Autism Insights

ORIGINAL RESEARCH

Effectiveness of Auditory Integration Therapy in Autism Spectrum Disorders—Prospective Study

Laila Y. Al-Ayadhi[1,2], Abdul Majeed Al-Drees[1,2] and Ahmed M. Al-Arfaj[3]

[1]Autism Research and Treatment Center (ART Center), Al-Amodi Autism Research Chair. [2]Department of Physiology, Faculty of Medicine, King Saud University, Riyadh, Saudi Arabia. [3]Department of ENT, Faculty of Medicine, King Saud University, Riyadh, Saudi Arabia. Corresponding author email: ayadh2@gmail.com

Abstract

Objectives: To determine the effectiveness of auditory integration training (AIT) in people with Autism Spectrum Disorders (ASD).

Method: Seventy two subjects with ASD aged up to 17 years old (70 male and 2 females) were recruited for the study. All subjects were screened by Diagnostic and Statistical Manual of Mental Disorders, (DSM-IV), and assessed by CARS (Childhood Autism Rating Scale). Pre-intervention scores and post-intervention (3 and 6 months) scores were calculated for each child using CARS, Social Responsiveness Scale (SRS), and the Autism Treatment Evaluation Checklist (ATEC). Auditory integration training was performed over 2 week, 30 minutes, twice a day.

Results: All subjects demonstrated improvement 3 and 6 months following the AIT. ASD subject showed 22% and 26% percentage improvement in SRS scoring 3 and 6 months respectively following the AIT intervention. Those changes were attributed to statistically significant changes in social awareness, social cognition, and social communication. Similar results were achieved with the ATEC check list: ASD subject showed 19.5% and 22.5% improvement 3 and 6 months following the AIT intervention, respectively. Those changes are due to statistically significant ($P < 0.05$) improvement in speech, communication and sociability only.

Conclusions: The results of this study support the therapeutic effects of auditory integration training on social awareness, social cognition, and social communication, as well as speech and communication.

Keywords: autism spectrum disorders, auditory integration therapy

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Introduction

Autism Spectrum Disorders (ASDs) are complex neurodevelopmental behavioral disorders with an onset prior to the 36th month. ASDs are characterized by impairment of social contact and communication, as well as restricted and repetitive interest and behaviors. Other characteristics include sensory dysfunction, inappropriate laughing and giggling, little or no eye contact, apparent insensitivity to pain, preference to be alone and many others.[1] Recent epidemiological studies suggested that autism might affect one in 150 American children. The prevalence of ASD has increased dramatically over the last few years and it cannot be attributed completely to improved diagnostic techniques and increased awareness.[1]

Sensory processing disorder (SPD) is relatively common among children with ASD ranging from 40% to 80% in American children.[2] Sensory integration (SI) theory was originally developed by Ayres and focused on neurological processing of sensory information. In ASD, the SI dysfunction manifest as difficulty in regulating responses to sensations and specific stimuli. Individuals with ASD may use self-stimulation to compensate for limited sensory input or to avoid over stimulation.[3–6] This suggests poor SI in the central nervous system and could explain the impairments in attention and arousal.[2,7] SI intervention is a type of intervention designed to provide controlled sensory experiences in order to elicit an adaptive motor response.[2] The administered sensory input must be in accordance with the child's needs, and is characterized by an emphasis on sensory stimulation, active participation of the client, and involvement of client-directed activities.

Auditory hypersensitivity is a common finding in ASD. Interventions to overcome variations in auditory sensitivity in people with ASD have been developed and are collectively called auditory integration therapy (AIT). Berard's method of AIT was first developed in France in 1982. Berard postulated that abnormal sensitivity or insensitivity to certain frequencies of sound waves, regardless of overall hearing ability, was associated with a range of behavior and learning problems, and that his technique of AIT would bring about a "re-education" of the hearing process.[8,9]

Thus, the aim of the current project is to test the effectiveness of AIT in reducing ASD symptoms.

Materials and Methods

Patients

All subjects participated in the study were recruited from the Autism Research and Treatment Center (ART Center) at King Saud University, King Khalid University Hospital. Seventy two ASD subjects, 2 girls and 70 boys, (ages ranging from 3 to 17 years old), were assessed for participation and enrolled in the study. All children were screened and assessed by psychologist and pediatrician using the Diagnostic and Statistical Manual of Mental Disorders, 4th Edition DSM-IV and Childhood Autism Rating Scale (CARS). Children with a history of seizure disorder were excluded from the study. Written consent was obtained from the parents of each subject, according to the guidelines of the ethical committee of King Khalid Hospital, King Saud University, Riyadh, Saudi Arabia. During the study period, children were not allowed to begin any new therapies or stop any current therapies, including medications and supplements.

Clinical outcome measures

All measurement was carried out by a qualified psychologists. Pre-intervention scores and post-intervention (3 and 6 months) scores were calculated for each child using CARS, Social Responsiveness Scale (SRS), and the Autism Treatment Evaluation Checklist (ATEC). The SRS is a validated test of interpersonal behavior, communication, and stereotypical traits in autism.[10] It consists of five subscales: social awareness, social cognition, social communication, social motivation, and autistic mannerisms. The SRS measures the degree of social impairments in autistic children and is suitable for assessing treatment outcomes. In this study, a total raw score was obtained and raw scores were calculated for each subscale. The ATEC is a questionnaire that was developed by the Autism Research Institute to evaluate treatment efficacy in autistic individuals. It consists of four subscales labeled Speech/Language/Communication, Sociability, Sensory/Cognitive Awareness, and Health/Physical/Behavior. The scores are weighted according to the response and the corresponding subscale. The higher the subscale and total scores, the more impaired the subject is.[11] ATEC is used in some studies as an outcome measure.[12,13] It is designed to allow parents and physicians to assess outcomes of certain treatments commonly used in autistic individuals.

In this study, scores were calculated for the total score and the four separate subscales.

Auditory integration training was conducted according to the following protocol.[8,9] The child was first examined by a medical doctor to ensure that no excessive wax and/or fluid is present. In general, the child's age should not be less than 4 years. The listener received 18 to 20 listening sessions, lasting for 30 minutes, over a 10- to 20-day period in most cases, and had a 1- or 2-day break after 5 days of listening. During the listening sessions, the child listened to processed music. That is, the AIT sound amplifier attenuated low and high frequencies at random from the compact discs, and then sent this modified music through headphones to the listener. The intensity level (volume) during the AIT listening sessions should not exceed 80 dBA (low scale) and was set at much lower intensities depending on the individual's comfort level. Overall, the music was played at a moderately loud, but not uncomfortable, level. The 80 dBA level for a total of one-hour per day is well below the Occupational Safety and Health Act (OSHA) guidelines for non-hazardous noise levels. The OSHA Noise Standard permits exposure to an average noise exposure of 85 dBA for eight continuous hours.

Audiograms were obtained prior to, at the mid-point, and at the completion of the AIT listening session. The first and the mid-point audiograms were used to set filters on the AIT machines. These filters are used to dampen (40 dBA or more) those frequencies which the person hears too acutely (peaks).

Data analysis

All data are presented as means ± SDs. The data were prospectively collected and analyzed using SPSS statistical software. Statistical differences in changes in each scale (CARS, SRS, and ATEC) were ascertained using the Student's *t* test with significance set at 0.05.

IRB ethical approval was obtained for the study. The project was approved by the IRB of the college of medicine, King Saud University.

Results

Seventy two subjects with ASD participated in the study, aged up to 17 years old (70 male and 2 females). Twenty two subjects had moderate ASD, and 52 subjects had severe ASD, according to CARS scale. Nine out of the moderate ASD subjects were verbal, whereas 12 out of the severe cases of ASD were verbal. Nineteen and twenty two ASD subjects had auditory hypersensitivity in the moderate and the sever ASD group respectively. In addition, none of the family members of any of the participating subjects had auditory hypersensitivity. Twelve moderate ASD subjects and 22 in the severe group had a history of repeated ear infection. All were treated successfully by the ENT specialist, and settled down with no further complication (Table 1).

Three months following the AIT, 9 and 15 ASD subject improved in the moderate and severe categories, respectively. In addition, a further 6 ASD subjects improved, in both categories, 6 months following the AIT (Table 2). This was obvious in the percentage change in mean CARS scoring. There was a 13.6% and 18% percentage improvement, 3 and 6 months following the AIT intervention, respectively (Table 3; Fig. 1). In addition, ASD subject showed 22% and 26% percentage improvement in SRS scoring, 3 and 6 months following the AIT intervention, respectively. Similar results were achieved by the ATEC check list, where ASD subjects showed 19.5% and 22.5% percentage improvement 3 and 6 months following the AIT intervention, respectively (Table 3).

A detailed look at the SRS subcategory revealed that the changes in the SRS scoring were attributed to statistically significant changes in social awareness, social cognition, and social communication ($P < 0.05$), but not to improvement in social motivation and autistic mannerism (Fig. 2). Furthermore, the

Table 1. Demographic data of ASD subject.

ASD (CARS)	Moderate (No = 22)	Severe (No = 52)
Age (mean ± SEM)	11 ± 2	8 ± 2.7
Age range	4–17	3–14
Sex		
Male	22	50
Female	0	2
Language		
Verbal	9	12
Non verbal	13	40
Auditory hypersensitivity	19	22
Family history of auditory hypersensitivity	0	0
Sensory dysfunction	22	50
Abnormal ABR findings	2	5
History of repeated ear infection	12	22
Family history of speech delay	5	29

Table 2. ASD Childhood Autism Rating Scale (CARS) before, 3 months, and 6 months following the AIT intervention.

ASD (CARS)	Minimal—no symptoms (0–29.5)	Mild-moderate (30–36.5)	Sever (37 and higher)
Before AIT	0	22	50
3 months post AIT	9	37	35
6 months post AIT	15	28	29

ATEC subcategory scoring system showed statistical significant ($P < 0.05$) improvement in speech, communication, and overall sociability, but there were no significant changes in the sensory/cognition or the health/physical/behavior subcategory (Fig. 3).

Discussion

Autism is a neurodevelopmental disorder currently affecting as many as 1 out of 166 individuals worldwide.[14] Autism is characterized by impairments in social interaction, difficulty with communication, and restrictive and repetitive behaviors.[1] Sensory dysfunction is a common finding in ASD, including tactile sensation, smell, taste, visual, and auditory stimulation. Hypersensitivity to sensory stimuli is considered a disturbing feature in autism, especially hypersensitivity to auditory stimuli. This leads to difficulties in communication which results in social isolation and consequently results in difficulties in rehabilitation and learning.[1,14]

AIT refers to listening to music that has been computer modified to remove frequencies to which an individual demonstrates hypersensitivities and to reduce the predictability of auditory patterns. This treatment has been proposed for improving abnormal sound sensitivity in individuals with behavioral disorders, including ASD.[8,9]

Results from the current study show a significant improvement in some aspect of ASD behaviors. This is demonstrated by significant changes in CARS, SRS, and ATEC scoring results (total and subcategory scores) three and 6 months following AIT intervention. The changes observed were mainly related to social awareness, social cognition, and social communication, but not social motivation or the autistic mannerisms. This was proved through statistically significant changes in SRS subcategory scoring. Furthermore, a statistically significant improvement in speech and communication and sociability was achieved and proved through the ATEC subcategory scoring system.

There is controversy in the literature regarding the effectiveness of AIT in reducing the auditory hypersensitivity. A Cochrane review was conducted with the objective of determining the effectiveness of AIT or other methods of sound therapy in individuals with ASD. Six randomized controlled trials of AIT were identified, including one crossover trial. Four trials had fewer than 20 patients involved in the study. Seventeen different outcome measures were used. It was noted that three studies did not demonstrate the benefit of AIT over the control conditions. In addition, 3 trials reported improvements at 3 months for the AIT group with the Aberrant Behavior Checklist (ABC).[15]

Eric Courchesne, of the University of California at San Diego, found significant impairments in auditory processing in autistic individuals using P300 brain wave technology. The P300 brain wave occurs 300 milli-seconds after the presentation of a stimulus. (The 'P' refers to the positive polarity of the brain wave.) The P300 is associated with cognitive processing, and this brain wave is considered an indication of long-term memory retrieval.[16] Edelson et al[17] examined auditory P300 activity prior to and three months following the AIT. Three autistic individuals participated in the experimental AIT group and two autistic individuals participated in a placebo group. Prior to

Table 3. Summary of mean CARS, SRS, and ATEC scores, before, 3 months, and 6 months following the AIT.

	Mean score before AIT	Mean score 3 months following AIT	Percentage improvement	Mean score 6 months following AIT	Percentage improvement
CARS	44 ± 9	38 ± 12	13.6%	36 ± 10	18%
SRS	109 ± 7	84 ± 5	22%	80 ± 4	26%
ATEC	133 ± 6	107 ± 7	19.5%	103 ± 7	22.5%

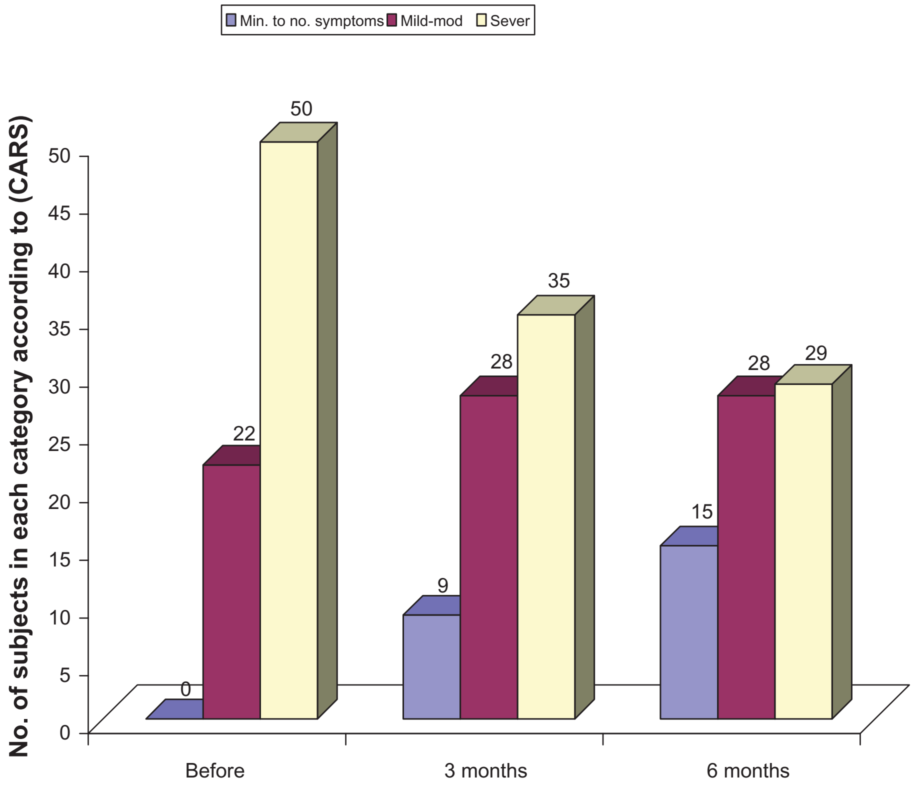

Figure 1. No. of ASD subject in each category according to Childhood Autism Rating Scale (CARS) clinical scales, before, 3 months, and 6 months following the AIT.

AIT, all five individuals had abnormal auditory P300 activity, indicating an auditory processing problem. Three months following AIT, the results showed dramatic improvement in P300 activity for those who received AIT (ie, a normalization of P300 activity) and found no change in those who received the placebo.[17]

It has been found that the hippocampus, part of the limbic system, is neurologically immature in autistic individuals. The hippocampus is responsible

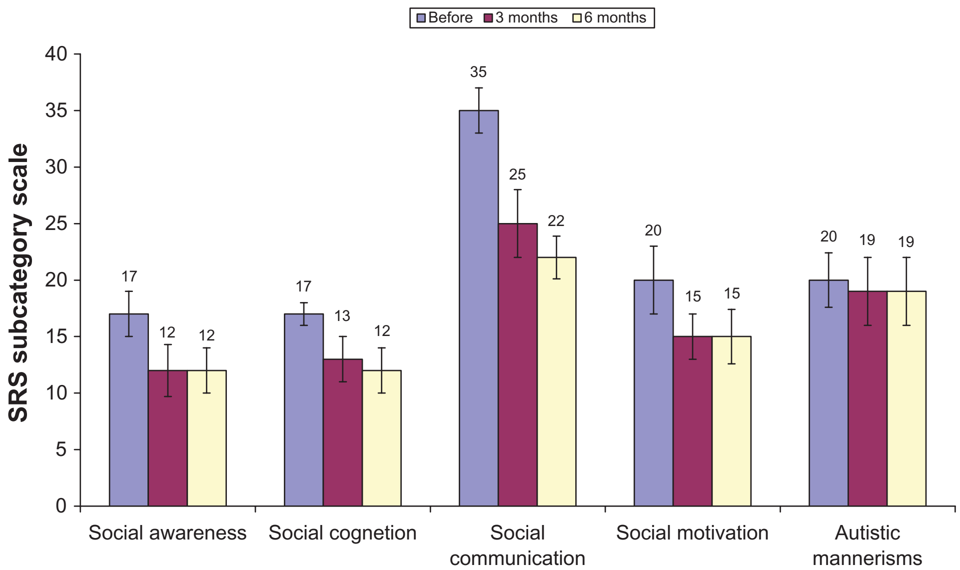

Figure 2. Changes in Social Responsiveness Scale (SRS) subcategories (social awareness, social cognition, social communication, social motivation and autistic mannerism) before, 3 months, and 6 months following the AIT.

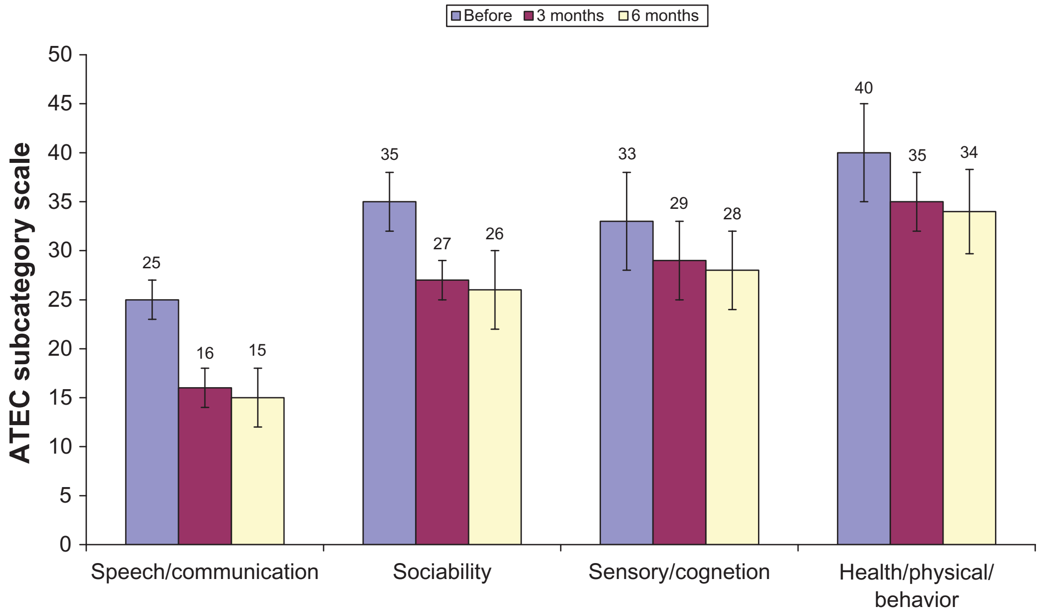

Figure 3. Changes in Autism Treatment Evaluation Checklist (ATEC) subcategories (speech/communication, sociability, sensory/cognition, health/physical/behavior) before, 3 months, and 6 months following the AIT.

for sensory input processing as well as learning and memory. Basically, information is transferred from the senses to the hippocampus, where it is processed and then transferred to areas of the cerebral cortex for long-term storage. Since auditory information is processed in the hippocampus, the information may not be properly transferred to long-term memory in autistic individuals.[18,19]

Auditory processing problems may also be linked to several autistic characteristics. Autism is sometimes described as a social-communication problem. Processing auditory information is a critical component of social-communication. Other characteristics that may be associated with auditory processing problems include anxiety or confusion in social situations, inattentiveness, and poor speech comprehension.

Interestingly, those individuals who do not have auditory processing problems are often 'auditory learners.' These children do very well using the Applied Behavior Analysis (ABA) approach, whereas those who are visual learners do not do as well with this approach.[20] Given this, one might suspect that many visual learners have auditory processing problems and that visual learners will do quite well with a visual communication/instruction approach. It is also possible to provide visual support with ABA programs that have an auditory component. In this way, the visual learner can process the auditory information more easily.

The better autistic children understand auditory information, the better they can comprehend their environment, both socially and academically. The better we understand the autistic child, the better we can develop ways to intervene in an effective manner. Results of this study are consistent with previous studies suggesting that auditory integration training improved behavior of individuals with ASD.[20–22] Madell and Rose[23] stated that following AIT, parents reported an improvement in their autistic child's language skills.[23] The results of the present study documented an effect along a similar trend to those reported in previous studies. This is consistent with the results of Rimland and Edelson[20] which show increases in comprehension abilities in autistic subjects ranging from four to 21 years of age. The results of the present study are also consistent with Hall and Case-Smith[21] in which 10 children with SPDs were administered eight weeks of AIT. While the AIT program in the study is four times longer than that of the present study, there were still similar trends in results between the two studies. Hall and Case-Smith[21] reported better communication and more consistency in following directions of those students tested according to changes in scores on the Sensory Profile.[11,24]

Speech perception and production are intimately linked from birth, and this functional link is likely to persist into adulthood. A perfect speech and language mechanism requires a precise temporal synchronization between speech areas to function to the optimum. In human beings, the two hemispheres are thought to contribute to the processing and understanding of language: the left hemisphere processes the linguistic meaning, while the right hemisphere processes the emotions conveyed. Wernicke's area, located in the posterior end of the superior temporal Gyrus, is responsible for comprehension, planning, and understanding of speech. While Broca's area, located in the lower end of the Premotor area, is responsible for execution of speech, formation of words according to orders supplied from Wernicke's area to Broca's through the neuronal connection between them. Generation of speech is dependent on the precise temporal synchronization of phonatory and articulatory muscle groups.[25,26] Language content modulates this process in a top-down fashion, requiring the close interaction between speech and language. This complex system is severely compromised in ASD. AIT depends on listening to computer modified digitally mastered sound frequencies leading to organized synchronized stimulation of the related areas in the brain, ie, Weirnikes area, Brocas area, and the Arcuat fasiculus. Thus neuronal connection harmony is achieved in those related areas in the brain which leads to improved neuronal communication between those areas, and consequently improved physiological functions are observed. It is reflected as an improvement in social communication, social interaction, and social awareness, as demonstrated in this study.

Recommendations for future studies and limitations

A larger homogenous sample size is strongly recommended, to determine the exact beneficial effect of the intervention, and to ensure the greatest level of validity and reliability.

Conclusions

The results of this study support the therapeutic effects of auditory integration training on social awareness, social cognition and social communication as well as on speech and communication. It is proved through CARS, SRS, and ATEC scales.

Author Contributions

Conceived and designed the experiments: LYA. Analyzed the data: LYA. Wrote the first draft of the manuscript: LYA. Contributed to the writing of the manuscript: LYA, AMD, AMA. Agree with manuscript results and conclusions: LYA. Jointly developed the structure and arguments for the paper: LYA, AMD, AMA. Made critical revisions and approved final version: LYA, AMD, AMA. All authors reviewed and approved of the final manuscript.

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Competing Interests

Author(s) disclose no potential conflicts of interest.

Disclosures and Ethics

As a requirement of publication the authors have provided signed confirmation of their compliance with ethical and legal obligations including but not limited to compliance with ICMJE authorship and competing interests guidelines, that the article is neither under consideration for publication nor published elsewhere, of their compliance with legal and ethical guidelines concerning human and animal research participants (if applicable), and that permission has been obtained for reproduction of any copyrighted material. This article was subject to blind, independent, expert peer review. The reviewers reported no competing interests.

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