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ABSTRACT

To further clarify the nature of sensory integrative dysfunction, 148 public school children (mean age 92.6, mean IQ 96.5) with learning disorders were first given a battery of sensorimotor, psycholinguistic, and cognitive tests, and factors were extrapolated. The test scores were also employed to generate step-wise regression equations predicting the reading and the total scores of the Wide Range Achievement Test. Experimental and control groups were set up, with the experimental group receiving remedial activity to enhance sensory integration for 25 to 40 minutes per day, 5 days a week, for a period of not less than 5 months. Post-testing of the remaining 128 children occurred 1 year later, and the subjects were divided into groups with generalized dysfunction or auditory-language deficits. Results showed that academic gains may have been related to enhanced sensory integration. The experimental group showed an increased ability to blend sounds and auditorily to remember and reproduce a sequence of numbers. Indications were that the learning disabled child may be helped by a program designed to enhance sensory integration, especially through brain stem mechanisms. (RJ)

Abstract of Research Project

Sensory Integrative Processes and Learning Disorders*

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Some learning disabilities are associated with inadequate sensory integrative and related motor development. It was hypothesized that enhancing sensory integration in children with these disorders would increase their capacity for academic learning. Success in increasing sensory organization is dependent upon the adequacy of a theory of the natuı e of dysfunction in the learning disabled child and how the brain functions relative to the integrative processes.

Objectives

The objectives of the study were to clarify further the nature of sensory integrative dysfunction, especially in relation to perception and early academic learning and to test the effect on academic learning of remedial activity administered according to a theory of the development of sensory integration. More

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specifically three major questions were asked and answered: (1) What factors will emerge from a R-technique factor analysis of intercorrelations of scores on sensorimotor, psycholinguistic and cognitive tests administered to a group of children with learning disabilities? (2) What group of tests of those used for the factor analysis are the best predictors of academic achievement in young children with learning disorders? and (3) Do children with learning disabilities who receive remedial activity for sensory integrative disorders show greater gains in perceptual-motor, psycholinguistic, reading, spelling and arithmetic test scores than will children with learning disabilities who receive the equivalent amount in time, of academic work instead of remedial activity?

Sample

The sample population for the study consisted of 148 public school children selected by the schools as having learning disorders and for receiving special educational help. The mean age was 92.6, the standard deviation 12.0 months; the mean intelligence quotient was 96.5, the standard deviation 12.3. Boys numbered 110, girls 38.

The three questions of the project employed different procedures which, along with the results, are presented separately.

The Factor Analysis

Procedure

The 148 children were given an initial battery of sensorimotor (including perceptual), psycholinguistic and cognitive tests. The intercorrelation of scores on 46 variables were subjected to R-technique orthogonal rotation factor analysis. Of the several analyses made, that extracting 8 factors was most meaningful.

Results and Discussion

The first factor to emerge pointed up the close operative bonds among tests of visual perception with a natural association of tests of finger identification, manual form perception, graphesthesia, perception of double tactile stimuli perception, arithmetic and writing of words and symbols.

Auditory, language and intelligence test scores shared variance. The fact that low scores on these tests tended to have relatively better left hand than right hand coordination suggested that sometimes auditory-language problems may reflect cerebral hemisphere involvement.

A factor reflecting postural andocular dysfunction is best delineated by poor ocular control and too much residual primitive postural response, especially of the tonic neck, labyrinthine and neck righting reflexes. Children with this problem tended to have less trouble with arithmetic than with other behavioral parameters.

The operative parameters of a fourth factor identified it as apraxia, or a disorder of motor planning. Associated with it was poor tactile stimuli.

Reading, with spelling closely associated, constituted another factor. Non-agreement between eye and hand dominance and left eye dominance shared variance with each other, but not substantially with the other parameters. (Left handedness associated very little with any of the variables.) The seventh factor, essentially a singlet, consisted of the degree to which the left hand coordination (relative to normative left hands) approached right hand coordination (relative to right hands).

In this sample of children, the correlation between left and right hand coordination scores was so much higher than that between either of those scores with any other variable that they tended to form a doublet on the eighth factor.

This analysis helps substantiate the existence of and delineate the nature of types of sensory integrative dysfunction in the research sample. The consistency of the analysis with previous comparable analyses on which the development of a theoretical system of treatment was based supports the appropriateness of the remediation procedures for the current sample.

Groups of Tests Predicting Academic Achievement

Procedure

The scores of the 148 children on the tests used in the factor analysis were employed to generate step-wise regression equations predicting the reading and the total (of reading, spelling and arithmetic standard) scores of the Wide Range Achievement Test. The academic level of the children necessitated the use of a sight, as opposed to a comprehension, reading test.

Results and Discussion

The resulting equations reflected the variety of behavioral parameters that contribute to the capacity for academic achievement. The role of language and visual space perception contribute the greatest proportion of variance to the equations. Most of the other contributants to the equation previously have been shown to characterize a type of disorder involving postural, oscular and bilateral motor integration. The proportion of variance on academic scores contributed by the other test scores was of a magnitude that indicated that many other factors not under evaluation were involved in determination of the academic scores.

Comparison of Difference between Pre- and Post-test Scores of Experimental and Control Children

Procedure

The sample population of 148 children were located in 6 different schools in 5 different school districts in Southern California during either the 1968-69 school year or the 1969-70 school year. In order to maintain control of experimental variables associated with school districts and individual teachers, an attempt was made to alternate the experimental or control status of a classroom or school the second year. A graphical illustration of the experimental paradigm is shown below.

Year	Classes or Schools					
	A	B	C	D	E	F
1968-69	exp.	con.	exp.	con.	exp.	con.
1969-70	con.	exp.	con.	exp.	con.	exp.

In one case the classroom which held experimental children during 1968-69 could not be used as a control classroom the following year because essentially the same children remained in the class. Since no children were included in the study two years, children at another comparable school were chosen as controls. In the case of children who attended regular as opposed to special classrooms and who left their classroom to receive special educational help for their learning difficulties, only the school or school district and not the classroom was controlled as a variable.

All children were pre-tested with portions of the Southern California battery of perceptual-motor tests, the Illinois Test of Psycholinguistic Abilities, and all of the Wide Range Achievement Test (WRAT) and the Slosson Oral Reading Test (SORT).

The experimental group received the remedial activity to enhance specific types of sensory integration for 25 to 40 minutes a day, 5 days a week, for a period of not less than 5 months. Emphasis was placed on normaliation of brain stem mechanisms, not on cognitive functions. Use of puzzles and comparable visual perception tasks were limited to 5 percent of the time or less. Language was employed for reasons of communication only, not for remedial purposes. The control children received a comparable amount, in time, of classroom experience. Of the original sample of 148, 128 children remained in the program and were available for and cooperative with the post-testing which occurred approximately one year after the pre-testing or the fall of the second year. Post-testing, utilizing a portion of the pre-test battery, was administered by assistants unfamiliar with the experimental versus control status of the child unless the child identified his status. Each examiner tested approximately the same number of experimental as control children.

Subjects had originally been selected by school districts using the criterion of learning disorder, which usually is defined as a discrepency between academic achievement and intelligence. Although most of the children showed moderate deficits in the identified areas of sensory integration, some of them manifested either no or minimal involvement of the type for which a system of remedial activity had been developed and was employed. It was necessary to select from the total sample those children for whom the treatment program was designed and to match experimental and control children on type and degree of dysfunction.

To accomplish this objective, regression equations were generated to determine degree and type of disorder. Employing the results of previous factor analyses which identified five recognizable types of sensory integrative disorder, each child was assigned, on the basis of his test results, scores indicating the degree of dysfunction in each of those five types of disorder. Using those five scores as criteria, regression equations were generated from the sensorimotor and psycholinguistic test scores of the total sample of 148. Those regression equations were then reapplied to the 128 children who had been retested, giving each a score indicating degree of dysfunction in the following areas: postural-ocular-bilateral integration, praxis, form and space perception, auditory-language problems, and disorder affecting the left side of the body.

Applying the equations to the same sample population from which the equations were generated represents an unavoidable limitation of this study. The disadvantage of the circularity of methodology is believed counter-balanced by the advantage of approximating the objective of matching subjects on the most critical variable— degree and type of sensory integrative dysfunction.

It was the original intention that the research subjects would be divided into disorder groups according to the main disability score, but the frequency with which children manifested problems in several areas reduced the categorization to two domains: (1) those with generalized sensory integrative disorders of postural mechanisms, praxis, visual perception and usually but not necessarily auditory-language problems, and (2) a much smaller group with auditory-language problems without significant disorder in the other systems.

To assure the inclusion in the experimental aspect of the project only those children for whom the treatment was designed, an arbitrary regression equation score was set, below which a child's score had to fall to qualify him for inclusion. This process excluded children with minimal or unrecognized types of disorder, with behavior disorders not linked to disordered sensory integration, and most of the children whose problem affected primarily the left side of the body. In the last category, there was an insufficient number of children to warrant statistical analysis of their results.

The selection process left in the research sample 31 experimental and 37 control subjects with generalized sensory integrative problems and 13 experimental and 21 control subjects with auditory-language problems. From this sample, 30 experimental and 30 control children with generalized dysfunction and 12 experimental and 12 control children with auditory-language deficits were selected using as a criterion the best match of each experimental with its respective control group on variables shown in Table 1.

The t-values in Table 1 show that there were no statistically significant differences in group means on any of the variables in the groups with generalized dysfunction. The largest difference between the groups was their mean age, the experimental group being $4\frac{1}{2}$ months older on the average. This additional age

Table 1

Characteristics of Experimental and Control Groups at Initial Testing and t-Values Expressive of the Significance of Difference between Scores of the Two Groups

Variable	Groups	Group with generalized dysfunction				Group with auditory-language disorders			
		Mean	S. D.	t-value	P-value	Mean	S. D.	t-value	P-value
Age	Experimental	94.1	10.4	+1.44	.154	99.6	10.9	0.07	.947
	Control	89.7	13.1			99.3	6.9		
Intelligence Quotient	Experimental	94.6	12.3	-0.09	.927	92.5	9.1	-1.02	.319
	Control	94.9	13.0			97.5	14.4		
WRAT Arithmetic (Scaled Scores)	Experimental	87.9	7.7	0.73	.470	87.6	4.9	1.63	.105
	Control	86.2	9.9			83.8	5.9		
WRAT Reading (Scaled Scores)	Experimental	84.0	7.2	1.17	.248	78.3	3.8	0.35	.731
	Control	81.6	8.6			77.6	5.4		
WRAT Total (Scaled Scores)	Experimental	249.9	17.0	.49	.627	245.3	10.6	1.13	.272
	Control	247.5	21.8			239.3	15.1		
Slosson Oral Reading (Scaled Scores)	Experimental	73.0	6.0	-.20	.839	69.3	3.7	0.06	.951
	Control	73.5	11.0			69.1	8.6		
Postural and bilateral integration	Experimental	1.9	0.62	-.43	.666	2.7	0.43	1.08	.294
	Control	1.9	0.69			2.6	0.33		
Praxis	Experimental	1.9	0.53	1.15	.255	2.5	0.43	-1.56	.133
	Control	1.8	0.65			2.8	0.41		
Functions of the left side of the body	Experimental	2.6	0.35	-0.98	.331	2.9	0.5	2.43	.023
	Control	2.7	0.59			2.4	0.5		
Form and space perception	Experimental	1.9	0.46	0.84	.404	2.6	0.43	0.37	.712
	Control	1.8	0.55			2.6	0.61		
Auditory-language Functions	Experimental	2.0	0.69	0.86	.393	1.7	0.37	-0.11	.915
	Control	1.9	0.53			1.8	0.39		
Total Dysfunction score	Experimental	10.3	1.1	0.71	.478	12.5	1.01	1.24	.228
	Control	10.1	1.3			12.0	0.89		

gave that group a disadvantage, for a correlation analysis showed that the younger children tended to gain more academically than the older ones. In the auditory-language groups, there was significantly more disorder affecting the left side of the body in the control groups. The lower score indicates more involvement.

Results

The significance of the mean difference(change)between pre- and post-test scores on each of the WRAT subtests and total score and on the SORT of each of the experimental groups compared to its respective control group was determined by computation of t-values. The means, standard deviations and t-values expressive of the degree of difference between the means for each of the two groups are shown in Table 2.

The mean gain of the experimental group with generalized dysfunction exceeded that of its control group in all instances, but only on the WRAT reading and total scores did the differences reach statistical significance. The change scores of the experimental group with auditory-language problems exceeded that of the control group on the spelling, reading and total WRAT tests and on the SORT. Of these the WRAT reading and the SORT change scores reached statistical significance. That on the WRAT spelling test approached significance. The experimental group gained less than the control group on the arithmetic test but the difference did not approach significance.

Determination of the significance of difference of change scores among the groups on the perceptual-motor and auditory-language tests was determined through discriminant analysis or the generalized D^2 after Mahalanobis. First the

Table 2

Means, Standard Deviations and t-values Expressive of the Degree of Difference between Means of Change Scores of Experimental and Control Groups

		Group with generalized dysfunction				Group with auditory-language disorders			
Test	Groups	Mean	S. D.	t-value	P-value	Mean	S. D.	t-value	P-value
WRAT Spelling (Raw Scores)	Experimental	7.06	7.30	1.33	.189	5.08	4.12	2.03	.055
	Control	5.03	4.12			2.17	2.79		
WRAT Arithmetic (Raw Scores)	Experimental	4.33	2.71	1.13	.264	4.50	2.32	-0.83	.413
	Control	3.40	3.63			5.33	2.57		
WRAT Reading (Raw Scores)	Experimental	13.0	8.00	3.08	.003	12.83	7.39	3.12	.005
	Control	7.3	6.23			5.08	3.18		
WRAT Total (Standard Scores)	Experimental	7.70	19.47	2.49	.016	4.50	18.18	0.93	.364
	Control	-3.47	14.92			-1.92	15.63		
Slosson Oral Reading (Raw Scores)	Experimental	22.17	23.9	1.80	.078	25.50	23.29	2.99	.007
	Control	13.13	13.67			4.92	4.13		

pre-test scores were subtracted from the post-test scores and the resultant change scores corrected by a procedure recommended by Hovland, Lumsdaine and Sheffield. The corrected change score for each individual was obtained by dividing the difference between the pre- and post-test scores by the improvement possible where there was an increase in scores. If the post-test score was lower than the pre-test score, the decrease in score was divided by the decrease possible by that subject. The procedure tends to make the actual change independent of the initial score and tends to normalize the distribution.

The D^2, expressive of difference in corrected change scores among the two experimental and two control groups on the perceptual-motor (including visual) tests was 70.98, which indicated that the differences among the four groups with respect to the perceptual-motor tests change scores were such that they were not likely due to chance. Likewise, the D^2 indicating the difference in corrected change scores among the two experimental and two control groups on the auditory-language tests was statistically significant beyond the .01 level. Additional computations of D^2 demonstrated that both of the experimental groups differ from their respective control groups on both sets of variables and that the differences were statistically significant.

Discussion

Inspection of the t-values indicating the difference between means of the experimental and control groups on the change scores of each variable suggests that the gains in academic scores may have been related to enhanced sensory integration. Of particular interest was the increased ability of the experimental group to blend sounds and auditorily to remember and reproduce a sequence of numbers. Basic brain research is placing increasing importance on the role of the brain stem in organizing auditory and visual processes as well as the dependence of the neocortex upon adequate organization of the brain stem level, for the two levels of the brain interact together. Because previous similar research implicated brain stem functions in learning disorders, the remedial activity placed emphasis on the normalization of brain stem mechanisms. These results suggest that it may be possible to increase the capacity of the learning disabled child to respond to academic teaching by providing a program designed to enhance sensory integration, especially through brain stem mechanisms.