American Speech-Language-Hearing Association

Second Opinion

# The Effects of Auditory Integration Training on Autism

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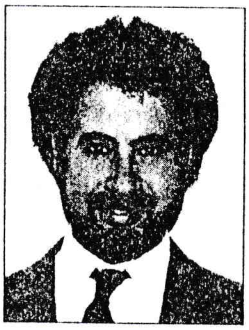

*Edelson*

Auditory integration training (AIT) was introduced in the United States through the publication of the book *The Sound of a Miracle*, by Annabel Stehli (1991), the mother of a formerly autistic child. Stehli's daughter was reportedly cured of autism by only 10 hours of AIT. Since recovery from autism is an extreme rarity and AIT is such a quick and benign form of treatment, the book and AIT received a great deal of media attention. *Reader's Digest* and other magazines, as well as the television show *20/20* and other electronic media, gave extensive coverage to AIT.

In this paper, we present a description of the AIT procedure, an overview of the background of AIT and of research on auditory problems in autistic individuals, a summary of the findings of our pilot study in 1991, and the preliminary findings of our large-scale study of AIT on 445 autistic subjects.

## Auditory Problems in Autistic Children

While auditory problems are clearly an important symptom of autism, there is a surprising paucity of research on the subject. Auditory problems include hypersensitive, painful hearing (Delacato, 1974; Grandin & Scariano, 1986; Ney, 1979); unresponsiveness to certain sounds (Kanner, 1943; Koegel & Schreibman, 1976); inability to modulate certain sounds, leading to excessive stimulation (Bruneau, Garreau, Roux, & Lelord, 1987); delays in auditory processing (Condon, 1975); abnormal processing of sounds in the brainstem as well as in higher centers in the brain (Courchesne, 1987; Thivierge, Bedard, Cote, & Maziade, 1990); and abnormalities in cerebral blood flow dynamics in response to auditory stimulation (Bruneau, Dourneau, Garreau, Pourcelot, & Lelord, 1992). These symptoms of auditory dysfunction have been linked to behavioral and attentional problems as well as to difficulties in speech, language, and comprehension (Delacato, 1974; Hayes & Gordon, 1977; Koegel & Schreibman, 1976).

Although it has received little professional attention, sound sensitivity, especially at certain frequencies, has been widely recognized as affecting a substantial proportion of autistic children and adults. In 1964, Rimland began collecting data on many aspects of autism, including sound sensitivity, through the use of a parent questionnaire, Form E-2, that appeared as an appendix to his book *Infantile Autism: The Syndrome and Its Implications for a Neural Theory of Behavior* (Rimland, 1964). Analyses of over 17,000 E-2 forms collected from parents worldwide since 1964 indicate that approximately 40% of autistic children exhibit at least some symptoms of sound sensitivity.

In only one other disorder known to us, Williams Syndrome, is a larger percentage of those affected reported to be troubled by sound sensitivity. In Williams Syndrome, about 95% of cases suffer from sound sensitivity (Klein, Armstrong, Greer, & Brown, 1990). While several authors have addressed sound sensitivity in autism (e.g., Delacato, 1974; Grandin & Scariano, 1986; Hayes & Gordon, 1977; Ney, 1979; Ney, Lieh-Mak, Cheng, & Collins, 1979), few suggestions for alleviating the problem have been made.

For the most part, the causes of sound sensitivity are unknown. Extremely loud sounds, trauma to the ear or brainstem, drug side effects, and deficiency of the mineral magnesium are among the few known causes for sound sensitivity across the population. With the exception of using ear plugs or ear protectors (Delacato, 1974) or administering supplements in magnesium-deficient cases (Rimland, 1974), until recently there have been no treatments offered to individuals, autistic or not, affected by sound sensitivity.

The Berard method of AIT, which is the primary focus of this paper, was developed by Guy Berard, a French otolaryngologist, and used in his practice in Annecy, France, from the 1960s until his retirement in 1991. His work was inspired by the earlier efforts of another French otolaryngologist, Alfred Tomatis, but there are important differences between the two approaches.[1] In 1981, Berard published his book

[1] *The Tomatis method.* A distinction must be made between the Berard type of auditory integration training described in this paper and its predecessor, the Tomatis Audio-Psycho-Phonology approach, which remains in wide use. The



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*Audition Egalé Comportment* (English translation, 1993), describing his experiences with over 8,000 clients, including 48 who were autistic. Most of the autistic clients were reported to have improved, but one of them, Annabel Stehli's daughter Georgie, was said to have totally recovered from autism.

A number of Berard's autistic patients had come from the U.S., and many of these families had been in contact with the Autism Research Institute in San Diego, which serves as a clearinghouse for information on all forms of treatment. The U.S. parents were enthusiastic about the improvement they had seen in their children, especially Annabel and Peter Stehli, the parents whose daughter Georgie was the one recovered client.

As noted above, the publication of the book *The Sound of a Miracle* (Stehli, 1991) brought AIT a great deal of attention and stimulated a strong demand. Many professionals, including speech-language pathologists and audiologists, sought training as AIT practitioners and purchased the necessary equipment so that they could offer AIT to families who wished to try this noninvasive approach with their autistic children.

### Description of the AIT Procedure

Berard's AIT device (the Audiokinetron), manufactured by SAPP in France, and a recently developed competing U.S.-made machine, the Audio Tone Enhancer/Trainer, manufactured by BGC Enterprises, accept music input from a source such as an audiotape or a compact disc, transform the sound electronically, then send these processed sounds through headphones to the listener.

One step in the processing—an optional step—permits the *filtering* out of sounds at certain selected frequencies in accordance with the needs of the individual client (trainee). The other step entails the *modulation* of the music by alternatively dampening and enhancing, on a random basis, the bass and treble musical output. The selection of low and high frequencies involves a broadband filter, alternating between frequencies at or below 1,000 kHz and frequencies at 1,000 kHz or above. Setting the filters requires audiometric testing of the trainee to determine whether he or she has "auditory peaks." Auditory peaks refer to frequencies at which there is a 5 or 10 dB difference between the specific frequency and its adjacent frequencies on the audiogram. If auditory peaks are present in the person's hearing, filters are used to dampen those frequencies to which the person is hypersensitive (i.e., which they hear "too well"). According to Berard, these auditory peaks can be reduced or eliminated by AIT. The eight filters on the Audiokinetron device (750 Hz to 8 kHz) and 14 filters on the Audio Tone Enhancer/Trainer instrument (125 Hz to 12 kHz) are activated by the operator according to a series of rules presented in the manufacturers' manuals. Although Berard states that AIT can reduce or eliminate sound sensitivity at specific frequencies, he also states that AIT tends to improve one's overall hearing ability.

In practice, the audiogram is obtained on the first day to determine the filter settings for the AIT device. The trainee then listens to the processed AIT music for a total of 10 hours over a 10- to 20-day period. Each listening session lasts for 30 minutes, and the listener typically receives two listening sessions per day. The maximum decibel level during the listening sessions is 85 dBA.

After 10 half-hour listening sessions (the halfway point), the person's hearing is assessed again to readjust the filters. If the person has speech-language problems, the volume level for the left ear is reduced at this point in the process based on the assumption that this will stimulate language development in the left hemisphere.

### The 1991 Pilot Study

In the first controlled study on the efficacy of AIT in autism, Rimland and Edelson (in press) conducted a blind experiment involving 17 autistic subjects ranging in age from 4 to 21 years. Eight subjects in the experimental group received AIT, and 9 subjects in the control group received unprocessed music under identical conditions during the 10-day treatment phase of the study. (One subject dropped out of the study due to transportation problems.) Subjects were matched on age, sex, degree of sound sensitivity, and the number of previous ear infections. The study was

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Tomatis approach is said to alleviate a number of "psychological disorders," including autism, by administering electronically modulated music through earphones. Berard was originally trained in the Tomatis method by Tomatis, but disagreed with Tomatis in a number of fundamental points, and soon left to develop his own approach, using a somewhat different apparatus. The differences between the Berard and Tomatis approaches were described in another paper by the present authors (Rimland & Edelson, 1991) but can be summarized briefly as:

*Etiologic assumptions.* Berard addresses the problem biologically; Tomatis assumes psychological antecedents such as prenatal effect of the mother's voice.

*Duration of treatment.* Berard considers one 10-hour series of sessions adequate, except for a few cases that may require a second set; Tomatis treatments are typically given in several phases, each phase lasting over 20 hours, and sometimes entailing hundreds of hours.

conducted under strictly blind conditions: the subjects, parents, and evaluators were unable to tell if a given subject was in the experimental treatment group or the control group.

Several criteria were used to assess hearing and behavior before, during, and after AIT. All evaluators were blind to group assignment. The pre- and post-assessments included audiometric tests (air and bone conduction), presentation of pure tones at a moderately loud volume (i.e., 85 dBA), and parent-completed questionnaires. When completing the questionnaires, parents were instructed to consider their child's behavior during only the previous 3 days. This allowed assessment of behavioral changes based on the subjects' current behavioral status rather than requiring parents to rely unduly on memory when considering their child's behavior.

Significant behavioral improvement was observed on both the Aberrant Behavior Checklist (Aman, Singh, Stewart, & Field, 1985a, 1985b) and the Fisher's Auditory Problems Checklist (Fisher, 1980) for subjects in the experimental group. These changes include decreases in irritability/agitation, stereotypic (repetitive) behavior, hyperactivity, and excessive speech, as well as increases in attention to auditory stimuli, memory for routine things, and comprehension. We did not find any significant changes in the person's auditory acuity or changes in sound sensitivity. We consider this experiment to be a pilot study because of the small sample size.

## 1991-1993 Large-Scale Research Study

Based on the relatively positive results of our pilot experiment, we proceeded with a much larger study designed to examine several specific issues in AIT. The pilot study had used all available autistic subjects in the Portland, Oregon, area. Because the pilot study entailed no travel or hotel costs, and relatively little family hardship was involved, we were able to recruit 17 families for the experiment, with the understanding that their child had a 50% chance of being assigned to the placebo-treatment control group. This was not possible for the large-scale study, for which autistic subjects were recruited from the entire U.S. Being unable to recruit new subjects to participate in a control group made it necessary to rely on the control group data from our pilot study in evaluating the effectiveness of AIT as an intervention—a serious limitation.

The second study did, however, enable us to investigate several important additional questions. These included:

- Does AIT reduce sensitivity to sounds?
- Is it helpful to use filters (versus no filters) during the AIT listening sessions?
- Is there a profile that predicts the best candidates for AIT?
- Are the several available AIT devices equally effective?

### *Subjects*

The opportunity to serve as subjects was offered to the families of all autistic and autistic-type children and adults who called or wrote to the Center for the Study of Autism after reading Stehli's (1991) *The Sound of a Miracle* or learning about AIT indirectly from the media. The families may be assumed to be highly motivated, since they were required to pay their own travel and hotel expenses, as well as to pay the standard fee (about $1,000) for AIT. The families were advised that:

- AIT was considered an experimental intervention, not yet scientifically validated, and that positive results were not guaranteed.
- Their child would be assigned at random to one of the two AIT devices, neither of which was known to be superior to the other, and to different filtering conditions.
- They would be required to complete checklists and questionnaires on an ongoing basis for 6 to 9 months.

A total of 445 children and adults with autism participated in this study. The age range was 4 to 41 years of age, with a mean of 10.73. There were 359 male and 86 female subjects.

All participants had either a primary or a secondary diagnosis of autism. Parents also completed an E-2 diagnostic checklist (DeMeyer, Churchill, Pontius, & Gilkey, 1971; Rimland, 1971). The mean score for subjects in the study was -1.44, very close to the mean of -2.00 for the cases labelled autistic in the Autism Research Institute's 17,000 case databank. E-2 scores from the positive range down to -15 are consistent with the diagnosis of autism.[2]

### *Method*

*Audiometric testing*. Air conduction audiometric testing was attempted with all of the participants. A total of 199 subjects (45%) were

[2] Subjects who applied to the Center for the Study of Autism who had not received a primary or secondary diagnosis of autism, or who did not exhibit autistic behaviors, were not included in the statistical analyses in this paper.

able to provide reliable responses to all three hearing tests. Those hearing tests considered unreliable were not used in the statistical analyses. All auditory tests were conducted by licensed audiologists who were unaware of the hypotheses of the study. These tests were conducted before, at the midpoint, and after the completion of the AIT listening sessions.

*Frequency Discomfort Test (FDT).* Sixteen pure tones, ranging from 20 Hz to 20 kHz, were presented to subjects through headphones for 10 seconds each at an 80-dBA level. The tones were presented using a digital audio tape player (Sony, Model 75ES). If a subject displayed any signs of discomfort in response to a tone, the tone was stopped. This test was presented before and after the listening sessions. All test sessions were videotaped. The raters of the tapes were blind to whether the test was presented before or after the listening sessions. Raters scored subjects' reactions with respect to verbal responses (such as saying "the sound bothers me") and nonverbal cues (such as removing the headphones, grimacing). No reaction = 0; verbal, physical, or negative reaction = 1.

*Test of Nonverbal Intelligence (TONI-2).* The TONI-2 intelligence test (Brown, Sherbenou, & Johnsen, 1990) assesses visual abstraction abilities without requiring verbal instructions by the examiner. Norms have been established for several populations, including individuals who are normally developing, deaf, dyslexic, gifted, and mentally retarded. Schubert and Edelson (1992) have analyzed TONI-2 scores from autistic individuals and have found the test to be reliable and valid. A total of 252 subjects were able to perform this test.

*Questionnaires.* Parents were asked to complete a series of questionnaires before, during, and after the AIT listening sessions.

1. Aberrant Behavior Checklist (ABC; Aman et al., 1985a, 1985b). This checklist was administered as a measure of problem behaviors. The ABC consists of 58 questions dealing primarily with behaviors such as aggression, self-injury, stereotypic behaviors, and temper tantrums. Parents were instructed to rate whether or not a behavior was considered a problem. The verbal descriptions and corresponding scores were: 0 = 'Not a problem,' 1 = 'A mild problem,' 2 = 'A moderate problem,' and 3 = 'A severe problem.' A summary score was calculated by summing all of the scores for each answered question.

2. Fisher's Auditory Problems Checklist (FAPC; Fisher, 1980). This checklist was used to measure changes in general auditory processing. The FAPC contains 25 questions concerning listening, comprehension, and attention skills. Parents were instructed to indicate whether their child had difficulty with each skill. Each question was scored with either 0 = 'not a problem,' or 1 = 'a problem.' A summary score for each subject was derived by summing the scores for all of the questions.

3. Conners' Rating Scales (CRS; Goyette, Conners, & Ulrich, 1978). The long version of the parent rating scale was used to examine various problem behaviors. The rating scale contains 93 questions involving social behavior, anxiety, compliance, obsessive-compulsive behavior, and hyperactivity. Each question was scored on a 4-point scale: 1 = 'Not at all,' 2 = 'Just a little,' 3 = 'Pretty much,' and 4 = 'Very much.' A summary score was derived by summing the responses to each question.

Posttraining assessments were conducted monthly on 254 (57%) of the subjects for 6 consecutive months, and 191 subjects (43%) for 9 consecutive months.

### Procedure

Subjects were randomly assigned to one of the three AIT devices—Berard's Ears Education and Retraining System (EERS, manufactured by SAPP in Amiens, France), the Audiokinetron (the updated [1992] version of the EERS), and the Audio Tone Enhancer/ Trainer (ATET, manufactured by BGC Enterprises in San Diego, CA). Initially, subjects were assigned at random to either the EERS device or the ATET device. When the Audiokinetron became available during the AIT listening phase of the study, subjects were then assigned to either the Audiokinetron or the ATET device, because we felt that collecting additional data for the now superseded EERS device was not worthwhile. By the completion of the testing, 126 cases had been trained with the EERS, 118 were trained with the Audiokinetron, and 201 were trained with the ATET.

Subjects participated in one of five different filtering conditions. Two conditions involved using filters to dampen specific frequencies during the AIT listening sessions. In one condition, termed 'filtered peaks' ($n = 143$), filters were used to dampen auditory peaks as evident in the audiogram. Berard's filtering rules were used for the EERS ($n = 25$) and Audiokinetron ($n = 47$), and Clark's filtering rules were used for the ATET ($n = 71$). In another condition, termed *filtering painful frequencies*, subjects who showed signs of discomfort when given the Frequency Discomfort Test (FDT), were trained with the painful frequencies dampened.

Three conditions required that filters not be used during the AIT listening sessions; however, the music was still modulated. One of these conditions, termed *peaks but no filters,* involved not using filters even though the subjects' audiograms showed clear signs of auditory peaks in their hearing. The condition termed *no audiogram, no filters* was used for subjects who were unable to respond to the audiometric tests in a reliable manner. The final condition, termed *no peaks,* was used for individuals who did not have any auditory peaks in their audiogram and did not show any discomfort in the FDT.

Assignment to these five conditions was based on the subjects' reactions to the tests. Those who were able to respond accurately to the audiometric test *and* had peaks in their hearing were assigned randomly to either the *filtered peaks* or the *peaks, no filters* conditions. If these subjects also reacted negatively to the FDT, subjects could be assigned, at random, to the *filtering painful frequencies* condition. Since many families traveled great distances to participate in this study, we were reluctant to assign subjects to the *peaks, no filters* group even though the families had agreed to the terms of the study. For ethical reasons, we wished to limit the number of subjects in this group. Only 36 of the 199 available subjects were assigned at random to this group.

Subjects who could not respond to the audiometric test but did respond to the FDT were assigned at random to either the *filtering painful frequencies* condition or the *no audiogram, no filters* condition. Those who did not react to the FDT or respond to the audiometric test were assigned to the *no audiogram, no filters* condition.

Finally, subjects who did not have any auditory peaks or show any signs of discomfort from the FDT were assigned to the *no peaks* condition. The number of subjects participating in each one of the five conditions is presented in Table 1.

## Results

*Analyses of the three AIT devices.* The data were analyzed for the three different AIT devices—the Ears Education and Retraining System, the Audiokinetron, and the Audio Tone Enhancer/Trainer—with respect to sound sensitivity, hearing acuity, filtering conditions, and behavioral changes reported by parents. Since none of the analyses showed results for the three devices to be statistically significant one versus another, the data were collapsed across the AIT devices.

*Frequency Discomfort Test (FDT).* As described previously, 16 different pure tones, ranging from 20 Hz to 20 kHz, were presented to the subjects for 10 seconds each at an 80-dBA level. The subjects' reactions to these tones were videotaped before and after the 10 hours of AIT. A general reaction score was calculated for each subject by assigning a score of 1 to a negative reaction to a tone (e.g., verbal or physical complaint) and a score of 0 to no reaction. The findings from this test are presented in Figure 1. The data from those subjects who did not exhibit any form of sound sensitivity before or after receiving AIT were not used in the analyses ($n$ = 107). A dependent $t$-test for the remaining subjects ($n$ = 338) revealed a statistically significant reduction in sound sensitivity ($t$ (337) = 2.99, $p < .01$) after AIT, across AIT devices, and regardless of filter use.

*Changes in hearing.* According to Berard, who considers AIT to be a form of physical therapy, one's hearing should improve slightly after receiving AIT, and any auditory peaks present in a person's hearing should be reduced or eliminated. Subjects' hearing was assessed before, midway through, and after receiving AIT. Hearing acuity was assessed by calculating the mean threshold level, in dBs, at all 11 frequencies recorded on the audiogram. (A subject whose audiogram was a straight line at 5 dB above normal [more acute than normal] would have a mean level of -5 dB.) Changes in the subjects' auditory peaks were assessed in terms of the variability in the subjects' audiogram, as indexed by the standard deviation across all of the frequencies for each subject. A (nearly) straight line would have a small standard deviation, whereas an audiogram characterized by peaks and/or valleys would have a large standard deviation. The means and standard deviations are presented in Figure 2.

The means and standard deviations for each of the three assessments were: before AIT: $M$ = 9.125, $SD$ = 6.706; midway through AIT: $M$ =

**TABLE 1. Number of subjects assigned to the five filtering conditions ($n$ = 445).**

| Filtered Peaks | Filtered Painful Frequencies | Peaks but No Filters | No Peaks and No Filters | No Audiogram, No Filters |
|---|---|---|---|---|
| 143 | 52 | 36 | 52 | 162 |

8.373, $SD$ = 6.127; and after AIT: $M$= 8.435, $SD$ = 6.014. A dependent $t$-test was used for statistical comparison. There was a slight, but statistically significant, improvement in the subjects' hearing from the first hearing test to the second hearing test ($t$ (198) = 3.192, $p < .01$); and this difference remained significant from the first to the third hearing test ($t$ (198) = 3.856, $p < .01$). There was no difference in acuity between the second and third hearing tests. There was also a statistically significant reduction in variability from the first hearing test to the second hearing test ($t$ (198) = 3.721, $p < .01$), and this difference remained significant from the first to the third hearing test ($t$ (198) = 4.378, $p < .01$). There was no difference between the second and third hearing tests. Overall, these findings are consistent with Berard's assertions that hearing acuity will improve slightly and auditory peaks will decrease as a result of AIT.

*Reduction of auditory peaks due to filtering.* Before AIT is administered to an individual, the AIT procedure requires setting filters for those frequencies at which the person has an exceptionally low (sensitive) threshold. We examined the variability in the hearing tests before and after AIT ($n$ = 179), to determine whether using filters reduced auditory peaks more than not setting filters. The variability with and without filters, before and after AIT, is presented in Figure 3. While AIT decreased the variability, as hypothesized, for both the filtered and nonfiltered groups (by 1.3 and 0.9, respectively), the effect of the filters was not significant.

*Behavioral changes reported by parents.* Parents were asked to provide monthly ratings of their child's behavior based solely on the 3 days preceding the ratings. Although the only no-treatment control group available was the small ($n$ = 9) group whose data were gathered in our earlier pilot experiment, the results nevertheless are felt to provide some, albeit limited, insight into subsequent behavioral changes. Figures 4 and 5 show the data for the first 3 months of the present study for the ABC and FAPC, superimposed on the ABC and FAPC data for the pilot study. The consistency in the data pattern for the ABC is reassuring, although less so for the FAPC. (The CRS was not used in the pilot study.) For all three questionnaires, there was a definite decrease in problem behaviors from the baseline levels to the 1-month levels following AIT, and then a gradual decrease over time for the ABC and the CRS. The 9-month data for the ABC, FAPC, and CRS from the current study are presented in Figures 6, 7, and 8. A comparison between the 1-month post-assessment period

**FIGURE 1. Verbal, physical, and total means for the Frequency Discomfort Test ($n$ = 338).**

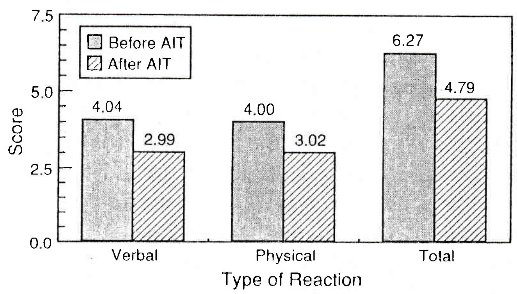



**FIGURE 2. Changes in audiograms before and after AIT ($n$ = 199).**

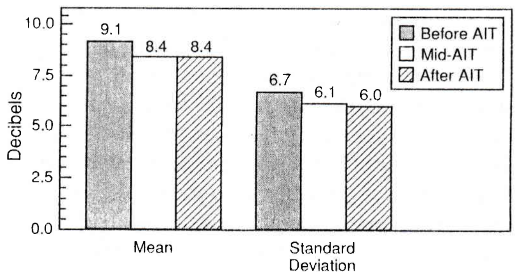



**FIGURE 3. Effects of filters on auditory peaks: Filters ($n$ = 143) versus no filters ($n$ = 36).**

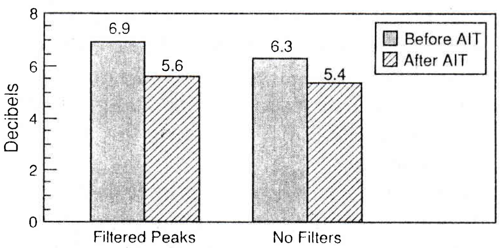



**FIGURE 4. Aberrant Behavior Checklist: Difference scores (post minus prior) for present study, first 3 months, superimposed on 3 month results of pilot study.**

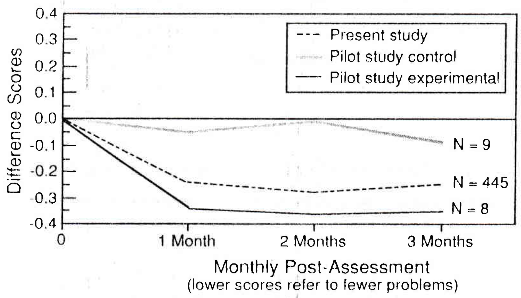


FIGURE 5. Fisher's Auditory Problems Checklist: Difference scores (post minus prior) for present study, first 3 months, superimposed on 3-month results of pilot study.

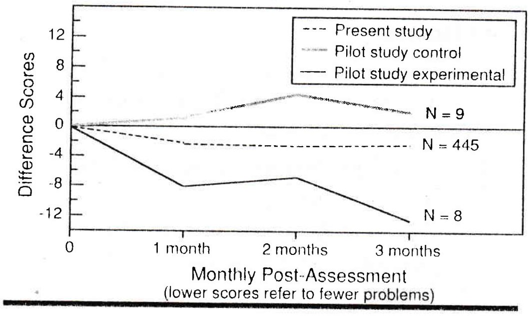



FIGURE 6. Aberrant Behavior Checklist: Pre- and post-assessment mean scores.

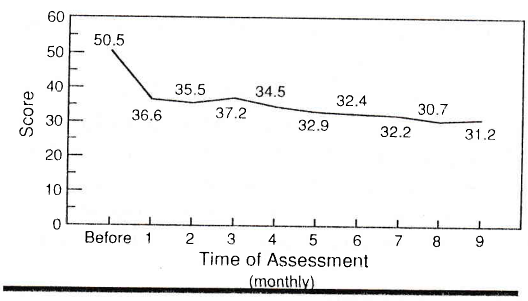



FIGURE 7. Fisher's Auditory Problems Checklist: Pre- and post-assessment mean scores.

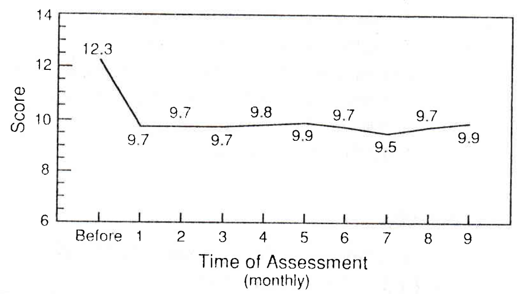
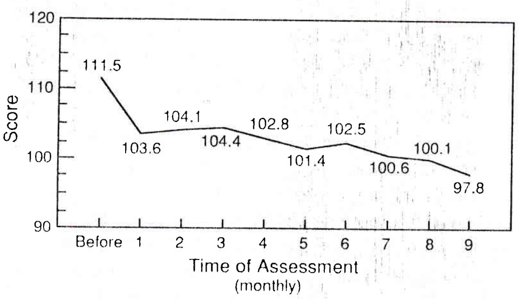



FIGURE 8. Conners' Rating Scale: Pre- and post-assessment mean scores.




and the 9-month post-assessment period revealed statistically significant decreases in problem behaviors for both the ABC ($t$ (186) = 4.299, $p < .01$) and the CRS ($t$ (178) = 3.251, $p < .01$).

*Relationships between subjects' characteristics and behavioral improvement.* Another goal of this study was to develop a profile of individuals who would be most likely to benefit from AIT. When AIT first received media attention, it was felt that autistic individuals with characteristics similar to Annabel Stehli's daughter, Georgie, would be most likely to benefit—that is, children who are high functioning, sound sensitive, and have many auditory peaks in their hearing. We examined these variables with respect to behavioral improvement using the ABC, FAPC, the CRS, and the TONI-2. There was a small, but statistically significant, negative relationship between the TONI-2 score and improvement at 9 months for the CRS ($r = -.36$, $t$ (288) = 6.47, $p < .01$) and the ABC ($r = -.21$, $t$ (288) = 3.59, $p < .01$), indicating lower functioning individuals had a tendency to make greater gains than higher functioning individuals in our study. Thus, our data do not support the idea that it is primarily high-functioning individuals who will benefit from AIT.

There was also a small but significant relationship between the subjects' audiogram variability and later behavioral improvement. Basically, a decrease in variability from the first to the last audiogram was correlated with improvement, as assessed by the ABC ($r = .32$, $t$ (198) = 4.78, $p < .01$) and the CRS ($r = .31$, $t$ (198) = 4.60, $p < .01$). In other words, a reduction in variability in the audiogram tended to be associated with improvement on behavioral measures. This is, of course, consistent with the idea that AIT "smooths out" hearing and improves behavior.

No relationship was found between age and degree of improvement on any of the questionnaires. In addition, no relationship was found between degree of sound sensitivity before AIT (as assessed by the FDT) and later behavioral changes.

## Discussion

The most important question a study on AIT can address is, simply stated, "Is AIT effective?" Because the circumstances under which the present study was conducted made it impossible to employ a new control group, it was necessary to re-use the small control group from our original study to address this question.

Despite the limitations, data from the present study continue to support the affirmative answer derived from our original study: there does appear to be a reasonable basis for expecting worthwhile improvement in various aspects of comprehension and behavior of autistic persons exposed to only 10 hours of AIT.

Several additional control studies of AIT with autistic populations are currently underway in the U.S. and Australia that will contribute significantly to the body of information available on the effectiveness of AIT.

Although the issue of efficacy of AIT is clearly of major importance, it was not the primary focus of the present study. This study was undertaken to address several subsidiary questions.

The AIT procedure entails both modulating the sound output and filtering auditory peaks in the listener's hearing. The filters are employed to decrease or eliminate auditory peaks in the person's hearing. An overall decrease in auditory peaks was found as a result of AIT. However, we found no difference in the reduction of auditory peaks for those whose sound sources were filtered, as compared to those for whom filters were not employed. This suggests that using filters during the AIT procedure may be an unnecessary component of the process, and that the modulation is probably the critical component of AIT. Our findings, however, are a function of the assessment measures employed. Other measures may yield differences when comparing filter versus no filter conditions.

A significant reduction in sound sensitivity was found for both the subjects' verbal and physical reactions; however, no relationship was found between sound sensitivity before AIT and later behavioral improvement. It is thus at least possible, as reported in our first study (Rimland & Edelson, in press), that both sound-sensitive individuals and persons without sound sensitivity may be viable candidates for AIT.

We examined several variables in an attempt to develop a profile of the most suitable candidates for AIT. The only variable related to later improvement was functioning level; lower functioning individuals tended to show more improvement than higher functioning individuals—possibly a consequence of the greater room for improvement among the lower functioning subjects.

This study did not address the frequently asked question: What mechanism(s) account for the effects of AIT? We are aware of at least 20 proposed explanations, ranging from the mechanical (for example, Berard's suggestion that AIT "massages" and thus enhances the function of the auditory system), to the biochemical (for example, improved production of neurohormones through auditory stimulation of the pineal gland). The actual mechanism is, however, unknown.

## Conclusions

1. Some evidence for benefit from AIT was found, almost all benefit being reported within the first 3 months.
2. The three AIT devices studied produced very similar results.
3. Contrary to expectation, the use of filters did not confer benefit beyond no-filter modulation.
4. Contrary to expectation, no relationship was found between pre-AIT sound sensitivity and reported behavioral improvement from AIT.
5. Lower functioning autistic subjects showed most benefit.

The present writers are pleased by the interest evinced by researchers in many fields, whose plans include conducting research using a variety of approaches, including electrophysiological and biochemical methods to further the understanding of this phenomenon.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