DEVELOPMENT AND STANDARDIZATION OF AN ARABIC TEST FOR SPATIAL LISTENING IN CHILDREN

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ABSTRACT:

Background: *The ability to understand speech in background noise is a crucial skill for proper communication. Understanding speech through noise is a skill that develops well through adolescence. Spatial listening is the capacity of the auditory system to interpret different spatial paths by which sounds may reach the head. It is used to isolate speech stream from simultaneous noise.*

Aim of the work: *To develop an Arabic test to evaluate spatial processing in children and to standardize the developed test on normal Arabic-speaking children.*

Methods: *Sixty normal hearing children classified into three subgroups. They were tested in a sound treated room using newly developed spatial listening material. The total number of the sentences were 128 sentences which were divided into 16 lists. The first 8 lists were recorded by female voice and the other 8 lists were recorded by male voice. They were mixed using Audacity software with story noise. Four test conditions were examined according to location of target sentences in relation to noise and type of voice. Scoring was done by measuring the SNR 50% which is the level at which the child repeated 50% of the number of words per list.*

Results: *The performance data of the entire study group and subgroups according to age were calculated. The 95% confidence limits were calculated to determine the cut off points for abnormal scores as a function of age for each of the three subgroups.*

Conclusion: *Spatial listening test was developed and standardized for assessment of spatial listening in Arabic-speaking children with age ranging from 6-12 years.*

Keywords: *Spatial Listening, Spatial Processing Disorder, Central Auditory Processing Disorder (CAPD).*

INTRODUCTION:

The term spatial processing, also known as spatial release from masking, is used to refer to the ability to isolate a target speech stream from simultaneous distracting noise based on the auditory spatial awareness [(1)]. The degree of auditory spatial awareness in a given environment depends on the hearing thresholds to listeners, the auditory experience, familiarity with the surrounding environment, motivation and attention [(1)].

Auditory spatial awareness results from human ability to identify the direction from which a sound is coming from, estimate the distance to the sound source and assess the size and character of the surrounding physical space affecting sound propagation. These three elements are commonly referred to in the psychoacoustic literatures as auditory localization, auditory distance estimation and auditory spaciousness assessmen[1].

Recent studies show that spatial processing disorder is one of the important problems in relatively high proportion of children with Central auditory processing disorder (CAPD). It is proposed that spatial processing disorder can cause speech perception difficulty in noise which is the main complaint of children with CAPD. Spatial hearing rehabilitation through sound localization and lateralization training can be effective in improvement of speech perception in noise[2].

Auditory processing disorder can lead to academic deficits in areas such as phonics, reading, and spelling, and may also result in mild speech-language impairments [3]. According to **Jerger and Musiek** [4], despite having normal peripheral hearing thresholds, children with APD display a number of behaviors similar to the symptoms associated with hearing loss—predominantly difficulty listening to speech in the presence of background noise. These behaviors may become apparent in the early school years, or at a later academic stage of the child's life, due to changes in the acoustic environment, or to increased academic demands[5].

There are two methods of assessment of spatial processing subjectively through questionnaires and objectively through psychophysical tests. According to the authors' knowledge, there is no available test in Arabic language that measure spatial listening abilities. So, this study aims to develop and standardize an Arabic test to evaluate spatial processing in children.

AIM OF THE WORK:

Development an Arabic test to evaluate spatial processing in children and Standardization of the developed test on normal Arabic speaking children

PATIENTS AND METHODS:

This study consisted of 60 children ranging in age from 6 to 12 years classified into three subgroups: Subgroup I: (6 to < 8 years), Subgroup II: (8 to <10 years) Subgroup III: (10 to 12 years). Criteria for inclusion were normal peripheral hearing with excellent speech discrimination scores and normal middle ears functions. They had normal language development and good scholastic achievement and average IQ. Children with history of delayed language development, history of recurrent otitis media with effusion, scholastic under-achievement, neurological or neuropsychological disorders were excluded.

Arabic sentences (3-6 words sentences) were taken from three sources which included: Speech in noise (SPIN) test for children developed by ***Tawfik and Shalaby, (1995)***[6], Competing sentences (CS) test for children developed by ***Tawfik and Shalaby, (1995)***[6], the Arabic computer-based remediation program for CAPD developed by Audiology Unit Ain Shams University and released in 2009. These sentences were suitable for children in the language age from 6-12 years old.

All lists were digitally manipulated using Audacity software program in the following steps. Stereo source was recorded on two separate tracks and re-fed through two separate channels. Every 8 sentences were put together on channel one and story noise was put on channel two. Normalization of the loudness level of the two channels of the stereo track was done by using Reply Gain plug-in. This ensured that the output gain of the two channels was of the same intensity level.

Pilot study:

Initially, a pilot study was conducted on 10 normal hearing children to determine the starting SNR and bracketing steps. The starting SNR was set at 0 in all conditions, then we decreased or increased the level by 8 dB steps, then bracketing by 4 dB steps was done once needed till the 50 % correct score was reached.

The test material was delivered from the built-in CD player of the laptop connected to the audiometer via three loudspeakers, one connected to the output 1 (for sentences) and the other two loudspeakers were connected to the output 2 (for story noise). The set-up was as follows: Speech material was presented at 0 degree azimuth in relation to the child (front loudspeaker) and noise was presented on both sides at ± 90 degrees azimuth on each side of the child.

Four test conditions were done using male and female voices and at different azimuths (Figure 1): condition 1: Sentences with female voice were presented at 0 degree azimuth and story noise with male voice was presented on both sides at ± 90 degrees azimuth at the same time, condition 2: Sentences with female voice and story noise with male voice were both presented at 0 degree azimuth, condition 3: Sentences with male voice were presented at 0 degree azimuth and story noise with male voice was presented on both sides at ± 90 degrees azimuth at the same time and condition 4: Sentences and noise story with male voice were both presented at 0 degree azimuth.

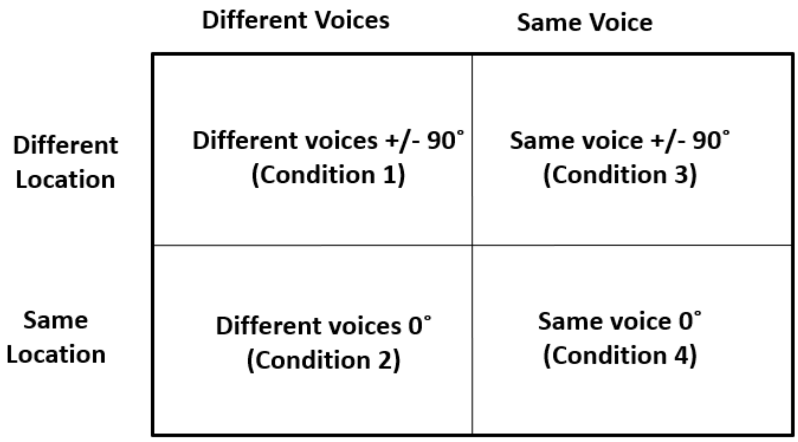

Figure (1): The four test conditions.

Calibration tone of 1000 Hz for 10 seconds was used. Familiarization was done for each child using sentences similar to the test items where the child was asked to repeat what he heard and to ignore the noise. The speech material was presented at an intensity level of 40 dBSL referenced to the SRT. Scoring was done by measuring the SRT which is the level at which the child repeated 50% of the number of sentences correct according to ***Cameron and Dillon (2007)***[8]**.** A lower SRT test score indicates better performance.

Ethical Consideration:

Verbal consent was obtained from all parents before testing after explaining the aim of the study and procedure to be done. Also, approval from Ethical committee of Ain shams University was obtained before start of this research.

RESULTS:

This research was conducted on 60 normal hearing (NH) children with an age range of 6 to 12 years with mean of 8.81 (SD ± 2.03). All children had normal peripheral hearing in all tested frequencies 250 Hz to 8000Hz as pure tone audiometry with mean of 12.5 (SD ± 2.84) and had excellent speech discrimination scores with mean of 98.8 (SD

± 2.36) in the right ear and mean of 98.5 (SD ± 2.39) in left ear. All children are of average social class.

In order to avoid the developmental variability, subjects were classified according to their age into three equal gender matched subgroups; I (6-8 years), II (>8-10 years) and III (>10-12 years).

Tables (1-3) show descriptive study of the study group and subgroups in all conditions and ANOVA test of significance between all conditions.

Table (1): Mean, Standard Deviation, range and 95% confidence interval of SNR 50% in each condition

SNR 50%	Mean ± SD	Range	95% confidence interval
Condition 1	-20.6 ± 3.59	-24 to -12	-21.53 to -19.67
Condition 2	-15.8 ± 3.56	-24 to -8	-16.72 to -14.88
Condition 3	-11.87 ± 3.21	-16 to -6	-12.7 to -11.04
Condition 4	4 ± 3.43	0 to 8	3.1 to 4.8

As shown in table (1): condition 1 has the least signal to noise ratio (SNR 50%) and condition 4 has the highest SNR 50% so condition 1 is the easiest condition and condition 4 is the most difficult condition.

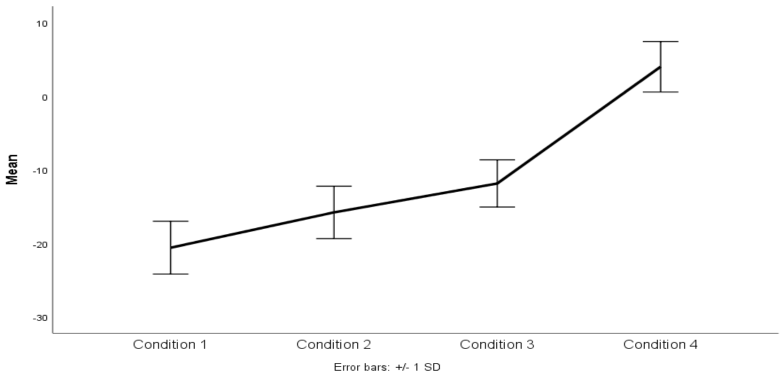

Figure (2): Mean and Standard Deviation of SRT in each condition

Table (2): Mean and SD of all age subgroup on SNR 50% in all conditions

SNR 50%	Age subgroups			ANOVA**		
	I	II	III			
	Mean ± SD	Mean ± SD	Mean ± SD	F	p value	sig.
Condition 1	-19 ± 3.4	-19.6 ± 3.65	-23.2 ± 2.09	10.58	<0.001[a]	HS
Condition 2	-14.4 ± 4.19	-15.6 ± 2.56	-17.4 ± 3.25	3.95	0.025 [b]	S
Condition 3	-11.3 ± 3.2	-11 ± 3.15	-13.3 ± 2.92	3.27	0.045 [a]	S
Condition 4	5.7 ± 2.99	4.1 ± 3.21	2.2 ± 3.3	6.11	0.004 [b]	HS

**Post hoc for ANOVA; a. Significant difference between age subgroup III vs subgroup II & subgroup III vs subgroup I in conditions 1& 3; b. Significant difference between subgroup III vs subgroup I in condition 2& 4

Table (3): Shows 95% confidence interval of SRT in each condition of all study subgroups

SNR 50%	95% confidence interval		
	Age subgroup I	Age subgroup II	Age subgroup III
Condition 1	-20 to -17.4	-21.3 to -17.8	-24.2 to -22.2
Condition 2	-16.3 to -12.4	-16.8 to -14.4	-18.9 to -15.8
Condition 3	-12.8 to -9.8	-12.4 to -9.5	-14.6 to -11.9
Condition 4	4.3 to 7	2.6 to 5.5	0.6 to 3.7

The scores that fell below the lower 95% confidence limit were considered abnormal.

DISCUSSION:

Results showed that condition 1 (different location, different voice) had the least signal to noise ratio (SNR), while condition 4 (same location, same voice) had the highest SNR. So condition 1 is the easiest condition and condition 4 is the most difficult condition. In other words, the estimated SNR 50% required for 50% sentence perception thresholds is higher (worse) for the co-located (0◦) as compared to the spatially separated (±90◦) conditions. That is because listening to speech with noise from the same spatial location is a particularly difficult task, even for an adult, because of the absence of any spatial cues that could contribute to segregation of the target speech from the background noise [(7)].

This agrees with the work of ***Cameron and Dillon (2007)***[(8)] who conducted a study on 82 Australian normal hearing children ages 5 to 11 years old with normal pure tone thresholds. Sentences and distracter story were presented in the same arrangement as the current study and it showed that there was a significant main effect of location with the ±90◦ condition resulting in lower SRT than the 0 condition.

There was also a significant main effect of voice (same versus different distracter) averaged across location. This can be referred to the benefit of “voice gender release from masking” (VGRM) that means that each voice has two unique vocal characteristics (pitch and timbre). Pitch is proportional to the rate and periodicity of vocal fold vibrations. Timbre is determined by vocal tract length[(9&10)].

According to ***Oh and Reiss (2017)***[(11)] investigations, when the target and masker talkers were different genders, percent correct target identification was 15% –20% points higher than conditions with same-gender talker and maskers.

Also, there is significant difference between all age subgroups in all conditions. This owed to maturation of the auditory system. Indeed, central auditory processing develops gradually till the age of 10-15 years, Thus improvement of children performance reflects normal maturation. ***Yathiraj and Vanaja (2015)***[(12)] reported that maturation of hearing abilities is a gradual process that reaches its maximum between the ages 10 and 13 years after complete myelination of central auditory system especially the corpus callosum, and children 12 years of age performed nearly as well as adults.

Conclusions:

The Arabic spatial listening test is a potentially valuable tool for assessing Spatial Listening skills in children. Speech recognition deteriorates as the noise level increased and is dependent on spatial location and talker’s voice physical characteristics of the target signal. SRT correct score significantly decreased in the spatially separated (±90◦) conditions compared to the co-located (0◦) conditions and in different-gender masker compared to same-gender masker. An expected improvement of performance as a function of increasing age was found.

Recommendations:

Spatial hearing evaluation is a crucial step in suspected (C)APD children, hearing impaired and geriatric populations who find listening in noisy environment a challenging process.

Conflict of Interest:

The authors state that the publishing of this paper is free of any conflicts of interest.

REFERENCES

1. **Litovsky R (2012):** Development of Binaural and Spatial Hearing *In* Werner, L.A. (eds): Human Auditory Development, Springer Handbook of Auditory Research 42:163-194.
2. **Moossavi A, Abdollahi F, Lotfi Y (2017):**

Spatial auditory processing in children with central auditory processing disorder. Aud Vest Res;26(2):56-63.

3. **Cameron S, Dillon H, Newall P (2006):** The listening in spatialized noise test: an auditory processing disorder study. Journal of the American Academy of Audiology;17(05):306-20.
4. **Jerger J and Musiek F (2000):** Report of the Consensus Conference on the Diagnosis of Auditory Processing Disorders in School-Aged Children. J Am Acad Audiol;11(09): 467-474.
5. **Bamiou D, Musiek F, Luxon L (2001):** Aetiology and clinical presentations of auditory processing disorders—a review. Archives of disease in childhood;85(5):361-365.
6. **Tawfik S, and Shalaby A (1995):** Development and standardization of Arabic central test battery for children. Proceeding of XXIII Word Congress of the International Association of Logopedics and Phoniatric, 416-419.
7. **Schafer E, Beeler E, Ramos H, Morais M, Monzingo J, and Algier K (2012):** Developmental Effects and Spatial Hearing in Young Children with Normal-Hearing Sensitivity, EAR & HEARING, VOL. 33, NO. 6, e32–e43.
8. **Cameron S, and Dillon H (2007):** Development of the Listening in Spatialized Noise—Sentences Test (LiSN-S). Ear Hear 28(2): 196–211.
9. **Brungart D, Simpson B, Ericson M, and Scott K (2001):** "Informational and energetic masking effects in the perception of two simultaneous talkers." The Journal of the Acoustical Society of America 109(3): 1101-1109.
10. **Ericson M, Brungart D, and Simpson B (2004):** "Factors that influence intelligibility in multitalker speech displays," Int. J. Aviat. Psychol. 14(3), 313–334.
11. **Oh Y, and Reiss L (2017):** "Voice gender release from masking in cochlear implant users is correlated with binaural pitch fusion," J. Acoust. Soc. Am. 141, 3816.
12. **Yathiraj A, and Vanaja C (2015):** Age related changes in auditory processes in children aged 6 to 10 years. International Journal of Pediatric Otorhinolaryngology;79(8):1224-34.

تطوير وتوحيد اختبار اللغة العربية للاستماع المكاني عند الاطفال

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المقدمة والهدف من البحث: تعتمد القدرة على فهم الكلام في وجود خلفية من الضوضاء على عدد من الخطوات. أحدها هو القدرة على فصل الكلام المستهدف عن الضوضاء الموجودة في عملية تسمى "فصل التيار السمعي" وهو أمر هام لاستخراج المعنى من الكلام.

يشار إلى المعالجة المكانية إلى القدرة على فصل الكلام المستهدف عن الضوضاء المتزامنة اعتمادا على الإدراك السمعي المكاني الذي يعتمد على: مكان الاشارة السمعية وتقدير المسافة السمعية وتقييم الاتساع السمعي.

يعد اضطراب الاستماع المكاني أحد المشكلات المهمة في نسبة عالية نسبيًا من الأطفال المصابين باضطراب المعالجة السمعية المركزية. يقترح أن اضطراب الاستماع المكاني يمكن أن يسبب صعوبة في إدراك الكلام في الضوضاء وهي الشكوى الرئيسية للأطفال المصابين بـاضطراب المعالجة السمعية المركزية. يتم تقييم الاستماع المكاني عن طريق الاختبارات النفسية الفيزيائية مثل اختبار الاستماع المكاني في الضوضاء باستخدام الجمل. وهو غير متوفر باللغة العربية لذلك فمن الضروري تطوير وتوحيد اختبار اللغة العربية للاستماع المكاني عند الاطفال عن طريق استخدام قوائم متعددة مماثلة صوتيا.

المرضي والطرق: ٦٠ من الاطفال ذوي السمع الطبيعي تتراوح اعمارهم من ٦ ل ١٢ سنوات. تم أخذ مجموعة مكونة من ١٢٨ جملة عربية من ثلاثة مصادر والتي تضمنت اختبار الكلام في الضوضاء **(SPIN)** واختبار الجمل المتنافسة **(CS)** وبرنامج المعالجة الحاسوبي العربي لاضطراب المعالجة السمعية المركزية الذي طورته وحدة السمعيات بجامعة عين شمس.

تم تقسيم الجمل إلى ١٦ قائمة. تم تسجيل القوائم الثماني الأولى بصوت امرأة والقوائم الثمانية الأخرى تم تسجيلها بصوت رجل.

تم خلط الجمل مع الضوضاء القصة واستخدامها في الاختبار بنسب سمعية مختلفة بين الإشارة والضوضاء**(SNR)** تتراوح من -٣٢ إلى +٨. تم اختبار ستين طفلاً يتمتعون بدرجة سمع طبيعية تتراوح أعمارهم من ٦ إلى ١٢ عامًا، تم تصنيفهم إلى ثلاث مجموعات فرعية متطابقة. تم إنشاء أربع حالات للاختبار حيث تم التلاعب بموقع تواجد الضوضاء بالنسبة لمكان الإشارة (٠ مقابل +/- ٩٠ درجة) والمتحدث (نفسه مقابل مختلف). تم التسجيل عن طريق قياس نسبة إشارة إلى ضوضاء (**SNR 50%**) وهو المستوى الذي كرر فيه الطفل ٥٠٪ من عدد الجمل الصحيحة.

النتائج: أظهرت نتائج الاختبار أن الحالة 1 لديها أقل نسبة إشارة إلى ضوضاء والحالة 4 لديها أعلى نسبة إشارة إلى ضوضاء، لذا فإن 1 هي الحالة الأسهل والحالة 4 هي الحالة الأصعب

في غياب الفصل المكاني بين الهدف والضوضاء، يمكننا استخدام ميزة المتحدث التي تؤدي إلى انخفاض نسبة الإشارة إلى الضوضاء إذا كان كلا الصوتين مختلفين عن بعضهما البعض. ينتج عن تأثير استخدام أصوات مختلفة من جنسين مختلفين نسبة الإشارة إلى الضوضاء أقل من استخدام الفصل المكاني بين الأصوات. أظهرت نتائج دراسة البيانات المعيارية أن هناك تحسنًا ملحوظًا في نسبة الإشارة إلى الضوضاء مع زيادة العمر في جميع الظروف المختبرة

الخاتمة: أثبت اختبار الاستماع المكاني أنه اختبار مناسب في تقييم الاستماع المكاني للأطفال الناطقين باللغة العربية الذين تتراوح أعمارهم بين ٦ إلى ١٢ عامًا