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Acceptable Noise Level: Reliability Measures and Comparison to Preference for Background Sounds

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Abstract

The present study (1) assessed the reliability of the acceptable noise level (ANL) measure using speech-spectrum and speech-babble noises as the competing stimuli, and (2) investigated the relationship between ANL and preference for background sounds in 30 young adults with normal hearing sensitivity. Listeners were evaluated during three test sessions approximately one week apart. Results demonstrated that ANLs are highly reliable over short periods of time, independent of the background noise distraction. Mean ANLs, however, were affected by type of background noise distraction, indicating ANLs obtained using different competing stimuli should not be compared directly. Results further demonstrated that participants' ratings of preference for background sound were consistent over time; however, listeners' preference for background sound was not related to their acceptance of background noise (i.e., ANL). This may indicate listeners cannot accurately assess their ability to accept background sounds, at least with the questionnaire used in the present study.

Key Words: Acceptable noise level, preference for background sound/noise, reliability

Abbreviations: ANL = acceptable noise level; BNL = maximum background noise level; MCL = most comfortable level; SBN = speech-babble noise; SSN = speech-spectrum noise; UCA = University of Central Arkansas; UT = University of Tennessee

Sumario

En el presente estudio, 1) se evaluó la confiabilidad del nivel aceptable de ruido (ANL) medido por medio de ruidos dentro de espectro de lenguaje y ruidos de balbuceo, como factor de lenguaje competitivo, y 2) se investigó la relación entre el ANL y la preferencia para ruido de fondo, de 30 adultos jóvenes con sensibilidad auditiva normal. Los sujetos fueron evaluados durante tres sesiones de prueba, con una separación de una semana. Los resultados demostraron que los ANL son altamente confiables durante cortos períodos de tiempo, independientemente de la distracción del ruido de fondo, indicando que los ANL obtenidos usando diferentes estímulos competitivos no deben ser comparados directamente. Los resultados demostraron también que la estimación de los participantes sobre sus preferencias en cuanto al ruido de fondo era consistente en el tiempo; sin embargo, la preferencia de los oyentes en cuanto al ruido de fondo no se relacionaba con su aceptación del ruido de fondo (p.e., ANL). Esto puede indicar que los oyentes no pueden evaluar con exactitud su habilidad para aceptar los ruidos de fondo, al menos con el cuestionario usado en el presente estudio.

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Palabras Clave: Nivel aceptable de ruido, preferencia para sonido/ruido ambiente, confiabilidad

Abreviaturas: ANL = nivel aceptable de ruido; BNL = nivel máximo de ruido ambiente; MCL = nivel más confortable; SBN = ruido lenguaje/balbuceo; SSN = ruido dentro del espectro del lenguaje; UCA = Universidad Central de Arkansas; UT = Universidad de Tennessee

It is well known that speech communication is affected by background sounds. Furthermore, speech understanding is decreased in the presence of background sounds for listeners with normal and impaired hearing; however, the effect is greater for listeners with impaired hearing (e.g., Olsen and Tillman, 1968; Findlay, 1976). Also, hearing aid users have reported difficulty with background sounds as the most critical issue related to hearing aid benefit, satisfaction, and use (Surr et al, 1978; Franks and Beckman, 1985; Kochkin 2002a, 2002b). Therefore, there have been many attempts to predict hearing aid use by measuring the influence of background sounds on speech understanding. Unfortunately, these attempts have resulted in weak correspondence between speech perception in noise scores and measures of hearing aid benefit, satisfaction, and hours of hearing aid use (Rowland et al, 1985; Bentler et al, 1993a, 1993b; Humes et al, 1996; Nabelek et al, 2004).

Nabelek at al (1991) investigated listeners' willingness to listen to speech in the presence of background noise, independent of speech perception ability. They believed that speech perception was not related to an individual's willingness to accept background noise and that acceptance of background noise, measured using acceptable noise levels (ANLs), may give insight into why individuals with hearing impairment are not accepting/wearing their hearing aids. The results demonstrated that individuals who wore hearing aids on a regular basis accepted higher levels of background noise (i.e., had lower ANLs) than those who wore hearing aids on a part-time basis or not at all. These results were the first indication that a relationship between hearing aid use and background noise acceptance might exist.

Acceptance of noise (i.e., ANLs) has been shown to be reliable in listeners with hearing impairment over a three-month time period (Nabelek et al, 2004). Prior to the present study, however, the reliability of ANL in listeners with normal hearing had not been investigated. Therefore, the first purpose of the present study was to determine the reliability of ANLs in a large cohort of adults with normal hearing.

It is well known that background sounds have various effects on an individual's ability to perform tasks in daily listening situations. Research has demonstrated that background sounds can decrease concentration and work efficacy and increase annoyance and psychological distress for some listeners. Furthermore, physiological changes in heart rate and blood pressure may be the results of unwanted background sounds for some listeners (Melnick, 1985; Banbury and Berry, 2005). On the other hand, some individuals find the presence of low-level background sounds soothing. For example, while cooking, cleaning, exercising, or driving, background sounds may be wanted sounds (Clark, 1998). The reason that some individuals prefer and others are bothered by background sounds is unknown.

Saunders et al (2004) reported that hearing aid performance is typically evaluated objectively (e.g., speech understanding in noise) and subjectively (e.g., questionnaires); however, results from these two types of tests are often conflicting. After performing a series of perceptual and performance tasks, Saunders et al (2004) concluded that most reported handicaps consist of a performance-related component and a (mis)perception-related component. Saunders et al contend that these components hold equal weight (Saunders et al, 2004). Therefore, we speculated that an individuals' ANL (i.e., performance component) might be related to his or her preference for background sounds (i.e., perceptual component). Specifically, we hypothesized that individuals who preferred background sound in their environment on a regular basis would have lower ANLs (i.e., accept more background noise on the performance tasks). If this were the case, individuals could predict their own acceptance of background noise ability (i.e., ANL score), or clinicians could predict an ANL score based on a questionnaire completed by the patient. If so, measurement of acceptance of noise may be a unique auditory task because the link between performance on an ANL task and patients' perception of background noise would be similar. Therefore, the second purpose of the present study was to examine the relationship between ANL and personal preference for background sound (Note: A preference questionnaire for background sounds in various daily listening situations was not available; therefore, a self-developed questionnaire assessing preference for background sounds was developed for the purposes of this study).

METHODS

Participants

Thirty adults (15 female and 15 male) served as participants for this study. Specifically, the sample population included 12 females that participated in the Fisher et al (1999) study plus 18 participants who were recruited at a later date. The participants (mean age = 23 years; SD = 1.48; range: 20–25 years) were recruited from two college campuses via posted notices. The inclusion criteria included (1) 18–25 years of age, (2) normal hearing sensitivity (pure-tone hearing thresholds ≤20 decibels hearing level [dB HL] at 0.5, 1, 2, and 4 kHz in each ear), and (3) native English speakers with no known neurological, cognitive, or learning deficits.

Apparatus and Test Materials

Data collected for this study was obtained from two different laboratories. The Fisher et al (1999) data (N = 12) were collected at the University of Tennessee, Knoxville (UT), and the remaining data (N = 18) were collected at the University of Central Arkansas, Conway (UCA). The experimental setup for the two labs was identical; however, different equipment was used (see Figure 1 for experimental setup).

Speech and noise stimuli were delivered via a cassette tape deck (TEAC W-790R [UT]; Pioneer CT-W205R [UCA]) and a compact disc player (Pioneer PD-103 [UT]; GPX Portable Compact Disc Player [UCA]), respectively. The signals were then routed through an audiometer (Grason Stadler 16 [UT]; Grason Stadler 61 [UCA]) into a sound-treated booth (IAC [UT: 1.92 x 1.83 m; UCA: 3 x 2.8 m]) with ambient noise levels appropriate for testing unoccluded ears (ANSI S3.1-1991). The signals were then delivered through one loudspeaker (Grason Stadler [UT and UCA]) located at 0 degrees azimuth approximately 1 m from the listener. The output levels of the speech and noise stimuli were calibrated at the vertex of the listener and were checked periodically throughout the experiment.

Running speech recorded by a female talker (Auditec audio recording) was used as the primary speech stimulus. The talker was reading an excerpt from Henry D. Thoreau's *Walden* (1939). The story was chosen to represent a typical daily listening environment that would be interesting to most adults. Twelve-person multitalker speech-babble noise (Auditec audio recording), which was originally recorded for the Speech Perception in Noise Test (Kalikow et al, 1977) and speech-spectrum noise (generated by the audiometer), were used as the competing stimuli.[1] Speech-spectrum noise was used as a competing stimulus because it is available on most diagnostic audiometers, and speech-babble noise was used because it more closely represents the background noise present in daily listening situations. Both the primary stimulus (a story) and the competing stimuli (speech-babble noise or speech-spectrum noise) were delivered through the same loudspeaker.

Preference for Background Sound Questionnaire

A questionnaire (Appendix 1), which was developed specifically for this study, was used to determine personal preference for background sounds. It contained seven questions, which were designed to determine how often individuals tend to have voluntary background sounds present in their daily

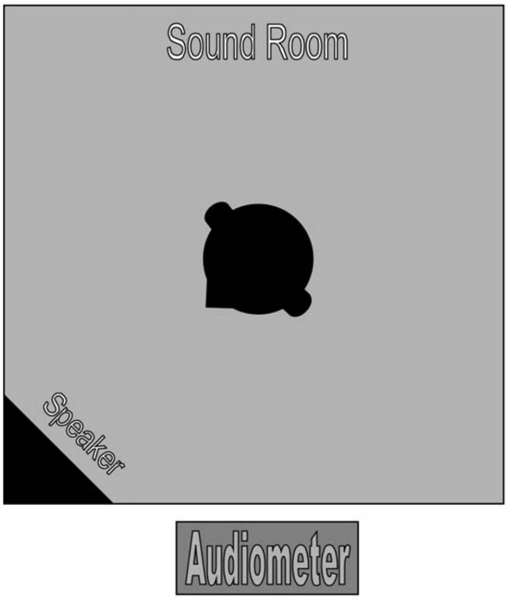

Figure 1. Experimental setup.

listening environments. The listeners were expected to answer the questions as if they had control of the environment. More specifically, if they had a choice, how often would they prefer to have some type of background sound in the environment? The questions focused on the presence of background sound while the listener did specific tasks: reading, sleeping, driving, studying, preparing for a test, and doing chores. These tasks were chosen because they are typical tasks in which college-age students regularly participate. The participants were asked to make judgments based on the following scale: 1 = never, 2 = seldom, 3 = sometimes, 4 = frequently, 5 = always. We expected that listeners who accepted more background sound in their daily listening environments would have lower ANLs.

Procedure

To obtain ANLs, participants were given two handheld buttons, which were used to adjust the intensity level of the story and the competing noise. The buttons were connected to a light display that signaled the examiner to manipulate the intensity of a given stimulus up or down in 1 dB steps. Using a bracketing procedure, the participant first adjusted the level of the story to the most comfortable listening level (MCL). Next, background noise was introduced and the participants adjusted the noise (speech-spectrum or speech-babble) to the maximum acceptable background noise level while listening to and following the words of the story (called "background noise level" or "BNL"). After each trial, the levels of the speech stimulus (e.g., 39 dB HL) and the background noise (e.g., 22 dB HL) were recorded. The ANL was calculated by subtracting the BNL from the MCL (e.g., ANL = 39 dB HL - 22 dB HL = 17 dB) (see Nabelek et al, this issue, for ANL instructions).

Participants were evaluated during three test sessions, each lasting approximately 30 minutes; sessions occurred approximately one week apart. During each test session, the participants completed the preference for background sound questionnaire. In addition, three ANLs were obtained for each background noise type (speech-spectrum and speech-babble noises). Therefore, the participants completed six ANL measures during each test session; thus, a total of 18 ANLs were measured over the three test sessions. An average of the three trials within each test session served as the mean ANL for that session and background noise condition. To account for possible order effects, the presentation of the type of background noise stimulus was counterbalanced between and within subjects.

RESULTS

ANL Test-Retest Reliability

One purpose of the present study was to determine the reliability of ANLs in adults with normal hearing. During each test session (N = 3), the ANL was obtained three times for each background noise type (i.e., speech-spectrum and speech-babble noises). Average ANLs were then determined for each test session and background noise for each participant. Mean ANLs obtained using speech-spectrum and speech-babble noises for each session are shown in Figure 2.

To determine test-retest reliability of ANLs within a session, a single measure intraclass correlation coefficient was calculated for ANLs within each session for each type of background noise. The correlation coefficients are shown in Table 1 and indicate high test-retest reliability of ANL across trials. ANL reliability was further assessed between sessions using single intraclass correlation coefficients. When speech-spectrum noise was the competing stimulus, the correlation coefficient was $r = 0.81$ ($p < 0.001$, CI = 0.71–0.89), and when speech-babble was the competing stimulus, the correlation coefficient was $r = 0.79$ ($p < 0.001$, CI = 0.87–0.96). These coefficients indicate high test-retest reliability

Table 1. Single Measure Correlation Coefficients for Trials within Each Session Obtained Using Speech-Spectrum (SSN) and Speech-Babble Noise (SBN)

Trials Compared	Correlation Coefficient (r)	Confidence Intervals	Significance
Session 1 Trials (SSN)	0.93	0.87–0.96	<0.001
Session 2 Trials (SSN)	0.94	0.89–0.97	<0.001
Session 3 Trials (SSN)	0.96	0.92–0.98	<0.001
Session 1 Trials (SBN)	0.90	0.83–0.95	<0.001
Session 2 Trials (SBN)	0.94	0.90–0.97	<0.001
Session 3 Trials (SBN)	0.97	0.94–0.98	<0.001

for ANLs obtained over a three-week period of time independent of background noise type.

A two-way repeated measures analysis of variance (ANOVA) was performed to evaluate the effects of test session and background noise type on ANL. The dependent variable was ANL. The within-subject factors were test session with three levels (Session 1, Session 2, and Session 3) and background noise with two levels (speech-spectrum noise and speech-babble noise). A significant main effect was observed for background noise type ($F[1,29] = 27.79$, $p < 0.001$). No significant main effects were seen for test session ($F[2,28] = 2.55$, $p = 0.097$) or for the test session by background noise interaction ($F[2,28] = 0.56$, $p = 0.58$). These results indicate that mean ANLs did not change over test session but were affected by the type of background noise distraction. Furthermore, since ANLs did not change over test session, mean ANLs for the three sessions were averaged to obtain one ANL for speech-spectrum noise and one ANL for speech-babble noise (Table 2).

Comparison of individual ANLs obtained with speech-spectrum and speech-babble noises yielded a significant correlation ($r = 0.90$, $p < 0.001$), showing the same ANL trend independent of type of background noise (Figure 3). Specifically, if ANLs were low when obtained with speech-spectrum noise, they were also low when obtained using speech-babble noise. Conversely, if ANLs were high when obtained using speech-spectrum noise, they were also high when obtained using speech-babble noise.

Self-Reported Preference for Background Sound

The second purpose of the present study was to examine the relationship between ANL and personal preference for background sound. Each participant (N = 30) completed the preference for background sound questionnaire a total of three times. Table 3 shows the number of responses that were assigned to each question. To determine if the participants' answers to the questionnaire were consistent, response reliability for each question was assessed using the single measure intraclass correlation coefficient. Table 4 shows that responses for each question were reliable over a three-week period of time, indicating that participants were consistent in the way that they answered the questions from test session to test session.

Since the responses on the questionnaire were reliable across test sessions, the responses for each question were averaged for each participant. The mean score for each question was then correlated with the mean ANLs for speech-spectrum and speech-babble noises. A Bonferroni adjustment was applied for multiple comparisons. No significant correlations were found between any of the preference for background sounds and ANLs measures (Table 5). These results indicate that ANLs are not related to the participants' ability to report preference for background sound using the questionnaire in this study.

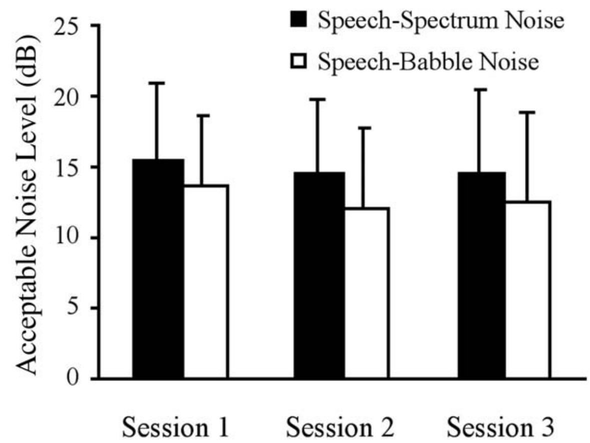

Figure 2. Mean ANLs obtained using speech-spectrum and speech-babble noises over three test sessions.

DISCUSSION

ANL Test-Retest Reliability

Previous research has shown that ANLs are reliable in listeners with impaired hearing and consistent over time for at least three months (Nabelek et al, 2004). Numerous

Table 2. Overall Means, Standard Deviations (SD), and Ranges for ANLs (in dB) Obtained Using Speech-Spectrum and Speech-Babble Noises

	Acceptable Noise Levels (dB)	
	Speech-Spectrum Noise	Speech-Babble Noise
Mean	15.0	12.9
SD	5.0	5.2
Range	8–24	4–24

Table 3. Number of Responses and Mean Response for Each Question on the Preference for Background Sound Questionnaire

Question	Never	Seldom	Sometimes	Frequently	Always	Responses	Mean
1	0	10	25	26	29	90	3.82
2	43	11	17	15	4	90	2.17
3	0	2	10	29	49	90	4.39
4	44	32	9	5	0	90	1.72
5	36	14	15	5	20	90	2.54
6	49	16	10	12	3	90	1.93
7	0	9	31	49	1	90	3.47

ANL studies have been performed on listeners with normal hearing. These studies have shown that ANLs are not related to gender (Rogers et al, 2003), cochlear responses (Harkrider and Smith, 2005; Tampas and Harkrider, 2006), efferent activity of the medial olivocochlear bundle pathway, or middle ear characteristics (Harkrider and Smith, 2005). Additionally, ANL research in listeners with normal hearing has shown that ANLs systematically increase when speech presentation level increases (Franklin et al, 2006). Furthermore, the amount of increase in ANL as a function of speech presentation level is related to the listener's ANL at MCL. Specifically, the effects are greater in listeners with high ANLs at MCL than in listeners with low ANLs at MCL (Tampas and Harkrider, 2006). Lastly, ANL research in listeners with normal hearing has shown that ANLs in individuals with attention deficit/hyperactivity disorder (ADHD) may be able to be changed with stimulant medications (Freyaldenhoven et al, 2005). ANL reliability has, however, never been investigated in the normal hearing population.

Therefore, one purpose of the present study was to determine the reliability of ANLs in adults with normal hearing. ANLs were highly reliable both within and between test sessions independent of the competing stimuli. These results might have been expected based on data from Nabelek et al (1991) and Nabelek et al (2004), which showed that ANLs are not dependent on hearing status and that ANLs in listeners with hearing impairment are reliable and consistent over a three-month time period. These results suggest that ANLs are reliable for both types of background noise over a three-week time period in listeners with normal hearing.

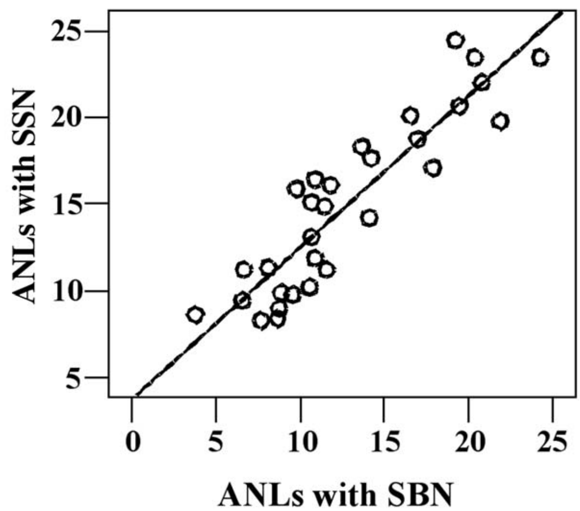

Figure 3. Scatterplot with line of best fit comparing average individual ANLs obtained using speech-spectrum noise to average individual ANLs obtained using speech-babble noise.

Table 4. Single Measure Correlation Coefficients for Each Question on the Preference for Background Sound Questionnaire

Question	Correlation Coefficient (r)	Confidence Interval	Significance
1	0.85	0.75–0.92	<0.001
2	0.93	0.88–0.96	<0.001
3	0.90	0.82–0.96	<0.001
4	0.82	0.70–0.90	<0.001
5	0.95	0.91–0.97	<0.001
6	0.93	0.87–0.96	<0.001
7	0.80	0.66–0.89	<0.001

In addition, mean ANLs across test session were similar, and mean ANLs for the two-background noise types were significantly different. These results suggest that mean ANLs do not change over short periods of time; however, the competing stimulus used does effect ANLs. Specifically, mean ANLs obtained using speech-babble noise were approximately 2 dB lower than mean ANLs obtained using speech-spectrum noise. It should be noted that although the 2 dB ANL difference between background noise types was statistically significant, this difference may not be clinically

Table 5. Coefficients of Correlation, and p Values, between Mean Speech-Spectrum and Speech-Babble Noises and Each Question from the Preference for Background Sound Questionnaire

Question		ANL (Speech-Spectrum Noise)	ANL (Speech-Babble Noise)
1	r	0.161	-0.049
	p	>.999	>.999
2	r	-0.036	-0.140
	p	0.851	>.999
3	r	0.367	0.326
	p	0.322	0.468
4	r	-0.252	-0.338
	p	>.999	0.476
5	r	-0.124	-0.043
	p	>.999	0.823
6	r	-0.136	-0.206
	p	>.999	>.999
7	r	0.044	-0.079
	p	>.999	>.999

significant. If ANLs are measured clinically, they will be measured in at least 2 dB steps to conserve time; therefore, a 2 dB difference in ANL may not be clinically relevant.

Correlation analysis between ANLs obtained with speech-spectrum and speech-babble noises showed a strong, positive correlation. These results suggest that participants who had low ANLs using speech-spectrum noise also had low ANLs using speech-babble noise as the competing stimulus. Therefore, we recommend that, if ANLs are measured clinically, audiologists should remain consistent in the competing stimulus used for given individuals and across individuals. Consistency across individuals is important because one can expect that most clinicians will use their own baseline when performing ANLs to aid in hearing aid fittings. Furthermore, ANLs that are measured with different competing stimuli should not be directly compared.

Self-Reported Preference for Background Sounds

Another purpose of the present study was to examine the relationship between ANL and personal preference for background sound. The purpose of the self-developed questionnaire was to determine if a relationship existed between ANLs and listeners' preference for voluntary background sounds. It was hypothesized that listeners who had low ANLs would tend to prefer background sounds in their daily listening environments (i.e., answer 4 or 5 on the questionnaire in Appendix 1). Results demonstrated that participant responses to the questionnaire were highly consistent over the three test sessions, indicating that listeners are able to consistently report their preference for background sound from week to week. This may indicate that listeners' perception of their ability to accept background sounds is not a good indication of the actual amount of background sounds they are willing to accept, at least measured using the questionnaire in the present study.

Limitations to the Present Study

Two limitations should be noted regarding the relationship of ANL to the preference of background sound questionnaire. First, the questionnaire responses were obtained over a three-week time period; therefore, it is possible that the participants remembered previous answered questions. Longer time periods may decrease the accuracy of self-reported preference for background sounds. Second, the questionnaire used in this study was self-developed to cater to young, college-age listeners with normal hearing. This questionnaire has not been standardized but was used because a questionnaire assessing the amount of background noise individuals typically want/need in their listening environments could not be obtained. Future studies should attempt to use standardized questionnaires that meet the needs of the intended population to determine the relationship between preference for background sound and ANL.

CONCLUSIONS

Results of the present study demonstrated that ANLs obtained using speech-spectrum and speech-babble noises are reliable over short periods of time in young listeners with normal hearing. ANLs are, however, dependent on type of background noise distraction, indicating ANLs obtained using different competing stimuli should not be compared directly. Results also demonstrated that participants' ratings of preference for background sound were consistent over time using the self-developed questionnaire in this study; however, listeners' preference for background sound was not related to their acceptance of background noise (i.e., ANL). This may imply that ANL cannot be determined by simply asking listeners about their preference for background noise.

NOTE

1. A pictorial description of the speech spectra for the female running speech, multitalker babble, and speech-spectrum noise can be found in the Nabelek et al (1991) paper.

REFERENCES

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

Banbury SP, Berry DC. (2005) Office noise and employee concentration: identifying causes of disruption and potential improvements. *Ergonomics* 48:25–37.

Bentler RA, Niebuhr JP, Getta CV, Anderson CV. (1993a) Longitudinal study of hearing aid effectiveness. I: objective measures. *J Speech Hear Res* 36:808–819.

Bentler RA, Niebuhr JP, Getta CV, Anderson CV. (1993b) Longitudinal study of hearing aid effectiveness. II: subjective measures. *J Speech Hear Res* 36:820–831.

Clark WW. (1998) Effects of noise on hearing and communication. In: Tye-Murray N, ed. *Foundations of Aural Rehabilitation*. San Diego, CA: Singular Publishing Group, 327–352.

Findlay RC. (1976) Auditory dysfunction accompanying noise-induced hearing loss. *J Speech Hear Disord* 41:374–380.

Fisher DL (presently Smiley DF), Burchfield S, Nabelek A. (1999) Acceptance of background noise when listening to speech. Unpublished research, University of Tennessee, Knoxville.

Franklin CA, Thelin JW, Nabelek AK, Burchfield SB. (2006) The effect of speech presentation level on acceptance of background noise in listeners with normal hearing. *J Am Acad Audiol* 17(2):141–146.

Franks R, Beckmann N. (1985) Rejection of hearing aids: attitudes of geriatric sample. *Ear Hear* 6:161–166.

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(9):677–686.

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

Humes LE, Halling D, Coughlin M. (1996) Reliability and stability of various hearing-aid outcome measures in a group of elderly hearing-aid wearers. *J Speech Hear Res* 39:923–935.

Kalikow DN, Stevens KN, Elliot 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.

Kochkin S. (2002a) 10-year customer satisfaction trends in the US hearing instrument market. *Hear Rev* 9:14–46.

Kochkin S. (2002b) Consumers rate improvements sought in hearing instruments. *Hear Rev* 9:18–22.

Melnick W. (1985) Industrial Hearing Conservation. In: Katz J, ed. *Handbook of Clinical Audiology*. 3rd ed. Baltimore, MD: Williams and Wilkins.

Nabelek AK, Tampas JW, Burchfield SB. (2004) Comparison of speech perception in background noise with acceptance of background noise 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.

Olsen WO, Tillman TW. (1968) Hearing aids and sensorineural hearing loss. *Ann Otol Rhinol Laryngol* 77:717–727.

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* 14:374–385.

Rowland JP, Dirks DD, Dubno JR, Bell TS. (1985) Comparison of speech recognition-in-noise and subjective communication assessment. *Ear Hear* 6:291–296.

Saunders GH, Forsline A, Fausti SA. (2004) The performance-perceptual test and its relationship to unaided reported handicap. *Ear Hear* 25:117–126.

Surr RK, Schuchmen GI, Montgomery AA. (1978) Factors influencing use of hearing aids. *Arch Otolaryngol* 104:732–736.

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.

Thoreau HD. (1939) *Walden or Life in the Woods*. New York: Heritage Press.

Appendix 1. Self-Reported Background Noise Preferences Questionnaire

Instructions: Please answer the following questions to the best of your ability. The purpose of this questionnaire is to see if there is any relationship between your preferences for background noise and your background noise toleration in the presence of a speech signal. It is very important that you answer these questions as honestly as possible (Note: Verbal instructions were also given to each participant. The verbal instructions stated that the listeners should answer the questions as if they had control of the environment [i.e., if given a choice, how often would the listener prefer to have background sound present when doing the following activities]).

1. How often do you tend to have some type of background noise on when you are doing "chores" (cooking, cleaning, ironing) around the house?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

2. How often do you tend to have some type of background noise on when you are studying?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

3. How often do you tend to have some type of background noise on when you are driving?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

4. How often do you tend to have some type of background noise on when you are reading?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

5. How often do you tend to have some type of background noise on when you are sleeping?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

6. How often do you tend to have some type of background noise on when you are preparing for a test?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always

7. Overall, how often do you tend to have some type of background noise present?

1	2	3	4	5
Never	Seldom	Sometimes	Frequently	Always