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REVIEW ARTICLE

Acceptable noise level test: bases and theories

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Abstract

Background and Aim: Acceptable noise level (ANL) is the loudest level of background noise that human can tolerate while listening a running speech. ANL test is used for the prediction that whether a hearing aid (HA) candidate can use HA successfully by determining how well the individual tolerates background noise while listening to speech. In the current review, we reviewed the basis and theories of the ANL test and the factors that identified from the studies that have conducted on ANL and the influence of this test in increasing the quality of life of hearing aid users along with a discussion of its application in clinical audiology.

Recent Findings: Research showed that subjects with a higher tolerance for background noise are most probable to be the successful hearing aid users. Clinical trials demonstrated that ANL test provides reliable results and can predict HA successful use with 85% accuracy.

Conclusion: Acceptable noise level is a reliable and valid test that can be used as a predictive index for the successful application of HA, and it is applicable in before/after HA fitting assessments. Thus, it is suggested that ANL can be implemented in the fitting and counseling process of HAs prescription. Further studies are required to resolve biases over the employment of this test in bilinguals.

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Introduction

One of the greatest problems of people who use a hearing aid (HA) is listening in noisy environments [1]. Although the problem of background noise was considered in all experiments evaluating the level of satisfaction of HA, it is not obvious that how much of background noise can cause a problem in using HA [1]. According to problems in noisy environments that affect the HA application, one of audiologist obsessions is to improve auditory reception, speech processing, and squelch background noise from central auditory system activities. Speech perception in noise (SPIN) is one of the most complex functions that listeners usually face it [2]. SPIN depends on the interaction between sensory and cognitive processes. The sensory processing is based on bottom-up mechanisms, which involve the spatial and spectral processing and the cognitive processing is based on top-down mechanisms, which involve the use of meaning, context, the linguistic rules, and information about the speaker. In fact, they are involved in what we hear and what we get, during speech processing. Speech processing in noisy environments occurs in several stages in different parts of central auditory nervous system (CANS). The role of the auditory brainstem includes phase lock response to stimulation regulators, strong pitch decoding, and preserve temporal segregation in noise. This

sensory-cognitive interaction is possible just by afferent fibers that take sensory information to mid brain (inferior colliculus) and auditory cortex in relation with efferent pathway [2]. In another word, pure signal income from cochlea to brainstem is not determined in the reception of the signal, but top-down processes play a role.

Several tests are designed to assess the auditory function in noise, and one of them is the acceptable noise level (ANL) test. This test was first developed in 1991 at Tennessee University by Nabelek et al. [3] and has been used for the central assessment of noise reception [4]. Since different levels of environmental noise affect amount and pattern of using HA [5], the NAL test was developed to assess the ability to hear in noise (tolerating the noise during listening to continuous speech); the test can also prospect the use of HA better than assessing the SPIN [1,5]. Hence, ANL denotes the amount of noise that one can tolerate during listening to speech in scalar quantity [3,6,7]. Few experimental studies demonstrated that activities of subcortical regions such as the thalamus and limbic systems affected the scores of ANL test [8]. According to experiences of Plyler, after taking the medicine and receiving an effective dose, ANL scores were improved significantly in adults with attention deficit hyperactivity disorder (ADHD) [8], and the results indicated that subcortical regions affect scores in ANL test. To get ANL in most comfortable level (MCL), a recorded continuous speech (like a story) was presented to the patient and the noise ipsilaterally was increased until the patient could follow speech while hearing the maximum level of noise. The maximum level of acceptable noise called background noise level (BNL). The authors declared ANL in dB, and it is calculated using the following equation:

ANL=MCL-BNL

Generally, the speech signal and the noise both present by the loudspeaker in azimuth of 0 degrees to get ANL [3].

To prepare materials for ANL, the continuous speech signal should be easy, long (it should be recorded more than 4 minutes) [9], like a story, and show routine auditory situation [10]. To create a noise, babble noise of 12 subjects [1], which read texts about different subjects and relatively long is used [9,11]. Since materials of these 12 texts influence the noise and because of the relatively large number of speaker of the noise, content, the language of texts has no effect on the final deed, so texts just need to be different.

Subjects who had low scores (less than 7 dB) in ANL can tolerate more noises in order to follow continuous speech than the ones who go high scores in ANL (more than 7 dB) [6].

Now ANL is applicable in different languages such as English, Danish, Swedish [9], Chinese [11], and Persian [12].

Methods

Type of study

The current study was used the narrative review method.

Standards to choose studies

In this study, we tried to deliberate all experiments on ANL and different author's theories for a period of 25 years, from1991 to 2016.

Method of extracting and selecting the studies

To find the protocol of experiments, different data bases were used including Scopus, PubMed, SID, EMBASE, and Google Scholar. To search in these data bases, the following keywords were used: acceptable noise level, background noise level, and hearing aid. A total of 62 articles about the targeted keywords were extracted out of which 45 articles were related and used in the current study.

Results

After reviewing all the enrolled articles, it was determined that several factors such as gender, age, mono -and bilingualism, hearing loss, condition of middle ear, cochlea and central nervous system (CNS), type of speech stimuli, spatial situation of signal and noise, echo,

stimulant medicines effects, and hearing aid circuits can affect ANL test.

Do gender and age affect the results of ANL test?

Due to structural and functional similarities between the auditory system of male and female, several studies demonstrated that neural circuits responsible for separating signal from noise have similar functions in both genders. A study by Rogers et al., compared level of accepting background noise between the genders; the study included 50 subjects (25 male and 25 female) with normal hearing, and the auditory comfort levels for speech as well as multi talker babble speech noise, were found out bilaterally. Results indicated that though the MCL and acceptance of BNL are higher in males than females, the ANL was identical in both genders [13]. A similar study was accomplished by Ahmadi et al., on Iranian subjects by the Persian version of the ANL test; they reported no significant difference between the genders [12].

Furthermore, because of the special role of the brainstem in signal processing and noise and maturation of the neural auditory system in 2 years after birth, it seems that age has no significant effect on ANL. Moore et al., compared the effect of age on MCL, ANL, and BNL in 2 groups including children aged 8 to 10 years and youngsters aged 19 to 29 years with normal hearing. The results of the study showed that MCL and BNL were significantly higher in youngsters group than that of in children, however, due to counterbalance changes in MCL and BNL over the age, ANL has no change during maturation [14].

In another study on subjects with normal hearing by Adams et al., results were similar to that of Moore et al. has found in his study, but they reported no effect for age on ANL [14,15].

How can personal traits affect ANL?

Effects of personal traits and temper on ANL were also studied. According to the point that ANL is a central factor, it is not out of mind that some of the personal traits such as aggression can affect results of this test. Wu et al., accomplished a study on the effect of traits on the results of ANL in subjects with normal hearing. In their study, 85 Chinese subjects within the age range of 21 to 27 years were evaluated. They used ANL test as well as the Eysenck personality questionnaire. Results indicated that subjects with higher ANL may show abnormal inimical, and aggressive behaviors [16].

Monolingualism and bilingualism

Despite the similar results of studies on the effect of bilingualism on ANL, we cannot suggest that all bilingual subjects in different languages with different language compounds, according to different language structures, have a similar function in ANL test. In a study, ANL scores of Korean-English listeners and English monolinguals were compared by von Hapsburg and Bahng. They had 30 participants in 3 groups, including 2 groups of bilinguals (Korean-English) and a group of monolinguals (English). In the group of bilinguals, Korean was native language, and English was the second language. All groups participated in ANL test, and results showed no significant difference between bilinguals and monolinguals [17].

In another study, the effect of the language of the speaker of the speech signal and the language of the speaker of the noise on results of ANL in bilingual subjects was studied. Subjects with normal hearing (46 and 30 Spanish-English bilinguals and 16 Russian-English bilinguals) were selected. Results indicated no significant association between ANL and the language of The speaker of the speech signal speech signal, the language of the speaker of the masker noise and number of speakers in creating masking noise, though ANL was higher in Russian-English bilinguals. Therefore, further studies are needed to explain the effect of bilingualism on ANL [18].

Hearing loss

One of the important issues in ANL test is the lack of association between the intensity level and subject's hearing level. A study on the patterns of HAs use in the elderly subjects was

accomplished by Nabelek et al. They studied the relation between the use of HA and tolerating background noise in participants. Four groups of the elderly subjects (aged≥65 years) and a group of young subjects enrolled in the study; it was noticed no association between hearing level and amount of hearing loss, according to ANL test [1].

Another study on the effect of signal presenting level on ANL in 10 participants with normal hearing and 10 subjects with hearing loss was done by Recker and Edwards; they demonstrated no significant difference between the 2 groups, based on ANL. The results were also consistent with similar studies [3,19-21].

Middle ear disorders

According to the previous section, one of the utilities of the ANL test is its' applicability in MCL, so lesions in the middle ear cannot affect results of the test. Harkrider and Smith performed a study on ANL test using, phoneme perception in noise as stimuli, evaluating the activity of the auditory efferent system. They used monaural and binaural ANL scores, monaural phoneme perception scores in noise, contralateral inhibition in otoacoustic emissions, and ipsi- and contralateral reflex thresholds on 31 participants aged 19 to 40 years with normal hearing, results showed no significant association between middle ear conditions and threshold of acoustic reflex, based on ANL [19]. Other studies also reported similar outcomes [20,22].

Responses of cochlea and central nervous system

Signal and noise processing in the central nervous system performs in several steps from lower parts of auditory neural pathways to upper parts, and it seems that in upper parts, we have premier processes on signal smeared by noise [23]. A study on responses of cochlea and central neural system in females aged 20 to 37 years with low ANL was accomplished by Harkrider and Tampas. They checked their responses by click evoked otoacoustic emissions (CEOAE), auditory brainstem response (ABR), and middle-latency response (MLR), and their results showed that there was no difference between CEOAE responses and the waves I and III of ABR in the 2 groups. And the differences in 2 groups were between amplitudes of wave V of ABR and Na in MLR that can show the effect of central systems on auditory system in accepting background noise [20].

A study by the mean of search on the relation between behavioral measuring of ANL and physiologic mechanism in normal subjects was done by Kooknoor and shetty, There were 40 subjects with normal hearing assigned in 3 groups of low, moderate, and high scores, based on the results of ANL. They measured contralateral suppression of otoacoustic emissions (CSOAE) in different intensities (50, 55, 60, and 65 dB) and concluded that CSOAE was higher in the subjects with lower ANL, but the difference was statistically insignificant [24].

Repeated measurement and working memory

A study on the effect of repeated measuring of auditory MCL during ANL test was accomplished to understand the probable relationship between the change in MCL and central cognitive processing. In the study performed by Brannstorm et al., 32 subjects with normal hearing received 12 MCL repeating by the usual method and a non-semantic version during ANL test, and phonological working memory (PWM) and visuospatial working memory (VSWM) were checked. Results demonstrated a significant relationship between MCL changing and PWM, but not with VSWM. Also, it recalled that if a usual method is used to assess ANL, ANL should be repeated before real assessment [25].

Speaker's gender and speech content of test

To process a signal and noise, the auditory system uses different strategies like fundamental frequency in speaker's signal or noise, spatial position of signal and noise, etc. [23].

Effect of speaker's gender and speech content on ANL scores were studied on 43 subjects (26 male and 17 female) with normal hearing. In this experiment, recorded signal of Arizona Travelogue (Cosmos Inc.) by the voice of a male

and a female and with the ipsilateral competing message (ICM) were used. Both speech signal and noise were presented by a same loud speaker with an azimuth of 0 degrees in 4 experimental situations 1) Arizona Travelogue signal by a male voice, 2) Arizona Travelogue signal by a female voice, 3) ICM signal by a male voice, and 4) ICM signal by a female voice. According to the usual clinical protocol of ANL, the test was repeated twice for each of the above situations. Moreover, 21 participants were asked to mention their opinion about speech signal's presenting level in two conditions of with and without noise. Scores were marked on a 5 pointed scale: 1= not eligible at all, 3= eligible, 5= completely eligible. Results of these scores about the level of eligibility showed that generally in speech samples, ICM had more eligibility than Arizona Travelogue and also signals with female speaker were more eligible than the signals with male speaker, but neither the type of speech signal nor the speakers gender was affected by the amount of MCL and ANL in subjects with normal hearing; so, we can use different speech signals to get ANL under clinical conditions [26].

Using different stimuli

The study to investigate if the speech signal's intelligibility can affect ANL scores on 30 participants with normal hearing was conducted by Gordon-Hickey and Moore [27]. They used intelligible speech signals, reversed signal, and a signal with a completely unknown language as a speech signal to get ANL. They calculated the MCL and BNL for participants in each of the signals. Results demonstrated no significant difference in average MCL among different signals; the average MCL for intelligible, reversed, and unknown signal were 51.5, 51.4, and 53.4, respectively. But, by changing the intelligibility of speech signals, amounts of BNL and finally ANL were affected, especially when the signal was intelligible, ANL scores were improved. According to the results of the current study, we can suggest that if the ability of speech perception cannot affect MCL, it can affect BNL; the effect of speech signal perception on ANL is because of BNL. Therefore, results indicated that participants could tolerate higher rates of noise when the signal is more intelligible, and ANL scores get worse by decreasing the ability of speech signals perception, and therefore, listeners accept lower amounts of noise [27].

Lots of studies were performed on the effect of speech stimulus on ANL, and results showed that by decreasing the ability of perception of speech signals, ANL scores got worse [26,27].

Effect of different intensities and loudness on ANL

A study conducted by Freyaldenhoven et al., on the effect of different intensities of speech signal's presenting level on ANL scores, 30 participants were selected with normal hearing and 69 with hearing loss. In this study, ANL performed by the routine method, and then, 8 different rates of the speech signal, as well as Global ANL scores (average of ANL in a constant speech presenting level) and ANL Growth (slope of ANL function results by linear regression analyses) were calculated. Statistical analyses showed no significant difference in Global and ANL Growth between normal subjects and ones with hearing loss. Therefore, Global and ANL Growth had no association with participant's average pure tone threshold. The study indicated that different signals presenting the level of ANL cannot affect by auditory sensitivity factor [28].

Franklin et al. studied the effects of different speech signal levels; they concluded that for each 4 dB increase in the intensity of speech signal presenting level, ANL score increased by about 1 dB. It means that ANL is related to speech presenting level, but to change the ANL significantly, speech signal presenting level should change much more [29]. ANL test can only anticipate success in using HA accurately. Subjects with the ability in accepting higher levels of noise during listening to the speech signal are better users of hearing aids (HAs). If it becomes obvious that what signs are used by listener to determine BNL, it may be possible to develop a technique to decrease these signs and increase the chance of success in using HAs. Thus, an

experiment was accomplished by Reckerkl et al., to delineate whether the listeners use loud sounds to measure ANL or not. They studied 21 subjects with normal hearing and 21 with SNHL participants. Each group had 7 subjects with low ANL (<7), 7 subjects with moderate ANL (7 to 13) and 7 subjects with high ANL (>13). The results demonstrated that most of the subjects do not use sound loudness to determine their ANL [30]. The summary of some outstanding studies in ANL is presented in Table 1.

Noise type

The effect of the type of background noise on the ANL has been studied. Gordon-Hickey and Moore [31], studied the effect of music as background noise on the ANL and compared with babbling speech sounds on people with normal hearing. The results demonstrated that participants were wanted to have music as background noise in comparison to babble noise. Also, further studies shows that music acts as background noise and differs from the noise of 12 spoken words. As well as in their study, the type of noise was not affected the ANL scores [1,32,33].

Spatial position of noise

As mentioned above, the hearing system uses different cues for signal processing and noise, out of which the most important is the spatial cues. In this regard, when isolated noise is separated spatially from the signal, it increases the ability to understand the words in comparison to when signal and noise are in with when signal and noise are in same spatial position [23]. The effect of noise spatial position effect on the ANL was evaluated in a study conducted by Ahlstrom et al., which presented all test moods, spoken signal from 0 degrees of azimuth and noise with 2 moods 1) Zero degree of azimuth and 2) Ninety degree of azimuth. The results of the study showed that the ANL points were better when spatial position of noise and speech were different in comparison with when the spatial position of noise and speech were in the same spatial position and had the same degree [34].

Reverberation effect

Adams et al., investigated the reverberation effect on the results of ANL test on 12 people with normal hearing, aged 22 to29 years and 50 to 69 years. They made 5 different positions (reverberation time 0, 0.4, 0.7, 1.2, and 2.0 ms) and calculated ANL for all of them. The results showed that age and reverberant time had no effect on ANL and MCL, and both factors had no notable effect on ANL [15].

What are the results of ANL study on cochlear implant users?

A study conducted by Plyler et al., on various aspects of ANL on cochlear implant (CI) users reported that it is used for ANL among the accepted noise when following the speech from ANL and hearing in noise test (HINT). They presented the abbreviated profile of hearing aid benefit (APHAB) questionnaire and satisfaction of questionnaire for comparing CI with pervious HA. They also showed that MCL and ANL had no considerable difference between the CI user and the one with normal hearing. In addition, ANL had no direct relationship with SPIN in scores of APHAB in participants in their research. Furthermore, ANL in CI users had a significant relation to the satisfaction of questionnaire responders; the users showed ANL evaluation is a useful tool in determining the satisfaction of CI user [35].

In an another study, it was reported that ANL and BKB speech in noise could be a valuable tool for communication disorders of CI users [36].

Does ANL test predict the usefulness of hearing aid in hearing aid users?

In a clinical study, ANL was introduced as a useful tool for the evaluation of accepting noise when following the continuous speech. ANL test is applicable to the ones with normal hearing as well as HA users. The findings showed that ANL test before prescribing HA can predict the quality of HA use, especially for those with low ANL without HA (low score of 7 dB). These people can tolerate more noise when following the continuous speech. On the other

Table 1. The summary of studies on acceptable noise level test

Author(s)	Published year	Subjects	Results
Nabelek et al [1]	1991	Environmental noise toleration and its relation with pattern of HA use by the elderly subjects	Acceptable noise level not depends on hearing level and amount of hearing loss in subjects
Rogers et al [13]	2003	Effect of gender on accepting background noise	No effect
Freyaldenhoven et al. [4]	2005	Effect of medication on accepting the noise in subjects with ADHD	ANL scores are affected by medication
von Hapsburg and Bahng [17]	2006	Effect of bilingualism (Korean-English) on ANL	No significant difference between ANL of monolinguals and bilinguals
Freyaldenhoven et al [10]	2006	Noise acceptance by monaural and binaural amplification	Binaural amplification can improve speech perception, but has no difference with monaural amplification on noise acceptance
Harkrider and Tampas [20]	2006	Difference in response of cochlea and central neural system of females with low ANL	Differences in the 5th wave of ABR and Na in MLR
Mueller et al [41]	2006	Effect of noise reduction circuit on the level of accepting noise	Digital noise reduction system had no significant effect on ANL
Franklin et al [29]	2006	Effect of different levels of presenting speech signal on ANL	ANL showed dependence on speech presenting level, but to change significantly, the presenting level should be changed more
Nabelek et al [3]	2006	ANL is a way for anticipating the use of hearing aid	ANL scores without hearing aid can anticipate success of using hearing aid to 85%
Freyaldenhoven et al [28]	2007	Effect of different speech signal intensities on ANL	No effect
Plyler et al [35]	2008	Different aspects of ANL in subjects with cochlear implant	No significant difference was observed on ANL of subjects with cochlear implants and subjects with HAs
Ahlstrom et al [34]	2009	Effect of spatial noise situation on ANL	When spatial situation of noise and speech were different, ANL scores were better
Donaldson et al [36]	2009	Use of ANL and BKB-SIN in anticipating the ability of perception and communications in subjects with cochlear implant	ANL and BKB-SIN was a good tool to assess communicational problems in subjects who use cochlear implants
Adams et al [15]	2010	Effect of echo on ANL in young and old subjects	No effect
Moore et al [14]	2011	Study on ANL in child and adults with normal hearing	ANL had no change from childhood to adolescence
Plyler t al [26]	2011	Effect of speaker's gender and speech content of test on ANL of subjects with normal hearing	No effect
Kooknoor and Shetty [24]	2015	Relation between behavioral measurement of ANL and physiologic mechanisms	CSOAE was better in subjects with lower ANL

hand, these people will use HA more than the ones who cannot tolerate noise (ANL score higher than 7 dB). In a different study (3,28) on ANL, the scores without HA can predict HA successful level by 85% accuracy. As well as the ANL evaluation before fitting can predict the amount of satisfaction of HA, ANL and APHAB can present useful information about the results and level of HA use (3,37).

Taylor [38] compared the ability of HA prediction by ANL and a self-reporting HA questionnaire benefit and satisfaction. A HA user (27 people) with SNHL for the first time formed samples. They collected the results of pure tone audiometry speech recognition in silence, quick speech in noise without HA, and ANL customary for all samples, after the participator received HA for both ears with wide dynamic range compression.

Exactly 30 days after fitting the HA, the participants completed the international outcome inventory of hearing aid (IOI-HA) for HA performance in the real world. Participants were divided into 3 groups based on the ANL scores as follow:

Group 1: low ANL (ANL scores= 0 to 6 include 16 people)

Group 2: moderate ANL (ANL scores= 7 to 12 include 7 people)

Group 3: high ANL (ANL scores= higher than 12 include 4 people)

The IOI-HA questions are scored 1 to 5. Point 1= for the worse result and point 5= for the best result. Although group 3 had a lower average in IOI-HA results, the total average points of IOI-HA showed all 3 groups got good results. The results of the study showed a significant relationship between ANL and IOI-HA total scores. And the people with lower scores in IOI-HA had higher scores in ANL and increase ANL scores when IOI-HA got worse. According to the abovementioned results, Taylor concluded that ANL scores without HA could be a valid predictor for utility/satisfaction of HA [38].

Prescribing unilateral or binaural

Freyaldenhoven et al., conducted a study on the ANL test results to observe the effects of unilateral or binaural HA on 39 people with hearing loss. The results showed that although binaural fitting increased speech perception, it had no effect on ANL. Hence, the results of ANL were not affected by single or binaural HA [39].

Shall we expect a decrease of ANL in special population?

The results showed that ANL was improved in 3 ways: 1) Using directional microphone in HA, 2) using HA with decrease circuit noise, and 3) drug intervention [4,40,41].

The effects of noise reduction circuit in HA

Mueller et al., [41] studied the effects of noise reduction circuit on background noise reception level. In their study, 22 adults (14 males and 8 females aged 23 to76 with the mean age of 58.8 years) participated with 16 channels HAs equipped by digital noise reduction circuit. Digital noise reduction circuit includes 2 modulation algorithm and Viner filter. Words clarity and level of ANL by HINT in digital noise reduction (DNR) position “On” and “Off” and ANL without HA was checked. This study focused on noise reduction circuit effect on ANL. The results showed no significant difference between off noise reduction circuit and without HAs scores; results also showed that the obtained ANL when noise reduction circuit is on was significantly lower than the non-HA or off-circuit mode. Furthermore, their study showed that the noise reduction circuit significantly increased the accepting of noise by the participants; the DNR circuit caused a 45% more decrement in ANL of the participants. In addition, the noise reduction circuit did not influence the scores of HINT. The result indicated the value and advantage of the ANL test results against HINT in evaluating and predicting the amount of HA utility in noisy environments [43].

Hearing aid with directional microphone

In a study by Lowery and Plyler, the effect of directional microphones, a noise reduction circuit, and a combination of both on the ANL by individuals while listening to background noise

was examined. It was found that the ANL score was reduced by the directional microphone alone or in combination with the digital algorithm, especially when the background noise was similar to speech [42].
In another study conducted by Kim and Bryan on 15 subjects with bilateral symmetric SNHL, the effects of non-symmetric directional microphone fitting on the ANL scores as well as speech perception in the presence of noise were examined. The results showed that the use of a microphone directed on one ear and non-symmetric can improve the scores of the ANL test, although the maximum ANL scores were obtained when the microphones were used on a binaural and symmetric positions [43]. Apart from this, the spatial separation of the source of the speech signal and background noise can also lower (improvement) the ANL scores [34].

The effect of stimulant medications on ANL
Freyaldenhoven et al., at Tennessee University of the United States, reported the effect of stimulant medications on the ANL in subjects with hyperactivity and inattention. They studied 15 females with a mean age of 22 years and with ADHD. Their hearing sensitivity was within the normal range of less than 20 dB, and used daily stimulant drugs for their illness. Ten patients were treated with Adderall® (a CNS stimulant medications used for the treatment of hyperactivity), or Adderall XR, and the rest were treated with other stimulants such as Dexedrine® and Ritalin®. The ANL test was performed with a recorded male voice, in a sound field, in a situation that examinee's distance was 150 cm to the loud speaker in 0-degree azimuth. The test was conducted in two stage for two groups. First group included 8 participants and ANL evaluation was performed without CNS stimulant and after the use of the stimulant medications. The second group included 7 participants and the test was first evaluated with medications, and then without drug consumption (the interval between the first and second evaluations was 2 to 20 days with mean of 2 weeks). The participants with no drug consumption were asked to take their medication 12 hours prior to the assessment (the effects of stimulant drugs appear after 30 minutes, reach to maximal after 3 to 6 hours, and disappear within a period of 12 to 15 hours). MCL, BNL, and ANL were assessed for all participants in the test. The results indicated that the average MCL for non-drug users was 42.3 dBHL and 42.1 dBHL for drug users. There was no significant difference in MCL between both groups using t-test. In fact, MCL is not affected by CNS stimulant medications. ANL was measured by ANOVA with drug variables (with and without drug) and presenting speech signal level (20 dBHL, MCL, and 76 dBHL), and the results indicated a very impressive effect of the stimulant and the level of stimulant medication, although relation between drug and signal level presentation was not significant. These results indicated that the amount of ANL is reduced by the CNS stimulants and increase in the level of signal presentation. However, subsequent studies showed that the decrease in the amount of ANL was due to the use of a stimulant medication and was not related to the level of signal presentation [40].The result of the their study also suggests that ANL can be affected by CNS stimulant medications.

Test reliability
The results of the ANL test are valid and reliable, and reliable for the subjects with hearing impairment for at least three months [3,10,12].

Conclusion
The test of ANL is a measure of the noise level that individuals can accept when listening to a speech signal without having a significant effect on speech comprehension. On the other hand, ANL test can be conducted in a very short time about 2 or 3 minutes. In this regard, subjects with ANL scores of less than 7 dB can tolerate more noise during continuous speech follow-up, compared with those with higher ANL rating scores;. The middle ear, gender, reverberation, spectral content of background noise, and the content of the spoken signal have no effect on results. Finally, there was no significant difference between the normal hearing subjects and

the cochlear implant users, based on ANL scores. Also, the results of studies showed that ANL is associated with personality traits, and subjects with higher ANLs are more prone to develop aggressive behaviors. The results of studies showed that using a directional microphone in the HA can reduce circuit noise in HAs and drug interventions can improve ANL scores. ANL can be used to predict the success of a person using HA with an accuracy of 85%. ANL and APHAB can provide useful information on the results and use of HAs.

Finally, ANL can be suggested as a valid test in pre-fitting hearing aids evaluations due to its relatively ease of implementation without any need for complicated and expensive equipment, although it still needs more advances. This test would reduce the percentage of HAs rejection in patients who have environmental noise problems. Of course, it should not be neglected that although noise assessment is a tool for helping subjects in the use of HAs, it is not an ultimate endpoint for HAs users.

Conflict of Interest

The authors declare that they have no conflict of interest.

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