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Auditory training program for Arabic-speaking children with auditory figure-ground deficits

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ABSTRACT

Objective: Listening to speech in noise makes up a great challenge for school children with auditory processing disorders mainly those with deficit in auditory figure ground (AFG) ability. These children are candidates for auditory training programs targeting AFG such as noise-desensitization programs. This work aimed to develop a new training material in Arabic language targeting this ability.

Methods: A noise-desensitization semi-formal training program was developed and standardized on normal children in a pilot study preceding the main one. Seventeen school children with AFG deficit were submitted to the program for eight weeks then reevaluated.

Results: The paired sample *t*-test revealed significant improvement of all trained children after training period in their psychophysical and electrophysiological results. The electrophysiological threshold of signal to noise ratio decreased from −5.3 dB to −11.3 dB after training.

Conclusion: The newly developed training material revealed efficacy in managing children with AFG deficit. The other affected auditory abilities improved also because of the multi-ability tapping character of the program.

1. Introduction

Auditory processing is the ability of the auditory system to recognize and interpret acoustic information using a number of coordinated processes and mechanisms. This is mediated by several auditory abilities such as sound localization and lateralization, auditory discrimination, auditory pattern recognition, temporal auditory processing, auditory performance with competing acoustic signals, and auditory performance with degraded acoustic signals [1]. Central auditory processing disorder is an observed deficit in one or more mechanisms despite the presence of normal auditory sensitivity [2]. The auditory figure-ground (AFG) ability is the auditory processing mechanism that extracts necessary and relevant sounds from extraneous background noises [3]. Individuals with AFG deficits have difficulty understanding speech when there is background noise, as the spoken message is degraded, making it difficult to understand despite having normal hearing acuity [4].

Background noise is a challenging and often unavoidable listening situation. An important drawback of impaired AFG ability is the difficulty experienced by school children in real-life challenging listening environments, such as in classrooms [1]. These children may face difficulties in extracting relevant sounds, even when noise levels are lower than the maximum allowed in classrooms (35 dBA) [5]. Impairment of AFG ability can be diagnosed psychophysically using speech tests with noise competitors [6,7], and electrophysiologically by assessment of speech-evoked cortical potentials with ipsilateral competing noise [8].

A reasonable training method for AFG is the noise-desensitization that was first described by Katz and Burge [9]. It simulates the method of allergy desensitization by gradual exposure to the allergen. The principle involves training speech recognition in gradually increasing levels of background noise. Persistent impairment after training needs some compensatory strategies such as monaural or binaural ear occlusion [4], FM system [10], preferential seating, and acoustic adjustments in the subject's listening environment [11].

Noise-desensitization programs target the affected AFG in a formal way and in a top-down strategy. Most programs involve recorded speech materials that are set in variable degrees of competing noise [9,12]. The aim is to improve the subject's speech recognition in noisy conditions in order to achieve its normal levels. In informal training methods, the trainer can adjust the tasks to be more enjoyable for children. This training flexibility increases the subjects' motivation during sessions but it is difficult

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to selectively target the AFG ability with a purely informal method. The aim of this work was to develop a new auditory training program for AFG deficits, which preserves the flexibility of informal programs and the selective ability tapping of formal programs. The program can be considered semi-formal as it uses simple material introduced live by a trainer in an interactive training session through a calibrated audiometer.

2. Methodology

2.1. Subjects

This study comprised 17 school children ranging in age from 10 to 14 years. The children had all previously been diagnosed with AFG deficits, either alone (ten children), or in association with other auditory processing deficit(s) (seven children). A history of each child was taken with an emphasis on any difficulties in hearing in noisy environments, language, and/or education. Children were excluded from the study if they had a chronic medical or neurological illness, a pervasive developmental disorder, or they were not attending school. The procedure was conducted at Audiology Unit, ORL department, Zagazig University, from May to September 2015. Approval from the institutional review board was obtained on May 2015.

2.2. Equipment

The study was performed using a two-channel audiometer, Orbiter model 922 connected to a cassette-tape player as an auxiliary input to the audiometer. Arabic versions of central auditory tests were loaded on to cassette tapes and utilized to perform central auditory testing. They included Arabic versions of speech in noise (SPIN) test, competing sentence test (CST) [7] and duration pattern test (DPT) [13]. Further testing was conducted using auditory memory tests [14] and auditory vigilance (AV) markers [15] to assess auditory cognition. An auditory evoked potential system, intelligent hearing model Smart EP, version 2.39 was used to record the cortical response. Stimuli were delivered using insert receivers. Three cup electrodes were attached to the subject's skin by ten/twenty paste after thorough cleaning using an abrasive gel. The newly developed AFG training material was prepared in written form, including the questions and answers.

Table 1
Gender distribution of the study group ($n = 17$).

	Males	Females	Total
Number (%)	10 (58.8%)	7 (41.2%)	17
Mean age (±SD)	11.8 (0.7)	12 (0.8)	11.9 (0.7)

Table 2
Number of affected children per ability.

No. of cases	Affected ability
10	Auditory figure ground (AFG) alone
1	AFG associated with affected sequence memory
1	AFG associated with affected auditory attention
1	AFG associated with affected auditory temporal processing
1	AFG associated with affected sequence memory and attention
3	AFG associated with affected sequence memory, content memory, attention and temporal processing

2.3. Development of training material

The principle of the material was to present live speech with noise competition and to test its recognition using information that had clearly inserted into the speech. Easily understood words and easily memorized information were selected to ensure that the only challenge was the background noise. Short stories were prepared from ideas of some interesting children's tales, such as Sinbad and Cinderella tales. Prepared stories were short to avoid being boring during training. Insertion of more than one piece of information in one sentence was avoided to prevent confusion.

The prepared training stories were presented to ten native-Arabic speaking children (six males and four females) with normal peripheral and central hearing abilities and with no intellectual or

Table 3
Comparison between the pre- and post-training results of the psychophysical tests of the study group ($n = 17$).

Psychophysical tests	No. of affected subjects per each tests	Normal confidence intervals of psychophysical tests [15]	Pre-training mean (±SD)	Post-training mean (±SD)	*t*-Value (*p*)
SPIN test	17	96.9–100 (%)	60.2% (8.7)	88.7% (7.5)	9.8 (**0.000**)***
CST	17	96.8–100 (%)	62.5% (11.9)	86.3% (10.7)	9.4 (**0.000**)***
DPT	4	82.7–90.1(%)	63.3% (12.8)	81% (6.1)	4 (**0.028**)*
CMT	3	5.6–7	2.7 (0.5)	4.5 (0.5)	4.1 (**0.05**)*
SMT	5	4.8–5.8	2.5 (0.5)	3.3 (0.3)	3.2 (**0.033**)*
AV markers	5	80.5–85.6 (%)	68.2% (8.2)	85.3% (5.6)	5.7 (**0.005**)**

SPIN test: speech-in-noise test; CST: competing sentences test; DPT: duration pattern test; CMT: content memory test; SMT: sequence memory test; AV markers: auditory vigilance markers.
* Statistically significant.
** Highly statistically significant.
*** Very highly statistically significant.

Table 4
Comparison between the pre- and post-training values of the cortical potential measurements of the study group ($n = 17$).

Cortical potential measurements	Normal confidence intervals of the cortical potential measurements [8]	Pre-training mean (±SD)	Post-training mean (±SD)	*t*-Value (*p*)
AFG threshold (dB S/N)	(−16.1) to (−12.6)	−5.3 (4.4)	−11.3 (3)	−5.9 (**0.000**)***
P1 latency (in ms)	69.8–82.6	96.9 (25.7)	93.6 (17.9)	0.5 (**0.634**)
N1 latency (in ms)	161.2–176	192.1 (18.3)	182.8 (17.8)	1.3 (**0.208**)
P1–N1 amplitude (in μV)	16.8–22.5	11.9 (5.3)	16.9 (4)	−3.6 (**0.003**)**

** Highly statistically significant.
*** Very highly statistically significant.