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# Evaluation of long term outcome of auditory training programs in children with auditory processing disorders

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ABSTRACT

*Objectives:* To evaluate the long term effects of Arabic auditory training 'AT' programs in Egyptian school-aged children with auditory processing disorders 'APD'.
*Methods:* Thirty children with APD who received the proper regular AT for minimum duration of 2 months were included. They were subjected to functional measures 'questionnaire for APD' and psychophysical test battery. It comprised dichotic digits, pitch pattern sequence 'PPS', gap in noise detection 'GIN' and the memory tests. New bench mark battery was applied in the form of the duration pattern, the dichotic rhyme and the informal memory tests. The results of different tests were compared across the evaluation sessions 'pre-training, immediate post training, and the late outcome'.
*Results:* The children were evaluated after mean duration 24.5 months, ranged 7–42 months from the end of AT. No deterioration in the scores of Arabic questionnaire or the psychophysical tests was observed compared to the immediate post training evaluation. The bench mark tests scores matched the age based norms. A statistical significant correlation existed between PPS, GIN tests and the functional measures.
*Conclusion:* The outcome of the AT program showed long term consistency. The temporal processing tests (PPS, GIN) were sensitive tools in monitoring the progress of training. The new bench mark test battery used was effective as the diagnostic test battery in assessing the long term effects of AT program.


## 1. Introduction

Auditory processing disorder (APD) is a complex problem affecting about 7% of school aged children [1]. It refers to difficulties in the perceptual processing of auditory information in the central nervous system as demonstrated by poor performance in one or more of the auditory skills [2]. The auditory skills comprises sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition; auditory performance in competing acoustic signals (including dichotic listening); and auditory performance with degraded acoustic signals [3]. Although APD may coexist with other disorders (e.g., ADHD, language impairment, and learning disabilities), it is not the result of these other disorders. These disorders are not due to a deficit in the central auditory nervous system (CANS) and the listening difficulties exhibited by these children occur when co-morbidity deficit in the CANS can be demonstrated [2].

Management of APD may be viewed as a tripod with three legs that include environmental modification, compensatory strategies and direct skill remediation techniques (auditory training). Without all the three legs, the tripod cannot stand [3,4]. Auditory training 'AT' programs relied on the fact that the auditory system can undergo changes in response to intensive auditory training. These changes are maximal within a certain critical period of time [5]. They are classified into formal and informal programs. Coupling formal and informal auditory training should maximize treatment efficiency [6,7]. The development and implementation of AT programs in Arabic language dated since 2000. Several programs, both formal and informal, targeting nearly all the affected central processing abilities were standardized and evaluated in the Audiology Unit, Ain Shams University. Satisfactory outcome and consistent results were reported when applied on Arabic-speaking children with APD [8–11].

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The process of capturing clinical outcomes of APD has been labor intensive work but has lacked integration. Many researchers reported significant improvement after AT in children with APD [12]. The recent technical report issued by experts in the field of APD and published by ASHA pointed that additional data are needed to demonstrate the effectiveness and efficacy of these approaches [2]

Preliminary findings indicated that late occurring effects of the remediation programs existed and showed improvement of skills in individuals with APD when assessed after 8 weeks of remediation [13]. Most of studies evaluating the outcome of AT programs considered a maximal period from 3 to 6 months after finishing training and not for longer periods. Tallal [14] showed consistent improvement for long term evaluation at 3 and 6 months. However, Tallal study was only on limited number of children using Fast forwards FFW. The short term consistency for the Arabic AT programs 'up to 6 months' was previously reported [8,9,11].

Rogowsky et al. [15] advised follow-up testing over time to determine the longer-term effects of computer-based interventions for improving reading and writing outcomes in struggling students. Future results would fill the gaps in literature and provide more definitive conclusions and recommendations about the consistency of AT programs which make real differences in the lives of children with APD and their families over longer periods [16].

Meanwhile the long term outcome of AT programs on the Egyptian children with APD has not been investigated yet. Accordingly, this study was designed to evaluate the long term effects of Arabic auditory training programs in a group of Egyptian school-aged children with APD. Those children were diagnosed with APD and received the proper intensive auditory training at time of diagnosis. Variables affecting such outcome were also highlighted.

## 2. Materials and methods

### 2.1. Subjects

The present study was conducted into two steps.

#### 2.1.1. Retrospective work up

This step was done to collect data about children that could participate in the study. All files of children in the clinic for APD – Audiology Unit, El-Demerdash Hospital, Ain Shams University, Cairo – Egypt were reviewed. Four hundred children were examined during the period from 2006 to 2013. Diagnosis of APD was settled in 115 (29%) children and 40 children (35%) completed the scheduled AT program.

Criteria for inclusion in the present study were settled diagnosis of APD, proper regular training at time of diagnosis. The minimum duration required for inclusion in this study was 2 months of regular therapy, twice weekly and for 30 min each. All children should have normal peripheral hearing sensitivity as shown by pure tone audiometry thresholds <15 dB HL for frequencies 500–4000 Hz, excellent speech discrimination scores and normal middle ears functions. They had at least average psycho-intellectual abilities as measured by the Arabic Hiskey Nebraska test of learning aptitude with no associated neurological disorders.

A group of 30 school-aged children (26 males '87%' and 4 females '13%') fitted the above mentioned criteria. Their mean age was 11 1/2 (±2.5) years, ranged from 7 to 16 1/2 years. All children had mean intelligence quotient 87 ± 7 and range 80–94. Twenty-six children (87%) were right handed and four children (13%) were left handed. They were enrolled in ordinary schools. Their school grades matched their chronological ages except two children. Twenty-two children (72%) were in primary grades, five (16%) in preparatory grades and the remaining three (1%) in secondary grades.

At time of diagnosis, the majority of study group children ($n$ = 17, 57%) had more than two affected auditory abilities; eight children had two affected abilities (26%), while one affected ability was met in five (17%). The auditory temporal processing ability was the commonest ability affected ($n$ = 21) followed by memory disorders ($n$ = 19) and dichotic listening disorders ($n$ = 17). The selective auditory attention problem was seen in three subjects. Other higher cognitive communicative ability deficit in the form of phonemic awareness problem was found in 11 subjects and auditory attention problem in 1 subject (Fig. 1).

All children started remediation for APD before the age of 12 years with a mean age 8 (±1.8) years. Twenty-two (73%) children were trained received formal training using the Arabic computer based Arabic auditory training program 'CBAT' [9]. The remaining eight (27%) children received combined formal and informal training. The mean duration of training was 5.45 (±3.97) months and range from 2 to 18 months. Only two children continued to receive training for 18 months as they had more than two affected central auditory abilities that necessitated long course of therapy.

The CBAT program used for training of study group children was specifically implemented for treatment of Arabic-speaking children with APD and associated language learning problems [9]. It was designed according to the scientific principle of remediation to train several auditory processing abilities in a highly interesting and attractive theme [3,4,7]. The developed program was classified according to the trained auditory abilities into: (1) Bottom-up processed abilities (central auditory processing abilities) which include auditory temporal processing, selective auditory attention, auditory dichotic listening, inter-hemispheric transfer of information and auditory closure [2]. (2) Top-down processed abilities (cognitive-communicative abilities) which include auditory vigilance, auditory memory, phonological awareness and language comprehension.

It consisted of three phases classified according to the used material: phase I with non-verbal material, phase II with simple verbal Arabic material, phase III with complex verbal Arabic material. Acoustic modifications were done whenever needed according to the ability trained. As an example, amplitude and frequency modulated tones with variable inter stimulus interval, prolongation of voice onset time for consonants were applied in games for auditory temporal processing disorder. Moreover, in each game the multimedia software extends to improve the visual attention and sustained visual/auditory attention together with the trained central auditory ability. This is accomplished through developing the ability to focus attention, ignore distractions, and respond quickly when stimulus changes. The program strengthens visual processing skills and sensory-motor integration through auditory to visual to motor co-ordination and fine motor skills.

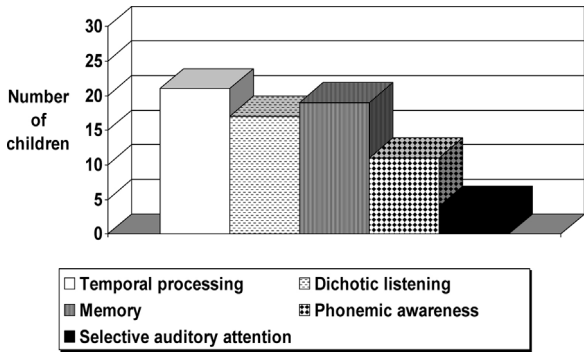


**Fig. 1.** Distribution of study group children according to the affected auditory ability.