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Autism Insights

Berard Auditory Integration Training: Behavior Changes Related to Sensory Modulation

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ABSTRACT

OBJECTIVE: The purpose of this study was to determine if behaviors specifically related to sensory modulation showed positive changes following 10 days of Berard auditory integration training (AIT).

METHOD: Cases of 54 children with disabilities (34 with autism), ages 3–10 years, who received Berard AIT, were reviewed. Children received 30 minutes of training twice a day, separated by a minimum of three hours, for 10 consecutive days. Data were collected within one week before intervention and at one, three, and six months post-intervention.

RESULTS: Analysis of variance (ANOVA) indicated that Short Sensory Profile (SSP) total test scores and individual factor sections improved from pre-test to post-test ($P < 0.01$). Behavioral problems reduced on all five factors of the Aberrant Behavior Checklist (ABC) ($P < 0.01$). Most changes occurred within one month of intervention and maintained at three and six months. Correlations among the ABC and SSP factors indicate that sensory modulation as measured by the SSP is a significant contributor to four of the behavioral factors measured by the ABC.

CONCLUSIONS: Although causality cannot be determined using this study design, scores on the SSP and ABC improved in a group of children who received Berard AIT.

KEYWORDS: autism, auditory processing, behavior, sensory integration, sensory modulation

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Introduction

Auditory integration training (AIT), created by Berard,[1] uses sound to enhance inner ear processes that stimulate auditory reorganization and increase efficiency of processing, which theoretically manifests in improved behaviors, and social, motor, and academic performance. Dr. Berard believes "everything happens as if human behavior were largely conditioned by the manner in which one hears".[1,p.4] AIT uses music electronically modified by randomly alternating low and high sound frequencies to stimulate auditory system reorganization. Berard's work was influenced by his colleague, Dr. Alfred Tomatis. Tomatis, a French physician who pioneered the understanding of the impact of modified auditory techniques on human functioning, also identified the ear as a powerful integrator that could facilitate brain organization at all levels within the nervous system.[2]

The impact of audition and vestibular stimulation on brainstem function was a primary interest of Dr. Jean Ayres.[3] Ayres identified the brain's processing of sound as an essential form of sensory integration and proposed that vestibular–auditory processing influences both survival and discriminative functions.[3]

Berard AIT was introduced in the United States in the early 1990s as an intervention for auditory hypersensitivity and

language development.[4] Various theories emerged to explain how AIT produced observed changes. These theories were published in *The Sound Connection*, the quarterly newsletter published by The Society for Auditory Intervention Techniques.[5–9] One theory directly associated changes occurring from Berard AIT with the effect of intense auditory vibrational stimulation. This potentially could impact auditory and vestibular–cerebellar connections, which could result in improvements in functions regulated by these structures.[1,3,10–12]

Anatomically, the inner ear receives information from sound vibrations, which has potential to impact vestibular and auditory perceptions and processes. The vestibulocochlear system is known to impact brainstem integration,[13] which has been of primary interest in sensory integration theory and treatment.[3] Specific facilitation of auditory/vestibular processing has been associated with changes in sensory processing and modulation, arousal, attention and focus, postural control, social emotional development, auditory filtering, and visual motor performance.[3,14,15]

Numerous investigators have attempted to evaluate the benefits of AIT since its introduction in 1991 in the United States. Rimland and Edelson published a review in *The Sound Connection*[16] of 28 completed efficacy studies on AIT, 11 presented papers and 17 published research papers, and reported their strengths and limitations. These studies evaluated physiological, behavioral, and cognitive changes in subjects completing AIT. Three studies stated that their data found no efficacy, and two reported contradictory results. However, 23 of these studies concluded that the resulting data supported the efficacy of AIT. A total of 16 studies reported benefits in one or more of the following areas: sound sensitivity, hyperactivity, language development, behavior, and attention.

Results from three related studies provide evidence that in children with autism, AIT is associated with improvements in sound sensitivity, hyperactivity, language development, and behavior.[12,17,18] A placebo-controlled pilot study by Rimland and Edelson[18] involving 19 children with autism, ages 4–21, found statistically significant improvements in sound sensitivity, behaviors, and hyperactivity following AIT. An expanded study involving 445 children with autism corroborated the results of the pilot study.[12] A third placebo-controlled study involving 19 children with autism investigated electrophysiological and audiometric effects of AIT. Behavioral changes were consistent with the previous two studies, and the auditory P300 event related potential (ERP) showed normalization of brain wave activity.[17]

Brockett conducted a pilot study on the effect of Berard AIT on behaviors related to sensory modulation with 14 children, 3–13 years, with varied diagnoses, which was published in *The Sound Connection* newsletter.[19] Using a sensory checklist, parents identified the occurrence of behaviors commonly related to sensory modulation before and six months after AIT. The results indicated statistically significant decreases in challenging behaviors (low tolerance for movement activities and postural changes, craving movement, lack of or delayed response to touch, ability to maintain a level of alertness appropriate to the activity, and ability to play and interact appropriately with others) with reductions ranging from 42 to 100%. The median overall improvement was a 79% decrease in behaviors related to sensory modulation. Following this study, a standardized measure of sensory modulation was introduced for use with all clients at Brockett's clinic.

Most research before the Brockett study[19] involved the efficacy of Berard AIT in children diagnosed with autism or attention deficit disorder (ADD), targeting the behavioral outcomes of the technique, but not the sensory modulation outcomes. As sensory modulation issues have long been observed in individuals with autism, these are important outcomes to study.[20–23] To date, there is no peer-reviewed, published research studying the impact of Berard AIT on specific aspects of sensory modulation. This chart review study fills an important void in the literature because it evaluates changes in behaviors specifically related to sensory modulation following the 10 days of AIT. In addition, a correlational analysis between the Sensory Profile and the Aberrant Behavior Checklist (ABC) was included to identify if sensory modulation was a significant contributor to the behavioral factors.

For the purposes of this study, sensory modulation is identified as a neurophysiological process reflected in the individual's ability to regulate and organize behavioral, motor, emotional, and anticipatory reactions to sensory information and events. It reflects the individual's ability to process and adjust behavioral and emotional responses to the "intensity, frequency, duration, complexity, and novelty" of the sensory information or experience happening in the environment or daily tasks.[24] Behaviors related to difficulties with sensory modulation have been categorized into the following according to Miller[24] and Dunn[25]: (1) sensitivity to sensory stimuli (example, crying when loud noises occur), (2) poor registration (example, shutting down, not orienting to or responding to loud noises occurring), and (3) sensation seeking (example, actively seeking high intensity movement without regard to safety) and sensation avoiding (example, resistant to change).

Evaluation tools such as the Sensory Profile, the Short Sensory Profile (SSP), and the research editions of the Sensory Processing Inventory[26] use observations of behaviors that are related to sensory aspects of daily living tasks in attempts to evaluate sensory processing and sensory modulation. Sensory modulation is critical to a child's ability to interact with the environment and master skills.[3,14,24] When a technique appears to be influencing behaviors reflective of sensory modulation issues, research on the efficacy of this technique becomes important.

Special interest newsletters have published clinical reports of behavioral changes related to sensory modulation as a result of Berard AIT.[9,19,27] Based on these reports, the impact of Berard AIT on behaviors related to sensory modulation was targeted for this study.

The following hypotheses were examined:

Hypothesis 1: At one, three, and six months after AIT, children with developmental differences who also have sensory modulation issues and problem behaviors, such as irritability, hyperactivity, lethargy, repetitive actions, aggression, etc., will show improved scores on the SSP as reported by parents.
Hypothesis 2: At one, three, and six months after AIT, children with development differences who also have sensory modulation issues and problem behaviors, such as Irritability, Hyperactivity, Lethargy, Stereotypy, and Inappropriate Speech, will show improved scores on the ABC as reported by parents.
Hypothesis 3: Children with developmental differences who also have sensory modulation issues and problem behaviors, such as irritability, hyperactivity, lethargy, repetitive actions, aggression, etc., will maintain improvements in scores on the SSP and the ABC at three and six months after completion of AIT as reported by parents.
Hypothesis 4: The child's age is not related to response to AIT.

Method

Participants. This study was a retrospective chart review conducted on charts of children who participated in a standard program of Berard AIT at one clinic. This study relied on preexisting data and therefore is exempt under the Office of Human Research Protection Policy at 45 CFR 46.101(b)(4). It is a standard procedure at this clinic for parents or caregivers to be requested to sign a written consent for their children's de-identified data to be used for chart review research (if needed). Signing the consent is totally voluntary and not a condition of receiving treatment. As Berard AIT has been in use for decades and has been provided to thousands of individuals, the program is not viewed as experimental.

This chart review was done on a diverse population of children who had completed Berard AIT and whose caregivers had completed statistically sound questionnaires that measured behaviors related to challenges in sensory modulation. Among those included were children with the following diagnoses: autism, pervasive developmental disorder, not otherwise specified (PDD-NOS), speech/language delay, and ADD. In addition to these children, there were others included who were reported to have sensory processing disorder (SPD), including sound sensitivities. Although SPD has not been recognized formally as a diagnosis, it is emerging in the literature as a promising area for research.[26,28] The purpose of this chart review was to determine if Berard AIT (provided twice each day for 10 consecutive days) produced statistically significant changes on two assessments, the SSP and ABC.

A sample of records of 54 children (34 with autism) was selected from the files of a clinic specializing in AIT. Parents had sought out the program of Berard AIT because of a variety of behavior and learning challenges experienced by their children. Inclusion criteria were based on the age range for the SSP, ages 3–10. Children not within this age range were excluded. The SSP and ABC questionnaires had to have been completed before the start of Berard AIT and one, three, and six months post-AIT. Only the de-identified scores of those children whose same parent/caregiver had completed all of the SSP and ABC forms for the pre-test and for one, three, and six-month post-AIT, and who had given permission to have their data used, were included in the chart review. There was no other exclusion criterion.

The median age of the participants was six years. There were 45 males (83%) and 9 females (17%). Diagnoses, identified by medical professionals, and reported by parents, included participants with autism/PDD-NOS (35), speech/language disorders (7), sound sensitivity/auditory processing disorders (6), ADD (5), SPD (4), and no diagnostic label (5). The remaining participants had a variety of developmental challenges that could not be delineated because of de-identification.

Measures.

SSP. The SSP is a 38-item checklist completed by the primary caregiver designed to measure a child's behavioral response to specific sensory stimuli that occur during daily life activities.[25] Items on this checklist were selected because they measured behaviors that supported the theoretical construct of sensory modulation. The SSP quickly identifies children with sensory modulation difficulties and has been recommended for use in research protocols.[25]

Seven factor groupings emerge out of the SSP scoring. They are (1) Tactile Sensitivity, (2) Taste/Smell Sensitivity, (3) Movement Sensitivity, (4) Under-Responsive/Seeks Sensation, which reflects the child's level of response to sensation that will drive avoiding and/or seeking behaviors to sensory events in daily life, (5) Auditory Filtering, (6) Low Energy/Weak, which reflects the child's ability to use muscles to move, and (7) Visual/Auditory Sensitivity. Internal reliabilities range from 0.70 to 0.95. Internal and construct validities are established.[25]

The SSP scores discriminate between Typical Performance in sensory processing (child scores within normal limits), Probable Difference in sensory processing (child scores greater than 1 and less than 2 standard deviations below the mean), and Definite Difference in sensory processing (child scores 2 or more standard deviations below the mean).

ABC. The ABC is a 58-item behavior rating scale used for children and adults with mental and/or learning and behavioral problems, including but not limited to autism spectrum disorders. The ABC has high internal consistency for all subscales (Irritability 0.92, Stereotypic 0.90, Lethargy 0.91, Hyperactivity 0.95, Inappropriate Speech 0.86). The ABC also has high test–retest reliability (0.98), and a high congruence coefficient ranging between 0.87 and 0.96.[29]

The primary caregiver completes the scale that measures behavioral outcomes resulting from treatment interventions.[29] The ABC has been used to measure behavioral outcomes of AIT in studies looking at response to treatment for children with a diagnosis of autism or ADD.[12,17] Behaviors assessed by the ABC (such as irritability, lethargy, stereotypy, and hyperactivity) have also been identified as behavioral reflections of poor sensory modulation.[14,25,30]

The items on the ABC are divided into five factor groupings or subscales designated as (I) Irritability, (II) Lethargy, (III) Stereotypic Behavior, (IV) Hyperactivity, and (V) Inappropriate Speech.[29] See Table 1 for examples of behaviors in each of the factor groupings.

Procedures. All children at the center participate in a standard protocol of Berard AIT following exactly the same procedure provided by the same Berard practitioner. The Berard practitioner holds a master's degree in special education and more than 30 years' experience working directly with children with developmental delays and learning disorders. She was personally trained by Dr. Berard in 1991, and had 15 years' experience providing the AIT program before the study.

Table 1. ABC—examples of behaviors for each factor grouping.

FACTOR	EXAMPLES OF BEHAVIORS FOR EACH FACTOR GROUPING
Irritability	Aggressive to others
	Temper tantrums
	Irritable, grizzly, whiny
	Cries over minor annoyances and hurts
	Mood changes quickly
Lethargy	Seeks isolation from others
	Preoccupied, stares into space
	Fixed facial expressions, lacks emotional reactivity
	Resists any form of physical contact
	Is difficult to reach or contact
Stereotypy	Meaningless, reoccurring body movements
	Odd, bizarre in behavior
	Repetitive hand, body, or head movements
	Rocks body back and forth
	Waves or shakes extremities repeatedly
Hyperactivity	Impulsive (acts without thinking)
	Restless, unable to sit still
	Disobedient, difficult to control
	Does not pay attention to directions
	Boisterous (inappropriately noisy and rough)
Inappropriate speech	Talks excessively
	Repetitive speech
	Talks to self loudly
	Repeats a word or phrase over and over

The standard protocol consists of two 30-minute sessions of listening each day for 10 consecutive days. The listening sessions were separated by a three-hour interval to allow a break from the auditory stimulation. Children leave the center and can participate in activities chosen by the families. These activities included but were not limited to excursions to the park/playground, beach, indoor play center, mall, etc. Some children return home in this interval. It is recommended that stressful activities be avoided.

Music for Berard AIT is generally a variety of light rock, reggae, and jazz, selected specifically to assure that it contains a wide range of frequencies from 20 Hz to 20 kHz. The Earducator™/6F (Hollagen Designs CC, Western Cape, South Africa), the Berard AIT device used for this standard program, processes the music, and does not exceed an average output of 85 dB. The Earducator/6F intermittently emphasizes low and high sound frequencies in the music (called gating or modulation). Children listen to the music through closed headphones (Beyerdynamic DT250-80) recommended by Hollagen Designs CC.

The protocol for Berard AIT recommends quiet listening without engagement in cognitive activities. Most children are able to listen quietly, and frequently choose to lie or sit on a beanbag chair. Some require small, passive sensory fidget toys to keep their hands away from the headphone cord. Reading, writing, assembling puzzles, and other cognitively stimulating activities are not provided.

An audiologist tests the child's hearing profile before AIT begins and after five days of intervention. In some cases, the child is not able to cooperate with the test procedure, or behaviors interfere with the testing. In these cases, the audiologist reports that the test could not be completed, or that the data obtained may not be highly accurate or reliable. When a reliable audiogram is obtained, it is analyzed using a computer program available to all Berard practitioners to determine if specific sound frequencies should be filtered from the child's music program.[31] Based on the analysis, specific Earducator filters are activated to reduce the stimulation of selected frequencies. When no reliable audiogram is obtained or when the analysis indicated none was needed, no Earducator filters are activated.

No additional sensory support activities are given to the clients during this listening process and no changes are made in sensory support activities for home programs. If the children already participate in home program activities before participating in the AIT, they continue with those recommendations to avoid additional changes in behavior that may occur with changes in home program.

Data analysis. The MicrOsiris Statistical Analysis and Data Management System 9.43 software was used for statistical analysis.

The scores for each factor on the SSP and the ABC were analyzed separately using two-way analysis of variance

(ANOVA) with repeated measures on time.[32] This was to determine if there were significant changes attributed to length of time after AIT. The two variables (the means of the subjects' pre- and post-data, and data from one, three, and six months post-treatment) were tested together and were considered to be independent. The averages of one, three, and six months each obtained the same number of data points from the same group of subjects, and thus, are not affected by possible differences from subject to subject. Also, the averages of months for each subject are not affected by any possible difference in the month to month data. The significance level for the ANOVAs was set at $P < 0.01$ because of the number of analyses (Bonferroni correction). Post hoc comparisons consisted of ANOVAs to test the influence of age on each of the variables.

Additionally, a one-way ANOVA was performed to analyze the final hypothesis to determine if age had a significant effect on the subjects' response to Berard AIT. Scores were averaged over all three post-test time periods (one, three, and six months) for this analysis.

Correlations were used to analyze relationships between all factors of the SSP and ABC.

Results

SSP. Table 2 shows the baseline and one-, three-, and six-month data reported by parents for the SSP. Table 3 shows the comparison of baseline with the averages of the three post-AIT assessments, percentage change, and significance.

The ANOVAs of the SSP showed that there were changes reported by parents in response to Berard AIT at statistically significant levels for all individual factors of the SSP. The factor of Under-responsive approached significance at $P < 0.03$. All other factors (Tactile Sensitivity, Taste/Smell Sensitivity, Movement Sensitivity, Auditory Filtering, Low Energy/Weak, and Visual/Auditory Sensitivity) were significant at $P < 0.01$ (Table 3). All sensory factors showed improvement at one month following AIT. These sensory changes continued to improve at three and six months following AIT in five areas and total. Visual/auditory sensitivity and low energy/weak decreased only slightly over time but were still significant ($P < 0.01$). Subject age did not have an effect on response. Although all factors on the SSP showed statistical significance based on parent observations, the highest percentage changes from baseline in score were found on factors of auditory filtering and visual/auditory sensitivity.

Figure 1 shows the percentage of the 54 subjects in each range on the SSP before the Berard AIT program and then at one, three, and six months post-AIT. Before the training program, 70% of the subjects scored in the Definite Difference range and only 6% were in the Typical Performance range based on parent reports. Six months after AIT was completed, only 33% of the subjects were still in the Definite Difference range and 44% were functioning in the Typical Performance range.

ABC. Table 4 shows the baseline and one, three, and six months data for the ABC. Table 5 shows the comparison of baseline with the averages of the three post-AIT assessments, percentage change, and significance.

The ANOVAs were performed on the ABC data using pretest and post-AIT data reported by the parents for each of the five factors and the totals for the 54 subjects. Improvement on each behavior factor was reported for each post-test

Table 2. Sensory processing changes—SSP mean scores at baseline and at one, three, and six months after AIT.

FACTOR		BASELINE	POST-AIT		
			ONE MONTH	THREE MONTHS	SIX MONTHS
Tactile sensitivity	Mean	26.9	29.4	29.9	30.5
	Std. dev.	5.0	4.8	4.4	4.1
Taste/smell sensitivity	Mean	12.8	13.6	14.1	14.2
	Std. dev.	5.7	5.0	5.0	5.2
Movement sensitivity	Mean	12.6	13.3	13.5	13.8
	Std. dev.	3.0	2.6	2.5	2.1
Under-responsivity	Mean	21.8	24.9	25.1	25.5
	Std. dev.	6.1	6.7	6.8	6.4
Auditory filtering	Mean	16.4	19.7	20.6	20.7
	Std. dev.	4.4	4.1	4.4	4.7
Low energy/weak	Mean	22.3	24.6	25.2	25.0
	Std. dev.	7.0	5.7	5.7	6.0
Visual/auditory sensitivity	Mean	16.9	19.9	20.9	20.6
	Std. dev.	4.8	3.9	4.0	3.9
Total	Mean	129.6	145.0	149.4	149.8
	Std. dev.	20.6	19.6	20.4	21.7

Table 3. Sensory processing changes—SSP mean scores at baseline and after AIT.

FACTOR		BASELINE	POST-AIT AVERAGE	PERCENTAGE CHANGE	SIGNIFICANCE
Tactile sensitivity	Mean	26.9	29.9		
	Std. dev.	5.0	4.0	11.5	$P < 0.01$
Taste/smell sensitivity	Mean	12.8	13.9		
	Std. dev.	5.7	4.7	8.5	$P < 0.01$
Movement sensitivity	Mean	12.6	13.5		
	Std. dev.	3.0	2.2	7.7	$P < 0.01$
Under-responsivity	Mean	21.8	25.2		
	Std. dev.	6.1	6.1	15.4	$P < 0.03$
Auditory filtering	Mean	16.4	20.4		
	Std. dev.	4.4	4.7	24.2	$P < 0.01$
Low energy/weak	Mean	22.3	25.0		
	Std. dev.	7.0	5.5	12	$P < 0.01$
Visual/auditory sensitivity	Mean	16.9	25.5		
	Std. dev.	4.8	3.5	21.2	$P < 0.01$
Total	Mean	129.6	148.1		
	Std. dev.	20.6	19.1	14.2	$P < 0.01$

at one, three, and six months ($P < 0.01$) (Table 5). All ABC factors showed significant improvements at one month post-AIT. At three and six months post-AIT, Irritability and Hyperactivity continued to improve over time significantly. All the other behavioral factors showed improvement one month after AIT, but their continuing changes slowed or plateaued. ANOVAs for subject age was only significant for Lethargy ($P < 0.01$) with greatest improvement shown for the ages 3 and 10. Age had little effect on the other ABC factors.

Figure 2 shows the median change in each of the factors over six months based on the 54 subjects whose parents provided data for pretest, one, three, and six months post-AIT. A decrease in negative behaviors was measured at one month for all factors. After month 1, the negative behaviors were further reduced and were relatively stable at months 3 and 6, with the exception of Inappropriate Speech.

Table 6 shows the effect sizes for the pre/post-SSP and ABC ANOVAs. It is interesting to note that the effect sizes for the SSP are considered higher than those for the ABC.

Correlational analysis showed that the intercorrelations between scores in the SSP factors for the 54 subjects closely followed those of the standardization sample (see Table 7).

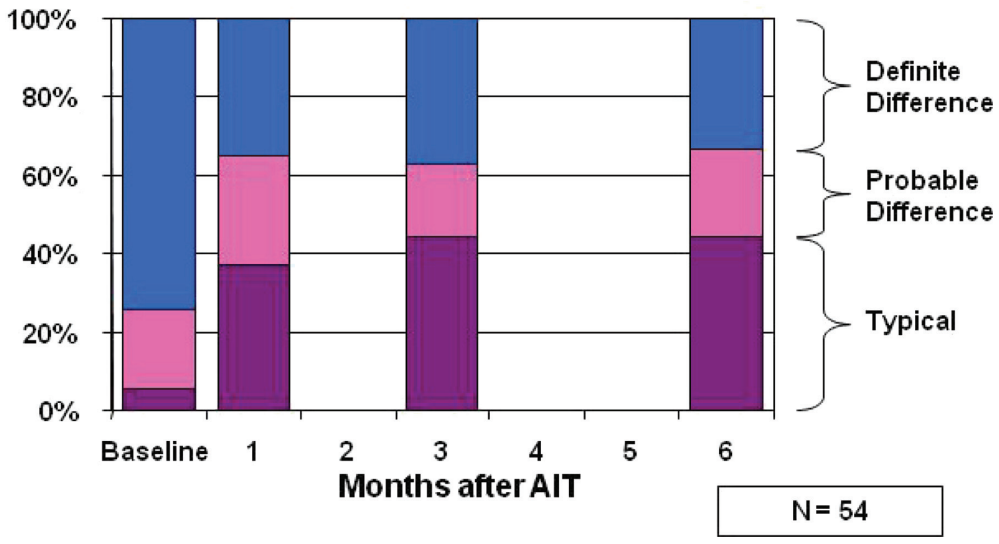

Figure 1. SSP—short form, change during six months after AIT.

Table 4. Behavior changes—ABC mean scores at baseline and one, three, and six months after AIT.

BEHAVIOR		BASELINE	POST-AIT		
			ONE MONTH	THREE MONTHS	SIX MONTHS
Irritability	Mean	9.3	7.7	6.4	5.6
	Std. dev.	6.5	6.3	5.4	5.2
Lethargy	Mean	5.4	3.8	3.6	3.3
	Std. dev.	5.9	5	5.3	4.7
Stereotypy	Mean	3.9	2.5	2.2	2.3
	Std. dev.	3.9	2.6	2.6	2.7
Hyperactivity	Mean	15.5	11.9	10.9	10.2
	Std. dev.	9.8	8.2	8	8.3
Inappropriate speech	Mean	3	2.4	2.1	2.1
	Std. dev.	2.8	2.5	2.8	2.6

Table 5. Behavior changes—ABC mean scores at baseline and after AIT.

BEHAVIOR		BASELINE	POST-AIT AVERAGE	PERCENTAGE CHANGE	SIGNIFICANCE
Irritability	Mean	9.3	6.6		
	Std. dev.	6.5	5.0	29	$P < 0.01$
Lethargy	Mean	5.4	3.6		
	Std. dev.	5.9	4.8	34	$P < 0.01$
Stereotypy	Mean	3.9	2.3		
	Std. dev.	3.9	2.4	40	$P < 0.01$
Hyperactivity	Mean	15.5	11.0		
	Std. dev.	9.8	7.5	29	$P < 0.01$
Inappropriate speech	Mean	3.0	2.2		
	Std. dev.	2.8	2.3	27	$P < 0.01$

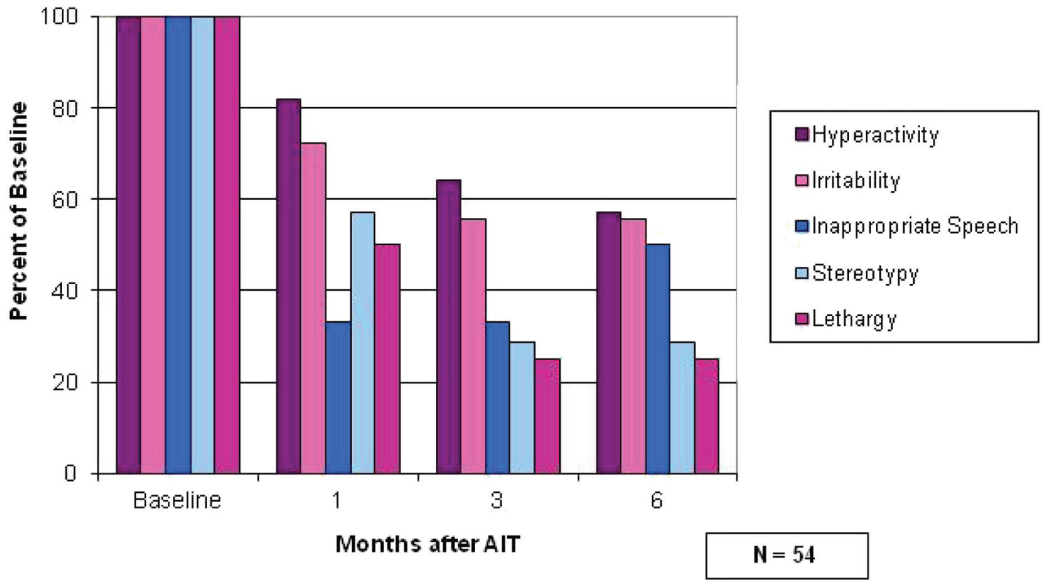

Figure 2. ABC—median change from baseline to six months post-Berard AIT.

Table 6. Size effect—Cohen's *d*-index.

FACTOR	COHEN'S *d*-INDEX (EFFECT SIZE)
SSP	
Tactile sensitivity	(0.66)
Taste/smell sensitivity	(0.21)
Movement sensitivity	(0.34)
Under-responsivity	(0.56)
Auditory filtering	(0.88)
Low energy/weak	(0.43)
Visual/auditory se nsitivity	(0.86)
Total	(0.93)
ABC	
Irritability	0.47
Lethargy	0.33
Stereotypy	0.49
Hyperactivity	0.52
Inappropriate speech	0.31

( ) indicates a negative value for Cohen's *d*-index, yellow shading indicates small effect size, green shading indicates moderate effect size, and red shading indicates high effect size.

Correlations between the SSP total score and the ABC factors were significant for four of the five factors (at the 0.05 level or higher): Irritability (−0.531, $P < 0.01$), Stereotypy (−0.410, $P < 0.01$), Hyperactivity (−0.399, $P < 0.01$), Inappropriate Speech (−0.288, $P < 0.05$). Individual sensory modulation factors that account for these correlations can be found in Table 8. As changes in behavior related to sensory modulation are the major focus of this study, it is important to investigate the commonalities between the SSP and ABC. Many of the behaviors seem to have a sensory modulation component, and the correlation in Table 8 helps to clarify this.

Discussion

Because there was no control group, it cannot be determined whether all the changes found were indeed because of the AIT alone. Placebo effect, parent expectations, and veracity of parent reports were not controlled by this study design. However, the compact length of the AIT program (30 minutes twice a day for 10 consecutive days) provides a treatment intensity that one could argue would be unusual to be matched by any uncontrolled variables.

The results of the analysis of the SSP and the ABC data indicate confirmation of hypothesis 1, which stated that children participating in Berard AIT would show improved scores on the SSP as reported by parents, and hypothesis 2, which stated that children participating in Berard AIT would show improved scores on the ABC as reported by parents. These changes were maintained over time (hypothesis 3) and were not affected by the child's age (hypothesis 4).

Table 7. Comparison of intercorrelations of SSP factor scores: normative sample and present study.

SSP FACTORS	NORMATIVE SAMPLE	PRESENT STUDY
Tactile sensitivity	0.80	0.74
Taste/smell sensitivity	0.54	0.44
Movement sensitivity	0.48	0.43
Under-responsivity	0.73	0.65
Auditory filtering	0.76	0.61
Low energy/weak	0.62	0.52
Visual auditory sensitivity	0.78	0.66

The SSP targets measurement of behaviors observed by parents reflecting sensory modulation during daily life activities. The assessment targeted measurable behaviors reflective of sensory defensiveness, vestibular processing, and behavior outcomes of sensory modulation. As the SSP was designed to measure the components of sensory modulation, the statistical results appear to support clinical observations that Berard AIT can result in improved abilities in these sensory modulation components, and these changes were maintained through the one, three, and six months post-testing.

Parents reported improvements in the ability to use and screen out sounds, and to modulate responses to auditory and visual information in daily activity. Improved awareness of sensory events in daily life as measured by the SSP was also reported by parents. To a lesser degree but still significant, subjects were able to modulate their response to touch taste/smell, and movement, and demonstrated improved ability to use their muscles to move efficiently in daily activities.

The Berard AIT had a statistically significant impact on problem behaviors observed by parents as measured by the ABC. Parents reported a significant improvement in each of the five behavioral factors (see Fig. 2): Irritability, Lethargy, Stereotypy, Hyperactivity, and Inappropriate Speech following Berard AIT. The changes in these scores also occurred in a very short period of time (one month) and were generally maintained or improved through the three- and six-month post-testing (hypothesis 3) (see Fig. 1).

Limitations and Recommendations

The limited number of standardized evaluation tools available, which objectively measure sensory modulation, and the wide range of abilities of the children attending the clinic, limited what pre- and post-testing tools could be used. A study using additional objective standardized evaluations or physiological measures is recommended.

Directions for Future Research

In light of the positive results of this chart review, future research using a control group or AIT sham treatment group is needed. Additionally, expanding the research to include more

Table 8. Significant correlations between SSP factors, SSP total, and ABC factors.

SSP/ABC	IRRITABILITY	LETHARGY	STEREOTYPY	HYPERACTIVITY	INAPPROPRIATE SPEECH
Tactile sensitivity	−0.527**		−0.312*	−0.312*	−0.385**
Taste/smell sensitivity	−0.388**		−0.342*		−0.289*
Movement sensitivity		−0.354**	−0.351**		
Under-responsivity	−0.428**	−0.293*	−0.328*	−0.598**	
Auditory filtering				−0.417**	
Low energy/weak					
Visual auditory sensitivity	−0.426**		−0.304*		
SSP total	−0.531**	−0.207 non-significant	−0.410**	−0.399**	−0.288*

*Correlation significant at the 0.05 level (two tailed).
**Correlation significant at the 0.01 level (two tailed).

extensive standardized testing tools that assess sensory modulation as well as other areas of sensory motor performance is recommended. Additional objective measures of behavioral changes that are related to sensory modulation would provide further documentation of the improvements observed by parents in this study.

Further study is needed to identify what specific types of sensory and motor issues are more likely to respond well to Berard AIT. There are clinical reports of changes not only in the sensory modulation but also in eye/hand control, praxis, and attention and focus. Further investigation and study of these areas is warranted.

Conclusions

This chart review of the cases of 54 children ages 3–10 with disabilities indicates an association between the Berard protocol and parent report of improvement in behaviors as measured by the ABC and in sensory modulation as measured by the SSP. The results are strong enough to encourage further study with additional control. Because the program was only 10 days long, results suggest that Berard AIT may be a time-efficient and cost-effective program. Additional research is needed to further identify and/or confirm which sensory and behavioral domains are affected by Berard AIT to expand understanding of this technique's effectiveness and use as an intervention. Relationships among SSP and ABC factors also should be further investigated.

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Author Contributions

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

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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