RESEARCH ARTICLE

Acceptable noise levels in Arabic-Persian bilinguals

Fateme Taheri[1], Ahmad Geshani[1*], Jamileh Fatahi[1], Shohre Jalaei[2], Mojtaba Tavakoli[3]

[1]- Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran

[2]- Biostatistics, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran

[3]- Department of Audiology, School of Rehabilitation, Ahvaz Jundishapour University of Medical Sciences, Tehran, Iran

Received: 8 Jul 2018, Revised: 12 Jul 2018, Accepted: 14 Jul 2018

Abstract

Background and Aim: Acceptable noise level (ANL) test is a reliable measure of people's ability to tolerate background noise. Central nervous system is one of the determinant factors in subject's tolerance of noise. Bilinguals' different central activity pattern may yield different ANL test results from monolinguals. This study aims to compare noise tolerance function in Arabic-Persian bilinguals with Persian monolinguals via Persian version of ANL.

Methods: In the present study, the Persian version of ANL was administered on 115 cases with normal hearing (56 male, 59 female) aged 18–37 years in three groups of the Persian monolingual, sequential Arabic-Persian bilinguals, and simultaneous Arabic-Persian bilinguals.

Results: The statistical analysis revealed significant difference in most comfortable level (p = 0.002) and background noise level (p = 0.011) among three groups, i.e. between Persian monolinguals and sequential Arabic-Persian bilinguals and between Persian monolinguals and simultaneous Arabic-Persian bilinguals. In other words, mean scores of bilingual were higher than monolingual scores. There was no significant difference among three groups with regard to ANL scores (p = 0.114).

Conclusion: Despite the difference between Persian monolinguals and Arabic-Persian bilinguals in most comfortable level and background noise level, there is no significance difference in ANL results. Therefore, auditory central processing acts similarly in normal hearing monolingual and bilingual subjects. As a result, Persian version of ANL can be used for Arabic-Persian bilinguals, too.

Keywords: Acceptable noise level; Arabic-Persian bilinguals; bilingualism; normal hearing

Citation: Taheri F, Geshani A, Fatahi J, Jalaei S, Tavakoli M. Acceptable noise levels in Arabic-Persian bilinguals. Aud Vestib Res.

[*] **Corresponding author:** Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Piche-Shemiran, Enghelab Ave., Tehran, 1148965141, Iran. Tel: 009821-77530636, E-mail: ageshani@tums.ac.ir

Introduction

One of the prominent abilities of auditory system is the speech perception in the presence of background noise and separating spoken message from noise [1]. In auditory evaluation, one of the concerns of audiologists is to evaluate auditory function in the presence of background noise in different populations, especially in those who suffer from hearing loss. One of common complaints of individuals with hearing loss, who use the hearing aids, is the intolerance of background noise and speech perception in this condition [2]. In this regard, different testes have been designed that examine different aspects of this issue. One of these tests is the acceptable noise level (ANL) [3]. ANL quantitatively determines the amount of noise that a person can tolerate when listens to speech [2-4].

This test was designed by Nabelek and associates in 1991 and were used in different studies [2-4]. To calculate ANL, a recorded running speech like a story is presented at subject's most comfortable level (MCL). In the next level, the noise is presented ipsilaterally way. The intensity of noise increases in 5 dB steps to the extent that the person can simultaneously tolerate the highest level of noise and follow the story. The maximum tolerated noise is called background noise level (BNL). ANL is calculated as ANL = MCL-BNL in terms of dB. To acquire ANL, speech and noise signal, both are presented with loudspeaker and 0° azimuth [2].

Nabelek et al. examined the relation between ANL and use of hearing aid. They concluded that the mean of noise tolerance in full time users (7.7 dB) is significantly less than part time users (13.5 dB) and non-users (14.4 dB). Also full time users are more inclined to use hearing aid and have more tolerance of noise. The authors proposed that individuals with ANL less than 7 dB will be successful users of hearing aids, while individuals with ANL more than 13 dB will not be successful users. In this study, accuracy of ANL prediction is estimated as 85% [3].

Other studies have indicated that ANL is not related to factors such as age [2,3], hearing aid amplification [4,5], speech in noise discrimination function [3-5], middle ear condition, acoustic reflexes thresholds and cochlear responses or contralateral suppression [6,7], but to peripheral hearing loss pattern [8].

Harkrider and Tampas examined different cochlear responses and central nervous system in women with high and low levels of ANL. The testes like click-evoked otoacoustic emissions (CEOAE), auditory brainstem response (ABR) and middle latency responses (MLR) were carried out on these individuals. In conclusion, they found that difference between two groups was on amplitudes of ABR wave V and N_a-P_a component of MLR [7]. These results suggested that probably neurophysiologic differences in central nervous system (CNS) areas could be considered as variability factor in tolerance of background noise. Based on this study, it can be deduced that CNS condition and its affecting variables can be determining factors in individual's tolerance for background noise [7]. Of these variables, we can refer to bilingualism that has been considered by some researchers.

With regard to control of two languages by bilinguals, we can point to the involvement of subcortical area, basal ganglia, and thalamus [9]. Also, striatum especially vertex of caudate nuclei are useful in most language functions like controlling two languages by bilinguals [10]. These issues indicate the role of subcortical area in language selecting and switching. Also different central activity pattern in bilinguals is related to age acquired of second language, need for a language, and learning strategy [11].

Harkrider and Tampas study reports that superior olivery complex, lateral lemniscus, inferior colliculus, temporal lobe, and auditory cortex are locations that affect individuals' acceptance noise level. Therefore this study aimed to determine whether bilingualism has any effect on bilinguals' noise tolerance compared to monolinguals and if Persian version of ANL test is applicable for Arabic-Persian bilinguals.

Methods

This study is an analytic observational (cross-sectional) research. Using convenience sampling method, a total of 115 individuals were recruited for this study. They were 18–37 years old with normal hearing thresholds, 25 dB or better, at 250–8000 Hz [12]. The inclusion criteria comprised having healthy middle ear that included type A tympanogram (with 0.4 to 1.6 compliance and peak pressure between +50 and -150 daPa) with normal acoustic reflex thresholds between 70 and 100 dB HL [13]; with 18–39 years old; Persian monolingual [14] or simultaneous Arabic-Persian bilingual [15] or sequential Arabic-Persian bilingual [15]. The Arabic language must be learned and spoken as a native language (The study bilinguals were selected from Persian-Arabic local bilinguals lived in Ahvaz City, Khozestan Province, Iran).

In bilinguals, the third language should not be at the good or excellent level. Also the participants should be right handed [16], with no history of alcohol use [17] or nervous system medications and drugs impact on central nervous system [17]. They should not report any history of otologic, psychological and neurologic problems like head trauma and accident [17], no operation on nervous system and history of seizure and migraine.

After the ethical code of this study was approved (IR.TUMS.FNM.REC.1397.026) by the Ethics Committee of Tehran University of Medical Sciences, the informed consent was obtained from all participants. The questionnaires were completed by individuals that included personal information, inclusion criteria, the Edinburgh handedness inventory, and the bilingual determining questionnaire to determine the type of bilingualism as well as to rule out the possibility of mastering the third language in bilingual subjects [18]. Simultaneous bilinguals learn the first and second languages simultaneously before the age of three, and sequential Arabic-Persian bilinguals have sequentially acquired the second language after the first language and after the age of three. In the next step, all of the subjects were evaluated routine hearing tests such as otoscopy by the German-made Riester-type otoscope, tympanometry with the 26AZ acoustic immittance system (by Interacoustic, Danmark) for the examination of middle ear, pure tone and speech audiometry by audiometer (Piano' Inventis Company, Italy) and eventually by the Persian version of the ANL test [19]. We also used Dual-Channel audiometer (Piano' Inventis Company, Italy), which has a sound field, free field speaker, and amplifier (12AP, Pejvak-Ava, Iran). In this study participants included 59 women and 56 men. Individuals were divided into three groups: the Persian monolingual language group (41 people including 21 women and 20 men) with mean (SD) age of 22.6 (3.9) years, sequential bilingual Arabic-Persian group (44 people 17 women, 27 men) with mean (SD) age of 24.9 (4.18) years and simultaneous Arabic-Persian bilingual group (30 participants including 21 women and 9 men) with mean (SD) age of 23.3 (3.45) years.

The language skill level was assessed by a self-administered questionnaire and visual analog scale (VAS) method. The VAS is a 10 cm line without labels and shows the two endpoints of a skill range. The subject was asked to estimate his/her proficiency in four skills of reading, writing, speaking, and listening in both Arabic and Persian languages. Finally, the average of four values was determined as the skill level of the subject in that language (1–2.5 weak, 2.5–5 average, 5–7.5 good and 7.5–10 excellent). In the current study, all bilingual participants had excellent skills in both languages [18].

The method of performing ANL test (the method for obtaining MCL and BNL) was provided to all individuals in written form. After placing the test subject in the acoustic room, the instruction was explained once again in spoken form (for all three groups in Persian language). After being ensured of the person's full awareness of the test, the ANL test started. After calibration, the running speech signal at 30 dB HL intensity level was broadcasted to the subject at a distance of one meter away, at a zero degree Azimuth. Then the sound intensity increased by 5 dB increment to the extent that the test subject signaled the sound (through patient signal system) as "very high." Afterwards, the intensity of the signal was reduced in 5 dB steps to the level that the test subject signaled the sound (through patient signal system) as "very quiet." At this stage, the intensity of the signal was raised in steps of 2 dB to the extent that the test subject would describe it as the "perfectly comfortable" signal. After two consecutive 2 dB changes (ascending and descending), the MCL level was determined. The intensity of this level was titled "MCL" in dB for a person in a table that was designed to record results of all subjects. After executing this step, simultaneous with the presentation of the running speech signal at the most comfortable level of hearing, the noise was broadcasted through the same speaker, at the same distance, at 30 dB HL intensity. The intensity of the noise was increased at increments of 5 dB

Table 1. Mean (standard deviation) of most comfortable level, background noise level, and acceptable noise level in Persian monolingual, sequential Arabic-Persian bilingual, and simultaneous Arabic-Persian bilingual in terms of gender (n = 115)

			MCL		BNL		ANL	
Language group	**Gender**	**Number**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Persian monolingual								
	Female	21	36.85	4.57	36.14	5.7	0.71	3.25
	Male	20	36.75	7.18	36.65	6.62	0.1	2.71
	Total	41	36.8	5.91	36.39	6.09	0.41	2.98
Sequential Arabic- Persian bilingual								
	Female	17	41.76	4.45	39.94	3.79	1.82	2.09
	Male	27	41.14	6.46	40.03	5.88	1.07	2.12
	Total	44	41.38	5.72	41.38	5.72	1.36	2.12
Simultaneous Arabic- Persian bilingual								
	Female	21	40.19	5.29	39.52	5.42	0.66	1.82
	Male	9	38.66	6.57	38.44	6.32	0.2	1.78
	Total	30	39.73	5.63	39.73	5.63	0.53	1.79

MCL; most comfortable level, BNL; background noise level, ANL; acceptable noise level, SD; standard deviation

up to the level that the test subject could not follow the spoken signal. After that, the intensity of the noise was reduced in 5 dB decreasing steps, to the level that the test subject could describe the sound of the spoken signal clear. Eventually, the intensity of the noise increased in steps of 2 dB to the level that the test subject could follow the running speech despite the noise. After two consecutive 2 dB noise level increase and decrease, the BNL level was determined and the intensity of this level was recorded on the record sheet as the BNL [3]. Finally, the ANL was calculated by subtraction of BNL from MCL.

The obtained data were analyzed by SPSS 23 and data normalization was tested by Kolmogorov-Smirnov test. The independent t-test was used to examine the effect of gender on MCL and BNL in three groups and on ANL in Persian monolingual group. We used Mann-Whitney U test to analyze the effect of gender on ANL in bilingual groups. In order to compare MCL and BNL parameters among three study groups, one way ANOVA was used. Moreover, the Least Significance Difference (LSD) was done. Due to the lack of normal distribution of ANL, non-parametric Kruskal-Wallis test was used to compare ANL scores among the three study groups. The level of significance was considered 0.05 and the power as 80%.

Results

Gender-specific values of MCL, BNL, and ANL were obtained in each language group (Table 1). Based on the findings, the average MCL values in women and men of the Persian monolingual group were 36.85 and 36.75 dB, respectively, in the sequential Arabic-Persian bilingual group, 41.76 and 41.14 dB, respectively, and in the simultaneous Arabic-Persian bilingual group 40.19 and 38.66 dB, respectively. The average BNL values for women and men of the Persian monolingual group were 36.14 and 36.65 dB, respectively, in the sequential Arabic-Persian bilingual group, 39.94 and 40.03 dB, respectively, and in the simultaneous Arabic-Persian bilingual group 39.52 and 38.44 dB, respectively. The mean ANL values for women and men of the Persian

monolingual group were 0.71 and 0.1 dB, respectively, in the sequential Arabic-Persian bilingual group 1.82 and 1.07 dB, respectively, and in the simultaneous Arabic-Persian bilingual group 0.66 and 0.2 dB, respectively.
In comparing MCL between women and men, the levels of significance in the Persian monolingual group, sequential Arabic-Persian bilingual and simultaneous Arabic-Persian bilingual were 0.955, 0.732, and 0.507, respectively. In comparing BNL between men and women, the levels of significance in the Persian monolingual group, sequential Arabic-Persian bilingual and simultaneous Arabic-Persian bilingual were 0.794, 0.948, and 0.638, respectively. In comparing the ANL between women and men, the levels of significance in the Persian monolingual group, sequential Arabic-Persian bilingual, and simultaneous Arabic-Persian bilingual were 0.517, 0.566, and 0.372, respectively.
The results show no significant difference between the mean scores of MCL, BNL and ANL in men and women in any language group. The mean scores of the two sexes in each language group were approximately equal ($p > 0.05$).
ANOVA test was used to investigate the effect of bilingualism on MCL ($p = 0.002$) that showed a significant difference among the three linguistic groups. As a result, we used the LSD post hoc analysis to find the difference between groups. In post hoc studies, a significant difference was observed between the Persian monolingual group and sequential Arabic-Persian bilingual group ($p = 0.037$) and between the Persian monolingual group and simultaneous Arabic-Persian bilingual group ($p < 0.001$). However, this difference was not significant between two bilingual groups ($p > 0.05$).
In studying the effect of bilingualism on BNL, p value was found as 0.011 that indicated a significant difference among the three linguistic groups. As a result, we used the LSD post hoc analysis to determine whether the difference among groups was significant. In post hoc studies, there was a significant difference between the Persian monolingual group and sequential Arabic-Persian bilingual group ($p = 0.004$) and between the Persian monolingual group and simultaneous Arabic-Persian bilingual group ($p = 0.04$). However, this difference was non-significant between two bilingual groups ($p > 0.05$).
In analyzing the effect of bilingualism on ANL, the ANL level values in the Persian monolingual group, sequential Arabic-Persian bilingual and simultaneous Arabic-Persian bilingual were found as 0.415, 1.36 and 0.53 dB, respectively, indicating no significant difference among three language groups in ANL scores ($p = 0.114$).

Discussion

As mentioned above, because of the involveement of subcortical regions, especially thalamus in bilingual people [9], and on the other hand, considering the centrality of the source of noise tolerance and the fact that the difference in activity levels from the brainstem to the temporal lobe can affect the extent of noise acceptance in people [7], in this study, the speech perception function was compared with the presence of background noise between Arabic-Persian bilinguals and Persian monolinguals.
In the present study, the effect of gender on the mean scores of MCL, BNL, and ANL was investigated and the results indicated no gender effect on any parameter.
In the study of Ahmadi et al., the mean scores of MCL and BNL were measured in 66 people with normal hearing (33 females, 33 males); these scores were significantly lower in women than in men ($p = 0.014$) [19]. The findings of this study are not in line with ours. In the study of Rogers et al. [20] MCL scores were 6 dB higher in men compared to women, and mean scores of BNL were 7 dB higher. This is not in line with the findings of our study either.
In the present study, all three language groups were the same, and the gender difference was not significant in any of the linguistic groups. Also, the ANL test is a behavioral test that is affected by attention or tiredness of the patient [21]. Perhaps considering the sample size and study population the larger sample size is valuable too. It should be noted that different results of our study with regard to MCL and BNL scores with previous study do not change

the clinical decisions for two reasons. First, MCL in all three groups were within normal comfortable hearing level [12], second the difference between MCL and BNL recalls the concept of ANL for us.

In the present study, there was no significant difference between the ANL results of two sexes (p = 0.114), which is in line with Rogers et al.' study. They studied 50 subjects including 25 men and 25 women with normal hearing sensitivity, and found ANL mean (SD) scores in women as 11.4 (7.7) and in men as 10.4 (6.6). Therefore, ANL scores were not significantly different between the two sexes [20]. The study of Ahmadi et al. [19] also confirms the findings of the present study, so that the mean (SD) ANL scores in women was 2.12 (2.28) and in men 1.94 (2.41) which was not significantly different (p = 0.47).

In examining the effect of bilingualism on the MCL and BNL, it was found that these two levels were significantly higher in both bilingual groups compared to the monolingual group, despite the fact that MCL in all three groups were within the comfortable range of hearing (i.e. 30–40 dB higher than hearing threshold) [21]. The cause of higher MCL and BNL level in bilingual subjects may be due to the fact that in the first place, the test material was chosen from the second language, not the first language. On the other hand, in bilingual people, both languages must be processed, and as they regularly use both languages, they are forced to control the interference of both languages, so that when they speak a language, unintentional use of non-target language does not happen [22]. Because in studies of ANL in bilingual people, the subtests of ANL have not been reported so far, this is the first study that examined the impact of language on MCL and BNL.

In the present study, the ANL scores in the sequential bilingual group (1.36 dB) were higher than monolingual group (0.41 dB) and simultaneous bilingual (0.53 dB), but their difference was not statistically significant. If because ANL difference becomes significant, when it is more than 4–5 dB [23].

In the study of von Hapsburg and Bahang, an English-speaking monolingual group with two Korean-English bilingual groups with low proficiency (LP) and moderate proficiency (MP) in the second language were examined by ANL test. The English monolingual group was tested with the ANL English language test and 12 Person English bubble, while two Korean-English bilingual groups once were tested with English test materials and then with Korean test materials. The ANL level with the English test materials in the monolingual, LPB and MPB groups were 6.4, 6.8 and 8 dB, respectively, and the ANL with Korean test materials in MPB and LPB were 7.3 and 7.7 dB. The results showed that bilingual people require a higher signal-to-noise ratio to perceive the second language, thus having a higher tolerance level (lower ANL) for their first language than the second language. Analytical analyzes of this study showed no significant difference between ANL level of monolingual people and bilingual subjects [24]. Findings of this study are consistent with these findings.

In another study, Shi et al. tested ANL on 24 Spanish-English (S) bilinguals, 16 Russian-English (R) bilinguals and 15 English monolingual (M) by placing the speakers at a distance of 1.5 meter and at zero degrees of Azimuth. They also changed the study variables, such as the type of listener (monolingual or bilingual), the type of speech signal language (Spanish or English, here the language's comprehensiveness has been considered) and the features of the babble (the tune of the language that the reader was familiar with, and the number of speakers was 4 or 12). The mean ANL values obtained under all of the above conditions in M, S, and R groups were 4.91, 4.11 and 8.84 dB, respectively. Considering the type of listener, the results showed that the R group had higher ANL than the other two groups, because both the signal language was presented in the second language (English) and the foreign language (Spanish), and the bubble noise was presented in the second language (English) and the foreign language (Spanish), therefore they have tolerated less noise. With regard to the speech signal language that was once in English and once in Spanish, it was concluded that the English signal would reduce ANL compared to the Spanish signal, but this difference is not clinically significant. Regarding the characteristics of the babble, no significant effect was observed in the M and S groups, but for the R group, a significance difference was found between 12 multi-talker English and Spanish babble, and when the 12 multi-talker Spanish babble had been used for them, they got higher ANL scores. The study authors concluded that the independence of ANL from language cannot be fully confirmed [17]. Lack of significant correlation between ANL in monolingual and Spanish bilingual groups in the Shi et al study is consistent with ANL findings in the current study between Persian monolingual and Arabic-Persian bilinguals.

Conclusion

Although MCL and BNL are higher in bilingual groups compared to monolingual group, the relationship between these two levels, which expresses the concept of ANL, does not have a significant difference in all three groups. This suggests that in normal people, the relationship between central hearing processing and noise tolerance during speech perception in each group works the same way. Thus in spite of the difference in the ANL parameters, this value in three groups is the same and is not affected by changes in the use of language patterns in bilingual subjects. As a result, the Persian version of ANL can be used for Arabic-Persian bilingual subjects.

Acknowledgements

This paper is part of the Master's thesis for Audiology at Tehran University of Medical Sciences. The authors would like to thank to Dr. Bayat, the director of the Audiology Department of the Faculty of Rehabilitation, Jundishapur University of Medical Sciences in Ahvaz, for providing the equipment used in this study and the location for running the tests.

Conflict of interest

The authors declare that they have no conflict of interest.

References

1. Anderson S, Kraus N. Sensory-cognitive interaction in the neural encoding of speech in noise: a review. J Am Acad Audiol. 2010;21(9):575-85. doi: 10.3766/jaaa.21.9.3
2. Nabelek AK, Tucker FM, Letowski TR. Toleration of background noises: relationship with patterns of hearing aid use by elderly persons. J Speech Hear Res. 1991;34(3):679-85. doi: 10.1044/jshr.3403.679
3. Nabelek AK, Freyaldenhoven MC, Tampas JW, Burchfiel SB, Muenchen RA. Acceptable noise level as a predictor of hearing aid use. J Am Acad Audiol. 2006;17(9):626-39.
4. Nabelek AK, Tampas JW, Burchfield SB. Comparison of speech perception in background noise with acceptance of background noise in aided and unaided conditions. J Speech Lang Hear Res. 2004;47(5):1001-11. doi: 10.1044/1092-4388(2004/074)
5. Mueller HG, Weber J, Hornsby BW. The effects of digital noise reduction on the acceptance of background noise. Trends Amplif. 2006;10(2):83-93. doi: 10.1177/1084713806289553
6. Harkrider AW, Smith SB. Acceptable noise level, phoneme recognition in noise, and measures of auditory efferent activity. J Am Acad Audiol. 2005;16(8):530-45.
7. Harkrider AW, Tampas JW. 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(9):667-76.
8. Jonas Brännström K, Olsen SØ. The acceptable noise level and the pure-tone audiogram. Am J Audiol. 2017;26(1):80-7. doi: 10.1044/2016_AJA-16-0033
9. Giussani C, Roux FE, Lubrano V, Gaini SM, Bello L. Review of language organisation in bilingual patients: what can we learn from direct brain mapping? Acta Neurochir (Wien). 2007;149(11):1109-16; discussion 1116. doi: 10.1007/s00701-007-1266-2
10. Wahl M, Marzinzik F, Friederici AD, Hahne A, Kupsch A, Schneider GH, et al. The human thalamus processes syntactic and semantic language violations. Neuron. 2008;59(5):695-707. doi: 10.1016/j.neuron.2008.07.011
11. Hernandez AE. Language switching in the bilingual brain: what's next? Brain Lang. 2009;109(2-3):133-40. doi: 10.1016/j.bandl.2008.12.005
12. Schlauch RS, Nelson P. Puretone evaluation. In: Katz J, Medwetsky L, Burkard R, Hood L, editors. Handbook of clinical audiology. 6th ed. Baltimore: Lippincott Williams & Wilkins; 2009. p. 30-49.
13. Clark JL, Roeser RJ, Mendrygal M. Middle ear measures. In: Roeser RJ, Valente M, Hosford-Dunn H, editors. Audiology diagnosis. 2nd ed. New York: Thieme; 2007. p. 380-99.
14. Richards JC, Schmidt R. Longman dictionary of language teaching and applied linguistics. 4th ed. New York: Routledge; 2013.
15. Harley TA. The psychology of language: from data to theory. 3rd ed. New York: Psychology Press; 2008.
16. Oldfield RC. The assessment and analysis of handedness: the Edinburgh inventory.

Neuropsychologia. 1971;9(1):97-113. doi: 10.1016/0028-3932(71)90067-4
17. Shi LF, Azcona G, Buten L. Acceptance noise level: effects of the speech signal, babble, and listener language. J Speech Lang Hear Res. 2015;58(2):497-508. doi: 10.1044/2015_JSLHR-H-14-0244
18. Khateb A, Abutalebi J, Michel CM, Pegna AJ, Lee-Jahnke H, Annoni JM. Language selection in bilinguals: a spatio-temporal analysis of electric brain activity. Int J Psychophysiol. 2007;65(3):201-13. doi: 10.1016/j.ijpsycho.2007.04.008
19. Ahmadi A, Fatahi J, Keshani A, Jalilvand H, Modarresi Y, Jalaie S. Developing and evaluating the reliability of acceptable noise level test in Persian language. J Rehab Med. 2015;4(2):109-17.
20. Rogers DS, Harkrider AW, Burchfield SB, Nabelek AK. The influence of listener's gender on the acceptance of background noise. J Am Acad Audiol. 2003;14(7):372-82; quiz 401.
21. McArdle R, Hnath-Chisolm T. Speech audiometry. In: Katz J, Medwetsky L, Burkard R, Hood L, editors. Handbook of clinical audiology. 6th ed. Baltimore: Lippincott Williams & Wilkins; 2009. p. 64-79.
22. Festman J, Rodriguez-Fornells A, Münte TF. Individual differences in control of language interference in late bilinguals are mainly related to general executive abilities. Behav Brain Funct. 2010;6:5. doi: 10.1186/1744-9081-6-5
23. Ho H-C, Wu Y-H, Hsiao S-H, Stangl E, Lentz EJ, Bentler RA. The equivalence of acceptable noise level (ANL) with English, Mandarin, and non-semantic speech: a study across the U.S. and Taiwan. Int J Audiol. 2013;52(2):83-91. doi: 10.3109/14992027.2012.733422
24. von Hapsburg D, Bahng J. Acceptance of background noise levels in bilingual (Korean-English) listeners. J Am Acad Audiol. 2006;17(9):649-58.