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RESEARCH ARTICLE

Acceptable noise level in learning disordered children

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Abstract

Background and Aim: Acceptable noise level (ANL) measures the amount of accepted background noise while listening to the story. In the current study, ANL was carried out in children with learning disability (LD) and compared with the results of normal children by using examiner- and self-adjusted methods.

Methods: Forty seven (25 male, 22 female) normal children with good and better educational background and 46 (27 male, 19 female) LD children ranging in age from 7-12 years old were participated. ANL was assessed using an ear-level loudspeaker in front of children. The differences of ANL, most comfortable level (MCL), and background noise level (BNL) between groups and their relationship between examiner- and self-adjusted procedures were investigated.

Results: Mean ANLs of LD children either in examiner- or self-adjusted methods (8.91± 4.66 and 11.00±5.38, respectively) were worse than those of normal children (7.19±3.63 and 9.61±3.41, respectively). The difference between mean ANL of normal and LD children was statistically significant only for examiner-adjusted method (p=0.05). There were also significant differences in BNL between groups for examiner- and self-adjusted method ($p< 0.05$). A strong positive correlation was found between examiner- and self-adjusted conditions for ANL, MCL, and BNL among groups ($p<0.001$).

Conclusion: ANL is clinically applicable in LD children. Moreover, LD children accept lower background noise; therefore modification of their listening environment is recommended. Because of a strong positive relationship between ANL in examiner- and self-adjusted procedures, both methods can be implemented in different situations.

Keywords: Acceptable noise level; children; learning disorder; examiner-adjusted method; self-adjusted method

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Introduction

In the educational environment, children are often exposed to multi talker babble noise. Basically, noise has a detrimental impact on learning and educational achievement [1]. Learning disability (LD) refers to some disorders which may influence on the acquisition, organization, retention, understanding or use of verbal or nonverbal information. These disorders affect learning in persons who otherwise demonstrate at least average abilities essential for thinking

and/or reasoning [2]. According to DSM-IV, children with learning disabilities are diagnosed when their achievement on individually administered standardized tests in reading, mathematics or written expression is significantly below than expected for age, schooling and level of intelligence [3]. Children with LD have more difficulty in listening performance in the presence of background noise than children without LD [4-7]. Learning disorder in children is the results of neurophysiological differences in the brain structure and function which affect a person's ability in receiving, storing, processing, retrieving, or communicating information [8].

Acceptable noise level (ANL) which has been introduced by Nabelek et al. measures the amount of background noise individuals are willing to accept while listening to the words of the story without becoming anxious or tense [9]. ANL is calculated by difference between the most comfortable level (MCL) for running speech adjusted by listener and the highest self-chosen background noise level (BNL) that a listener will accept (ANL=MCL-BNL) [9]. ANL also can be administered by the examiner for the pediatric population (i.e. examiner turns intensity dial for the children) [10]. Studies have shown that ANL can predict hearing aid use [9,11]. People with small ANL are willing to accept more background noise and they would be successful hearing aid users, however, individuals with large ANL are going to choose less background noise and they will be either unsuccessful or rejecter hearing aid users [9,11]. ANL is not correlated with hearing sensitivity, however, it is mediated by more central regions of the auditory system [12]. ANL has been conducted among normal children in 2006, and it showed that measured ANL features in children appear to behave in the same way with ANL characteristics measured in adults [10]. In fact, ANL is a quick test which takes only 2-4 minutes [10].

According to Warrier et al., children with learning disorder have deficits in auditory pathway timing which may influence on their hearing performance at the presence of background noise [13]. Moreover, studies have shown that children with learning disabilities have abnormal neural representation of brief and rapidly successive sensory inputs [14]. These individuals also have deficits in their brainstem responses to the syllable /da/ and cortical processing of signal in noise [15]. Researchers have shown that people with central auditory processing disorder (CAPD) have larger ANL in comparison with normal individuals [16]. Prevalence of auditory processing disorder (APD) among children with LD is estimated as high as 43% [17]. Moreover, many studies suggest difficulty in speech understanding in noise in a large proportion of individuals with LD [4-7,18]. Therefore, it was hypothesized that children with LD are willing to accept less background noise around and it seems that investigating ANL among LD children is worth studying.

It would be interesting to study the acceptance of background noise of children with LD, so necessary recommendations can be considered during their intervention process. This information can be useful in making simple modifications of listening environment (e.g. classroom acoustic) in order to improve listening performance in noise and effectiveness of teaching in children with LD.

Consequently, our main goals of this study were exploring the acceptance of background noise among learning disordered children and comparing it with normal children as well as examining the correlation between two procedures of assessing ANL named examiner-adjusted and self-adjusted.

Methods

Forty six learning disordered children (27 male, 19 female) referred by Learning Disorder Center of Rofeideh Rehabilitation Hospital and Hazrat-e- Fatemeh Clinic as examination group, and forty seven (25 male, 22 female) normal children randomly chosen from ordinary primary schools of Tehran with good and better educational background as control group participated in our study. To diagnose LD children, firstly, children whose parents and teachers were complaining of their educational achievement were screened by the Wechsler Intelligence Test (for

children) [19] to assess their intelligence status. Then, children with normal intelligence were evaluated for detecting learning disorder by: Dyslexia Test (for reading status assessment) [20], Iran Key Math Mathematical Test (for examining the status of math) [21], and task analysis (for writing status) [22]. In this way, children with learning disorder were diagnosed according to these criteria by psychologist.

The inclusion criteria for of all children were studying in ordinary school, normal intelligence, lack of autistic spectrum disorders, normal or corrected sight, lack of any type of emotional disorder, bilaterally pure tone hearing threshold of 20 dBHL or lower at octave frequencies between 250 and 8000 Hz, and good speech discrimination score.

Participants came to Audiology clinic of School of Rehabilitation Sciences, Iran University of Medical Sciences, for all assessments related to the current study. This study was confirmed by ethics committee number of IR.IUMS.REC. 1396.9411301006. First of all, the consent letter was signed by parents of the children. Outer and middle ear of all participants were examined using a Reister otoscope and a Clarinet Inventis Tympanometer (Invenis Company, Italy). Children with any type of obstruction or infection in external ear canal and/or Type B or Type C tympanogram were excluded from the study. Next, air condition (AC) audiometry from 250 to 8000 Hz using supra-aural headphones and Orbiter 922 clinical Audiometer (GN Resound Company, Denmark) was assessed. For audiometry, we presented a 1000-Hz tone with 1 to 2 seconds duration at 30 dB hearing level (HL). If a clear response was given, then threshold measurement started. If no response was signaled by children, we presented the tone at 50 dBHL by successive additional increments of 10 dB until a response was obtained. Then we changed the intensity 10 dB down if children response and 5 dB up if they didn't response until their hearing threshold was obtained at 1000, 2000, 4000, 8000, 500, and 250 Hz, respectively [23].

After evaluation of peripheral hearing system, ANL of all children was examined using an ear-level loudspeaker in front of children in one meter distance in the acoustic room. We used the Persian version of ANL conducted by Ahmadi et al. and Taghavi et al. [24,25]. The acceptable noise level (ANL) instruction for the pediatric population developed by Freyaldenhoven and Smiley, were used except children were asked to giving a "thumbs-up" sign for examiner-adjusted method while the examiner turn the intensity dial for them in order to obtain MCL and BNL, and "turning intensity dial" by themselves for self-adjusted procedure to get to their MCL and BNL [10]. The running story started at the level of 30 dBHL, and was steadily turned up in 5 dB then 1 dB steps until the child signaled that her most comfortable listening level has been achieved (MCL) for examiner-adjusted method. We ignored 2 dB steps because of fatigue characteristic of LD children. After that, multi talker babble noise was added into the same loudspeaker. Children were asked to signal the examiner by picking up their hand when the background noise became the most they could put up without becoming tense or anxious while listening to the words of the running story in examiner-adjusted method. This was termed as a background noise level (BNL). For self-adjusted method children themselves turned intensity dial of audiometer to get their most comfortable level of the story and then to get acceptable BNL. The intensity of the given multi talker babble noise was adjusted up or down in 1-dB steps for all participants. The ANL was then calculated by subtracting the BNL from the MCL. Moreover, the presentation level was calibrated by using a tone on the recording and the audiometer VU-meter.

In order to determine the mean ANL, MCL, and BNL of children as well as the difference between mean ANL, MCL, and BNL of normal children and children with LD, we used independent t-test by SPSS 21. In order to convey the relationship between ANL's results in self-adjusted and examiner-adjusted method for normal children and children with LD, bivariate correlation between two data sets was applied. A criteria of $p<0.05$ was used for significance of statistical analysis.

Table 1. Comparison of mean, standard deviation, and range of acceptable noise level, most comfortable level, and background noise level between normal and learning disability children

	Normal children		LD children		
Measures	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**	**Equality of means (p)**
Examiner-adjusted ANL	7.19 (3.63)	0-20	8.91 (4.66)	0-22	0.050*
Self-adjusted ANL	9.61 (3.41)	2-10	11.00 (5.38)	1-24	0.144
Examiner-adjusted MCL	51.17 (4.86)	40-60	49.34 (7.06)	32-65	0.152
Self-adjusted MCL	53.65 (4.30)	44-62	52.23 (8.44)	35-70	0.312
Examiner-adjusted BNL	43.89 (5.23)	35-53	40.65 (5.61)	28-55	0.005*
Self-adjusted BNL	44.23 (4.90)	36-54	41.36 (6.69)	29-54	0.021*

LD; learning disability, ANL; acceptable noise level, MCL; most comfortable level, BNL; background noise level, *$p<0.05$

Results

The results related to peripheral assessment of auditory system indicated that all children had normal pure tone hearing thresholds at 20 dBHL or better across octave frequencies 250-8000 Hz. They also showed Type A tympanograms. Moreover, speech discrimination score (SDS) in quiet of each participant was 90% or better at their MCL.

The mean ANL, MCL, and BNL of normal children for examiner-adjusted method were 7.19±3.63, 51.17±4.86, and 43.89±5.23, respectively. These results for self-adjusted method among normal children were 9.61 ±3.41, 53.65± 4.30, and 44.23±4.90 respectively. Moreover, for children with learning difficulties in examiner-adjusted method the mean ANL, MCL, and BNL were 8.91±4.66, 49.34±7.06, and 40.65± 5.61 respectively. The mean ANL, MCL, and BNL for children with LD in self-adjusted method were 11.00±5.38, 52.23±8.44, and 41.36± 6.69, respectively.

The results related to mean, standard deviation, and range of ANL, MCL, and BNL for self-adjusted and examiner-adjusted methods in normal children and children with LD are shown in Table 1.

The analysis related to the difference of ANL, MCL, and BNL between two groups of normal children and children with learning disorder using independent t-test showed that there is a statistically significant difference of ANL between two groups of normal and LD children in examiner-adjusted method at p=0.05. The difference of self-adjusted ANL between normal children and children with LD was not statistically significant at p=0.144. The difference of BNL between two groups of examination and control in examiner-adjusted and self-adjusted methods was statistically significant at p=0.005 and p=0.021, respectively. The difference of MCL between two groups of children with and without learning disorder was not statistically significant at p=0.152 for examiner-adjusted method and p=0.312 for self-adjusted method. The results of equality of ANL's results between two groups of examination and control are also shown in Table 1.

The amount of background noise which learning disordered children accept while listening to the words of the story in their MCL without becoming fatigued or tense is less than normal children in examiner-adjusted method of obtaining ANL for pediatric population. There is no significant difference between most comfortable level of normal children and children with LD in self-adjusted and examiner-adjusted methods. However, the amount of background noise that children with LD choose for self-adjusted and examiner-adjusted methods is significantly less than the amount of background noise that normal children select.

Table 2. Means of acceptable noise level, most comfortable level, and background noise level in examiner- and self-adjusted methods

Measures	Examiner-adjusted method (mean)	Self-adjusted method (mean)	p*	r
ANL in LD children	8.91 (4.66)	11.00 (5.38)	<0.001	0.63
ANL in normal children	7.19 (3.63)	9.61 (3.41)	<0.001	0.87
MCL in LD children	49.34 (7.06)	52.23 (8.44)	<0.001	0.90
MCL in normal children	51.17 (4.86)	53.65 (4.30)	<0.001	0.82
BNL in LD children	40.65 (5.61)	41.36 (6.69)	<0.001	0.94
BNL in normal children	43.89 (5.23)	44.23 (4.90)	<0.001	0.72

*P-value for the correlation between self-adjusted and examiner-adjusted methods in all measurements was <0.05
ANL; acceptable noise level, LD; learning disability, MCL; most comfortable level, BNL; background noise level

The findings related to the correlation between ANL's findings in self-adjusted and examiner-adjusted methods among pediatric population with and without LD indicated a significant correlation between self-adjusted and examiner-adjusted ANL, MCL, and BNL at $p<0.01$ (2-tailed) ($p<0.001$).It means that children who have a good ANL (small ANL) in examiner-adjusted method they will also have a good ANL in self-adjusted method. The mean ANL, MCL, and BNL for self-adjusted and examiner-adjusted method in LD and normal children are shown in Table 2.

Discussion

The present study conducted ANL among children with learning disorder. This is the first clinical study of ANL in pediatric population with learning difficulties. Our results showed the worse ANL in LD children when compared with normal children. In more details, the finding revealed that the mean ANL in examiner-adjusted method for normal children and children with LD was 7.19 and 8.91, respectively. Moreover, the mean ANL in self-adjusted method for these two groups of participants was 9.61 and 11.00, respectively. Therefore, the results of the current study indicated that mean ANL of LD children was larger than mean ANL of normal children in conventional method of obtaining ANL for children. It means that children with LD are willing to accept less background noise when they are listening to the story in comparison with children without LD. The MCL that children chose in order to listen to the words of the story was not significantly different between normal children and children with LD, either in examiner-adjusted (51.17 and 49.34, respectively) or self-adjusted methods (53.65 and 52.23, respectively). Conversely, children who suffer from learning disorder tended to accept less background noise (BNL was 40.65 for examiner-adjusted method and 41.36 for self-adjusted method) while listening to the story in comparison with normal children (BNL was 43.89 in examiner-adjusted method and 44.23 in self-adjusted method). Furthermore, we found an important significant correlation between two procedures of obtaining ANL named self-adjusted and examiner-adjusted methods among all participants.

The study which has been done by Freyaldenhoven, and Smiley [10] investigated the ANL in normal children. In their study in order to obtain ANL, the intensity dial was turned by examiner after children's signals. The mean ANL among 32 normal children was 9.7, however, in the present study the mean ANL of 47 normal children was 7.19 for examiner-adjusted method and 9.61 for self-adjusted method. The difference between mean ANL measured by previous study and the mean ANL conveyed by our study in examiner-adjusted method might be the results of sample differences and the influence of the

examiner.

Acceptable noise level has not been directly carried out among children with learning disorder in previous studies. According to Sheehan et al. individuals with central auditory processing disorder (CAPD) have larger mean ANL [17.12] than individuals without any kind of disorder in their central auditory system (6.61) or suspected individuals who passed the APD test battery (8.36) [16]. Prevalence of CAPD among children with learning disorder is 30-50 % [15,26,27]. Besides, a study conducted by Freyaldenhoven et al. revealed that ANL has increased in individuals with attention deficit/hyperactivity disorder (ADHS/ADD), and it would be improved by using stimulant meditation [28]. These evidences are along with our results that children with LD had larger ANL in comparison with normal children.

The difference of mean examiner-adjusted ANL between children with LD and normal children was significant. Children with LD prefer less background noise in comparison with normal children. Previous researchers also have demonstrated that children diagnosed with learning disorder have delayed brainstem responses to the syllable /da/ in comparison with normal children. This study also showed that these children have also deficits in cortical processing of signal in the noise [15]. Furthermore, Warrier et al. in compared speech-evoked cortical responses in the presence of background noise with the responses recorded in quiet among LD children and children diagnosed without any kind of learning problem. The results revealed that 23% of LD children had abnormalities in cortical timing such that distorted neurophysiological representation of speech sound in the presence of background noise [13]. These studies are also aligned with the result of our study.

Interestingly, the finding revealed a significant positive correlation between examiner-adjusted and self-adjusted procedures of obtaining ANL. So clinicians are allowed to use each one of these two methods in different situations. For example, if children who are not able to turn the intensity dial due to environmental or personal struggling, the examiner can adjust intensity dial for them. Meanwhile, the ANL's results in two methods of assessing ANL were not the same (e.g. if children turned the intensity dial by themselves, they choose more intensity for MCL as well as less intensity for BNL in comparison with examiner-adjusted procedure). On the other hand, the difference of ANL between normal children and children with LD was statistically significant only in examiner-adjusted method, not self-adjusted method. One of the probable reasons would be the examiner's bias towards children with LD. So, additional researches need to be undertaken to investigate the norm of ANL among pediatric population in self-adjusted and examiner-adjusted methods, blindly.

Conclusion

Based on our findings children who suffer from learning disorder tend to less background noise around when they are listening to the speech in their MCL in comparison with children without learning disorder. These results confirm the idea of using more acoustically developed classroom for children in the primary school who may suffer from learning problem. Moreover, as ANL is a quick test, simple to explain, and requires minimal language processing, it may be used for children suspected with learning disabilities. Moreover, the strong positive correlation between self-adjusted and examiner-adjusted methods indicated that audiologists are allowed to use both procedures in different conditions.

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Conflict of interest

The authors declare that they have no conflict of interest.

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