moments, select the loudness of the story that is most comfortable for you, as if listening to the radio. The thumbs-up and thumbs-down gestures will allow you to make adjustments. First, turn the loudness up until it is too loud and then down until it is too soft. Next, select the loudness level that is most comfortable to you.

Instructions for Establishing Background Noise Level:

You will listen to the same story with background noise of music or several people talking at the same time. After you have listened to this for a few moments, select the level of background noise that is the MOST you would be willing to accept or "put up with" without becoming tense and tired while following the story. First, turn the noise up until it is too loud and then down until the story becomes very clear. Next, adjust the noise (up and down) to the MAXIMUM noise level you would be willing to "put up with" for a long time while following the story.

These instructions were adapted from Nabelek, Tampas, et al (2004).

Appendix B. Exit Questionnaire

1. Did you recognize any of the music samples?

2. If yes, can you name the musical artist and/or song title?

3. Do you like this type of music?

4. How much time (in hours) do you listen to music per week?