DEVELOPMENT AND STANDARDIZATION OF ARABIC LOW-VERBAL SENTENCES- IN-NOISE TEST (LV–SIN) IN EGYPTIAN CHILDREN

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ABSTRACT:

Background: *Children's reduced speech recognition abilities in noise may affect how well they learn in a noisy classroom, through both education and incidental learning. Various speech in noise tests in children have been developed to estimate the perception of speech in the presence of noise. This study was performed to develop a new Arabic open-set sentence material suitable for children aged 4 to 7 years using different types of noise.*

Aims of the work: *Development of a new Arabic LV-SIN test and its standardization on Arabic-speaking normal hearing children of age ranging from 4 to 7 years.*

Studying the effect of different types of noise and sentence difficulty level on performance of children of different age groups.

Patient and methods: *Sixty-six normal hearing children classified into three subgroups: Subgroup A: (4 to< 5 years), Subgroup B: (5 to< 6 years) Subgroup C: (6 to 7 years). They were tested using the newly developed LV-SIN test using white, multi-talker babble and story noise. The sentences were divided into nine lists, with three levels of difficulty. Scoring was done by measuring the SNR50 which is the level at which the child repeated 50% of the number of words per list.*

Results: *The majority of children reached SNR50 at -14 SNR in story noise, and -16 SNR in white noise and multi-talker babble noise. The mean average of number of trials until SNR50 score was reached was 2 - 3 in subgroup 1, and 3 - 4 in subgroups 2 and 3. There was statistically significant effect of age and list difficulty on SNR50 test scores. In contrast to white noise, multi-talker babble and story noise were able to segregate sentences based on difficulty level.*

Conclusion: *Arabic LV-SIN test was developed and standardized for assessment of speech perception in noise in pre-school age children with age ranging from 4 – 7 years. Age, type of noise and list difficulty had a significant effect on LV-SIN test scores.*

Keywords: *Speech perception in noise, white noise, multi-talker babble noise, story noise, SNR.*

INTRODUCTION:

Previous studies have shown that children have more difficulty than adults with recognizing speech in noisy situations, as they spend many hours in complex acoustic environments with noise and reverberation, such as kindergarten and school[(1)]. Children's reduced speech

recognition abilities in noise may affect how well they learn in noisy situations, through both education and incidental learning[2].

Speech recognition abilities in noise develop at the age of 7 to 10 years in children[3&4]. One of the greatest challenges for audiologists is identifying and addressing the deleterious effects of classroom noise on speech perception of children who have hearing loss and other auditory disorders[5].

In an ordinary acoustic environment, a single auditory signal is rarely confronted; the auditory system must process simultaneously occurring complex acoustic signals to extract relevant information [6]. The canonical example of this is listening to speech-in-noise (SIN), a task requiring a complex set of cognitive and perceptual skills; including stream segregation, auditory working memory and the detection of time varying perceptual cues. To extract the target acoustic signal, our auditory system must resolve two issues. First, there must be a process that extracts the acoustic input into separate auditory units. Second, there must be a mechanism for appropriately organizing these acoustic units over time. Auditory scene analysis is the term given to the internal process of segregating and subsequent grouping of an auditory stream[7].

If a listener presents with a good word recognition-in-quiet score, this does not indicate their performance for word recognition in background noise. A words-in-noise task adds significant cognitive load, compared to a similar task without noise. SIN testing should be considered as the "stress test" of auditory function[2].

Listeners with normal hearing have the ability to localize sound sources using better than 5 degrees of accuracy in both azimuth and elevation. This level of precision is due in part to the ability of the central auditory nervous system to detect and perceive small differences in the arrival time and intensity of the signals reaching the two ears. This ability, referred to as binaural processing, can improve our ability to detect and analyze signals in noisy backgrounds[8].

Various speech in noise tests in children have been developed to evaluate the perception of speech in presence of noise. The material used was either words such as Words in Noise Test (WIN)[9] or sentences such as Connected Sentence Test (CST)[10], Pediatric Speech Intelligibility test[11], Hearing in Noise Test (HINT-C)[12],Quick Speech-In-Noise Test (Quick SIN)[13], Bamford-Kowal-Bench Speech in Noise Test (BKB SIN)[14], and Listening in Spatialized Noise-Sentences (LiSN-S)[15].

Several tests were developed in Arabic language for children such as Arabic WIN test [16], Arabic SPIN test [17], Arabic PSI test [18] and Arabic BKB SIN test for children[19]. All tests are different in terms of target age, measure, procedure, speech material, noise type and level. Audiologists must select the speech-in-noise test depending on availability, ease of administration, time required to run the test, age of the patient, hearing status, type of hearing disorder, and if the individual uses a rehabilitation device[16].

Since the Arabic battery of tests presently lacks the inclusion of open-set sentences in noise with low linguistic load, this research was designed to develop and standardize a new test suitable for evaluation of pre-school children using different types of noise.

AIM OF THE WORK:

- Development of a new Arabic Low-Verbal Sentences-In-Noise (LV-SIN) test and its standardization on Arabic-speaking normal hearing children of age ranging from 4 to 7 years.
- Studying the effect of different types of noise and sentence difficulty level on

performance of children of different age groups.

MATERIAL AND METHODS:

Study group: It included (66) normal hearing children classified into three subgroups: Subgroup A: (4 to <5 years), subgroup B: (5 to< 6 years) and subgroup C: (6 to 7 years).

Arabic LV-SIN test: The test material is composed of 90 Arabic sentences adapted from the Arabic PSI test [18] and digitally manipulated using Audacity software program. Sentences were divided into nine lists which were phonetically balanced as regards the following criteria: Syllable structure, equal phonetic structure and contain all phonemes present in Arabic language with phonological similarity between the lists. Sentences were composed of words which were familiar and common to children and matched their age and intelligence.

Lists 1 to 3 represent the easiest level of difficulty, each list consists of 10 (3 word sentences) giving rise to 30 words per list. Lists 4 to 6 represent the medium level of difficulty with 10 sentences per list (3 or 4 word sentences) and total number of words is 32 words per list. Lists 7 to 9 represent the highest level of difficulty with 10 sentences per list (4 or 5 word sentences) and 36 words per list.

Speech-in-noise testing using the newly developed Arabic LV-SIN test was conducted in a double walled sound treated room I.A.C. model 1602 and delivered from the built-in CD player of the laptop connected to two channel audiometer model Grason-Stadler Inc (GSI) model 61 via 2 loudspeakers; front for the speech material (at 0 degree azimuth in relation to the child) and back for noise (at 180 degrees azimuth).

For each type of noise the starting point was (-10 SNR) then SNR was decreased in 4 dB. If the child did not reach 50% correct score, we increased 2 dB steps until the child scored 50% correct of the words in each list. Scoring was done by measuring the SNR50 which is the level at which the child repeated 50% of the number of words per list.

Ethical Considerations: Verbal consent was obtained from all parents before testing after explaining the aim of the study and procedure to be done.

RESULTS:

This research was conducted on 66 normal hearing children classified into three subgroups Each subgroup was tested using nine lists which were classified into three levels of difficulty: Easy, medium & difficult. Each list was presented in three background noise: Multi-talker babble, white noise and story noise.

1. LV-SIN percent scores at different SNRs:

Tables (1 - 3) show the LV-SIN percent scores for the whole group using different types of noise. There was an evident reduction in mean percent scores of LV-SIN test with decrease in SNR ratio using different types of noise.

Table (1) Mean, SD, 95% CI and range of the study group at easy level of difficulty using different types of noise

			Mean ± SD	95% CI of mean	Range
Easy	-18	White noise	27.86 ± 9.21	19.34 - 36.37	13 - 40
		Multitalker	31 ± 8.49	23.91 - 38.09	13 - 43
		Story	37.29 ± 4.19	33.41 - 41.16	30 - 43
	-16	White noise	50 ± 0	50 - 50	50 - 50
		Multitalker	50 ± 0	50 - 50	50 - 50
		Story	49.57 ± 2.71	49.39 - 50.74	50 - 60
	-14	White noise	59.78 ± 5.72	56.93 - 62.62	50 - 70
		Multitalker	58.63 ± 5.12	56.16 - 61.1	50 - 70
		Story	61.14 ± 5.85	58.88 - 63.41	50 - 80
	-10	White noise	74.56 ± 8.18	73.2 - 81.92	56 - 90
		Multitalker	73.05 ± 6.28	74.19 - 79.91	69 - 90
		Story	70.91 ± 6.01	73.25 - 78.57	63 - 86

Table (2): Mean, SD, 95% CI of mean and range of the study group at medium level of difficulty using different types of noise

		Mean ± SD		95% CI of mean	Range
Med	-18	White noise	34		
		Multitalker	37		
		Story	37		
	-16	White noise	47.91 ± 5.03	45.68 - 50.14	34 – 50
		Multitalker	50 ± 0	50 - 50	50 – 50
		Story	50 ± 0	50 - 50	50 – 50
	-14	White noise	55.44 ± 4.41	53.85 - 57.03	50 – 62
		Multitalker	59.5 ± 5.07	56.98 - 62.02	50 – 68
		Story	54.2 ± 4.81	51.95 - 56.45	50 – 62
	-10	White noise	66.65 ± 5.88	64.6 - 68.7	56 – 81
		Multitalker	73.33 ± 6.55	70.35 - 76.32	62 – 84
		Story	72.21 ± 6.88	68.89 - 75.53	62 – 86

Table (3): Mean, SD, 95% CI of mean and range of the study group at difficult level using different types of noise

			Mean ± SD	95% CI of mean	Range
Difficult	-18	White noise	32 ± 4.69	24.54 - 39.46	27 - 38
		Multitalker	31.5 ± 6.36	-25.68 - 88.68	27 - 36
	-16	White noise	50 ± 0	50 - 50	50 - 50
		Multitalker	49.81 ± 0.75	49.41 - 50.21	47 - 50
		Story	50 ± 0	50 - 50	50 - 50
	-14	White noise	55.18 ± 3.38	53.44 - 56.91	50 - 61
		Multitalker	54.52 ± 4.59	52.77 - 56.26	50 - 66
		Story	53.53 ± 4.1	51.55 - 55.5	50 - 62
	-10	White noise	69.43 ± 4.05	67.09 - 71.77	63 - 75
		Multitalker	66.82 ± 6.81	63.8 - 69.84	55 - 77
		Story	66.7 ± 6.77	63.53 - 69.87	55 - 77

2. LV-SIN percent scores at supra threshold level (-10 SNR):

All children were evaluated at -10 SNR which was assigned as the starting point based on results of the pilot study. Table (4) shows that the mean percent scores ranged from 66% to 75%; which is significantly above 50%. Also, the hierarchy of difficulty

was evident among the lists. Table (5) shows that there was no significant effect of type of noise on mean percent scores at -10 SNR in different age subgroups.

Table (4): Mean & SD of LV-SIN percent scores of the study group at -10 SNR using different lists.

		Percent scores at -10 SNR	
		Mean	SD
List	1	74.96%	6.29%
	2	73.83%	2.32%
	3	73.70%	5.40%
	4	70.55%	6.67%
	5	70.75%	5.56%
	6	67.00%	4.75%
	7	68.18%	5.87%
	8	66.00%	6.82%
	9	70.19%	5.39%

Table (5): Mean, SE and 95 % CI of LV-SIN test scores at -10 SNR and results of two way ANOVA test for age and type of noise

Type of noise	White	Multitalker babble	Story	ANOVA		
				F	p value	
subgroup 1	Mean ± SE	68.82 ± 1.4	71.18 ± 1.4	70.5 ± 1.4	0.75	0.472 (NS)
	95% CI	66.05 to 71.58	68.42 to 73.95	67.73 to 73.27		
subgroup 2	Mean ± SE	69.55 ± 1.4	69.77 ± 1.4	69.32 ± 1.4	0.03	0.974 (NS)
	95% CI	66.78 to 72.31	67.01 to 72.54	66.55 to 72.08		
subgroup 3	Mean ± SE	72.64 ± 1.4	72.14 ± 1.4	73.23 ± 1.4	0.15	0.859 (NS)
	95% CI	69.87 to 75.4	69.37 to 74.9	70.46 to 75.99		
ANOVA	F	2.09	0.72	2.05		
	p value	0.126 (NS)	0.488 (NS)	0.132 (NS)		

3. <u>LV-SIN SNR50 test scores in the study subgroups:</u>

Table (6) shows the breakdown of children according to their SNR50 scores. The majority of children reached SNR50 at -14 SNR in story noise, and -16 SNR in white noise and multi-talker babble noise. As shown in Table (7), the range of number of trials until SNR50 score was reached was 2 - 3 in subgroup 1, and 3 - 4 in subgroups 2 and 3.

Table (6): Number and percentage of children scoring SNR50 using different types of noise

SNR 50 / Type of noise	-14	-16
White noise	19 (28.78%)	47 (71.21%)
Multitalker babble	18 (27.27%)	48 (72.73%)
Story	48 (72.73%)	18 (27.27%)

Table (7): Mean, SE, 95% CI of the number of trials until SNR50 score was reached in the study subgroups in different types of noise

Number of trials		White	MT	Story	Range
subgroup 1	Mean ± SE	2.55 ± 0.12	2.64 ± 0.12	2.41 ± 0.12	2-3
	95% CI	2.3 to 2.79	2.39 to 2.88	2.17 to 2.65	
subgroup 2	Mean ± SE	3 ± 0.12	2.82 ± 0.12	2.36 ± 0.12	3-4
	95% CI	2.76 to 3.24	2.57 to 3.06	2.12 to 2.61	
subgroup 3	Mean ± SE	2.91 ± 0.12	3 ± 0.12	2.55 ± 0.12	3-4
	95% CI	2.67 to 3.15	2.76 to 3.24	2.3 to 2.79	

4. Effect of variables on LV-SIN SNR50 test scores:

4.1. Comparison between three levels of difficulty in different types of noise in subgroup (1)

Table (8) shows the difference between the LV-SIN SNR50 scores using the three types of noise in different difficulty levels in subgroup (1). Two-way ANOVA for the effect of difficulty of list and noise on SNR50 showed that easy and difficult levels were not significantly different with change of type of noise. Post hoc analysis showed significant difference between multi-talker babble noise and story noise in medium level of difficulty. In multi-talker babble noise, there was significant difference between medium and difficult lists.

Table (8): Mean, SD, 95% confidence interval and results of two-way ANOVA for the effect of difficulty of list and type of noise on SNR50 in subgroup (1)

Lists \ Type of noise		White noise	Multitalker noise	Story noise	ANOVA	
					F	p value
Easy	Mean ± SE	-15.43 ± 0.34	-15.6 ± 0.4	-15 ± 0.28	0.90	0.412 (NS)
	95% CI	-16.11 to -14.75	-16.4 to -14.8	-15.57 to -14.43		
Medium	Mean ± SE	-14.89 ± 0.3	-15.75 ± 0.32	-14.4 ± 0.4	3.87	**0.026 (S)**b
	95% CI	-15.49 to -14.29	-16.38 to -15.12	-15.2 to -13.6		
Difficult	Mean ± SE	-14.33 ± 0.37	-14.67 ± 0.3	-14 ± 0.34	1.09	0.342 (NS)
	95% CI	-15.07 to -13.6	-15.27 to -14.07	-14.68 to -13.32		
ANOVA	F	2.41	3.52	2.65		
	p value	0.099 (NS)	**0.036 (S)**a	0.08 (NS)		

Post hoc test:

Easy vs Medium p:0.77 (NS), Easy vs Difficult p:0.067 (NS) and Medium vs Difficult **p:0.016 (S)**
White vs Multitalker p:0.053 (NS), White vs Story p:0.332 (NS) and Multitalker vs Story **p:0.011 (S)**

4.2. Comparison between three levels of difficulty in different types of noise in subgroup (2) Table (9) shows the difference between the LV-SIN SNR50 scores using the three types of noise in different difficulty levels in subgroup (2). Two-way ANOVA and post hoc analysis showed significant difference of mean SNR50 scores between multi-talker babble noise & story noise in all levels of difficulty. There was no significant effect of white noise on mean SNR50 scores in all difficulty levels.

Table (9): Mean, SD, 95% confidence interval and Two-way ANOVA of the effect of difficulty of list and noise on SNR among age subgroup 2

Lists \ Type of noise		White noise	Multitalker babble noise	Story noise	ANOVA	
					F	p value
Easy	Mean ± SE	-16 ± 0.34	-16 ± 0.25	-14.73 ± 0.2	9.89	**0 (S)** c
	95% CI	-16.67 to -15.33	-16.51 to -15.49	-15.13 to -14.32		
Medium	Mean ± SE	-15.56 ± 0.22	-16 ± 0.24	-14 ± 0.3	14.29	**0 (S)** d
	95% CI	-16 to -15.11	-16.48 to -15.52	-14.6 to -13.4		
Difficult	Mean ± SE	-15.78 ± 0.22	-14.57 ± 0.25	-14 ± 0.27	13.93	**0 (S)** e
	95% CI	-16.23 to -15.33	-15.08 to -14.06	-14.55 to -13.45		
ANOVA	F	0.65	10.81a	3.23 b		
	p value	0.526 (NS)	**0 (S)**	**0.047 (S)**		

Post hoc test:
Easy vs Medium p:1 (NS), Easy vs Difficult p:0 (S) and Medium vs Difficult p:0 (S)
Easy vs Medium p:0.049 (S), Easy vs Difficult p:0.037 (S) and Medium vs Difficult p:1 (NS)
White vs Multitalker babble p:1 (NS), White vs Story p:0.002 (S) and Multitalker babble vs Story p:0 (S)
White vs Multitalker babble p:0.178 (NS), White vs Story p:0 (S) and Multitalker babble vs Story p:0 (S)
White vs Multitalker babble p:0 (S), White vs Story p:0.001 (S) and Multitalker babble vs Story p:0 (S)

4.3. Comparison between three levels of difficulty in different types of noise in subgroup (3)

Table (10) show the difference between LV-SIN SNR50 test scores using the three types of noise in different difficulty levels. Two-way ANOVA and post hoc analysis showed significant difference of mean SNR50 scores in easy vs medium and easy vs difficult levels. There was also significant difference between white noise vs story noise and multi-talker vs story noise.

Table (10): Mean, SD, 95% confidence interval and two-way ANOVA of the effect of difficulty of list and noise on SNR among subgroup 3

lists \ Type of noise		White noise	Multitalker babble noise	Story noise	ANOVA	
					F	p value
Easy	Mean ± SE	-16 ± 0.35	-16 ± 0.32	-15.27 ± 0.24	2.39	0.101 (NS)
	95% CI	-16.7 to -15.3	-16.64 to -15.36	-15.74 to -14.8		
Medium	Mean ± SE	-15.33 ± 0.26	-16 ± 0.32	-14.29 ± 0.29	8.08	**0.001 (S)** b
	95% CI	-15.85 to -14.81	-16.64 to -15.36	-14.88 to -13.7		
Difficult	Mean ± SE	-15.75 ± 0.28	-15.2 ± 0.25	-14 ± 0.39	6.71	**0.002 (S)** c
	95% CI	-16.3 to -15.2	-15.69 to -14.71	-14.78 to -13.22		
ANOVA	F	1.31	2.87	5.54		
	p value	0.279 (NS)	0.065 (NS)	**0.006 (S)** a		

Post hoc test:
Easy vs Medium p:0.011 (S), Easy vs Difficult p:0.007 (S) and Medium vs Difficult p:0.561 (NS)
White vs Multitalker babble p:0.111 (NS), White vs Story p:0.01 (S) and Multitalker babble vs Story p:0 (S)
White vs Multitalker babble p:0.143 (NS), White vs Story p:0.001 (S) and Multitalkerbabble vs Story p:0.012 (S)

4.4. Comparison between different lists in "Easy" level of difficulty:

Table (11) shows a comparison between SNR50 scores of the study subgroups in lists (1-3). No significant difference was recorded.

Table (11): ANOVA test results for comparison between lists in the easy level of difficulty in all age groups

Easy	List			ANOVA		
	1 (N = 3)	2 (N = 13)	3 (N = 6)	F	p value	sig.
subgroup1	-15.33 ± 1.15	-14.92 ± 1.04	-16 ± 0	2.909	0.079	NS
subgroup2	-15 ± 1.15	-15.33 ± 1	-15.56 ± 0.88	0.453	0.642	NS
subgroup3	-15.6 ± 0.89	-15 ± 1.15	-15.85 ± 0.55	1.918	0.174	NS

4.5. Comparison between different lists in "Medium" level of difficulty

As shown in Table (12), ANOVA test showed no significant difference between SNR50 scores in lists (4-6) in subgroup (1). Conversely, there was significant difference between lists (5 & 6) in subgroup (2). In subgroups (3), list (5) differed significantly from the other 2 lists.

Table (12): Comparison between lists in the medium level of difficulty in all subgroups

Medium	List			ANOVA			Post hoc test		
	4 (N = 5)	5 (N = 9)	6 (N = 8)	F	p value	sig.	4 vs 5	4 vs 6	5 vs 6
subgroup1	-14.8 ± 1.1	-14.89 ± 1.05	-15.5 ± 0.93	1.027	0.377	NS			
subgroup2	-15.56 ± 0.88	-14.75 ± 1.04	-16 ± 0	3.717	0.043	S	0.066 (NS)	0.36 (NS)	0.018 (S)
subgroup3	-15.6 ± 0.89	-14.33 ± 0.82	-15.45 ± 0.93	3.743	0.043	S	0.031 **(S)**	0.767 (NS)	0.023 **(S)**

4.6. Comparison between different lists in "Difficult" level of difficulty

ANOVA test showed no significant difference between SNR50 scores in lists (7-9) in subgroup (1) (Table 13). There was significant difference between list (8) and the other 2 lists in subgroups (2 & 3).

Table (13): Comparison between lists in the most difficult level in all age groups

Difficult	List			ANOVA			Post hoc test		
	7(N = 7)	8 (N = 11)	9 (N = 4)	F	p value	sig.	7 vs 8	7 vs 9	8 vs 9
subgroup1	-14.29 ± 0.76	-14.36 ± 0.81	-14.5 ± 1	0.086	0.918	NS			
subgroup2	-15.33 ± 1.03	-14 ± 0	-15.33 ± 1	6.045	0.009	S	0.03 **(S)**	1 (NS)	0.016 **(S)**
subgroup3	-15.2 ± 1.1	-14 ± 0	-15.82 ± 0.6	14.455	<0.001	S	0.023 **(S)**	0.305 (NS)	<0.001 **(S)**

4.7. Regression analysis for the effect of age, type of noise and difficulty of list on SNR50 test scores

Table (14) shows the results of multivariable logistic regression analysis of age, type of noise and difficulty of list on SNR50 scores in the whole study group. As shown, there was statistically significant effect of age and list difficulty on SNR50 test scores. On the other hand, type of noise did not show significant effect using this analysis.

Table (14): Multivariable logistic regression of age, type of noise and difficulty of list on SNR

SNR n = 198		p value	OR (95% CI)
Age group	4-5	Ref.	
	5-6	**0.009**	2.78 (1.28 - 6.02)
	6-7	**0.001**	3.92 (1.73 - 8.9)
Difficulty of the list	Easy	Ref.	
	Medium	**0.010**	0.29 (0.11 - 0.74)
	Difficult	**0.006**	0.27 (0.1 - 0.69)
Type of noise	White	0.344	1.47 (0.66 - 3.26)
	Multitalker	0.347	1.47 (0.66 - 3.3)
	Story	Ref.	

DISCUSSION:

The Arabic Low-Verbal Sentence-in-Noise test (LV–SIN) was developed in the present study in order to be suitable for evaluation of children with an age range of 4 to 7 years. Results showed that all children were able to perform the test easily; even young children could perform the difficult lists.

Performance of children at different SNRs:

The performance of the whole study group was recorded in percent correct scores of LV-SIN test in order to ensure the homogeneity of data before calculating the SNR50 scores. As shown in Tables (1 - 3), there was an orderly reduction in the mean percent scores with the decrease in SNR ratio using different types of noise.

Similar finding was reported by many investigators. Fallon et al. (1999) reported an increase in percent scores of children when tested using open-set sentences in multi-talker babble from 81.125% to 89.17% at -22 and -20 SNR ratios respectively. Also, Tawfik et al. (2003) evaluated pre-school children using the Arabic PSI test for sentence material in noise and stated that their scores decreased as a function of SNR ratio.

Performance of children at supra threshold level:

Following the pilot study, it was decided to set the starting point at -10 SNR which is considered a supra threshold level. At this level, the mean scores ranged from 66 % to 75 %, and the hierarchy of difficulty was evident among the lists (Tables 1-3). In comparison, **Fallon et al. (1999)** stated that their pediatric sample, ranging in age from 5 to 11.5 years, achieved a score of 85% at -20 SNR ratio which is relatively higher compared to the data in the present study. This is obviously explained on the bases of the age range in both researches.

Performance of children at SNR50 threshold:

All children tested with Arabic LV–SIN tests gave an SNR50 score at -14 and -16 SNR (Table 6). The majority of children reached SNR50 at -14 in story noise and -16 in white and multi-talker babble noise. This indicates that story noise was more difficult even in normal hearing children.

El-Kholy et al. (2022) applied Arabic LV-SIN test using the same material on 10 normal hearing children with age ranging from 6 to 10 years. Children were tested with easy level of difficulty only (lists 1 - 3). They reported that mean LV-SIN SNR50 scores were -16, -14, and -13.6 using white noise, multi-talker babble and story noise respectively. Except for multi-talker babble, their results agree with results of the present study. The difference in multi-talker babble may be due the difference in material used and the higher age range tested.

The fact that story and multi-talker babble noise are more distracting during speech recognition testing are essentially based on the contextual composition of different noises. **Francart et al. (2011)** emphasized that properties such as temporal gaps, temporal fine structure and intelligibility among different maskers significantly affect speech recognition scores, even in normal listeners.

As regards the number of trials until SNR50 was reached, the younger age subgroup needed less number of trials than older groups (Table 7). This may be related to the adaptive bracketing technique used by the examiner to reach SNR50 (down 4 dB, up 2 dB). Scores of younger children showed narrow fluctuations around the 50% level.

Effect of variables on LV SIN test scores:

Effect of age on the LV SIN test scores:

The effect of age on supra-threshold LV-SIN test results was studied using 2 way ANOVA and showed no significant effect (Table 5). Conversely, at SNR50 thresholds, regression analysis showed a significant effect in the sense that younger children needed more favorable SNR ratios to give similar scores compared to older children (table 14). Stated differently, when children ranging from 5-7 years were given enough loudness, the age-related differences were diluted.

Tawfik et al. (2001) reported a significant positive correlation between the age of normal hearing children and percent test scores using two groups of sentences, varying in number of words per sentence. However, the age range was from 6 to 12 years which is significantly higher than our study group. This also agreed with the studies conducted on Egyptian children aged from 4-12 years using SPIN test **(Tawfik and Shalaby, 1995).**

Ng et al. (2011) applied BKB-SIN test on 15 children with normal hearing aged 6 to 18 years. Scoring was done by the mean percent words correct for each SNR.

ANOVA analysis revealed a significant difference in SNR50 scores between age groups.

Effect of type of noise on the LV SIN test scores:

The effect of type of noise on supra-threshold LV-SIN test results showed no significant effect (Table 5). At threshold, analysis was done using 2 way ANOVA in each subgroup in comparison to difficulty level (Tables 8-10). Taken together, different patterns of significance were noted in different age subgroups. However, when multivariable logistic regression analysis was done for the whole study group, there was no significant effect. Such complexity of data may be explained by the small sample size, especially that not all children were evaluated with the same type of noise in each list due to the adaptive technique used and the fear of learning effect if the child was examiner by the same sentence more than once.

In this respect, previous researchers report contradicting data. **Tawfik et al. (2001)**[23] applied Arabic speech material using either stories or multitalker babble and showed that there was no significant effect on the test scores. **Chermak & Montgomery (1992)**[24] found that speech noise was more distracting than speech materials when used as background noise.

Effect of list difficulty on the LV-SIN test scores:

Using regression analysis for the whole group, there was statistically significant effect of list difficulty on SNR50 test scores (Table 14). Tables (8 to 10) show results of ANOVA test for the effect of list difficulty. Statistically significant differences were obtained in multi-talker babble in subgroups (1 & 2), and in story noise in subgroups (2 & 3), where children tested by difficult lists needed less negative SNR ratio to achieve

SNR50 scores. On the other hand, white noise did not show this segregation based on list difficulty. It is therefore, postulated that white noise is not the suitable type of background noise to be used solely with the LV-SIN test.

Further analysis was done for list differences in each level of difficulty (Tables 11-13). In the easy group of lists, no significant differences were encountered, and, therefore, lists (1 – 3) can be used interchangeably. In the medium set of sentences, post hoc analysis showed that list 5 was significantly different from the 2 other lists. Similar observation was seen in list 8 in the difficult set of sentences. Accordingly, based on this data, both lists 5 and 8 can be removed from the developed test, at least until larger data is collected.

In conclusion, the Arabic LV–SIN test was developed and standardized on children 4-7 years of age. Being composed of sentences of low linguistic profile, it can be used to evaluate speech in noise recognition ability of pre-school children. It can also be used as a validation tool in rehabilitation of hearing-impaired children using hearing aids and/or cochlear implants, and in evaluating preschool children suffering from auditory processing disorders.

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

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تطوير وتقنين اختبار الجمل البسيطة لغويا في الضوضاءعند الأطفال المصريين ذوى السمع الطبيعي

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المقدمه والهدف من البحث: لتطوير وتقنين الجمل العربية القصيرة المفتوحة في اختبار الضوضاء (LV-SIN) مرتبة في قوائم متعددة مماثلة صوتيًا ، وذلك باستخدام أنواع مختلفة من ضوضاء الخلفية والاستفادة من التقنيات المطورة حديثًا لتقييم مختلف فئات الأطفال الناطقين بالعربية والذين يعانون من قصور في السمع و كذلك الذين يستخدمون أجهزة التأهيل المختلفة.

المرضي والطرق: ٦٦ من الاطفال ذوي السمع الطبيعي تتراوح اعمارهم من ٤ الي ٧ سنوات تم تقسيمهم الي ثلاث مجموعات :

المجموعة الاولي الاطفال الذين تتراوح اعمارهم من ٤ الي ٥ سنوات، المجموعة التانيه الاطفال الذين تتراوح اعمارهم من ٥ الي ٦ سنوات ، المجموعة الثالثه الاطفال الذين تتراوح اعمارهم من ٦ الي ٧ سنوات وقد تم تقيم ادراك الكلام وفهمه في الضوضاء عن طريق الاختبارالمعد حديثا للجمل العربيه المتوسطه لغويا باستخدام انواع مختلفه من الضوضاء(الضوضاء البيضاء, ضوضاء متعددة المتحدثين وضوضاء القصة).تعتمد نتيجة اختبار تقييم وادراك الكلام في الضوضاء المعد حديثا علي حساب معدل الاشارة الي الضوضاء الذي يحقق الطفل عنده ٥٠٪ من عدد الكلمات في كل قائمة من الاختبار.

النتائج: هناك اختلاف إحصائى كبير بين نتائج اختبار تقييم ادراك الكلام وفهمه فى الضوضاء عن طريق استخدام الاختبار المعد حديثا للجمل العربية المتوسطة لغويا باستخدام أنواع مختلفة من الضوضاء فى الأطفال ذوى السمع الطبيعى حيث وجد أن النتائج تتأثر بعمر الطفل استخدام ضوضاء القصه يعد اكثر الانواع تحديا.

الخاتمه : يعد اختبار LV-SIN مناسب لتقييم مختلف فئات الأطفال الذين تتراوح اعمارهم من٤ الي ٧ سنوات الناطقين بالعربية والاطفال الذين يعانون من قصور في السمع و كذلك الذين يستخدمون أجهزة التأهيل المختلفة.