Acceptable Noise Level Stability Over a One-Year Period of Time

Melinda F. Bryan[1] Susan Gordon-Hickey[2] Ashton L. Hay[1] Shelby T. Davis[2]

[1] Louisiana Tech University, Ruston, LA
[2] University of South Alabama, Mobile, AL

Address for correspondence Melinda F. Bryan, Department of Communication Disorders, Louisiana Tech University, Ruston, LA 71272 (e-mail: melinda@latech.edu).

J Am Acad Audiol 2020;31:336–341.

Abstract

Background The acceptable noise level (ANL) is a measure of willingness to listen to speech in the presence of background noise and is thought to be related to success with amplification. To date, ANLs have only been assessed over short periods of time, including within a session and over a 3-week and 3-month time period. ANL stability over longer periods of time has not been assessed.

Purpose The purpose was to examine the stability of ANL over a 1-year time period.

Research Design A repeated-measures, longitudinal study was completed.

Study Sample Thirty young adults with normal hearing served as participants. The participants were tested at two different sites.

Data Collection and Analysis Two trials of most comfortable listening levels (MCLs), background noise levels (BNLs), and ANLs were assessed for each participant during three experimental sessions: at 0 months, 6 months, and 1 year.

Results Two-way repeated-measures analysis of variances revealed no significant change in MCLs, BNLs, or ANLs within a session or over a 1-year time period. These results indicate that ANLs remain stable for 1 year in listeners with normal hearing.

Conclusions The finding that the ANL is stable over a longer period of time supports the theory that the ANL is an inherent trait of the listener and mediated at in the central auditory nervous system.

Keywords
- acceptable noise level
- background noise acceptance
- stability

Introduction

The acceptable noise level (ANL) is a measure of an individual's willingness to listen to speech in the presence of background noise. During ANL assessment, listeners are directed to adjust the level of the background noise to a level that they can "put up with" while following the words of the story (Nabelek et al).[22] The ANL is of interest to the audiology community as it may be a successful predictor of hearing aid success (Nabelek et al;[21,23]). Nabelek et al (2004)[23] demonstrated that listeners who readily accept background noise are more likely to be successful hearing aid users than listeners who do not easily accept background noise.

The ANL is measured by playing a recording of speech at the listener's most comfortable listening level (MCL). While the speech is playing, background noise is added to the signal. The background noise is typically twelve-talker babble or speech noise. The listener is instructed to adjust the level of the background noise using a three-step bracketing procedure with specific instructions. First, the listener is directed to adjust the background noise up to a level at which they can barely hear the speech signal. Next, the listener is directed to adjust the background noise to a level where they can easily hear the speech signal. Last (and most importantly), the listener is instructed to adjust the level of the noise to the maximum amount of background noise that they would be willing to put up with for a long period of time without becoming tensed or tired.

To date, researchers have only identified a few variables that influence a listener's ANL. Research has demonstrated

DOI https://doi.org/10.3766/jaaa.19044.
ISSN 1050-0545.

that the ANL is not related to listener characteristics of age, hearing sensitivity, gender, preference for background noise, loudness discomfort level, speech understanding in noise, or interest in the speech material used for assessment of the ANL (Nabelek et al;[22] Lytle;18 Crowley and Nabelek;[6] Rogers et al;[27] Freyaldenhoven and Smiley;[8] Plyler et al;[25] Bentley and Ou;3 Jones and Moore).[15] Factors associated with the measurement of the ANL such as altered instructions or different stimuli could, however, impact the measurement results. For stimuli, music as a background noise affects the ANL (Nabelek et al;[22] Gordon-Hickey and Moore).[12] Furthermore, Freyaldenhoven et al (2006)[21] reported that ANLs obtained using speech spectrum noise and speech babble were highly correlated but slightly different (2 dB). They suggested that comparison of ANLs should not be carried out if measured to differing types of background sound.

Research indicates that the ANL is mediated in the central nervous system rather than the peripheral auditory system. Harkrider and Smith (2005) found that monotic and dichotic ANLs were highly correlated and that listeners with lower ANLs in the dichotic task were better able to recognize phonemes in noise. These findings suggest that the advantage of binaural processing did not occur, leading the authors to conclude that the ANL is mediated at or above the superior olivary complex as binaural processing first occurs in this location. Harkrider and Tampas (2006) reported click-evoked otoacoustic emissions, auditory brainstem response, and middle latency responses for two groups of listeners, one group with low ANLs and the other with high ANLs. There were no significant differences between groups for click-evoked otoacoustic emissions or latency or amplitude of waves I or III on the auditory brainstem response; however, significant amplitude differences were found for wave V of the auditory brainstem response and Na-Pa of the middle latency response. Listeners with low ANLs had smaller wave V and Na-Pa amplitudes than those with high ANLs. The authors concluded that these findings provide further support that the ANL is mediated centrally and that listeners with lower ANLs likely possess stronger central efferent system function. In another study, Tampas and Harkrider (2006) reported significant differences for peak-to-peak amplitudes of Na-Pa of the middle latency response and P1-N1 and N1-P2 of the late latency response. These findings further support the central origins of ANL. In addition, Freyaldenhoven et al (2005b) evaluated the influence of central stimulant medication on the ANL by testing listeners with attention deficit disorder or attention deficit hyperactivity disorder with and without their medication. Findings revealed improved ANLs for listeners in the medicated condition, supporting the theory that the ANL is mediated centrally.

Nabelek has suggested that the ANL is inherent to the individual and is reliable over time. This is supported by studies evaluating the relationship of personality traits and ANL. Alworth et al (2007) reported that listeners with Type B personalities had lower ANLs than those with other personality types. Nichols and Gordon-Hickey (2012) reported that individuals with higher levels of self-control had lower ANLs than those with lower self-control. These findings support ANLs as an inherent trait to an individual.

ANLs recorded during a session are reliable and repeatable (Nabelek et al;[23] Freyaldenhoven et al;[8] Gordon-Hickey et al;[11] Xia et al).[30] Furthermore, the measurements of MCLs and background noise levels (BNLs) have been found to be reliable (Nabelek et al;[23] Freyaldenhoven and Smiley;[8] Freyaldenhoven et al;[8] Mueller et al;[20] Nabelek et al).[20,21] Interrater reliability of ANLs is strong (Gordon-Hickey et al).[24] In addition, ANLs measured over a 3-week period and a 3-month period are stable; however, no studies have reported stability of ANLs over longer periods of time (Nabelek et al;[23] Freyaldenhoven et al).[8] Therefore, the purpose of the proposed research project was to determine the stability of ANLs over a 1-year time period in young adults with normal hearing. It is possible that ANLs are stable over longer periods of time, thus providing additional evidence that the ANL is an inherent trait of the individual and most likely mediated in the central auditory nervous system. It is also possible that ANLs are not stable over longer periods of time. If this is the case, audiologists should be aware that ANLs will need to be repeated over time.

Methods

Participants

This longitudinal study began with 45 young adults with normal hearing, 30 from Louisiana Tech University (LaTech; Ruston, LA) and 15 from the University of South Alabama (USA; Mobile, AL). The inclusion criteria were as follows: (a) normal hearing sensitivity (i.e., thresholds of 25 dB HL or better bilaterally at 250, 500, 1000, 2000, 4000, and 8000 Hz); (b) no reported neurological, cognitive, or hearing impairments; and (c) no change in medications for psychological abnormalities over the course of the study. Each participant was followed for 1 year. At the end of the study, a complete data set was obtained for 21 adults (age range = 22-28 years) from LaTech and nine adults from the USA (age range = 22-28 years). Thus, a pool of 30 young adults (mean age = 24.8 years, standard deviation [SD] = 4.1) completed the study. Attrition rates of 30% from LaTech and 40% from USA were documented over a 1-year time period. Reasons for attrition were participant relocation, participant disinterest, and medication change during the study.

Materials

Both laboratories (LaTech and USA) were equipped with sound-treated booths that met ANSI standards for acceptable ambient noise levels (ANSI S3.1-2013). The laboratory at LaTech was equipped with a GSI 61 audiometer (Grayson-Stadler, Eden Prairie, MN), and the laboratory at USA was equipped with a Madsen Astera audiometer (GN Otomet- rics, UK). Both were calibrated in accordance with ANSI (ANSI, S3.6-2010) specifications for audiometers. TDH-50 supra-aural headphones were used for hearing screenings. Experimental test stimuli included a commercially available ANL compact disc, routed through the audiometer and presented through a loudspeaker at 0° azimuth. The ANL compact disc included a recording of the *Arizona Travelogue* routed to Channel 1 and

12-talker babble from the Revised SPIN (Bilger et al)[4] routed to Channel 2.

Procedures

Before experimental procedures, case history information was obtained from each participant to ensure no history of a neurologic disorder or change in medication over the course of the study. In addition, an audiometric screening was completed at 25 dB HL at octave frequencies from 250 to 8000 Hz. Experimental measures included acceptance of background noise testing using the ANL procedure. Initially, the participants were asked to adjust male talker running speech (*Arizona Travelogue,* Frye Electronics) to their MCL using a three-step bracketing procedure. First, participants were instructed to "turn the story up until it was too loud." The initial level used to obtain the MCL was 30 dB HL; this level was increased in 5-dB steps until the participant signaled the story was too loud. Next, participants were instructed to "turn the story down until it was too soft." Again, 5-dB steps were used until the participant signaled the story was too soft. Last, participants were asked to "adjust the level of the story to their most comfortable listening level or a level that they would want to listen to the story." This adjustment was completed in 2-dB steps until the participant indicated the story was at their MCL.

To determine the BNL, the 12-talker background noise was introduced at 30 dB HL while the male talker running speech played at the listener's MCL. The same three-step bracketing procedure was used to measure the BNL; however, the participant now controlled level adjustments to the background noise. First, participants were instructed to "turn up the noise until the story could not be heard." The story was increased in 5-dB steps until the participant signaled the noise was too loud. Next, the participant was instructed to "turn the noise down until the story was very clear," and the noise was decreased in 5-dB steps until the participant signaled the story was very clear. Last, participants were instructed to "turn the noise up to a level to where it was the most they can put up with and still follow the story for a long period of time without becoming tensed or tired." This adjustment was completed in 2-dB steps, and when the participant signaled, this level was set; this was recorded as the BNL. The BNL was subtracted from the MCL to achieve the ANL. MCLs and BNLs were obtained three times per experimental session, once as practice and twice as trial attempts. ANLs were completed during 3 experimental sessions over a 1-year time period: initial ANL, at 6 months, and at 12 months.

It should be noted that during the ANL procedure, the participant signals the examiner to adjust the level of the signal up or down, or to stop adjustments. The signals used at the two sites were slightly different. At LaTech, signals for up and down were made as the participant pushed buttons (one labeled louder and one labeled softer), which were connected to flashlights. Each time the "louder" button was pressed and the flashlight lit up, the examiner turned up the stimuli using an audiometer. Likewise, when the "softer" button was pressed, the examiner turned down the stimuli. Stop adjustments were signaled by the participants using a flat palm. At USA, a slight difference was used to signal the examiner to adjust the signal up and down; however, the same flat palm hand motion was used to signal stop adjustments. When the participant wanted to adjust the signal up, a "thumbs up" was given; when the participant wanted to adjust the signal down, a "thumbs down" sign al was given. Each time the "thumbs up" or "thumbs down" signal was given, the examiner adjusted the signal using the audiometer accordingly. Both of these signaling procedures have been proven to be reliable in previous ANL investigations (Nabelek et al;[23] Freyaldenhoven et al;[7] Nabelek et al;[21] More et al;[19] Gordon-Hickey et al).[24]

Table 1 MCL and BNL Means (SDs) for Sessions 1 (at 0 Months), 2 (at 6 Months), and 3 (at 12 Months)

	Session 1	Session 2	Session 3
MCL	45.2 (7.6)	46.6 (7.4)	46.4 (6.0)
BNL	43.1 (7.4)	45.2 (7.9)	44.0 (7.7)

Results

The primary purpose of the present study was to investigate if ANLs are stable over a 1-year period of time. Thus, MCLs, BNLs, and ANLs were measured at 0, 6, and 12 months in young participants with normal hearing. Two experimental trials were completed at each session, and these trials were averaged to obtain a mean MCL, BNL, and ANL for each participant. Mean MCLs and BNLs across participants for each experimental session (0, 6, and 12 months) are shown in ►**Table 1**; mean ANLs across participants from each experimental session are shown in ►**Figure 1**.

Reliability of MCL, BNL, and ANL

For assessment of test-retest reliability of MCL, BNL, and ANL within a session, the average measure intraclass correlation coefficient was calculated. This measurement was used as it provides a statistical estimate of reliability across two trials and was appropriate because the two trials were averaged to

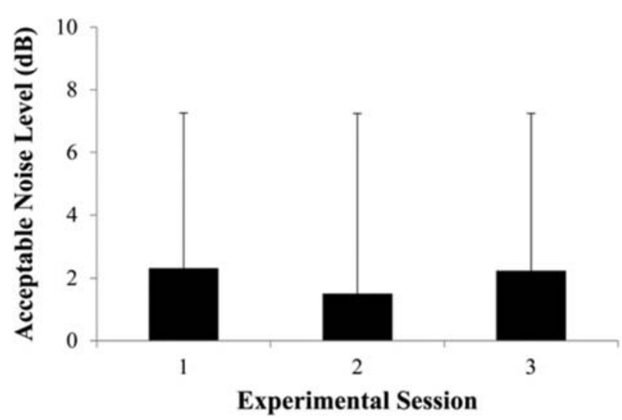

Fig. 1 ANL means and SDs for Sessions 1 (at 0 months), 2 (at 6 months), and 3 (at 12 months).

Table 2 Correlation Coefficients for MCL, BNL, and ANL Obtained over a 1-Year Time Period

	MCL	BNL	ANL
Session 1 (0 months)	$r = 0.96$ ($p < 0.001$, CI = 0.91–0.98)	$r = 0.93$ ($p < 0.001$, CI = 0.85–0.97)	$r = 0.90$ ($p < 0.001$, CI = 0.79–0.95)
Session 2 (at 6 months)	$r = 0.96$ ($p < 0.001$, CI = 0.91–0.98)	$r = 0.96$ ($p < 0.001$, CI = 0.92–0.98)	$r = 0.91$ ($p < 0.001$, CI = 0.81–0.96)
Session 3 (at 12 months)	$r = 0.95$ ($p < 0.001$, CI = 0.90–0.98)	$r = 0.96$ ($p < 0.001$, CI = 0.91–0.98)	$r = 0.91$ ($p < 0.001$, CI = 0.81–0.96)

obtain the overall ANL. ►**Table 2** displays the correlation coefficients for MCL, BNL, and ANL. All correlation coefficients for MCL, BNL, and ANL indicate excellent test-retest reliability among trials within a session (Koo and Li).[16]

To further examine MCL, BNL, and ANL reliability within a session and stability over time, three 2-way repeated-measures analysis of variance (ANOVA) analyses were conducted. The within-subject variables for each ANOVA were session with three levels (Session 1 = 0 months, Session 2 = 6 months, and Session 3 = 12 months) and trial with two levels (Trial 1 and Trial 2). First, the MCL and BNL ANOVA results showed no significant main effects for session [MCL: $F_{(2, 58)} = 0.77$, $p = 0.47$; BNL: $F_{(2, 58)} = 1.28$, $p = 0.29$], trial [MCL: $F_{(1, 29)} = 0.76$, $p = 0.39$; BNL: $F_{(1, 29)} = 0.68$, $p = 0.42$], or the session by trial interaction [MCL: $F_{(2, 58)} = 0.25$, $p = 0.78$; $F_{(2> 58)} = 0.57$, $p = 0.56$]. In addition, the ANL ANOVA results showed no significant main effects for session [$F_{(2, 58)} = 0.87$, $p = 0.42$], trial [$F_{(1, 29)} = 0.05$, $p = 0.83$], or the session by trial interaction [$F_{(2, 58)} = 0.70$, $p = 0.50$]. These results indicate that the MCL, BNL, or ANL does not change significantly either within a session or over a year's time period for young listeners with normal hearing.

Discussion

The focus of the present study was to determine if ANLs changed over a 1-year period of time in young adults with normal hearing. This research was warranted as researchers have assumed for some time that ANLs are reliable over time; however, current ANL research has obtained ANLs within a session (Freyaldenhoven et al;[21] Nabelek et al;[21] Plyler et al;[26] Gordon-Hickey et al)[11] and over short periods of time. Specifically, Freyaldenhoven et al (2006)[8] and Wu et al (2013)[29] showed ANLs to be reliable over a 3-week time period, whereas Nabelek et al (2004)[23] showed ANLs to be reliable over 3 months. To date, the stability of ANLs over longer periods of time has not been investigated. Thus, MCLs and BNLs were measured during three experimental sessions, with each session separated by 6 months, and ANLs were subsequently calculated. The results revealed MCLs, BNLs, and ANLs were highly reliable and consistent both within and between sessions, indicating MCLs, BNLs, and, most importantly, ANLs were stable over a 1-year period of time. These findings were expected and agreed with previous ANL research, which indicated that ANLs are consistent within and between sessions.

The stability of the ANL over a longer period of time provides additional evidence that the ANL is an inherent individual trait, which is most likely mediated in the central auditory nervous system. Alworth et al (2007) demonstrated that different personality types affect ANL, whereas Nichols and Gordon-Hickey (2012) demonstrated that individuals with differing levels of self-control had different ANLs. Both of these findings support the ANL as an inherent trait. Likewise, if the ANL is inherent to the individual, it would be expected to remain stable over a long period of time, at least if extraneous variables such as medication, technology changes, or other intervention did not interfere with a listener's ANL. For example, Freyaldenhoven et al (2005b) showed stimulant medication for attention deficit hyperactivity disorder lowered ANL. These medications are thought to increase the dopamine levels in the brain to improve attention, thus alternating the central auditory nervous system. Likewise, various studies have shown improvements in the ANL, which resulted from technological advancements such as directional microphones or noise reduction algorithms (Freyaldenhoven et al;[7] Mueller et al;[20] Lowery[20] and Plyler).[17] This change in the ANL did not change the participants' inherent ANL; it simply altered the signal being delivered to the ear, which resulted in an improved ANL.

As with other more recent ANL studies, ANLs in the present study are lower than the ANLs obtained by Nabelek et al (2006) among others. Nabelek et al (2006) reported aided mean ANLs of 7.3 (range: 1-18) for full-time users of hearing aids. Likewise, Rogers et al (2003) reported means of 10.9 (range: 0-24), and Freyaldenhoven et al (2006) reported means of 12.9 (range: 4-24) in young listeners with normal hearing. The current study results showed means for Sessions 1, 2, and 3 of 2.3 (range: −7 to 11), 1.5 (range: −11 to 13), and 2.3 (range: -5 to 13), respectively. More recent ANL research has showed means of 3-9 dB for listeners with normal hearing (Gordon-Hickey and Moore;[12] Adams et al;[1] Chen et al;[5] Moore et al;[5] Gordon-Hickey et al).[11] Gordon-Hickey et al (2012)[11] suggested this might be due to the abundant use of handheld devices today versus 15 years ago, which allows listeners to have 24-hour access to distractions. Also, they suggested that young listeners with normal hearing have likely developed coping mechanisms to deal with noisier daily environments. This in combination with the current lifestyle of young college students may be allowing them to adapt to noise in their environment, which may be one reason mean ANLs seem to be reduced in comparison with data obtained in the early 2000s. Another possible reason that the means are reduced in comparison to previous data could be due to the sample size. Although the sample size is large enough to study the issue of stability over time, it may not be large enough to determine the mean ANL for the entire population of listeners with normal hearing. Nabelek et al (2004) examined ANLs in 50 listeners with hearing loss, whereas 191 listeners were examined in the Nabalek et al (2006) study. In the current study, testing was conducted with 30 listeners. Therefore, it could be that the pool of listeners used in the current research is on the low end of the ANL distribution, which Nabelek et al (2006) stated ranged from 0 to 30 dB.

Future Research

The current study focused on young, college students with normal hearing and took volunteers at random. This yielded low mean ANLs for most listeners. In fact, 24 listeners in the current study had mean ANLs $<$7 dB while six listeners had ANLs between 7 and 13 dB; no listeners had ANLs above 13 dB. Future research might focus on the stability of ANLs in listeners in all three ANL categories: low, medium, and high. Likewise, all listeners were young, college students, which may not be representative of the average population of listeners in an area. Future research could also measure ANLs in young listeners with a variety of education levels and/or a variety of age groups.

Last, past research has linked acceptance of background noise to hearing aid use. Nabelek et al (2006) determined unaided ANLs could predict a person's success with hearing aids with 85% accuracy. Specifically, listeners who accept small amounts of background noise are more likely to become successful hearing aid wearers, whereas listeners who are unable to accept background noise are more likely to become unsuccessful hearing aid users. Furthermore, previous research has demonstrated that ANLs are not related to hearing sensitivity (Nabelek et al;[22] Nabelek et al),[21] whereas the current research shows ANLs remain stable over a 1-year time period; therefore, it would be reasonable to speculate that ANLs would remain stable in listeners with hearing impairment. To this end, future research should examine the stability of ANLs over longer periods of time in listeners with impaired hearing.

Summary

The present study measured MCLs and BNLs and calculated ANLs for young listeners with normal hearing over a 1-year time period. Measurements were obtained at the initial experimental session and at 6 and 12 months. The results indicated that MCLs, BNLs, and ANLs were reliable and stable over a 1-year time period, further supporting the ANL as an inherent trait of the individual and mediated in the central auditory nervous system.

Abbreviations

ANL	acceptable noise level
ANOVA	analysis of variance
BNL	background noise level
LaTech	Louisiana Tech University
MCL	most comfortable listening level
SD	standard deviation
USA	University of South Alabama

References

1 Adams E, Gordon-Hickey S, Moore R, Morlas H. Effects of reverberation on acceptable noise level measurements in younger and older adults. Int J Audiol 2010;49:832–838

2 Alworth L, Plyler P, Madix S. Effect of personality type on the acceptance of noise. Poster Presentation. American Academy of Audiology ConventionDenver, Colorado2007

3 Bentley LE, Ou H. Using QuickSIN speech material to measure acceptable noise level for adults with hearing loss. Unpublished AuD Capstone Project, Illinois State UniversityNormal, IL2017

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

5 Chen J, Zhang H, Plyler P, Cao W, Chen J. Development and evaluation of the Mandarin speech signal content on the acceptable noise level test in listeners with normal hearing in mainland China. Int J Audiol 2011;50:354–360

6 Crowley H, Nabelek I. Estimation of client-assessed hearing aid performance based upon unaided variables. J Speech Hear Res 1996;39:19–27

7 Freyaldenhoven M, Nabelek A, Burchfield S, Thelin J. Acceptable noise level (ANL) as a measure of directional benefit. J Am Acad Audiol 2005a16:228–236

8 Freyaldenhoven M, Smiley DF. Acceptance of background noise in children with normal hearing. J Educ Audiol 2006;13:27–31

9 Freyaldenhoven M, Smiley DF, Muenchen R, Konrad T. Acceptable noise level: reliability measures and comparison to background noise preference. J Am Acad Audiol 2006;17:640–648

10 Freyaldenhoven M, Thelin J, Plyler P, Nabelek A, Burchfield S. Effect of stimulant medication on the acceptance of background noise in individuals with attention deficit/hyperactivity disorder. J Am Acad Audiol 2005b16:677–685

11 Gordon-Hickey S, Adams E, Moore R, Gaal A, Berry K, Brock S. Intertester reliability of the acceptable noise level. J Am Acad Audiol 2012;23:534–541

12 Gordon-Hickey S, Moore RE. Influence of music and music preference on acceptable noise levels in listeners with normal hearing. J Am Acad Audiol 2007;18:417–427

13 Harkrider A, Smith S. Acceptable noise level, phoneme recognition in noise, and measures of auditory efferent activity. J Am Acad Audiol 2005;168:530–545

14 Harkrider A, Tampas J. Differences in responses from the cochleae and central nervous systems of females with low versus high acceptable noise levels. J Am Acad Audiol 2006;17:667–676

15 Jones AL, Moore RE. Acceptable noise levels and speech perception in noise in children with normal hearing and hearing loss. J Educ Pediatr (Re)habil Audiol 2017;23:1–12

16 Koo K, Li M. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. J Chiropr Med 2016;15:155–163

17 Lowery K, Plyler P. The effects of noise reduction technologies on the acceptance of background noise. J AmAcad Audiol 2013;24:649–659

18 Lytle S. A comparison of amplification efficacy and toleration of background noise in hearing impaired elderly persons. Unpublished Master's Thesis, University of TennesseeKnoxville, TN1994

19 Moore R, Gordon-Hickey S, Jones A. Most comfortable listening levels, background noise levels, and acceptable noise levels for children and adults with normal hearing. J AmAcad Audiol 2011; 22:286–293

20 Mueller H, Weber J, Hornsby B. The effects of digital noise reduction on acceptance of background noise. Trends Amplif 2006;10:83–93

21 Nabelek A, Freyaldenhoven M, Tampas J, Burchfield S, Muenchen R. Acceptable noise level as a predictor of hearing aid use. J Am Acad Audiol 2006;17:626–639

22 Nabelek A, Tucker F, Letowski T. Toleration of background noises: relationship with patterns of hearing aid use by elderly persons. J Speech Hear Res 1991;34:679–685

23 Nabelek AK, Tampas JW, Burchfield SB. Comparison of speech perception in background noise with acceptance of background in aided and unaided conditions. J Speech Lang Hear Res 2004; 47:1001–1011
24 Nichols A, Gordon-Hickey S. The relationship between locus of control, self-control, and acceptable noise levels. Int J Audiol 2012;51:353–359
25 Plyler P, Alworth L, Rossini T, Mapes K. Effects of speech signal content and speaker gender on acceptance of noise in listeners with normal hearing. Int J Audiol 2011;50:243–248
26 Plyler P, Bahng J, von D.Hapsburg. Acceptance of background noise in adult cochlear implant users. J Speech Lang Hear Res 2008;51:502–515
27 Rogers D, Harkrider A, Burchfield S, Nabelek A. The influence of listener's gender on the acceptance of background noise. J Am Acad Audiol 2003;14:372–382
28 Tampas J, Harkrider A. Auditory evoked potentials in females with high and low acceptance of background noise when listening to speech. J Acoust Soc Am 2006;119:1548–1561
29 Wu Y, Stangl E, Bentler R, Stanziola R. The effect of hearing aid technologies on listening in an automobile. J Am Acad Audiol 2013;24:474–485
30 Xia L, He J, Sun Y, Chen Y, Luo Q, Shi H, Feng Y, Yin S. Comparison of acceptable noise generated using different transducers and response modes. Neural Plast 2018;18:1–9