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Original Article

Development and Validation of the Persian Version of the Acceptable Noise Level (ANL) Test in Normal Children Aged 5-8 Years

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ABSTRACT

Background: The goal of the present study was to develop and validate the Persian version of the Acceptable Noise Level (ANL) test in normal, Persian-speaking children aged 5-8 years.

Methods: This tool-making and non-experimental research was conducted in two stages. In the first stage the proper story was selected and recorded after evaluation of its content validity. In the second stage this test material was administered to a total 181 normal children (97 girls and 84 boys) randomly chosen from the population of preschool and primary school children of Tehran (District 5), aged 5-8 years in four age groups to evaluate the reliability of test in order to develop the Persian version of the ANL test and assess its changes during the growth. Lawshe's method and Cronbach's alpha coefficient were used to assess the content validity and reliability of the test, respectively. Mann–Whitney U test was used to examine gender differences, and Kruskal-Wallis test was to examine age differences.

Results: Test-retest correlation of 0.74 indicated acceptable reliability of the test. Significant differences were found between most of different age groups for the ANL mean scores ($P<0.05$). There was no significant gender difference for the ANL mean scores ($P>0.05$).

Conclusion: The study results indicated good validity and reliability of the Persian version of the ANL test in children. Therefore this test can be useful in designing classrooms suitable for 5-8 year-old children of both genders.

Introduction

During oral communication, the speech message, being transferred to the listener's ears through the air, may be mixed with interfering noise and not clearly received by listener's ears, and a communication breakdown occurs. Several factors are responsible for this breakdown, including hearing loss, interfering sounds (commonly referred to as noise), distance, and some environmental factors (heat and humidity) [1]. Noise can affect all important aspects of hearing speech in both children and adults, being more important in children since an accurate hearing is crucial for speech and language development in them [2]. Background noise leads to a reduction in Signal to Noise Ratio (SNR), and can affect the ability of hearing the speech.

Children, compared to adults, differently benefit from hearing for two reasons: first, the hearing structure in the human brain does not fully mature until age 15, therefore children cannot fully benefit from their hearing system

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completely. Second, children lack the vast language experiences of adults to infer and fill in the gaps of lost information [3]. It is shown that children under age 15 need greater SNR (+15 dB) than adults (+7-11 dB) for clear hearing. This reaches to 20 dB for classroom. Therefore, due to the fact that children access to less hearing information, they need more quiet environments or greater SNRs [4-6].

Accurate transfer of acoustic information in the classroom is important for academic achievement. Some acoustic properties of classroom may have negative effects on the speech-perception ability, including: reverberation, the overall level of the background noise, relation between teacher's voice and noise (or SNR), and distance between teacher and child. In addition, speech reception in classroom may be affected by a reduction in hearing sensitivity or auditory processing disability of the child [7]. Children despite having good hearing, perform worse on speech-in-noise tests compared to adults due to the lack of maturation of the auditory system and also lack of adequate skills to use acoustic cues [8]. Speech-in-noise tests; indicate that around age 14, children's performance on these tests reach the level of adults [9]. Although speech-in-noise tests assess speech perception in the presence of noise, they do not provide any information about the interruption that noise imposes on the speech perception. Previous studies indicate that willingness to listen to speech in background noise, is independent from the speech-perception ability [10].

Nabelek designed the Acceptable Noise Level (ANL) test for assessing the acceptance of background noise in hearing aid users. This test measures the maximum level of background noise acceptable for the person when following words of a story. ANL is calculated by subtracting Background Noise Level (BNL) from Most Comfortable Level (MCL) [11].

ANL shows the maximum acceptance of background noise level by a person while keeping connection to the running speech signal while increment of background noise from this level causes a communication breakdown. Therefore, the ANL test can provide an insight into the level of noise in the classroom that is acceptable for a student, and may be useful in determining the point of communication breakdown in a child [12]. Since children's communications are differently affected by noise than those of adults due to immaturity of their central auditory system, and are more influenced by noise, therefore, ANL could be different in children and adults [13]. Measurement of ANL in children provides suitable hearing conditions in the classroom and also helps to determine the need and the level of hearing rehabilitation for hearing impaired children when prescribing and adjusting hearing aids [4].

However, there are few studies on this issue, especially in preschool children. In Persian language only Ahmadi et al, developed and evaluated ANL test and its reliability and validity for Persian speaking adults (19-29 years old)[14].Considering the important effects of noise on children's academic performance, the present study is aimed to develop and validate ANL test and to evaluate its developmental process in children.

Methods

This is a tool-making and non-experimental study that includes the selection of proper running speech material, assessing the content validity of it and recording them. The text for using as continuous speech signal must be easy, long enough (more than 4 minutes of recorded materials), and fiction, represent daily hearing situations, and must be in standard Persian for Persian-speaking participants [14] and must also be suitable for the age group under the study. In order to eliminate the incomprehensibility effect of the text, the text was selected from the stories published by the Institute for the Intellectual Development of Children and Young Adults that were suitable for the proper age group (books for the A and B age groups). Multi-talker speech babble noise (eight-talker used) was chosen as noise to represent daily listening situations more accurately. To choose the most appropriate text, the "Uninvited Guest (mehmanhaye nakhandeh)," "Sinbad the Sailor (sand bad)," "Little Red Riding Hood (shenel ghermezy)," and "Hey, little elephant! Where is your nose? (fil kochulu damaget ku?)" were selected which were designed for the age group 5-8 years and sent to 10 experts in audiology and speech and language pathology active in children-related rehabilitation areas. The Content Validity Ratio (CVR) was calculated for each story. According to the Schipper's table (showing statistically acceptable CVR values for examination of content validity), the minimum acceptable CVR value for 10 experts was obtained as 0.62. According to the experts' opinions, "Hey, little elephant! Where is your nose?" obtained enough score. Then the text was narrated by a female talker, reading the text fluently keeping the level of voice unchanged and recorded in a studio. The output of intensity level of raw material of story and noise were made equivalent by a sound level meter (using 1000 Hz pure tone for calibration of the device output).

In the next stage, the prepared test material was administered to 181 normal children (97 women and 84 men) aged 5-8 years, who were randomly selected according to the inclusion criteria from the population of preschool and primary school children of Tehran (District 5).

The inclusion criteria were: informed consent and willingness of parents and children for participation in the research, age of participants 5-8 years, normal results of otoscopy, air conduction (AC) thresholds 20 dB or better at frequencies 1, 2, and 3 KHz for both ears (ASHA, 1996), no history of otologic or neurologic problems or learning disability, studying in normal daily classrooms, right-handedness (determined using the Edinburgh Handedness Inventory in order to reduce the hemisphere effects) and being monolingual (Persian language). For applying the inclusion criteria, a researcher-made questionnaire was used. Children, who met the inclusion criteria, entered the study after obtaining their consents. The exclusion criteria included losing the inclusion criteria or showing unwillingness to remain in the study at any stage.

The ANL test scores were obtained based on the method

suggested by Nabelek. The speech and babble noise were binaurally presented using TDH50 headphones, an MP3 player, and a two-channel audiometer (MAICO MA53). The procedure was carried out in a silent room. During the process, first the MCL and then the BNL were obtained, and finally the ANL was calculated. For obtaining MCL the speech stimulus (story) was presented at 30 dB, and increased at 5 dB steps. The child was told that the intensity level of the story would gradually increase, and was asked to report when the intensity level would go higher than the level in which s/he usually listened to TV. When the child reported that the sound level was high, it was turned down to reach to the lower level that usually they listened to TV. Then with the help of a 2 dB steps change child was asked to report when the sound intensity level would be the same that s/he usually listened to TV. After determining the satisfactory intensity level of the stimulus it was recorded as the MCL for the listener. In order to obtain the BNL, the speech stimulus (story) was presented at the MCL, the background noise was presented at 30 dB, and it was increased in 5 dB steps to a level that the story became not clearly audible for the child. Then, it was decreased to a level in which the story would be clearly heard and finally, by changing the noise intensity level at 2 dB steps, the noise intensity was adjusted at the highest possible level in which child could listen to the story for a long time without getting tried. This intensity level of noise was recorded as the BNL. ANL was the difference between these two values (BNL and MCL). In order to examine reliability of test, the test was administered again to 16 of the same participants in different age groups two weeks following the initial procedure, and their results were compared.

The study protocol was approved by the ethical committee of University of Social Welfare and Rehabilitation Sciences under the ethical code of IR.USWR.REC.1394.286. All the ethical principles suggested by the Ethics Committee were taken into consideration in this research.

The Lawshe's method and the Cronbach's alpha coefficient were used to assess the content validity and reliability of the test, respectively. Since Kolmogorov-Smirnov test showed that the data distribution was not normal, therefore the Mann–Whitney U test was used to examine gender differences, and the Kruskal-Wallis test was used to examine age differences. Data analysis was performed using SPSS software v.21, at the 5 percent level of significance ($P<0.05$).

Results

CVR values were obtained using the Lawshe's method. CVR Scores were 0.4, 0.2, 0.8 and 1 for stories of "Uninvited Guest", "Sinbad the Sailor", "Little Red Riding Hood" and "Hey, little elephant! Where is your nose", respectively. The story "Hey, little elephant! Where is your nose?" gained the highest score and was selected for recording.

A total of 181 normal children (84 boys and 97 girls) aged 5-8 years (mean= 83.31 months, ± 13.55) participated in the study. Table 1 shows the measures of central tendency and dispersion for age (months).

Using Mann–Whitney U test, the ANL calculated by subtracting BNL form MCL showed no significant gender difference (Table 2).

The Kruskal-Wallis test results indicated a significant difference between different age groups. Figure 1 shows the mean, standard deviation and upper and lower limits for MCL (diagram A), BNL (diagram B), and ANL (diagram C) in each age group and in both genders.

Regarding lack of gender difference in mean, scores the results for ANL are shown for different age groups including both genders as a whole in Figure 2. Mean ANL scores for each study groups of 5, 6, 7 and 8 years old was 11.59, 10.23, 9.81 and 8.44, respectively.

According to Figure 1, the results indicated a significant difference in MCL scores between children aged 5 and children aged 7 years (P=0.000), but no significant

Table 1: Measures of central tendency and dispersion for age, divided based on gender and age

Age	Gender	Number	Mean(month)	Standard Deviation
5 years	Girl	21	67.38	1.910
	Boy	28	67.23	2.200
6 years	Girl	21	76.95	3.106
	Boy	23	76.43	2.982
7 years	Girl	21	87.86	3.321
	Boy	22	89.59	3.500
8 years	Girl	21	102.33	102.33
	Boy	24	101.76	101.79

Table 2: comparison of scores on the MCL, BNL, and ANL tests for two genders

Test	Gender	Mean Rank	Level of Significance (P value)
MCL	Boy	97.67	0.106
	Girl	85.22	
BNL	Boy	97.60	0.110
	Girl	85.28	
ANL	Boy	91.43	0.915
	Girl	90.63	

MCL: Most Comfortable Level; BNL: Background Noise Level; ANL: Acceptable Noise Level

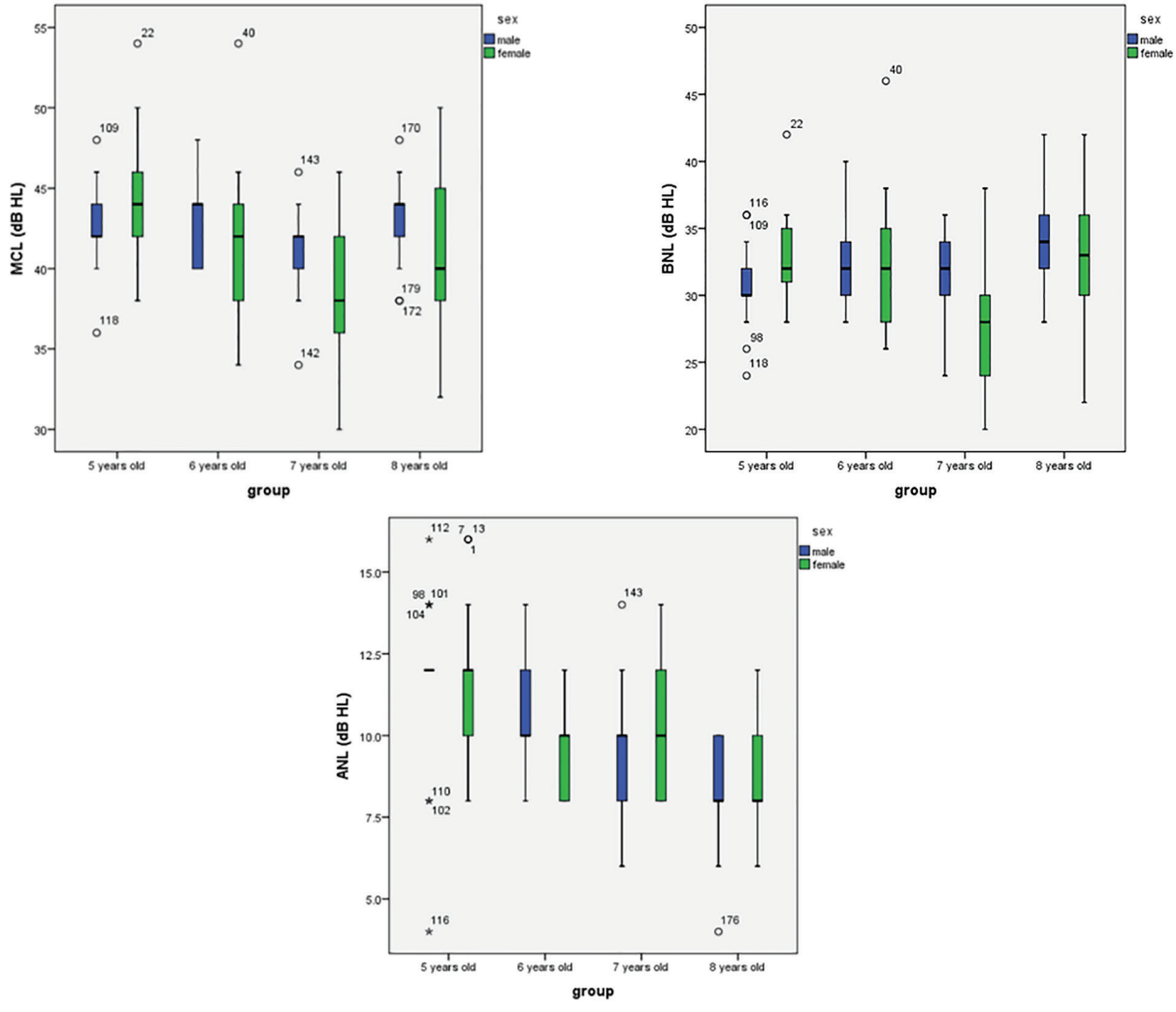

Figure 1: Diagrams A, B, and C, show the mean, standard deviation, and upper and lower limits for MCL, BNL, and ANL, respectively.

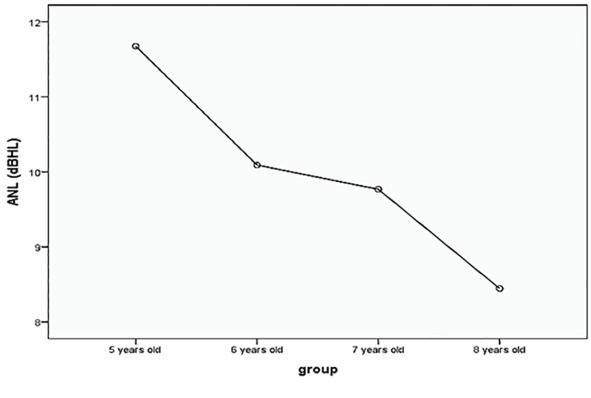

Figure 2: Comparison of average ANL scores between the four age groups (5-8 years)

Table 3: Level of significance for ANL in different age groups

Group	Group being compared	Level of Significance (P value)
5 years	6 years	0.003
	7 years	0.000
	8 years	0.000
6 years	5 years	0.003
	7 years	0.909
	8 years	0.003
7 years	5 years	0.000
	6 years	0.909
	8 years	0.027
8 years	5 years	0.000
	6 years	0.003
	7 years	0.027

difference was found between the other age groups (P>0.05) (diagram A). There was a significant difference in BNL scores between children aged 7 and children aged 8 years (P=0.002), but no significant difference was found between the other age groups (P>0.05) (diagram B). Table 3 shows the level of significance for ANL in different age groups. The comparison of ANL average scores between children aged 5 and children aged 6, 7, and 8 years showed significant difference (P=0.003, 0.000, 0.000, respectively). The comparison showed significant differences between ANL average scores for children aged 6 and 8 years (P=0.003), but it was not significantly different from the results for children aged 7 years (P>0.05).

Reliability was examined using the Cronbach's alpha coefficient, and found to be 0.74; indicating acceptable reliability of the test.

Discussion

The present study was aimed to develop and validate the Persian version of the ANL test in normal, Persian-speaking children aged 5-8 years. In the present study, the Lawshe's CVR method was used to examine content validity. The story "Hey, little elephant! Where is your nose?" obtained the highest CVR value.

A Cronbach's alpha of 0.74 indicated good reliability of the Persian version of the test in test-retest procedure. A common criterion for describing reliability by Cronbach's alpha value is: 0.9=excellent, 0.7-0.9=good, 0.5-0.7=average and less than 0.5=acceptable reliability. Different studies have been conducted on the reliability of the ANL test in children. In a study for ANL on children aged 8-12 years with normal hearing, Freyaldenhoven and Smiley reported a correlation coefficient as r=0.87, indicating a high test-retest reliability of ANL [15]. In a study on acceptable noise level in children ages 10 to 11 years and 14 to 15 years, ware found correlation values of 0.67, 0.86, and 0.73 for 10 and 11 year-old, 14 and 15 year-old, and all children of 10 to 15 years old, respectively [12]. Using the test-retest method, Bryan also reported good reliability of the ANL test for 5 years old children with normal hearing [16] results of the present study regarding the reliability of the Persian version of the ANL test in children is in line with them.

Our findings showed no gender differences in ANL scores; indicating the similarity of background noise acceptance in both genders. The study by Freyaldenhoven and Smiley and also Ware showed the same result in 8-12 and 10-11 and 14-15 years normal hearing children [12,15].

Regarding the effects of developmental changes on the ANL results, significant differences were found between different age groups with a decrease trend from age 5 to 8 years (Figure 1, diagram C). According to Freyaldenhoven and Smiley, ANL was not age-dependent, at least for 8 and 12 year-old children [15]. Ware also found no significant differences in ANL scores between 10 and 11 year-old and 14 and 15 year-old participants [12]. In a study on children and adults with normal hearing, Moore found no significant differences in ANL scores between 8-10 year-old children and 19-28 year-old adults, but adults had significantly higher BNL and MCL scores than children. Moore attributed this difference to different instructions given to children for obtaining MCL and BNL values, and also to physiological differences between children's and adults' hearing. Moore also stated that the lack of difference between the age groups under study could be due to the fact that the maturity of ANL occurred in a lower age [13]. According to our findings in this study and as evident in Figure 2, ANL is decreasing from age 5 to 8 years, in other words, background noise becomes more acceptable for children and less interfering with hearing.

Conclusion

The results of this study indicated acceptable validity and reliability of our Persian version of the ANL test for children Aged 5-8 Years. Measuring ANL in normal children is useful in determining the acceptable background noise for them before the communication breakdown occurs. This test is useful to control the background noise level in classrooms, especially for age 5 (in preschool education) since we found its highest value for age 5 then declining towards adult values in children up to 8 years indicating its immaturity under age 6 years and a rapid maturation thereafter, a finding being in line with moore's conclusion about early maturity of ANL. Having ANL determination in children can help in providing appropriate hearing conditions in classrooms for normal hearers regarding their ages and also it makes a scientific base in handling and management of hearing rehabilitation programs in children who suffer from hearing loss.

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