Hyper-responsivity to Touch and Vestibular Stimuli as a Predictor of Positive Response to Sensory Integration Procedures by Autistic Children

(autism, vestibular, touch, sensory integration)

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Sensory processing disturbance in autistic children as a predictor of response to sensory integrative procedures was investigated. Ten autistic children, ages 3-½ to 13 years (mean, 7.4 years), were initially evaluated in regard to their hypo-, hyper-, or normal responsivity to visual, auditory, tactile, vestibular, proprioceptive, olfactory, and gustatory stimuli. After evaluation, each child received therapy that provided somatosensory and vestibular stimulation and elicited adaptive responses to these stimuli. At the end of one year of therapy, each child's progress was judged in relationship to that of the others, and the group was divided into the six best and the four poorest respondents. Stepwise discriminant analysis identified which initial test variables predicted good or poor responses to therapy. The good respondents showed tactile defensiveness, avoidance of movement, gravitational insecurity, and an orienting response to an air puff. Results suggest that children who registered sensory input but failed to modulate it responded better to therapy than those who were hypo-responsive or failed to orient to sensory input.

Autistic children represent a heterogeneous group with certain symptoms in common, one of which is disturbance in sensory processing (1-5). The sensory disturbance may vary from child to

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child and reflects poor modulation or inadequate registration of incoming stimuli (6, 7). These difficulties are often characterized by either an over- or under-reaction to sensory input (2). Since a major symptom of autism is a disturbance of sensory processing, it is logical that sensory integration procedures would be employed in an attempt to ameliorate the autistic symptoms. An earlier clinical impression of the results from this form of therapy was that some autistic children responded very well but some did not. This study investigated the nature of the sensory processing disturbance as a predictor of response to therapy. At the beginning of the investigation, no preconceived ideas about predictors of response were held, except that those autistic individuals with shortened duration of postrotary nystagmus would probably respond well to therapy.

Method

Subjects. The subjects of this study (N = 10) were all of the autistic children referred to the principal investigator between May 1977 and May 1978 and who received therapy twice a week for at least one year. The only exception was one child who received 11 months rather than a year of therapy. All children met the official definition of autism (1). Their mean age was 7.4 years; the standard deviation was 3.4. Two of the children were deaf, and one of these was partially sighted. Six different ethnic groups were represented in this small sample. All children had participated in a special education program for at least one academic year before therapy was initiated. The youngest had attended a school for the deaf.

To provide an external measure of the number of autistic symptoms present, all children were rated on a scale developed by Ornitz and coworkers (2). This "Ornitz Scale" enables one to rate the presence of 15 different parameters characteristic of autism on a scale of 1 to 5. Since the method did not include any measurement of receptive or expressive language, those 2 parameters were added, making a total of 17 variables on which each child was judged. The scale does not provide for measuring the severity of each parameter. Age, sex, severity of autism as subjectively judged by the principal investigator, and the Ornitz Scale Score of each subject are shown in Table 1.

Initial Evaluation. A test (described below) constructed to measure hypo-, hyper-, or normal reaction to sensory input was administered to each child at the beginning of the study. Five degrees of reaction were possible and scored as follows: 1 = no reaction or definite under-reaction, 2 = slight under-reaction, 3 = normal reaction, 4 = slight over-reaction, and 5 = definite over-reaction. Sensory channels tapped were visual, auditory, tactile, proprioceptive, vestibular, olfactory, and pain. Parents' report of the child's sense of taste was also recorded.

To enhance the accuracy of the observations, most test procedures were administered on two separate occasions by the same investigator, and, on three occasions, when responses were inconsistent or equivocal. Scores on some of the items

Table 1
Age, Sex, Severity of Autism, and Ornitz Scale Score of Subjects

Subject	Age (Years, Months)	Sex*	Severity of Autism	Ornitz Scale Score
1	4:4	M	Mild	29
2	3:6	M	Moderate	42
3	5:7	M	Moderate	49
4	3:7	M	Moderate	45
5	10:6	M	Mild	38
6	13:2	M	Severe	51
7	11:2	F	Severe	60
8	5:2	M	Moderate	46
9	6:7	M	Moderate	42
10	6:5	M	Severe	49

*M = Male, F = Female.

were based on observation by two therapists during treatment sessions through the first month or two of therapy. Except for that introduced as part of therapy, the sensory stimulation was given in a situation where there were as few other competing stimuli as possible. The constructed test consisted of procedures used to evaluate degree of responsivity to 14 specific forms of sensory stimuli. Reactions to the following types of input were recorded:

1. *Light Touch; Air Puff.* A puff of air was delivered by an ear syringe to the back of the neck. If there was no visible reaction, a second puff was given. Failure to respond to the puff was an under-reaction; orienting to the first puff was considered normal.

2. *Touch-pressure.* Pressure was applied to the entire body by rolling a foam bolster over the child or by placing a large pillow or mat on the child and pressing down. Children who sought this sensory experience frequently and preferred very hard pressure were considered hypo-reactive. Liking mild pressure occasionally was a normal response. Hyper-reactive children rejected the procedure.

3. *Light Touch; Tactile Defensiveness.* Children were rated on the basis of their reaction to being touched by people or to other tactile stimuli, especially of a light or moving type. Defensive children reacted adversely; there was no hypo-responsive rating on this parameter. A normal response was a lack of adverse responses to tactile stimulation.

4. *Pain.* Judgment of pain threshold was based on the child's reaction to bumps, falls, or situations to which most children would react with evident discomfort. Parents' observations were also considered. Complete lack of reaction to painful stimuli was judged as definite hypo-reactivity; reaction only to relatively severe injury was considered slight hypo-reactivity.

5. *Joint Traction.* Processing proprioceptive input was rated by the children's response to having their fingers, arms, and legs pulled. Traction stimulates joint and muscle stretch receptors. Those subjects who sought joint traction were considered underreactive. There was no hyper-responsivity to joint traction in this group.

6. *Vibration.* Response to vibration was evaluated by the child's acceptance of a facial or other small vibrator applied to the face or body, and by preference for lying on a vibrating surface. Strong and prolonged preference for the stimulation was considered under-reaction; avoiding it was considered an over-reaction. The normal response was a few minutes of interest and then disinterest.

7. *Movement.* Observations were made of the child's response to being on therapeutic equipment moving in a linear or rotary manner. Those who avoided movement were considered over-reactive; the under-reactive sought it with a frequency and speed that the average child could not tolerate.

8. *Gravitational Forces.* An alarm or anxiety reaction to sudden movements or nonhabitual postures indicates gravitational insecurity. This hyper-reaction is considered an inability to modulate the barrage of sensory impulses generated by the earth's gravitational force acting on the gravity receptors. No under-reaction was noted in this group of children.

9. *Rotation.* The duration of nystagmus was measured by use of the Southern California Postrotary Nystagmus Test. If no nystagmus was clinically observable, the response was considered definitely hypo-reactive. One to five beats following rotation in each direction was considered mildly under-reactive. One child had nystagmus of normal duration and none were over-reactive to rotation.

10. *Watching Spinning Stripes.* A rotating disk with radiating stripes was spun before the child's eyes and the length of time he or she looked at it was recorded. Attending for 9 or more seconds was considered a hypo-reaction to the effect of optokinetic nystagmus on the vestibular nuclei. Brief regard, for 3 seconds or less, was judged a normal response.

11. *Sound of Bell.* Response to the single ring of an out-of-sight desk bell was noted. If there was no orientation to the first ring, the bell was rung again. Failure to respond to a second ring was considered definitely hypo-reactive; failure to respond to the first was considered slightly hypo-reactive.

12. *Sound of White Noise.* White noise was produced by a machine for 1 minute. Immediate orientation to the noise was considered normal; a fleeting orientation within 3 seconds was rated slightly hypo-reactive; no response indicated definite hypo-reaction. There were no hyper-reactive responses. In order to enter the scores of the two deaf children on the two auditory parameters into the statistical analysis, predicted scores were calculated via simple linear regression based on the scores of the rest of the group on those variables that were most highly correlated with the parameters of response to white noise and ring of a bell.

13. *Odor.* Ground orange peel, vanilla bean, and vinegar were successively placed below the child's nostrils to gauge the sense of smell. Children who showed no reaction

to any of the odors were considered definitely hypo-reactive reacting only to the vinegar when placed under the nose was judged mildly under-reactive. Two children were considered hyper-responsive because they showed negative reactions as soon as the vinegar bottle was opened and before it approached the nose.

14. *Flavors.* Parents' observation of the child's sense of taste was used as an index of response to gustatory stimuli. Six of the children were thought to be less responsive than the normal child to the taste of various foods and were considered slightly hypo-reactive. No children were judged to be hyper-reactive.

Following evaluation, each child (except the one who had had only 11 months of therapy) received at least 1 year of occupational therapy using sensory integration techniques that focused on carefully providing somatosensory and vestibular sensory experiences and on eliciting an adaptive response to these stimuli.

Results

Measuring changes in learning or behavior of autistic children is difficult at best. Most of the children could not cooperate with formal testing. The area of behavior in which change could be observed varied from child to child. Children differed in age and severity of dysfunction. For these reasons therapeutic progress was judged qualitatively and differently for each subject. Observations were made in five major behavioral areas: language, awareness of the environment, engagement in purposeful activity, self-stimulatory behavior, and social and emotional behavior. Each of the ten subjects was ranked according to the amount of change and number of therapy, and then the subjects were grouped as the six best respondents and the four poorest respondents. Each child's changes during the therapeutic period are summarized.

Individual Subject Changes.

Subject 1. The child considered to have made the greatest change during the first year of therapy scored initially on the Carrow Language Comprehension Test below the 3-year level (raw score 40); and after 6 months of therapy at the 5-year, 2-month level (raw score 73), a gain of about 2½ years. He refused testing at the 1-year point. Other changes included an increase in interaction with the physical environment, particularly in climbing, jumping, and relating to environmental or body-centered space. In addition, he developed a desire for companionship during therapy, although he generally could not maintain his behavior organization if another child was in the same treatment area with him.

Subject 2. Initially, this deaf boy preferred to do nothing but lie on his back and rock his head back and forth. He would not interact with large objects in body-centered space, but he would line up small objects in typical autistic manner. By the end of the year the head rocking during therapy had virtually disappeared but still occurred occasionally at home. He began to relate to his brother, father, and peers. His greatest gain was in interacting purposefully, with pleasure, and with self-direction to large objects in the environment.

Subject 3. Initially, this child's behavior was characterized by aimlessly wandering about, grasping some favorite small object such as a magazine or piece of garden hose. Vocalization consisted mainly of "chirping," much echolalia, and a few phrases such as, "Time to go." He was usually unhappy and frequently threw tantrums. There was no self-directed, whole-body, meaningful interaction with the physical environment, nor could he be lured into it by the therapist. He had to be treated alone in a room to achieve any semblance of organized behavior. After a year of therapy his behavior showed considerable self-direction; he actively chose various therapeutic activities involving whole-body interaction. Echolalia and "chirping" were reduced, while meaningful verbalizations increased, and he sought the company of other children for parallel play.

Subject 4. At the beginning of therapy this child would do little else but wander around, lie on the floor, self-stimulate with arm and head motion, or lie passively on an oscillating table. At the end of a year he actively and consistently sought purposeful activity requiring adaptive responses far more complex than he had evidenced a year earlier.

Subject 5. Since this child was testable, seven of the subtests of the Bruininks-Oseretsky Test of Motor Proficiency and the Peabody Picture Vocabulary Test (PPVT) were administered both initially and at the end of about 11 months of therapy. Pre- and post-testing on the Bruininks-Oseretsky Test showed an average gain of 3 years, reflecting improvement in perceptual-motor skill or ability to interact with the physical environment. The PPVT scores on pre-and post-tests demonstrated a gain of 4 years, 5 months. This mildly involved boy showed no change in his ability to relate to people.

Subject 6. The poorest respondent of the good response group showed great reluctance to move about in body-centered space and to interact with objects in that space. He moved only very slowly, was mute, and showed poor awareness

of the environment. There was no change in verbalization after a year of treatment, but there was an increase in his ability to listen to conversation and to respond to other's verbalization, such as in following directions. Change was apparent in his awareness of the environment, ability to take responsibility in choosing a purposeful activity and to enjoy it, and in self-help skills.

All of the above subjects were considered to have had a good response to therapy. Those discussed below responded less well, although there was little difference between the quality of change in Subjects 6 and 7.

Subject 7. The best respondent of the poor-response group, a severely involved, deaf, and partially sighted girl, was referred because of nearly constant self-stimulation. To evaluate change in this behavior she was videotaped periodically at a time when the immediate effects of therapy would have worn off. The behavior was analyzed quantitatively for both duration and intensity of stimulation. Self-stimulation was reduced by 80 percent at the end of 11 months of therapy, but no other changes were noted.

Subject 8. This child had a history of being emotionally upset with frequent, sometimes uncontrollable, outbursts. When first seen he obtained a raw score of 24 on the Carrow Test of Auditory Comprehension. Although he rejected testing at 1 year, he showed a gain of 20 points during a 16-month period. Both scores were still below the 3-year level. There were no other changes observable in the clinical situation.

Subject 9. Initially, this child interacted with the therapeutic equipment to a greater extent than any of the other subjects except the two judged only mildly involved.

Table 2
Univariate Analysis of Independent Parameters

Parameter	Mean of Good Response Group* ($n = 6$)	Mean of Poor Response Group ($n = 4$)	F† ($df = 1, 8$)	p-Value
Reaction to:				
Light touch: air puff	2.5	1.5	2.954	‡
Touch-pressure	2.7	1.8	3.951	$< .10$
Light touch: tactile defensiveness	4.2	3.0	5.407	$< .05$
Pain	2.2	2.3	0.024	‡
Joint Traction	2.0	1.5	1.600	‡
Vibration	2.2	1.3	4.502	$< .10$
Movement	3.8	1.8	4.255	$< .10$
Gravitational forces: insecurity	4.3	3.5	2.105	‡
Rotation: postrotary nystagmus	1.7	1.0	2.560	‡
Watching spinning stripes	1.7	1.8	0.022	‡
Sound of bell	1.8	1.0	2.759	‡
Sound of white noise	2.0	1.5	1.600	‡
Odor	3.0	2.0	2.600	‡
Flavors: taste	2.5	2.3	0.533	‡

* Key to variable measurements:
1 = no reaction or definite underreaction
2 = slight underreaction
3 = normal reaction
4 = slight overreaction
5 = definite overreaction

† H_0: The means of the two groups are equal.
‡ $p > .10$

Furthermore, he was more emotionally stable than most of the other autistic children. He participated in the therapy willingly throughout a 22-month period, but there was little change in the nature of that participation, either at the end of a year or at the end of 22 months. He did, however, show increased affection and sociability. Toward the end of the first year his teacher reported he was doing better academically and his mother felt that he was coping better with stress.

Subject 10. Of this group of children, the child showing the least favorable response to therapy demonstrated little or no permanent change that could be attributed to therapy. His most prominent autistic behavior was extreme hyperactivity. Although therapy initially calmed him down and increased his environmental awareness and vocalization, at the end of the year of therapy his overall day-to-day activity level had not changed appreciably. However, his initiative in choosing therapeutic activity had somewhat increased.

Statistical Analysis. Stepwise discriminant analysis was used to identify which of the parameters best discriminated between subjects who had a good response to therapy and those who had a poorer re-

Table 3
Probability of Misclassification When One- to Four-Parameter Models Were Used in Stepwise Discriminant Analysis

No. of Parameters in the Model	Parameters in the Model				Probability of Misclassification	Approx. F^*	*df*	*p*-value
1	Tactile defensiveness	—	—	—	.20	5.407	1, 8	$< .05$
2	Tactile defensiveness	Movement	—	—	.30	6.962	2, 7	$< .025$
3	Tactile defensiveness	Movement	Gravitational insecurity	—	.10	13.845	3, 6	$< .01$
4	Tactile defensiveness	Movement	Gravitational insecurity	Air puff	.00	18.211	4, 5	$< .005$

* H_0: The means of the two groups are equal, given all of the variables in the model.

sponse. This type of analysis is multivariate in nature; that is, it looks at combinations of parameters interacting with one another. The linear combination of one or more parameters that predicts into which group a subject will fall is called a model.

Table 2 presents the 14 independent parameters that were analyzed in the stepwise discriminant analysis. A univariate analysis was performed in order to compare the measurements of the good response group with those of the poor response group on a single variable. The groups were found to be significantly different in relation to the presence of tactile defensiveness ($p < .05$). The two groups were somewhat different from one another on the parameters of reaction to touch-pressure, vibration, and movement; however, these differences were not significant ($p < .10$). No other single variable differentiated between the two groups.

Table 3 summarizes the results of the stepwise discriminant analysis. The combination of parameters that best discriminated between the good and poor response groups consisted of tactile defensiveness, reaction to movement, gravitational insecurity, and reaction to an air puff. Using the 4-parameter model, subjects who tended to have normal or over-reactions to the stimuli were predicted to be members of the good response group.

The remaining 10 parameters failed to improve the discrimination between the groups. The best 1-parameter model included tactile defensiveness. The best 2-, 3-, and 4-parameter models added reaction to movement, gravitational insecurity, and reaction to an air puff. The probability of misclassification decreased with the addition of the last 2 parameters to the model. This probability expressed the chance that a subject would be incorrectly predicted to have a good response to therapy when the response would actually have been poor, or vice versa. The approximate F statistic, on the other hand, increased significantly with the addition of each variable. This statistic tested the null hypothesis that the multivariate means of the two groups were equal. Because of the small sample size, it should be noted that the results of the analysis are suggestive, rather than predictive for other autistic children under treatment.

Discussion

These results indicate that, in this group of ten autistic children, the therapeutic procedures employed were more effective with the hyper-reactive children than with the hypo-reactive ones. Normal reactions to sensory input also carried a positive prediction but were not frequently present. The differences in responsivity might be interpreted to mean that therapy as provided was more effective in modulating sensory input than in helping the brain to register or orient to it. Also to be considered is the knowledge and theoretical framework of the principal investigator. Other therapists with other approaches might obtain different responses.

These results suggest the importance of the tactile and vestibular systems and their probable influence on the processing of input over other sensory channels. It is hypothesized that the language comprehension score gains made by several of the subjects were a reflection of improved auditory processing, thus allowing the growth of receptive vocabulary from exposure in other situations since therapy did not include teaching language skills. Also to be considered is the probability that score changes were influenced by increased behavioral organization, enabling the child to attend to and engage in a complex purposeful task.

Since all but one of the children had severely attenuated postrotary nystagmus, the original supposition that those with shortened duration vestibulo-ocular reflex activity would be the best respondents to therapy was an inappropriate hypothesis. Rather, in this group those who had some clinically observable nystagmic beats showed better therapeutic response than those in whom none was seen.

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