Journal of Autism and Developmental Disorders, Vol. 15, No. 3, 1985

Effect of Using an Auditory Trainer on the Attentional, Language, and Social Behaviors of Autistic Children[1]

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Two groups of seven autistic children wore an auditory trainer for an average of 24 minutes per day over two 5-week periods interspersed with 5-week control periods in a time series design. Videotapes were coded for three attentional states (normal, withdrawn, attacking), for verbalization and signing, and for appropriate and acceptable behaviors. Results demonstrated a decrease in time spent withdrawn and increases in signing and in school-appropriate behavior. Results are interpreted as congruent with Katz's theory of reduced attention due to deficits in auditory conductance.

Of the several symptoms of autism identified by Kanner (1944), Wing (1969), and others, deficits in language and in attentional focusing seem to be paramount (Lovaas, Koegel, & Schreibman, 1979; Ornitz & Ritvo, 1976). Direct training in language for such children, recently reviewed by Margolies (1977), produces responses that fail to generalize beyond the instructional context. However, temporary increases in both spontaneous verbalization and attention were reported by Smith, Olson, Barger, and McConnell (1981), who used an auditory trainer with three autistic children,

[1]This research, project title "Language and Sensory Stimulation in Autistic Children," was made possible by a grant from the National Institute of Mental Health (No. MH37035-02). We wish to acknowledge the substantial assistance of the teachers and administrators of Ingham Developmental Center in completing this work.

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0162-3257/85/0900-0285$04.50/0

ages 9-14. One 9-year-old boy used the trainer for 30-minute periods on 26 days. Mean utterances per period increased from 0 to 64, then returned to 0 after nonuse of the trainer.

This study reports the effect on verbalization and attentional behaviors of using the trainer over an extended period with a larger group. The purpose was to determine whether there are changes in verbalization and/or signing, in attentional behaviors, and in social behaviors attributable to use of the trainer.

LITERATURE

Autistic children present a shifting array of behaviors that seem to defy analysis. Causal hypotheses offered by earlier generations of investigators are modified by each new generation. One of these is the "overarousal" hypothesis of Hutt and Hutt (1968), still espoused by some investigators (e.g., Palkovitz & Wiesenfeld, 1980). It has been modified by Zentall and Zentall (1983), who make a strong case for an "optimal-stimulation" model to account for many of the defining characteristics of deviant children, specifically autistic, hyperactive, and learning-disabled. The Zentalls suggest that organisms work to maintain optimal levels of arousal (defined as response to stimulation) and that the withdrawal and stereotypies of autistic children are compensatory reactions to overarousal (overstimulation). Such responses are attempts to reduce the number and/or intensity of stimuli, with a consequent reduction in arousal. Hyperactive children, on the other hand, are "underaroused" (p. 453) and compensate by increased activity (thus, increased opportunity for stimulation), resulting in increased arousal (stimulation). When stimulating drugs are used with hyperactive children, the increased physiological arousal results in reduced activity (Barkley, 1977).

A problem with this otherwise compelling theory results from the definition of *arousal*. As pointed out by the Zentalls (1983, p. 447), "if the homeostatic model is correct in assuming that organisms will work to optimize the level of stimulus input and thereby will optimize the level of arousal, measures of physiological arousal may deviate from 'normal' levels only prior to behavioral compensation." Thus, if measures of arousal (behavioral variability or physiological measures such as heart rate response or skin conductance level) are viewed as a *consequence of stimulation, the* homeostatic position holds true and accounts remarkably well for diverse behaviors: Autistics withdraw or attack, apparently to reduce stimulation; hyperactives increase activity, apparently to increase stimulation. If, however, the measure is taken *preceding* stimulation, the most parsimonious view is that autistic, learning-disabled, and hyperactive children all suffer from varying degrees of reduced capacity to *respond* to stimulation, i.e., underarousal. Symptoms of "overarousal" in autistic children can be explained by an inability to process and/or filter normal stimulation so that even low levels of stimulation produce "input overload" (Miller, 1978), what the Zentalls call "overarousal." Learning-disabled and hyperactive children may be viewed as processing and filtering information better than autistic but less well than normal children.

In all these cases, reduced capacity to respond is explicable using the model proposed by Katz (1978) to account for language deficits in learning-disabled children. This model is based partly upon stimulus deprivation studies with animals such as those of Riesen (1960) and Webster and Webster (1977). Briefly stated, conductive hearing loss during early development of the brainstem, especially of those cells that drive the reticular formation (in turn, modulating attention), results in cell damage and may account for reduced arousal and attentional deficits in behavior throughout later development. Ventry (1980) has questioned the validity of several studies cited by Katz. However, a study by Keating (1977) lends supporting evidence to the reduced arousal hypothesis. She studied visual nystagmus in response to bithermal caloric stimulation of the ear among dyslexics and normals. Abnormal reflex activity in the dyslexics was traced to a difference in brainstem activity rather than to a vestibular deficit, as postulated by deQuiros (1976). Congruent with this evidence, Smith, Walter, McConnell, Miller, and Stewart (1984) have reported possible conductive loss resulting from chronic negative pressure in the middle ears of autistic children along with greater than normal pressure fluctuations. A correlate of such losses, chronic otitis media, has been reported for populations of learning-disabled children by Holm and Kunze (1969) and Needleman and Menyuk (1977), among others.

If the argument of conductive loss in autistic children is sustained, the salutary effect of using an auditory trainer becomes more reasonable. As suggested by Smith et al. (1981, 1984), autistic children may suffer both from fluctuating hearing and from a reduced ability to filter background noise. The auditory trainer is thought to reduce both of these problems: It allows augmented sound by means of a gain control, and it improves the signal-to-noise ratio.

The present study has been designed to examine further the effects of consistent, brief periods of use of the trainer on the verbal, attentional, and social behaviors of autistic children. The Phonic Ear (H.C. Electronics) was used for brief periods daily with 14 autistic children over a 20-week semester. Children were videotaped during a baseline period and at 5-week intervals thereafter. Videotapes were analyzed to determine the incidence of certain behavioral states related to attending, of verbalization and signing, and of social behaviors. The wearing of any prosthetic tends to be aversive to autistic children, whether corrective lenses, hearing aids, or protective helmets. Two of the children had been fitted with lenses and two with hearing aids, but they wore them only sporadically. One practical question to be answered was whether or not the children would be willing to use the trainer.

METHOD

Subjects

Subjects were 14 children (13 males and 1 female), aged 54 to 197 months, in three classrooms of a developmental center, a day school for severely impaired children operated by a midwestern intermediate school district. Extensive medical, psychometric, social and educational histories were available on each child. Demographic data appear in Table I. Median age was 106 months. Twelve were Caucasian and 2 were black. Estimated developmental quotients varied from 5 to 80, with a median of 30.

Table I. Selected Characteristics of Autistic Children (N = 14)

Subject	Sex	Ethn[a]	CA	LA	DQ	Onset (months)	Init audi eval (months)
A	M	C	54	04	25	12	31
B	M	C	56	04	37	12	15
C	M	Bl	65	27	60	12	12
D	M	C	73	27	33	12	30
E	M	C	80	00	25	02	46
F	M	C	93	05	20	10	27
G	F	C	106	07	18	11	26
H	M	C	106	09	28	12	22
I	M	C	117	39	80	18	06
J	M	Bl	131	40	54	12	53
K	M	C	157	21	20	12	30
L	M	C	180	49	45	30	24
M	M	C	189	07	05	18	32
N	M	C	197	45	72	24	–

[a]Ethn: Ethnicity – (C = Caucasian, Bl = black); CA: chronological age in months; LA: language age – estimate in months of receptive language based on two or three measures by age-appropriate scales (Uzgiris-Hunt; Zimmerman; REEL); DQ: developmental quotient – estimate based on two or three most recent measures by age-appropriate scales (Bayley; Vineland; Leiter; Peabody; S.B.; WISC-P); Onset: Age in months of onset of autistic symptoms, parent interview data; Init audi eval: Age at time of initial audiological evaluation.

Table II. Comparison of Sample Values with Norm Data from the Autism Behavior Checklist of the Autism Screening Instrument (ASIEP) (N = 13)

	Norm		Sample			
	$\bar{X}$	*SD*	$\bar{X}$	*SD*	*t*	*p*
Sensory	12.67	(5.2)	13.0	(4.3)	.23	n.s.
Relating	23.99	(7.8)	21.6	(5.1)	1.10	n.s.
Body and object use	15.79	(8.3)	15.7	(5.8)	.01	n.s.
Language	12.20	(6.8)	10.1	(5.1)	1.10	n.s.
Social and self-help	12.80	(5.7)	14.5	(5.0)	1.07	n.s.
Total score	77.49	(20.0)	74.8	(14.9)	.48	n.s.

Language ages were severely restricted, varying from 0 to 49 months, median 8 months. Ages of onset of autistic symptoms, taken from social worker interviews at the time of initial placement, were for the most part 12 months or below. Results of thorough audiological examinations, reported elsewhere (Smith et al., 1984), showed sensorineural loss in two children (D and I). Sensorineural loss was defined as >80 dB across speech frequencies binaurally. A condition of negative pressure significantly different from normal was found in both ears of all cases. Middle-ear pressure was defined as the mean of impedance measures taken on five occasions over a 10-week period.

Thirteen of the 14 children were evaluated during the preceding 6 months with the aid of the ASIEP scale (Krug, Arick, & Almond, 1980). The sample means and standard deviations for the Autism Behavior Checklist subscale are compared with norm values for autistic children in Table II. All sample means are within .3 standard deviations of the normative group. These data provide some confirmation of the correctness of the initial diagnoses.

Design

Children were assigned randomly by classrooms to one of two groups and were equated by age. Both groups experienced treatment and no-treatment control conditions in a multiple-baseline time series design over five 5-week periods, as shown in Table III.

Group 1 began with baseline testing and 5 weeks of treatment followed by 5 weeks of no treatment, repeated during periods III and IV. Group 2 began with baseline testing and 5 weeks of no treatment and thereafter followed the same pattern as Group 1.

The design is based upon an assumption that, if any change were to occur, it would do so in a 5-week period. It assumed further that a 5-week control period would allow a return to baseline. Evidence concerning these assumptions was derived from a single child reported in Smith et al. (1981), in which changes in verbalizations occurred over similar brief intervals with loss during a control period. The design met demands by administrators and parents for equal treatment of children within a one-semester period. It also allowed each student to be used as his own control in a replicated design.

Measures

Three kinds of measures were taken: proportion of time spent in each of three behavioral states, incidence of verbalization and signing, and proportion of appropriate and acceptable social behaviors.

States. Attentional states in autistic children have been defined by Milburn and her associates (Konieczny & Milburn, 1975; Konieczny, 1977) and are summarized here.

State I: Alert and responsive; normal eye movements, muscle tonus, vocalizations, body movements [NORMAL].

State II: Absence of purposive movement; absence of eye movement (staring); unbalanced body tonus; vocalizations absent or high pitched, whining; reduced facial tonus [WITHDRAWN].

State III: Rigid arching of body; self-mutilating; shrill screams; covers eyes and/or ears; great distress [ATTACKING].

According to Konieczny and Milburn, the three states are sufficiently distinct to allow reliable coding. They used their measures on seven autistic children in a rigidly controlled environment to determine characteristics of the auropalpebral (blink) reflex to a click stimulus. The reflex occurred reliably when children were in State I and did not occur in States II or III. State was assessed from videotaped recordings by two observers. With 750 events, defined by onset and cessation of the auditory stimulus, observer agreement was 100%.

Table III. Experimental Design for a Study of Augmented Hearing in Autistic Children

		Period				
		1	2	3	4	5
Group	*N*	Weeks 1-5	6-10	11-15	16-20	21-25
1	7	BL C[a]	T	C	T	–
2	7	BL –	C	T	C	T

[a]BL: baseline testing; T: treatment; C: no treatment (control).

Table IV. Status and Activity Cues for Coding Three Behavioral States of Autistic Children

	State I	State II	State III
Eyes	Normal focus Normal shift of focus Normal following	Unfocused stare Blinking reduced or absent Gaze aversion Peripheral vision	Erratic movements
Head	Normal angle Face and neck tonus normal and varying appropriately	Chin down, shoulders hunched Mouth and jaw slack	Taut facial muscles Neck arched
Body	Posture appropriate to activity	Loose, limp	Back rigid, arching Fists clenched Great energy
Behaviors	Smiles, laughs, cries appropriately	Vocalizations few or none: whining Repetitive behaviors (stereotypies) Hitting hand with objects Blowing on hand, hair Hand or wrist fondling (tickling) Aimless wandering Hand gazing Hand flapping Scratching surfaces String fetishes Ruminating Mouthing objects, hands, toys Chewing tongue Thumb sucking Fearfulness	Kicking, yelling, screaming, crying without tears, bizzare laughter Biting hand, wrist, objects, people Rocking Head banging Tantrums Frantic activity

In the present study, children were taped in naturalistic settings (classroom groups, individual tutorials, and free play) where opportunity for distraction was much greater than in the laboratory setting. Therefore, a taxonomy of commonly occurring behaviors was developed and each entry was classified as a State I, II, or III behavior for coding purposes (Table IV).

Three 1-hour videotapes selected randomly from 22 tapes produced during the study were used for determining interobserver agreement on classification of behaviors. A *behavioral event* was defined as those behaviors of a target subject occurring between two auditory signals, superimposed on the tapes, separated by a 5-second interval. Coding was recorded during a 10-second interval following the 5-second observation. If two or more behaviors occurred within an event, the behavior with the greater duration was recorded.

The tapes selected for assessing observer agreement provided 474 events. Agreement on state may be inferred from a coefficient of .905 for two independent observers. Virtually all disagreements involved definitions of State II and State III. The 18% disagreements were reduced to 4% by consensus and the remaining events were eliminated. The same procedure for eliminating interobserver disagreements was followed for all coding of videotapes.

Verbalization and Signing. Verbalization was defined as any phoneme, syllable, word, or phrase uttered by a target subject within an event. Signing was defined as any approximation to an ASL sign supported by the environmental context, i.e., which could reasonably be interpreted as an attempt to communicate or to comply with a teacher demand. Incidence of verbalization and signing was sufficiently rare to be highly discriminable. In the few instances where a question arose, knowledgeable outside observers were called upon as arbiters.

Social Behavior. Behavior was judged to be appropriate or inappropriate in a classroom; inappropriate behaviors were judged to be acceptable or unacceptable, as follows:

Appropriate: Task- or play-related, observing, or normal transitional behavior.
Inappropriate: Not task-related, abnormal or bizarre (e.g., stereotypies).
Acceptable: Appropriate behaviors; inappropriate behaviors were judged acceptable if they did not disrupt the behaviors of others.
Unacceptable: Causing a teacher intervention; if a rule-testing behavior (e.g., climbing on a table), it was coded unacceptable if the rule was enforced, acceptable if not enforced.

Apparatus

Apparatus consisted of auditory trainers and videotape recording devices. Auditory trainers were battery-operated and consisted of a Phonic Ear Model 431T transmitter (housed in a lavaliere-style directional microphone) and a Model 455 R headset system (a plastic case strapped to the child and attached to cushioned earphones).

Appliances were rotated among the treated children. Three children (A, G, K), one in each classroom, strongly resisted wearing the device. Behavior shaping with food (K) or music (G) as a reinforcing stimulus resulted in compliance by two children. The other (A) was monitored continuously by the investigator, who simply replaced the headset each time it was shaken off until desensitization occurred. No failure of equipment occurred during the 20-weeks of treatment.

Videotape recording was achieved with a Sony SL0325 Beta recorder/ player, a Panasonic WV3400 camera, and a Crown Pressure Zone 6LPB microphone. Taping was carried out by the senior author at strategic locations in each classroom. A Panasonic color video monitor, Model CT1330M, was used for coding. Quality of tapes and fidelity of sound were judged excellent and appeared to impose no limitation on subsequent coding.

Procedure

Arrangements. The procedures for the study were modified and approved by the several units involved: intermediate school district, school administrators, teachers, and parents. It was agreed that children would use the equipment self-selectively: Children were allowed to refuse participation on any day and/or after any period of use. Teachers were assured that their activities would not be constrained and that they were to carry out their usual instrumental programs without interference. In general, then, use of the auditory trainers and videotaping of the children were kept as nonintrusive as possible. (Videotaping was a routine activity in the classrooms.) Shaping procedures with the three noncompliant children were carried out on the recommendation of and with the cooperation of the teachers.

Staff Training. Participating teachers and some aides had received extensive instruction previously in behavior modification procedures, instructional design, and classroom management. All teachers were certified as teachers of autistic children.

Videotaping. Baseline taping was carried out over a 2-week period in early December. Each child was taped during several activities (free play, tutorial instruction, group instruction, gymnasium, and cafeteria) for a total of approximately 60 minutes. Gymnasium and cafeteria tapes were later discarded as uncodable. There remained approximately 20 minutes of tape for each child in classroom activities.

Subsequent taping occurred every 5 weeks and included from 10 to 30 minutes of tape for each child. Virtually all taping included some segment during which language instruction occurred.

Auditory Trainer. Children wore the training equipment as designed, with two exceptions: (1) The directional microphone was worn by the child, suspended from the neck, about 4 inches from the mouth, rather than being worn by the teacher as is common in classrooms for the deaf; (2) a second microphone built into the receiver case and designed to transmit environmental sounds was taped securely in the *off* position.

Theoretically, the gain control could be used self-selectively by the child. The three oldest children did adjust the volume at each wearing. So far as could be determined, no other child changed the setting. Gain for the remaining 11 children was initially set at 10 dB (if no measured loss) or at 20 dB below the level of measured loss. It was increased every 2 weeks by increments of 5 dB until one or another of two conditions obtained: (1) The dB level reached 10 dB below measured loss or (2) the child indicated discomfort, in which case gain was reduced by 10 dB from the discomfort level.

Equipment was checked prior to and following use for each child on every treatment occasion. On five occasions (involving 3 children) following use, the lavaliere microphone was found to be switched off (3% of wearing occasions). Whether these were purposeful or accidental events could not be determined.

RESULTS

Two questions were posed: (1) Will autistic children tolerate the auditory trainer? (2) Does the trainer make a difference in time spent in the three behavioral states, in verbalization and signing, and in social behavior?

Tolerance

Wearing times by children are reported in Table V. Mean time of use on any single occasion was 21.5 minutes for Group 1 and 26.9 minutes for Group 2. The difference of 5.4 minutes is significant ($t = 7.05$, $p < .001$).

Table V. Tolerance for Wearing an Auditory Trainer by Two Groups of Autistic Children During Successive Treatment Periods

		T_1[a]		T_2		Total	
Group	N	No. sess	$\bar{X}$ min	No. sess	$\bar{X}$ min	No. sess	$\bar{X}$ min
1	7	78	23.2	95	20.2	173	21.5
2	7	87	32.0	91	22.0	178	26.9

[a] T_1 and T_2: treatment periods (5-week duration); No. sess: total number of wearing occasions; $\bar{X}$ min: mean number of minutes per occasion.

Range was 0 to 120 minutes. One child in Group 1 (K) refused to submit to earphones throughout the first treatment period, while two children (L and N) in Group 2 sometimes wore it for extended periods, perhaps accounting for the differences between groups. Subject K apparently responded to modeling by his peers and to the reinforcement schedule since he participated during treatment period 2. Nevertheless, he tied for lowest in tolerance time (14.7 minutes).

There is some evidence of a 2 week habituation period for the four children with the lowest developmental quotients as contrasted with the four having the highest developmental quotients. Mean difference in chronological age was 1 year (n.s.), while the difference in wearing time favored those with higher developmental quotients by almost 4:1 ($\chi^2 = 32.8, p < .001$).

Changes in Behavior

Behaviors were assessed by two independent observers from the videotape data taken at five points: at baseline and at the termination of periods 1 to 4. Tapes were coded blind. Twenty-two tapes provided 18 hours of behavior, with total events numbering 3,911.

Data were entered in the Michigan Terminal System and were analyzed by the MIDAS program (Fox & Guire, 1976). Data were transformed to appropriate percentages to compensate for unequal numbers of events among children: Behavioral states were entered as proportions of events coded as State I, or II or III where the sum of all states totaled 100%; social behaviors were entered as proportion of "appropriate" and "inappropriate" totaling 100%; "inappropriate" behaviors were subdivided into "acceptable" and "unacceptable" together totaling 100%. Verbalization and signing were entered as proportion of total events during the period in which they occurred.

Behavioral States. Proportion of time spent in each behavioral state at each time of measurement (BL, Treatment$_1$, Control$_1$, Treatment$_2$, and Control$_2$) was calculated by child and by group. A repeated-measures analysis of variance showed that the two groups (group 1 and group 2) were equivalent for the three states (I, II, and III) at each time of measurement. Therefore, the groups were combined. Means and standard deviations are shown in Table VI, and tests of equivalence appear in Table VII. It may be noted that, at baseline, mean proportions of time spent in the three states were 69.5%, 26.3%, and 4.1%, respectively. These results are similar to Konieczny's data on seven autistic children exposed to click stimuli at a loudness of 93 dB: 68.6%, 28.0%, and 3.4% (1977, p. 29). By period C_2,

Table VI. Proportion of Time Spent in Three Behavioral States by Autistic Children Under Conditions of Augmented Hearing and of No Treatment ($N = 14$)

State		BL[a]	T_1	C_1	T_2	C_2
I	*M*	69.52	73.01	78.55	79.99	82.52
	SD	27.44	22.92	20.73	20.39	17.10
II	*M*	26.34	18.73	16.52	11.49	12.66
	SD	26.75	19.69	18.01	14.86	15.62
III	*M*	4.14	8.26	4.91	8.46	4.76
	SD	4.55	11.03	7.01	13.00	5.75

[a]BL: baseline; T_1 and T_2: treatment periods; C_1 and C_2: control (no treatment) periods.

comparable value in the present group were 82.58%, 12.66%, and 4.76%. Standard deviations were substantial throughout.

A repeated-measures ANOVA was calculated for each state to assess change in state over time. Summary data appear in Table VII. The equivalence of groups is shown first. *F* values for differences attributable to period or to group-period interactions failed to reach significance for states I and III. However, differences across periods for State II were significant ($F(1, 4)$, $p < .05$). Therefore, pairwise *t* tests were calculated for values at each period contrasted with every other period. Results show the primary effect ($p < .015$) to be contributed by the difference between the baseline value (26.3%) and that of the final control period (12.7%). A marginal effect appears between baseline and the end of treatment period 1 (18.7%, $p < .08$). Post hoc comparison using the Newman-Keuls procedure yielded similar results ($p < .05$).

Observation of the data for individual children suggested substantial individual differences in response patterns. A Q-type cluster analysis

Table VII. Summary of Analysis of Variance of State Data

State	Source	*df*	*SS*	*F*	$p =$
I	Group	1	122.23	.08	.789
	Period	4	1595.82	1.93	.121
	Group × period	4	1842.12	2.23	.080
II	Group	1	353.93	.30	.594
	Period	4	1951.45	2.66	.044
	Group × period	4	1278.47	1.74	.157
III	Group	1	61.29	.49	.498
	Period	4	241.87	.98	.428
	Group × period	4	588.61	2.38	.064

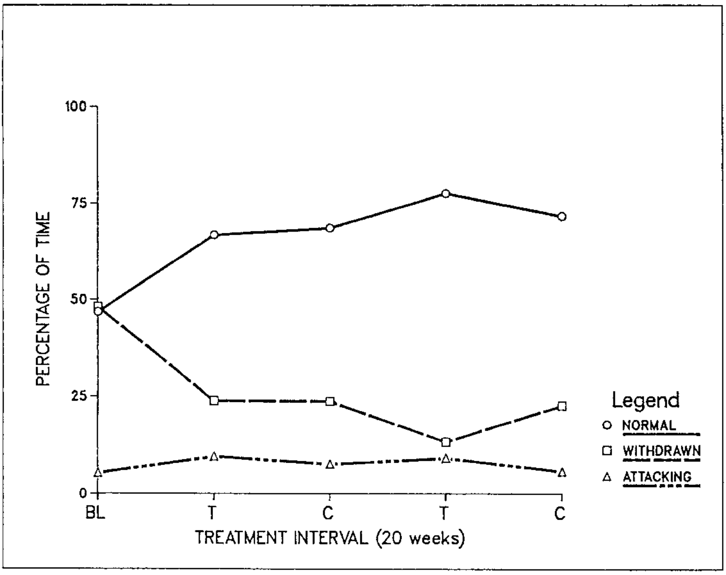

Fig. 1. Percentage of time spent in three behavioral states by a central cluster of seven autistic children at baseline (BL), after 5 weeks of treatment (T), no treatment (C), a second period of treatment, and a second control period.

revealed a primary cluster of seven children (Table I: A, E, G, I, J. K, M). The pattern of change over the course of the treatment for this cluster is displayed in Figure 1. Proportion of time in State I (normal) at baseline was 46.7%, reaching a high of 77.5% at the end of treatment period 2. For State II (withdrawal), the baseline value was 48%, reaching a low of 13.2%, also at the end of the second treatment period. State III (attack) began at 5.3% and appears to rise (to 9.5% and 9.1%) congruent with drops in State II values. At the end of the final control condition, it returned to its baseline value (5.7%).

Verbalization and Signing. Analysis of variance of verbalization and signing data are shown in Table VIII. There appears to be no difference in verablization between groups (p = .234) or across periods (p = .312). Signing, however, shows significant differences between groups (p = .013), across periods (p = .034), and for the group-period interaction.

Analysis of verbalization by group by period shows an apparent rise (from 5.4% to 10.7%) at the 10th week and a return to baseline. At the same time, signing increased in the final no-treatment period.

Appropriate and Acceptable Behavior. Analysis of variance of changes in appropriate behavior are shown in Table VIII. Variance attributable to membership in Group 1 or 2 is not significant; however, that

Table VIII. Summary of Analysis of Variance of Verbalization, Signing, and Appropriate Behavior

Measure	Source	*df*	*SS*	*F*	*p* =
Verbalization	Group	1	1320.23	1.57	.234
	Period	4	223.63	1.23	.312
	Group × period	4	311.91	1.71	.162
Signing	Group	1	6900.36	8.44	.013
	Period	4	1293.80	2.84	.034
	Group × period	4	1377.00	3.02	.027
Appropriate behavior	Group	1	321.42	.18	.677
	Period	4	2056.77	2.83	.035
	Group × period	4	1933.86	2.66	.044

attributable to treatment period and to group-period interaction is significant in both cases ($p < .05$). Behaviors of the total group were appropriate 67.4% of the time at baseline and increased by increments of 2.1%, 7.7%, −.2%, and 5.1% to reach a level of 82.1%.

"Acceptability" levels began at 78.9% and ended at 90.0%. The difference was not significant ($p = .473$).

SUMMARY OF RESULTS

Two groups of seven autistic children wore an auditory trainer for a mean of 24 minutes each day for two 5-week periods separated by 5 weeks of no treatment in a multiple-baseline design. Data were gathered on tolerance for the device and on changes in behavioral states, verbalization, and social behavior.

Despite frequent reports of the "aural defensiveness" of autistic children, 11 of 14 participated without resistance. Three children required behavior shaping before participation. Care was taken to see that increased volume was not painful. Under these conditions, children tolerated the headset for about 24 minutes per day on the average. There was a tendency for the children with the lowest developmental quotients to be less tolerant and for those with higher DQs to wear the headset for extended periods, up to 2 hours.

Children were videotaped at five points during the study, and tapes were coded for time spent in three behavioral states (normal, withdrawn, attacking) for incidence of verbalization and signing, and for appropriate and acceptable behaviors.

Significant changes were found in the time spent in the withdrawn state, from 26.3% at baseline to 12.7% after two treatment periods. Most of this effect was contributed by a cluster of seven children, those most seriously disabled, with a baseline withdrawn rate of 48%, decreased after treatment to 13.2%. Appropriate behaviors for the total group increased from 67.4% to 82.1%. No changes in verbalization were found. However, the rate of signing doubled from a baseline of 10.2% to 21.0%. (Similarly, the cluster of seven children drawn from behavioral state data did not increase in verbalization but increased their signing from 3.1% to 15.4%, increased appropriate behavior from 51.1% to 81.0%, and increased acceptable behavior from 71.1% to 90.6%).

DISCUSSION

The several changes in behavior accompanying the use of the auditory trainer are consistent with Katz's theory of conductive loss (1978) in learning-disabled children. An augmented auditory signal should have two effects for such children: (1) increased discriminability of speech sounds and (2) increased attentiveness of the child (via increased activity in the brainstem and reticular formation). The first effect, increased discriminability, should improve speech reception and might be expected to influence expressive speech. Such outcomes have yet to be demonstrated. Evidence of increased attentiveness of the present children appeared in the coding data for time spent in State II and in an increase in appropriate behavior. A fivefold increase in signing, from 3% to 15% by those in the central cluster, provides indirect evidence that increased attention is accompanied by increased communication.

If autistic children are viewed as being overaroused, as proposed by Hutt and Hutt (1968) and Zentall and Zentall (1983), one might expect an augmented auditory signal to result in further withdrawal. There was no evidence of such a result. Furthermore, overarousal should result in increased use of stereotypies. The opposite result occurred.

Some attention should be given to negative cases. Of the 7 children not included in the central cluster, 3 were at or near 100% in State I at the time of the baseline measure. Of the 4 remaining 2 increased their time in the withdrawn state during the treatment condition. In the following control conditions, however, each increased in verbalization or signing and in appropriate and acceptable behaviors beyond baseline. Of the final 2 children, 1 hovered at 25% time in State II throughout until the final control condition, when he spent 100% time in State I. The final child was being treated for a brain tumor. He made negligible changes in movement toward State I (48% to 60%) and no changes in other variables. Therefore, it can be stated that 13 of 14 children apparently profited from the treatment, while 1 was not influenced by it.

Critique

Let us consider alternative explanations. It may be argued that increased volume of the auditory signal provided an aversive stimulus, thus increasing stress and arousal level. The auditory trainer might then be viewed as a way of breaking through the child's defenses. This is a reasonable alternative explanation, although it may be argued that 11 of the 14 children did not resist using the trainer and, in fact, on some occasions demanded to be allowed to wear it for a full morning (3 of the children received tolerance training). On balance, then, use of the trainer appears to be more reinforcing than aversive.

Perhaps wearing the trainer constitutes a novel stimulus, a different way of experiencing the world. If so, it might result in a temporary increase in arousal and attentiveness, soon replaced by boredom and resistance to continued use. To assess this possibility, we asked teachers, 3 months later, to report on resistance to continued use. Two teachers reported no resistance. One teacher reported that 3 of her children, the oldest and the most mature, had begun resisting from time to time. All 3 had reached 100% of time spent in State I, the normal attentional condition. If this development occurs in other children, we may find that the hypothesis of a salutary effect on attention occurs within a limited time, perhaps 6 to 12 months, and thereafter the trainer becomes only a bulky and uncomfortable hearing aid.

But let us consider the possibility that the results reported constitute a Type 1 error, that they would not be replicated in a double-blind study (if that were feasible). Were there differences in the behavior of the teachers and aides, of the on-site investigator, or of school conditions that might have accounted for behavioral changes? The senior investigator had been a frequent visitor in those classrooms for 3 years and, throughout, had maintained the role of nonparticipating observer. That role continued. Teachers remained a constant; most aides also did. There was clearly a change in the nature of tasks: Prior to the study, tasks tended to remain constant from month to month. During the treatment period, most of the children demonstrated mastery of some objectives and moved on to more complex tasks.

But perhaps the teachers had high expectations, resulting in greater effort by the students. While the teachers appreciated the effort to help them, they were merely tolerant of the extra presence and, if anything, somewhat cynical about the effectiveness of any treatment short of drug therapy. However, when polled about continued use of the trainer, two were positive and one was neutral. Therefore, teacher expectancy as a factor in the results cannot be ruled out.

One troublesome question remains. Increased verbalization by an autistic child was found in a prior study (Smith et al., 1981). The verbalization extinguished when the trainer was removed. In this study, verbalization did not increase but signing did. The problem of increasing verbalization is yet to be resolved.

Theoretical Implications

The Hutt and Hutt (1968) arousal hypothesis and the modification of it offered by the Zentalls seem to be contradicted by the present results. One reason may be failure to distinguish between the pre- and postresponse states of the subject. Arousal as "capacity to respond" and arousal as "information overload" occur at differing times. It appears that the augmented sound provided by the auditory trainer may increase "capacity to respond," perhaps by its effect upon the brainstem-reticular-cortical system. The outcome, then, will appear as increased attentiveness, increased information processing, less susceptability to information overload, followed, finally, by an increase in adaptable behavior. This formulation is congruent with our findings and is amenable to experimental verification.

CONCLUSIONS

The data analyses reported here appear to justify several conclusions.

1. Use of an auditory trainer with autistic children is feasible, despite their typical aural defensiveness. It must be used with care so that children have time to habituate to increases in signal volume.

2. Those autistic children who respond to normal stress by withdrawing (Milburn's State II) show increased attentiveness after several weeks of treatment with an auditory trainer. When they reach a high level of attentiveness (Milburn's State I), they may resist further use of the trainer.

3. Increased attentiveness by autistic children is accompanied by an increase in appropriate behavior, a decrease in stereotypies and improved signing, assuming appropriate instruction.

4. Increased aggressiveness, a normal accompaniment to decreased withdrawal, returns to baseline levels (assuming appropriate handling).

5. The hypothesis that autistic children suffer from reduced arousal is confirmed.

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