

# **Autism Research Institute**

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## **The Efficacy of Auditory Integration Training: Summaries and Critiques of 28 Reports (January, 1993 - May, 2001)**

**Stephen M. Edelson, Ph.D. and Bernard Rimland, Ph.D.**

Auditory integration training (AIT), as developed by French otolaryngologist Guy Berard and based on the work of his predecessor, Alfred Tomatis, typically consists of 20 half-hour sessions of listening to specially modulated music over a 10- to 20-day period. AIT has been reported to be beneficial in several conditions, including AD/HD, autism, dyslexia, and hypersensitive hearing at certain frequencies.

The present review covers 28 reports on AIT. Twenty-three reports concluded that AIT benefits various population subgroups, three studies claim to show no benefit (or no benefit over that seen in a control group), and two studies reported rather ambiguous or contradictory results. Considering the great difficulties in both providing a credible placebo treatment and assessing improvement in the subject populations, these results are quite encouraging. The balance of the evidence clearly favors AIT as a useful intervention, especially in autism.

Following are summaries of all research studies known to us that have investigated the efficacy of AIT. These studies were published between January, 1993 and May, 2001 and have appeared in peer-reviewed journals, professional newsletters, and/or were presented at professional conferences. Twenty-six of the studies utilized subjects with autism, attention deficit/hyperactivity disorder, central auditory processing disorder, and/or mental retardation. Two of the studies evaluated the physiological effects of AIT on animals.

Section A of the paper summarizes those studies supporting the efficacy of AIT; Section B summarizes those studies that claim to have found no support for its efficacy; and Section C summarizes the results of two studies which we have classified 'ambiguous, contradictory, or controversial.' Following these three sections, Section D, we discuss two additional reports in a Discussion section, followed by our Conclusions.

The summaries are listed chronologically within each disorder. All used Berard-type equipment and procedures. (We are not aware of any relevant research using the Tomatis approach during the time period covered.)

The following abbreviations are used for the tests/checklists utilized most often in the studies: Aberrant Behavior Checklist (ABC-1), Autism Behavior Checklist (ABC-2), Behavior Summarized Evaluation (BSE), Childhood Autism Rating Scale (CARS), Clinical Evaluation of Language Fundamentals--Revised (CELF-R), Conner's Parent Rating Scales (CPRS), Fisher's Auditory Problems Checklist (FAPC), Screening Test for Auditory Processing Disorders (SCAN), Self-Injurious Behavior Questionnaire (SIBQ), Staggered Spondaic Word (SSW), and the Test of Nonverbal Intelligence (TONI).

## Section A -- Studies Reporting Positive Effects of AIT (N=23)

### AUTISM STUDIES

#### **(1) Ocular Movements Among Individuals with Autism Pre- and Post-Auditory Integration Training**

Margaret P. Creedon in collaboration with Stephen M. Edelson and Janice E. Scharre  
Easter Seals Therapeutic Day School, Autism Research Institute, and Illinois College of  
Optometry

Paper presented at the Annual Conference of the Association for the Advancement of Behavioral Therapy, New York, 1993.

In an open-clinical study, visual tracking movements and optokinetic nystagmus (a visual reflex) were assessed in 22 autistic individuals, ages 6 to 13 years, prior to, immediately following, and three months after AIT. Significant improvements were seen in horizontal tracking immediately following AIT and in both horizontal and vertical tracking three months post AIT. No changes were seen in optokinetic nystagmus.

Parents completed the FAPC and the ABC-1. The FAPC indicated significant improvement at 3 months post-AIT, and the ABC-1 indicated significant improvement both immediately following and 3 months post-AIT.

*Comment.* This was an open-clinical study with no control group for comparison.

#### **(2) Study of the Effects of AIT in Autism**

Dawn Cortez-McKee and Jaak Panksepp

Bowling Green State University, Ohio

Paper presented at the Annual NW Ohio Autism Society Conference, 1993.

This open-trial clinical study utilized 33 autistic individuals. Participants were assessed using multiple measures prior to (two baseline measures), and at 1-week, 1-month, and 3 months following AIT. The measures included: ABC-1, BSE, CARS, CPRS, FAPC, and SIBQ. Significant improvement was seen on all of the measures, except the FAPC, at the one- and three-month follow-up assessment periods.

*Comment.* This study was also an open-clinical trial with no control group for comparison.

#### **(3 & 4) Two Studies of the Effects of Auditory Integration Training in Autism**

Tina K. Veale

Comprehensive Concepts in Speech and Hearing, Cincinnati, Ohio

Paper Presented at the International ASA Conference on Autism, Toronto, Canada, 1993.

Study I. In a double-blind placebo pilot study, five autistic subjects participated in the experimental group and five in the control group. Parents completed three different evaluation forms--the ABC-1, the CPRC, and the FAPC. These instruments were completed prior to, one month following, and three months following AIT. There were no initial differences between the experimental and control groups, but positive trends indicating improvement in the experimental group were seen at three months following AIT for all three evaluation forms.

**Study II.** This was an open clinical study involving 46 autistic participants. Parents completed the ABC-1, CPRS, FAPC as well as the Autistic Behavior Composite Checklist and Profile. Significant improvements were observed at one month and six months following AIT. Some of the behavioral changes included: reductions in hyperactivity, social withdrawal, auditory problems, restlessness, and anxiety.

*Comment.* Study I included a control-placebo group, but there were only five subjects in each group. Given this small number, it is not surprising that, despite the benefits seen, there were no significant differences between the two groups. Study II which did find significant pre- and post-treatment differences was an open-clinical trial and did not include a placebo-group.

#### **(5) The Effects of Auditory Integration Training in Autism**

Bernard Rimland and Stephen M. Edelson

Autism Research Institute, San Diego, California

*American Journal of Speech-Language Pathology*, 1994, 5, 16-24.

This study involved an open-clinical research design which included several experimental control measures. There were 445 autistic subjects in the study, with ages ranging from 4 to 41 years. A significant reduction in sound sensitivity was found, based on the presentation of pure tones prior to and immediately following the AIT sessions. Analyses of the hearing tests conducted prior to, after 5 hours of listening, and after 10 hours of listening, showed hearing acuity to have improved slightly while the amount of variability within the audiogram decreased. Subjects were also assigned at random to one of several filtering conditions (e.g., filter auditory peaks, no filters, filter painful frequencies). No differences in the efficacy of the AIT were found among the filtering conditions.

Parents completed several different questionnaires on a monthly basis for 9 months. These included the ABC-1, CPRS, and the FAPC. The responses to these behavioral measures indicated a sharp reduction in problem behaviors, starting one month following the AIT listening sessions. These changes remained stable throughout the entire 9 months of post-AIT evaluations.

Participants were assigned at random to one of three different AIT devices. No differences were found in the efficacy of the devices.

Correlational analyses were employed to attempt to develop a profile of those individuals who may benefit from AIT. Lower functioning individuals displayed significantly greater improvement, as indicated by the ABC-1 and the CPRS.

No significant relationships were found between behavioral improvement and age, degree of sound sensitivity, and the amount of variability in the pre-AIT audiogram.

*Comment.* Although a placebo group was not employed in this research project, the study did include several experimental controls, such as videotape raters who were 'blind' to before/after conditions, and random assignment to filter conditions and to AIT devices.

#### **(6) Positron Emission Tomography Measure of Modified Auditory Integration Therapy:**

##### **A Case Study**

Jacqueline M. Cimorelli and Melanie K. Highfill

University of North Carolina at Greensboro & Center for the Dev. of Comm. and Learning,  
Winston-Salem, NC

Presented at the ASA National Conference, Las Vegas, 1994.

Reported in *ADVANCE for Speech-Language Pathologists and Audiologists*, June 26, 1995.

A single-subject research design investigated changes in brain functioning following AIT using Positron Emissions Test (PET) Scan technology. The research subject was an 8-year old male with mental retardation and autism. PET scans were conducted prior to a second set of AIT listening sessions (baseline), one day after the listening sessions, and six months later. The results at both the one-day and six-month follow-up evaluations indicated a normalization of brain wave activity, including a decrease in hyper-metabolism in the frontal lobe and an increase in activity in the occipital lobe.

*Comment.* Although these results are encouraging, this study involved only one subject; and there was no control subject for comparison. Additionally, a PET scan had not been given prior to the first set of AIT sessions; thus, the baseline information used in the research study may not be an appropriate measure for comparison.

### **(7) Changes in Unilateral and Bilateral Sound Sensitivity as a Result of AIT**

Deborah Woodward

Woodward Audiology, McLeansville, NC

*The Sound Connection*, 1994, 2, p.4.

Loudness tolerance was investigated in 60 children with autism and related disorders. Uncomfortable loudness level (UCL) measurements were performed prior to and immediately following AIT. Prior to AIT, the results from the left and right monaural presentations (to each ear independently) as well as the binaural presentation (to both ears simultaneously) were much lower than 90 dBHTL, where 90 dBHTL is considered a normal lower limit of UCL. Furthermore, the binaural tolerance to the speech noise was 9 to 11 dBHTL less than the monaural tolerance level, where 3 to 6 dBHTL is considered normal. Following AIT, the monaural tolerance level to each ear increased 13 to 15 dBHTL, but overall, the monaural and binaural tolerance levels were lower than normal. This increased tolerance to speech noise was statistically significant. In addition, the binaural tolerance level was only 5 dBHTL lower than the monaural sound presentations, indicating a more normal response.

*Comment.* This study involved a relatively large number of subjects; however, the study did not employ a control group.

### **(8) Parental Perceptions of Change Following AIT for Autism**

Dana Monville and Nickola Nelson

Western Michigan University

Paper presented at the American Speech-Language-Hearing Conference, New Orleans, 1994.

A survey was mailed to 150 parents of children diagnosed with either autism or pervasive developmental disorder whose children had received AIT between 1991 and 1993. Forty parents (27%) responded to the survey. Of those who responded, 25 (63%) reported an increase in attention span; 25 (63%) reported a decrease in sound sensitivity; and 12 (30%) reported an increase in language. Four parents (10%) reported an increase in tantrums and aggression.

*Comment.* Although the survey was sent to 150 families, only 27% responded to the survey. It is possible that those who observed positive changes in their children were more likely to complete the survey than those who did not observe any changes.

### **(9) Auditory Integration Training**

Jane R. Madell and Darrell E. Rose

Long Island College Hospital, Brooklyn, NY; and Mayo Clinic, Jacksonville, FL

*American Journal of Audiology*, March, 1994, 14-18.

This study involved an open clinical trial of AIT on four children. Their diagnoses included: autism, PDD, and learning disabilities. Audiograms of all four children showed improvement following AIT (i.e., a decrease in variability). Behavioral improvement was observed in three of the four children. The benefits reported were: increased calmness, decreased sound sensitivity, and improvements in speech/language and word recognition in noise.

*Comment.* Although this report included a great deal of clinical detail, only four subjects participated in the study; and there was no control group.

#### **(10) Auditory Integration Training: A Pilot Study**

Bernard Rimland and Stephen M. Edelson

Autism Research Institute, San Diego, California

*Journal of Autism and Developmental Disorders*, 1995, 25, 61-70.

The study utilized a blind-placebo controlled experimental design. Eight subjects were assigned at random to the experimental (AIT) group, and 9 were assigned to the placebo group. The placebo group listened to the same, but unprocessed, music. Three months following AIT, significant improvements were observed on the ABC-1 and the FAPC. Although there were no changes in sound sensitivity nor changes in the audiogram, the majority of subjects had not been reported to be sound sensitive, nor were they able to be tested audiometrically.

*Comment.* Although the subjects were assigned at random to the AIT and placebo groups, there were initial differences between the two groups. Regression analysis suggested the effects observed were not artifacts of the initial differences.

#### **(11) Epileptic Activity in Autism and Acquired Aphasia: A Study Using Magneto-Encephalography**

Jeffrey D. Lewine, Sherri L. Provencal, John T. Davis, and William W. Orrison, Jr.

Department of Radiology, School of Medicine, University of Utah Medical School

Paper presented at the Autism Society of America National Conference, Orlando, Florida, 1997

Magnetoencephalography and EEG recordings were used to measure electrical activity in the brain in one child with dyslexia and one high-functioning autistic adult. Baseline recordings demonstrated larger than normal responses in the areas associated with hyperacusis. Following AIT, a more normalized balance or symmetry in electrical activity was observed.

*Comment.* These findings document physiological changes due to AIT; however, there were only two subjects in the study and no control group.

#### **(12) Auditory Integration Training: A Double-Blind Study of Behavioral, Electrophysiological, and Audiometric Effects in Autistic Subjects**

Stephen M. Edelson, Deborah Arin, Margaret Bauman, Scott E. Lukas, Jane H. Rudy, Michelle Sholar, and Bernard Rimland

Autism Research Institute, San Diego, CA; Massachusetts General Hospital, Boston, MA;

McLean Hospital, Belmont, MA; and Upper Valley Medical Centers, Troy, OH

*Focus on Autism and Other Developmental Disabilities*, 1999, 14, 73-81.

Nineteen autistic subjects were assigned at random to either the experimental group (n=9), which listened to AIT-processed music, or a placebo group (n=10), which listened to the same, but unprocessed, music. All evaluations were 'blind' to group assignment. Behavioral, electrophysiological, and audiometric measures were assessed prior to and following AIT. Behavioral: A significant improvement was observed in behavioral problems (using the ABC-1) in the

experimental group at the 3-month follow-up assessment. **Electrophysiological:** Of the 19 subjects, three experimental group and two placebo group subjects were able to cooperate with the auditory P300 Event Related Potential (ERP) task. All five subjects showed abnormal P300 ERPs prior to the AIT listening sessions. Three months following AIT, all three subjects showed a dramatic improvement in their auditory P300 ERP. No improvement was seen in the placebo group. **Audiometric:** The subjects' poor communication and attention skills precluded formal statistical evaluation of the data from a battery of audiometric tests; however, an audiologist was able to assign correctly 10 of the 15 subjects for whom partial data were available to the treated and non-treated groups, on a 'blind' basis.

*Comment.* AIT was reported to produce both behavioral improvement and normalization of brain wave activity. The behavioral changes on the ABC-1 are consistent with those obtained in a previous study (Rimland & Edelson, 1995, Section A, #10). Although the electrophysiological findings are encouraging, they are based on a total of only five subjects.

### **(13) Auditory Integration Training and Autism: Two Case Studies**

Mark Morgan Brown

Private Practitioner, Republic of Ireland

*British Journal of Occupational Therapy*, 1999, 62, 13-18.

This is a clinical study of two autistic siblings, a 5-year old male and a 3 1/2-year old female. Observations were made at three and six months following AIT. Improvements were reported in attention, arousal and sensory modulation, balance and movement perception, praxis and sequencing, speech and language, social and emotional maturity, and eye control.

*Comment.* Although this study provided detailed descriptions of subjects prior to and after AIT, it involved only two subjects and no control group for comparison.

### **Attention Deficit/Hyperactivity Disorder Reports**

#### **(14) Non-Pharmacological Techniques in the Treatment of Brain Dysfunction**

Jeffrey M. Gerth, Steve A. Barton, Harold F. Engler, Alyne C. Heller, David Freides, and Jane Blalock

Georgia Institute of Technology, Emory University, and the Atlanta Speech School

Technical Report prepared for the GTRI Fellows Council, Georgie Tech Research Institute, Georgia Institute of Technology, June, 1994.

This study evaluated the effectiveness of AIT on 10 children with auditory-based learning deficits. Eight of the ten had also been diagnosed as having Attention Deficit Disorder. Subjects were given a series of diagnostic tests, and parents were requested to complete several questionnaires. Two subscales from the Woodcock-Johnson Psycho-Educational Battery test were used to evaluate changes in auditory processing. These subscales, the Sound Blending scale and the Incomplete Words scale, indicated an improvement of one standard deviation or more in 4 of the 10 subjects, and moderate improvement in two other subjects. Performance on other criteria (e.g., CPRS and the FAPC) "could not be meaningfully evaluated, given the amount of missing data."

*Comment.* Although improvement was reported in 6 of the 10 subjects, there was no control group.

**(15) Auditory Processing Skills and Auditory Integration Training in Children with ADD**

Donna Geffner, Jay R. Lucker, Ann Gordon and Dolores A. DiStasio  
 St. John's University, Jamaica, NY and Ann Gordon Associates, Stony Brook, NY  
 Paper Presented at the Annual Convention of the American-Speech-Language Hearing  
 Association, New Orleans, 1994

This study investigated changes in audition and language in 16 children with AD/HD. A large number of tests were employed to evaluate possible changes as a result of AIT. The measures included: standard audiometric threshold testing, tolerance for tones and speech, speech recognition in quiet and noise conditions, and the Goldman-Fristoe-Woodcock (GFW) Test of Auditory Selective Attention. Post-assessments were conducted within 3 months following AIT. Significant improvement was observed in the subjects' tolerance to tones and speech, speech recognition in the noise condition, and in listening skills as measured by the GFW Auditory Selective Attention Test and several subscales from the Detroit Test of Learning Aptitude (oral commissions, attention span for unrelated words, and attention span for related words).

*Comment.* No control group was utilized in this study.

**(16) Long-Term Effects of AIT Comparing Treated and Non-Treated Children**

Donna Geffner, Jay R. Lucker, and Ann Gordon  
 St. John's University, Jamaica, NY; and Ann Gordon Associates, Commack, NY  
 Paper Presented at the Annual Convention of the American Speech-Language-Hearing  
 Association, Seattle, 1996.

The study involved a one-year follow-up evaluation of children with Attention Deficit Disorder. Those receiving AIT (n=10) were compared to a control group (n=10) which did not receive AIT. Using a tolerance testing procedure for 'uncomfortable' listening levels, improvement of 6 dB in the left ear was observed for the AIT group, but no change was observed in those in the control group. No differences were found between the two groups with respect to listening to 'comfortable' speech. Additionally, tests evaluating speech recognition in noise and auditory-language processing showed improvement for those in the AIT group but not for those in the control group.

*Comment.* Although a control group was used in this study, those in the control group did not receive a placebo treatment that would have controlled for the possibility of a 'placebo effect.'

**(17) The Effects of Auditory Integration Training on Children Diagnosed with Attention Deficit/Hyperactivity Disorder: A Pilot Study**

Wayne J. Kirby  
 University of North Carolina at Asheville  
 Paper presented at the First Annual Congress of International Association of Berard Practitioners,  
 Antwerp, Belgium, 2000.  
*The Sound Connection*, 2000, Vol. 7, pp. 4 & 5.

This study employed a placebo-control design in which five children listened to AIT-processed music and five children listened to the same, but unprocessed, music. Subjects were assessed using the Auditory Continuous Performance Test (ACPT) prior to and three months following the

experimental/placebo listening sessions. The ACPT provides measures for impulsivity and inattention and also includes a 'total number of errors' score. Comparison of the two groups at three months post-AIT indicated a statistically significant reduction in the total number of errors for those in the AIT group. Improvement was also observed on the impulsivity and inattention scores for the AIT group, but these results were not significantly different from the results obtained from the placebo group.

*Comment.* Although a placebo group was utilized in this study, there were only five subjects in each group.

### **Central Auditory Processing Disorder (CAPD) Reports**

#### **(18) The Effects of Auditory Integration Therapy on Central Auditory Processing**

Brenda Huskey, Kathryn Barnett, and Jacqueline M. Cimorelli

University of North Carolina at Greensboro

Paper presented at the American Speech-Language-Hearing Conference, New Orleans, 1994.

In an experimental study, two auditory processing tasks were administered to six subjects in the AIT treatment group and six subjects in a control group. These tasks included the SSW test and the Phonemic Synthesis Test (PST). Pre- and post-tests were given prior to, and at 4 to 6 weeks, and at 8 to 12 weeks following AIT. For the SSW test, there were no improvements in the subjects 4 to 6 weeks following AIT, but there were improvements on the total score and on the left competing condition at 8 to 12 weeks following AIT. There were no changes in the results from the PST.

*Comment.* Although a control group was employed, there were only six subjects in each group. Additionally, the control group did not receive a placebo treatment to permit evaluation of the possibility of a 'placebo-effect.'

#### **(19) Clinical Outcome Evaluation: Auditory Integration Training**

Jane H. Rudy, Sharon S. Morgan, and Marianne Shepard

Upper Valley Medical Centers, Troy, Ohio

Paper presented at the Ohio Speech-Language-Hearing Conference, 1994.

In an open-clinical study, 13 subjects diagnosed with attention deficit/hyperactivity disorder (ADHD) and/or central auditory processing dysfunction (CAPD) were given a variety of assessments prior to, immediately following, and three months post-AIT. These tests examined hearing acuity, central auditory processing (SSW, SCAN), auditory evoked potentials (i.e., brain waveforms--P200 and P300), language function (CELF-R), and intelligence (TONI). Immediately following AIT, there were significant improvements in the SSW, SCAN, and CELF-R, and no change in the TONI. Three-months post-AIT, there was additional improvements in the SSW and CELF-R, but no further change in the SCAN. There was also a significant improvement in the TONI. An analysis of the P200 waveform indicated a significant change in amplitude but no change in the P300 waveform latency. No significant changes in hearing acuity were detected during any of the assessments.

*Comment.* This was an open-clinical study, and there was no control group.



## **Studies Investigating Mixed Populations**

### **(20) Auditory Integration Training: One Clinician's View**

Jane R. Madell

Long Island College Hospital and State University of New York, Brooklyn

*Language, Speech, and Hearing Services in Schools*, 1999, 30, 371-377.

Changes in speech perception were evaluated in several disorders prior to and following AIT. The populations included: autism, pervasive developmental disorder (PDD), multisystem developmental disorder (n=46), attention deficit disorder or attention deficit/hyperactivity disorder (n=26), and central auditory processing disorder with learning disabilities (CAPD/LD, n=46). Subjects' speech perception was assessed by asking them to recognize words in both quiet and competing noise environments. Improvement in speech perception was documented in both the quiet and noise conditions following AIT. In a second part of this study, uncomfortable loudness thresholds (UCLS) were evaluated in individuals diagnosed with autism (n=24), PDD (n=26), and CAPD (n=10). UCLs also improved in these children following AIT.

*Comment.* This is an excellent clinical study with many subjects and multiple measures of change. However, a control group was not used for comparison.

### **(21) A Comparative Study of the Earducator and the AudioKinetron**

Sally Brockett

IDEA Training Center, North Haven, Connecticut

*The Sound Connection*, 2001, 8, 1 & 6.

This study compared the effects of two Berard AIT devices--the Earducator and the AudioKinetron. A total of 19 children diagnosed with autism, learning disabilities and attention deficit disorder participated in this study. The children were assigned at random to either the Earducator or the AudioKinetron; and the evaluators, the parents, were 'blind' to group assignment. The ABC-1 and the Attention Deficit Disorders Evaluation Scale were used to assess changes. The results showed improvement in both groups of children and no differences between the two AIT devices.

*Comment.* Although the aim of this study was to compare two Berard AIT devices, a placebo group would have also provided additional information regarding the effectiveness of the two AIT devices.

## **Reports of Animal Studies**

### **(22) An Animal Model of Auditory Integration Training**

M. Waldhoer, J. Panksepp, D. Pruitt, M. Vaningan, D. McKee, J. Rossi III, and J. Lindsey

Bowling Green State University & Toxicology, Wright-Patterson Air Force Base

Paper presented at the Annual Society for Neuroscience Convention, San Diego, 1995.

This study was undertaken to follow up the positive findings seen in an earlier study on autistic children conducted by these authors (see Section A, #2). AIT was administered to newborn domestic chicks, selected as the species of choice because of their responsiveness to sounds. Starting at two days of age, subjects were included in one of three groups--AIT (experimental), music (control 1, same music as the AIT group but not processed), and silence (control 2). Following AIT, those in the experimental group exhibited an increase in growth and a reduced inhibition to separation-induced vocalizations in response to music. Post-mortem analysis of the brain tissue indicated a reduction in serotonin and 5-HIAA levels in the two music groups (experimental and control 1). In addition, an analysis of the behavioral effect of cyproheptadine, a general serotonin antagonist, yielded comparable behavioral effects. The data suggest that AIT may modify serotonergic tone in the brain.

*Comment.* Although behavior changes were observed in chicks who received AIT, neurochemical changes were found both in the AIT and placebo-music groups (control 1).

### **(23) Biochemical Changes As a Result of AIT-type Modulated and Unmodulated Music**

Jaak Panksepp, John Ross III, and T.K. Narayanan

Bowling Green State University, Ohio

*Lost & Found: Perspectives on Brain, Emotion, and Culture*, 1996/7, Vol. 2, p. 1 & 4.

This experiment involved four conditions in which groups of chicks were exposed to either AIT-type modulated music (using the EASe Disc 1, produced by Vision Audio, Inc., Joppa, MD); unmodulated music (the same music source but not processed); human voices (male and female); or no sound. For both the modulated and unmodulated conditions, neurochemical assays indicated a dramatic increase in norepinephrine and its principle metabolite, MHPG. The researchers also found increases in brain dopamine and its metabolite (HVA), but these changes were not as large. No clear changes were observed in brain serotonin and epinephrine. Very little change was observed for those included in the 'human voice' and 'no sound' conditions.

*Comment.* Changes were not observed in the human voice condition (placebo group) and no sound conditions, but neurochemical changes were found in the modulated condition (AIT group) and the unmodulated condition (placebo group). These findings indicate that listening to music produced neurochemical changes.

## **Section B -- Studies Purporting AIT to be Ineffective (N=3)**

### **Autism Reports**

#### **(1) Auditory Integration Training for Children with Autism: No Behavioral Effects Detected**

Oliver C. Mudford, Barbara A. Cross, S. Breen, Chris Cullen, David Reeves, Judith Gould, and Jo Douglas

Keele University, University of Manchester, and UK National Autistic Society

*American Journal of Mental Retardation*, 2000, 105, 118-129.

In a double-blind crossover design, 16 autistic children were evaluated for a 4-month period. Several measures were used in this study including: parent and teacher rating scales (ABC-1,

Nisonger Child Behavior Rating Form), direct observations (stereotypy, object obsessive, disruptive behaviors, stigmatising behaviors, vocal stereotypy), intelligence/cognitive testing (Leiter International Performance Scale), speech-language evaluation (Reynell Developmental Language Scales III), social/adaptive behavior (Vineland Adaptive Behavior Composite), standard audiometric testing, and parent reports. Improvements were observed in both the AIT group and the placebo group on adaptive/social behavior and expressive language. Statistically significant improvements in hyperactivity and ear occlusion were observed in the subjects who participated in the placebo condition.

*Comment.* Although the significant improvements seen in those in the placebo condition were dismissed by the authors, it is quite possible that these improvements may have been due to the subjects having received AIT eight months earlier (i.e., they may have participated in the AIT group prior to the crossover). This is a real possibility given: (a) the two areas of improvement in the placebo group are consistent with findings associated with AIT; and (b) Rimland and Edelson (1994, see Section A, #5) and Gillberg et al. (1997, see Section C, #2) documented improvement up to 9 months following AIT. The present authors called this possibility to Mudford's attention and suggested that the data be reanalyzed to test it. Mudford refused, claiming that additional analyses of the data would increase the likelihood of error. On the contrary, reanalysis of the data would have decreased the likelihood of error. Here we see an eagerness to declare AIT ineffective when the data do not necessarily support such a conclusion.

### **Central Auditory Processing Problems (CAPD) Reports**

#### **(2) The Effects of Auditory Integration Training for Children with Central Auditory Processing Disorder (CAPD)**

Karen A. Yencer

State University of New York at Buffalo

Doctoral Dissertation, 1996; *American Journal of Audiology*, 1998, 7, 32-44.

Thirty-six children diagnosed with central auditory processing disorder participated in an experimental condition (i.e., listened to AIT music), a placebo condition (i.e., listened to unmodulated music), or a control condition (i.e., did not listen to music). Children with autism, pervasive developmental disorder (PDD), and multiple-handicaps were excluded from the study. A battery of tests were administered to the subjects prior to and one month following the listening sessions. These included: standard audiometric testing, the SSW test, the Phonemic Synthesis test, the Standard Progressive Matrices test, FAPC, auditory brainstem response (ABR), event-related potential (P300), and a speech-in-noise test. The P300 analyses indicated some improvement in the AIT condition (mean latency from 366.2 msec. to 348.5 msec.) versus a slight worsening in the placebo condition (mean latency from 400.8 msec. to 402.2 msec.). Significant improvements were found for the three conditions on all measures except the speech-in-noise test.

*Comment.* Yencer examined changes following AIT after only four weeks following the AIT sessions. Stephen M. Edelson, who consulted on this study, noting that Berard and others had stated a need for at least 3 months of follow-up, insisted that she examine changes for at least three months following the AIT sessions. However, Yencer chose to conduct follow-up measures for only one-month because of her dissertation schedule. Cutting corners may be acceptable in meeting academic requirements, but not acceptable where decisions affecting the welfare of

handicapped children are concerned. Note that Huskey, Barnett, and Cimorelli (1994) investigated AIT on a similar population (i.e., CAPD) and found no improvement at 4 to 6 weeks following AIT, but did observe improvement at 6 to 8 weeks post-AIT (see Section A, #18).

### **Studies Investigating Mixed Populations**

#### **(3) The Efficacy of Auditory Integration Training: A Double Blind Study**

William Zollweg, Vere Vance, and David Palm

University of Wisconsin at La Crosse; Research Associates, Inc.; and Gundersen Lutheran Hospital

*American Journal of Audiology*, 1997, 6, 39-47

The study involved a double-blind research design involving 30 participants who were assigned at random to either an experimental (AIT) group or a placebo-control group. The participants were 7 to 24 years old, and the majority carried diagnoses of mild to profound mental retardation. Some of the participants were diagnosed as having autism. Evaluations were conducted using audiometric tests, a Loudness Discomfort Level test, and the ABC-1 at 3, 6, and 9 months following AIT. Although no differences were found between the AIT and control groups with respect to hearing and behavioral changes, both groups showed improvements. The results from the Loudness Discomfort Level test indicated that the control group had a higher tolerance for the frequency 250 Hertz than the AIT group at the 9-month post-assessment measure.

*Comment.* There are several severe problems with this study. First, the title should have stated "... in a Mixed Population" since fewer than a third of the subjects were autistic; thus one cannot generalize these findings to the autism population. Neither Berard, nor any other responsible investigator, has proposed AIT as a treatment for mental retardation. Second, the volume level was much higher than recommended. The recommended volume level is 80 dB SPL or lower. The decibel level in the Zollweg et al. study was measured as high as 122 dB SPL. Finally, an analysis of the audiograms indicated that 27% were given the wrong narrow band filters. Given the methodological flaws, these findings are not applicable even to the mentally retarded population.

### **Section C: Studies Presenting Ambiguous, Controversial, and/or Contradictory Findings (N=2)**

#### **(1) The Long-Term Effects of Auditory Training on Children with Autism**

Sue Bettison

Autism Research Institute, Sydney, Australia

*Journal of Autism and Developmental Disorders*, 1996, 26, 361-374.

"Eighty children, 3-17 years of age, with autism or Asperger syndrome and mild to severe distress in the presence of some sounds, were randomly allocated to two groups. The experimental group received auditory training and the control group listened to the same unmodified music under the same conditions. Significant improvements in behavior and severity of autism were maintained for 12 months by both groups. Informal data suggested that a range of abnormal responses to

sound and other sensory abnormalities may also have improved. Verbal and performance IQ increased significantly 3 to 12 months after interventions. Findings suggest that some aspect of both auditory training and listening to selected unmodified music may have a beneficial effect on children with autism and sound sensitivity, ..." [Author Abstract]

*Comment:* The results indicated significant improvement in both the experimental (AIT) and placebo groups, but there were no differences between the two groups. Bettison attributed these improvements to listening to music in a structured environment. However, critics have interpreted these findings as evidence of 'no benefits' associated with AIT, which is a debatable point.

While this is an exemplary study in many respects, the instruments used to assess changes associated with AIT had severe shortcomings. One of the primary measures used to investigate changes in sound sensitivity was a modified version of the Hearing Sensitivity Questionnaire (HSQ) designed by Rimland and Edelson (1991). The HSQ was designed only as a survey of sound sensitivity in the autism population and not an instrument to evaluate treatment effectiveness. Rimland and Edelson did not use it as an assessment measure in any of their three studies on AIT. Additionally, Bettison employed a scoring method for the HSQ that was said to provide a measure of the person's degree of sound sensitivity. This scoring method lacks even face validity (i.e., the appearance that the checklist is valid). For example, if a parent agreed with the item: 'Have there been certain sounds which the person does not seem to hear?', this response was considered an indication of hypersensitivity to sounds rather than hyposensitivity to sounds.

Another measure used in the study, the Developmental Behavior Checklist, had been used previously in clinical settings, but it was also not designed to measure treatment effectiveness. When evaluating the efficacy of an intervention, it is crucial that the appropriate measurement tools be used.

## **(2) Auditory Integration Training in Children with Autism: Brief Report of an Open Pilot Study**

Christopher Gillberg, Maria Johansson, Suzanne Steffenberg, and Orjan Berlin  
*Autism*, 1997, 1, 97-100

Nine children with "an autistic disorder" were given AIT for 10 days, in accordance with the procedure recommended by Guy Berard. No control group nor control procedure was used. At the end of the 9-month follow-up period, 8 of the 9 children showed improvement on the Autism Behavior Checklist (ABC) total score, and 7 of 9 children showed improvement on the ABC sensory subscale. Rimland and Edelson calculated the significance level of the differences, using standard matched paired t-tests and derived a  $p < .01$  level for the ABC total score and  $p < .02$  for the sensory score ("Auditory integration training in children with autism [Letter to the Editor]," 1998, *Autism*, 2, 91-92).

*Comment.* This study has several serious problems. Gillberg relied on two diagnostic checklists to measure changes as a result of AIT, the CARS and the ABC-2. Neither checklist was designed to evaluate treatment effectiveness. Additionally, despite the small sample size (only 9 cases), Gillberg et al. required an alpha level of .005 to test for statistical significance instead of the usual .05 and .01 level. This extremely low, very conservative alpha level is

uncommon in research. Its use in a small sample study virtually guarantees that no treatment will be found effective. As a result, Gillberg et al. (1997) erroneously concluded that no benefits were seen in their study on AIT. In response to Rimland and Edelson's (1998) 'Letter to the Editor,' protesting Gillberg et al.'s statistical analyses, Gillberg et al. (1998) stated "... a moderate reduction in sensory problems may have occurred" (p. 94; "Auditory integration training in children with autism: reply to Rimland and Edelson [Letter to the Editor]," *Autism*, 1998, 2, 93-94). Contrary to what Gillberg et al. concluded, the results were definitely positive. The failure to include a control group is unfortunate, but should not result in understating the value of AIT.

## Section D: Tabulation of Studies, Discussion and Conclusion

**Table 1: Tabulation of Studies**

(Number of Studies)

Disorders	Positive Findings	Ambiguous, Controversial, &/or Contradictory	Results Unclear/ Questionable	No Effects <sup>a</sup>
Autism	13	1 (Bettison) 1 (Gillberg)	1 (Mudford et al.)	0
ADHD	4	0	0	0
CAPD	2	0	1 (Yencer)	0
Several Populations	2	0	1 (Zollweg et al.)	0
Animals (chicks)	2	0	0	0

<sup>a</sup>Note that none of the studies failed to show discernible benefits.

Of the 28 research studies that evaluated physiological, behavioral, and cognitive changes in the subjects, the authors of 23 (82%) studies concluded that their data supported the efficacy of AIT, three (11%) claimed to have found no evidence of efficacy, and two (7%) report ambiguous, contradictory results.

## Discussion

### Negative Bias

We recognize at the outset that no research study is perfect--all have flaws and shortcomings of various kinds. However, the 23 studies with positive outcomes, by and large, exhibited fewer and less serious shortcomings than the subset of three supposedly negative studies. All three of these studies demonstrated an alarming bias favoring negative results [Mudford et al. (Section B, #1), Yencer (Section B, #2); and Zollweg et al. (Section B, #3)].

Two additional published reports clearly show a negative bias regarding AIT by some researchers. In a 'Letter to the Editor' entitled "When is a significant change not significant?," Patricia Howlin criticized a controlled-placebo AIT study (Rimland and Edelson, 1995, Section A, #10) by stating that the statistically significant differences on two measures were clinically not important (*Journal of Autism and Developmental Disorders*, 1997, 27, 347-348). Howlin's

criticisms were based on her misunderstandings. She stated "Thus, the mean fall in the ABC score was less than 0.4 points; hardly a dramatic change in a scale of 58 items" (page 348). Howlin assumed that the maximum possible score on the ABC-1 was 58; however, the maximum possible score was only 3. Thus, the difference of almost 0.4 points is a meaningful proportion of the 0 to 3 range and is clinically significant. Regarding another measure, Howlin stated that a 12-point difference on the 93-item FAPC was also not clinically important. Howlin was wrong again. The FAPC contains 25 items, not 93 items; thus, an average change on 12 of 25 items is quite dramatic and clinically significant. Again, the results were positive, not negative.

In another report, Rankovic, Rabinowitz, and Lof (1996) measured the sound output levels of a single AudioKinetrone, as reportedly used by a local AIT practitioner (*American Journal of Speech-Language Pathology*, 5, 68-72). The highest output level used by the practitioner was measured at 110 dB SPL, and the maximum output level of the AIT device was measured at 118 dB SPL. The authors concluded that these output levels can be harmful to hearing, and warned that AIT is potentially dangerous. However, an AIT device, like any radio, compact disc or audiocassette player, can be set to play too loudly. Should all be banned as potentially dangerous? Every practitioner is aware of his/her responsibility to make sure that the device is played at an appropriate level. Basing conclusions on a single, very probably atypical case, is a poor practice—the authors' conclusions are not justified.

A good deal of what has been written about AIT is excessively skeptical, negative or derogatory, permeated with the assumption that AIT is ineffective. Our review of all the research on the efficacy of AIT that we have been able to find refutes this negative view.

Probably because AIT lacks a plausible rationale and is counter-intuitive, it has become the target of skepticism and of negatively biased research. One's opinion about an intervention, like one's opinion about an individual, should be based on evidence rather than prejudice. The present authors were themselves skeptical when first learning about AIT. Their interest was stimulated, despite their initial skepticism, by a number of almost-too-good-to-be-true clinical reports from parents of autistic children who had been treated at Dr. Guy Berard's clinic in Annecy, France. There is a place for skepticism, but there is also a place for safe, non-intrusive, short-term and relatively inexpensive therapies with reasonably good track records.

### Physiological Findings

It is of interest that all seven studies that sought evidence of physiological change (e.g., electrophysiological, biochemical) as a result of AIT, including the two animal studies, reported positive findings (Section A, #s 6, 11, 12, 19, 22, 23; Section B, #2). This is an area where further research is indicated, in our opinion.

### 'Placebo' Music -- Less Inert Than We Think?

Five studies described in this paper utilized a placebo group and found significant improvements in both the AIT group and the placebo group (Bettison, 1996, Section C, #1; Panksepp et al., 1996/7, Section A, #23; Waldhoer et al., 1995, Section A, #22; Yencer, 1998, Section B, #2; Zollweg et al., 1997, Section B, #3). While such findings are typically construed to indicate 'no benefits' from AIT, we believe there may be more to the story than that.

Jaak Panksepp has raised the intriguing possibility (personal communication) that the presumably inert 'placebo' music may have had, contrary to expectation, a significant beneficial effect. Guy Berard specified that the music used in his version of AIT must have (1) a good tempo/beat, (2) a large variation in frequency within short intervals, and (3) a strong unpredictability component. Bill Clark, an audio engineer and developer of a popular AIT device, after analyzing the output of over one thousand compact discs, identified about 70 discs that best meet Berard's specifications. Most AIT practitioners use the music from Clark's list. As Panksepp points out, this small subset of carefully selected, attention-arousing music is not a random sample of available music and may, in fact, confer benefits that disqualify it from placebo status. Panksepp suggests such music arouses and activates attentional circuits in the brain (Panksepp, 1996/7, See Section A, #23).

### Future Research on AIT

Based on our monitoring of AIT research, we offer the following suggestions for consideration in future research studies.

- \_\_\_ Diagnostic instruments are inappropriate for evaluating treatment efficacy. Assessment instruments designed specifically for evaluating treatment efficacy should be utilized.
- \_\_\_ An assessment follow-up period of at least three months is necessary.
- \_\_\_ In a mixed population, separate statistical analyses should be conducted to assess specific populations (e.g., AD/HD, autism, CAPD, dyslexia).
- \_\_\_ When describing the AIT procedure, specify the filter settings, loudness levels, etc. to permit assessment and replication of the research.
- \_\_\_ The consistent findings of better than expected outcomes for the placebo groups in a number of studies, as well as evidence from other sources, suggests that certain kinds of music may stimulate significant improvement in attention and learning in some individuals, even without filtering and/or modulation of the music. Additional research in this area is clearly needed.
- \_\_\_ All seven of the studies in this review that have measured electrophysiological or biochemical responses have reported such changes in the subjects given AIT. Further study of physiological responses to AIT is indicated.

### **Conclusion**

Our review of the available literature on AIT has produced 23 studies with positive results and only 3 claiming no benefits from AIT. While none of the research done thus far on AIT is of Nobel Prize quality, the positive studies are far more credible than those with negative results. As we point out in our comments, the 3 studies that claim no benefits are deeply flawed, with conclusions that are not supported by the research procedures nor the research data.

AIT does, in fact, appear to be a worthwhile, frequently beneficial intervention which confers improvement in a number of symptoms, in a significant proportion of disorders on the autism spectrum.

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The Autism Research Institute does not offer AIT nor any other form of treatment.