DOCUMENT RESUME

ED 033 757 PS 002 512

AUTHOR	Ayres, A. Jean
TITLE	Effect of Sensorimotor Activity on Perception and Learning in the Neurologically Handicapped Child. Final Progress Report.
INSTITUTION	University of Southern California, Los Angeles.
Spons Agency	Childrens Bureau (DHEW), Washington, D.C.
Pub Date	Sep 68
Note	21p.
EDRS Price	EDRS Price MF-$0.25 HC-$1.15
Descriptors	Academic Achievement, *Academically Handicapped, Behavior Patterns, Elementary School Students, *Exceptional Children, Factor Analysis, *Learning Disabilities, *Neurological Defects, Neurologically Handicapped, Perceptual Motor Coordination, Perceptual Motor Learning, Sensory Integration, *Sensory Training

Abstract

Because some learning disorders in children may be associated with perceptual-motor dysfunction, this study tested the effects of sensorimotor treatment on learning disorders and explored the nature of neurodevelopmental disorders. In Part One, 64 neuromuscular, perceptual, and cognitive measurements made on 36 educationally handicapped children with normal IQ's were subjected to Q-technique factor analysis. The two major patterns of deficits associated with low academic achievement were (1) auditory, language, and sequencing, and (2) postural and bilateral integration. Part Two sought syndromes of dysfunction from an R-technique factor analysis of perceptual-motor test scores. Q-analysis subjects and additional children with academic problems were tested. Emerging factors represented types of statistical associations among behavioral parameters apt to be affected by neurodevelopmental disorders. Part Three hypothesized that educationally handicapped children in special classes receiving sensorimotor training show a greater change in perceptual-motor, language, and academic achievement scores than children receiving the equivalent amount of additional classroom instruction. Test scores failed to support this hypothesis. The major contribution of the entire project was the identification of postural and bilateral integration deficit which interfered with learning. (JF)

Final Progress Report

Effect of Sensorimotor Activity on Perception and Learning in the Neurologically Handicapped Child.

(Project Number H-126)

Funded by
Children's Bureau
Department of Health, Education, and Welfare

A. Jean Ayres
(Principal Investigator)
University of Southern California
Los Angeles, California

September, 1968

Some learning disorders in children are believed to be associated with perceptual-motor dysfunction. Treatment of these children, many of whom have neurodevelopmental disorders, has largely been symptomatic, although sensorimotor activity has been finding favor as a means of enhancing central nervous system integration to provide a better foundation for academic learning. The theoretical concepts upon which many of the sensorimotor approaches are based are in their formative stages and not noted for their reliance upon neurological or behavioral research findings. Concurrently, basic biological research on brain function flourishes, but little of the resultant knowledge filters into the theory upon which treatment is based.

The goal of this study included both testing the effects of sensorimotor treatment on learning disorders and exploring the nature of the neurodevelopmental disorders. Although the project was conducted as a whole, its results are most easily understood if presented in three parts, each part related to one of the three objectives.

Appreciation is extended to the following individuals and institutions for their assistance with the research: the Wiseburn School District and Palos Verdes Unified School District for incorporating the project into their curricula; the Hermosa Beach City, Inglewood Unified, Redondo Beach City, San Gabriel City, and Torrance Unified School districts for enabling testing of children; Edward Levonian for aid with the statistical analyses; and Betty Ann Altman, Virginia Fair, James Kaatz, Carolyn M. Owen, and Jerelyn Bresnan for assistance with the testing. The Western Data Processing Center, University of California, Los Angeles, and the Computer Sciences Laboratory, University of Southern California were utilized for computational services.

Part One

Objective

The objective of Part One of the study was to seek patterns or syndromes of perceptual-motor dysfunction from a Q-technique factor analysis of neuromuscular, perceptual-motor, academic, and language test scores.

Procedure

Subjects. The sample population was 36 children who had been selected by two different school districts for inclusion in classes for educationally handicapped children. District selection was based primarily on (1) an IQ within normal limits, (2) moderate to severe lack of academic achievement, and (3) evidence of either neurological or emotional disorder. The testing by the principal investigator indicated that all children had some degree of sensory integrative deficit. The age range, mean, and standard deviation of age of the group of 36 at initial testing were, respectively, 73 to 118, 97.72, and 11.86 months. The mean and standard deviation of the IQ's were 93.47 and 11.29, respectively. There were 29 males and 7 females.

Method. To collect the data for the Q-technique factor analysis, the sample of 36 subjects was given a battery of neuromuscular, perceptual-motor, psycholinguistic, and academic tests and observations yielding 75 scores. From this battery, 11 of the observations were removed because of failure to meet reliability standards. The 64 scores were subjected to Q-technique factor analysis utilizing ipsative standard scores in a manner recommended by Guilford (1963). First, each of the 64 tests was standardized normatively to zero mean and unit variance. The resulting scores were then standardized ipsatively to zero mean and unit variance. Thus the initial test scores were standardized first across subjects, then within subjects. Based on the ipsatively standardized scores, a between subjects correlation was computed. The main diagonal entry for a subject was the square of his multiple correlation with the remaining 35 subjects. Six factors were extracted by the principal components method as described in Dixon (1967), and rotated according to the orthogonal varimax criterion (Kaiser, 1958).

Table I

Rotated Factors: Q-technique Analysis

Sub-ject	Writing Hand	A	B	C	D	E	F	Commu-nalities
1	R			.43				.46
2	R	-.67						.54
3	R			.50				.41
4	R							.20
5	R				-.45			.37
6	R		-.45					.44
7	L					.52		.34
8	R							.45
9	R	.42						.32
10	L			.42				.26
11	R		.58					.49
12	L				.67			.52
13	R							.38
14	L				.56		.47	.58
15	R		.58					.58
16	L							.15
17	R		-.40					.37
18	R		.46					.28
19	R						-.65	.57
20	L					.64		.50
21	R					.57		.40
22	R				-.57			.41
23	R			-.66				.50
24	R	-.53						.40
25	R	.82						.69
26	R		-.69					.52
27	R			.64				.54
28	R						.40	.29
29	R			-.56				.50
30	R	.44			-.43			.48
31	R						.67	.57
32	R							.51
33	R	-.68						.52
34	R						-.47	.45
35	R							.35
36	R					-.59		.52

Results. The objective in employing the Q-technique factor analysis was to force order through classification on a large number of symptoms attributed over the past several decades to children with learning disorders or minimal brain dysfunction. The procedure involved comparing one subject's pattern of dysfunction with each other subject's pattern, with the influence of the degree of dysfunction eliminated. The rotated factors, subject loadings, the hand each subject used for writing, and communalities are shown in Table I. Only loadings of .40 or above were recorded and used to define factors. The ipsative standard test scores of the positive loading subjects were compared with those subjects with negative loadings. The tests on which there were large differences between the two groups were listed in a hierarchical sequence, the order being determined by the magnitude of the difference between scores of the positive versus negative loading subjects. Greater significance was accorded the test scores of the subjects with higher loadings regardless of sign (+ or -) than those with lower loadings on any factor, although agreement of scores among subjects with loadings of the same mathematical sign was considered.

The mathematical nature of a Q analysis results in a number of factors in each of which certain behavioral dimensions are shown in contrast to others, i.e. several test scores will represent a constellation of deficits in children with loadings in one direction and relative lack of deficits in children with loadings in the opposite direction. The mathematical sign before each test listed below in the factors indicates that the subjects with loadings in that direction had low ipsative standard scores on that test and not on the tests of the opposite sign. When low ipsative standard scores on a given test characterized subjects with both positive and negative loadings on a test, that test did not delineate a factor. This was true of some of the tests.

Factor A was predominantly identified by association between auditory-language functions, sequencing, reading achievement, and possibly some dominance discrepancies. The behavioral parameters which showed a congruent relationship in contrast to language-sequencing symptoms center around postural mechanisms and tactile functions. The tests on which positive and negative loading subjects showed marked differences in ipsative standard scores were:

- \- ITPA Auditory-vocal Automatic
- \- ITPA Auditory-vocal Sequencing
- \- ITPA Auditory Decoding
- \- Arm Extension Test of Schilder (AET): raised arm
- \- AET: agreement between raised and writing arm
- \+ SC Figure-ground Visual Perception

- \- Sequence of commands
- \- Gates-MacGinitie Reading Test, comprehension
- \- ITPA Visual-motor Sequencing
- \+ Arched back posture
- \+ Postural background movements
- \+ SC Localization of Tactile Stimuli
- \+ Freedom from tactile defensiveness
- \- Agreement between eye and hand dominance
- \+ AET: resistance to head turning
- \+ AET: arm position
- \- Gates-MacGinitie Reading Test, vocabulary
- \+ Design copying
- \+ AET: arm position during passive head turning
- \- Wepman Auditory Discrimination
- \- WRAT, spelling
- \- SC Crossing Mid-line of Body

Factor B appeared to reflect disorders of the tactile-motor planning domain among subjects with negative loadings and of postural and bilateral integration with reading and language problems among subjects with positive loadings. The term "postural and bilateral integration" refers to a hypothesized neural system concerned with postural reflexes and the coordination of motion (and possibly other functions) of the two sides of the body. Tests evaluating these two behavioral dimensions of the same neural system are shown to have association in several of the factors described by this study. The tests delineating the factor in this group were:

- \- SC Manual Form Perception
- \+ Gates-MacGinitie Reading Tests, vocabulary
- \+ AET: resistance to head turning
- \+ ITPA Auditory-vocal Automatic
- \+ SC Standing Balance: eyes open
- \+ Gates-MacGinitie Reading Tests, comprehension
- \- Peripheral eye movements
- \+ AET: arm position
- \+ AET: arm position during passive head turning
- \+ Drawing double circles opposite directions
- \- SC Localization of Tactile Stimuli
- \- SC Imitation of Postures

The tests on which subjects with positive loadings on Factor C had low ipsative standard scores suggest poorer coordination on the left than the right side of the body along with deficiencies in postural and bilateral integration. The question of lateralized dysfunction arises. This constellation was compared with deficits suggestive of a more complex integrative or cognitive nature found among the subjects with negative loadings. The tests which define Factor C were:

+ SC Motor Accuracy, left hand
+ Postural background movements
+ Non-dominant hand SC Motor Accuracy compared to dominant hand SC Motor Accuracy
+ Horizontal eye movements
+ Conjugate eye movements
+ SC Crossing Mid line of Body
- SC Graphesthesia
- Intelligence
- SC Right-left Discrimination
+ Arched back posture
+ AET: arm position during passive head turning
- ITPA Motor Encoding
- ITPA Auditory-vocal Sequencing
- Design Copying
- ITPA Visual-motor Association
+ Diadokokinesia
- SC Kinesthesia
- Discrimination of Reversed Images

The major associations between academic achievement tests and the sensory-perceptual-cognitive tests were reflected in Factor D. The close relation between postural and bilateral integration and academic achievement was shown among the subjects with positive loadings. They were also relatively free of tactile defensiveness, hyperactivity, and distractibility. The tests reflecting the operative parameters of Factor D were:

+ WRAT, spelling
- Freedom from tactile defensiveness
- Freedom from hyperactive and distractible behavior
+ Postural background movements
+ WRAT, reading
+ WRAT, arithmetic
+ Arched back posture
+ SC Crossing Mid-line of Body
+ Gates-MacGinitie Reading Tests, vocabulary
- ITPA Auditory Decoding
+ Muscle Tone
- Attention span

- \- AET: raised arm
- \+ Intelligence
- \+ Writing hand
- \+ Design copying
- \+ Gates-MacGinitie Reading Tests, comprehension

The relevance of the relationships expressed by the clustering of the following tests on Factor E is not immediately clear.

- \- Agreement between eye and hand dominance
- \+ AET: raised arm
- \+ SC Manual Form Perception
- \+ Birch-Belmont Audio-visual Integration
- \+ SC Finger Identification
- \+ Cocontraction of muscles

The following tests, defining Factor F, suggested that the ability to make auditory or visual cognitive associations was contrasted with the ability visually to perceive a horizontal sequence of stimuli.

- \+ AET: agreement between raised and writing arm
- \+ Muscle tone
- \- Drawing double circles opposite directions
- \- ITPA Auditory-vocal Association
- \- ITPA Visual-motor Association
- \+ ITPA Visual-motor Sequencing
- \+ Sequence in Space

Interpretation and Discussion

Q-technique factor analysis provides the advantage of detecting naturally occurring combinations of deficits that are often lost in conventional correlations or tests of significance of test score differences between groups which are chosen by the criterion of academic achievement. As a statistical process, it also has limitations which must be considered in interpreting the factors. One limitation lies in the fact that the size of subject sample must be small compared to the number of tests and observations made. Considering only subjects with loadings of .40 or greater reduced the number of subjects identifying a factor but clarified the probable nature of the disorders.

The factors derived from Q-technique analysis were expressed as tests which contrast relative (as opposed to absolute) deficit areas in the children. The parameters were chosen because they had been associated with learning disorders. Consequently, as a group the subjects scored below average relative to the normative population on every measurement and the contrasting of deficits of one group of children with another was relative. It is contrary to what is known of neurological organization to conclude that behavioral dimensions represented by tests carrying a positive sign are compensatory to those carrying a negative sign. It is not clear what neurological conditions determined the appearance of certain subjects with positive loadings and others with negative loadings on the same factor, but it is hypothesized that the affiliation was less one of sharing a neural process than it was independence of two neural systems which, because of their relative independence, were differentially vulnerable.

Consistent with this postulate was the reoccurrence on several factors of variations of a pattern of test scores that appeared to have a natural affiliation and which could be tentatively identified as a syndrome of disorder in postural and bilateral integration. The tests which were hypothesized to contribute to this syndrome in different combinations under certain circumstances were tests of residual primitive postural reflexes, equilibrium reactions, integration of function of the two sides of the body, and extraocular movements. In Factor A this postulated neural system was seen in contrast to the auditory-language sequencing function. In Factor B postural and bilateral integration was in contrast to tests associated with praxis. This same syndrome in Factor C included deficits in eye movements and suggestive evidence of greater right than left hemisphere involvement. It was found in contradistinction to the more complex, cortically directed functions.

Another variation of poor postural and bilateral integration was found to be independent of the tactile defensiveness-hyperactivity-distractibility syndrome in Factor D. All of these hypothesized patterns of dysfunction are consistent with previous studies (Ayres 1964, 1965). It is suggested that a possible parameter differentiating the syndrome of postural and bilateral integration in Factor D from its manifestation in the other factors was the presence of low muscle tone, a condition which tends to obscure the presence of abnormal reflex activity in the Arm Extension Test. This syndrome appears to be particularly related, in this sample, to academic achievement.

It is noteworthy that the test, SC Crossing Mid-line of Body, a version of Head's (1926) hand-eye-ear test, appeared both with the combination of deficits apparently reflecting left hemisphere function (Factor A) as well as right hemisphere function (Factor C) and on Factor D.

A severe methodological limitation, contributing undoubtedly to the grouping of subjects on Factor A, lay in the nature of the Gates-MacGinitie Reading Test. As a multiple choice test, a chance score often places a first grade child with severe learning difficulty at a reading level greater than his age expectation, while the older a child becomes, the greater the discrepancy between his actual reading grade and his expected reading grade. Subjects 2 and 33, who had the highest negative loadings on Factor A were two of the three oldest children in the study, while subject 25, with the highest positive loading was next to the youngest child. This difficulty in controlling age-reading relationship in quantifying scores is present to a lesser extent on the WRAT.

The deficits associating with auditory and language functions in Factor A deserve further exploration. Tests involving sequencing shared something in common with language for reasons which, of course, are not clarified by the study beyond that given by the mathematical calculations and face validity of the tests.

Summary of Part One

Sixty-four neuromuscular, perceptual, and cognitive measurements made on 36 children with educational handicaps were subjected to Q-technique factor analysis. The two major patterns of deficits associated with low academic achievement were (1) auditory, language and sequencing, and (2) postural and bilateral integration. Both of these syndromes could be differentiated from previously identified syndromes of apraxia and tactile defensiveness.

Part Two

Objective

The objective of Part Two of the project was to seek patterns or syndromes of dysfunction from an R-technique factor analysis of perceptual-motor test scores.

Procedure

Subjects. The sample population consisted of those subjects included in the Q-technique factor analysis plus an additional number of children with academic problems and intelligence within normal range. The total N was 100. Most of these children came from classes for the educationally handicapped in school districts not involved in the experiment. Some had been seen in private evaluations. The mean age was 94.9 months and the standard deviation was 10.5.

Method. Subjects were given a battery of 19 perceptual-motor tests (see Table 2), most of which were from the Southern California Perceptual-Motor Tests. The resultant scores were subjected to an R-technique orthogonal rotation factor analysis. The correlation was modified by insertion in the diagonal of the squared multiple correlation coefficients. Six factors were extracted by the principal components method. Extracted factors were rotated by the Kaiser varimax criterion (1958).

Results

The rotated factors, showing all loadings above .30 on the tests entered into the analysis and the communalities (com.) are shown in Table 2.

Interpretation and Discussion

The factors emerging from this analysis did not represent clearly defined syndromes as hypothesized but, instead, types of statistical associations among behavioral parameters apt to be affected by neurodevelopmental disorders.

In Factor A, the clustering tests are dependent upon perception through several different sensory modalities. It is difficult to hypothesize regarding the neuropsychological process common to manual identification of geometric forms, duplicating designs drawn on the dorsum of the hand, moving arms together rhythmically and visually perceiving reversed images. In each instance, bilaterality is present and may be the basis for the associative bond.

Table 2

Rotated Factors: R-technique Analysis

Tests	A	B	C	D	E	F	Com.
1. Ayres Space			.61				.54
2. S.C. Figure-ground Vis. Percep.			.46				.35
3. S.C. Kinesthesia						.54	.41
4. S.C. Manual Form Perception	.56						.43
5. S.C. Finger Identification						.46	.40
6. S.C. Graphesthesia	.71						.65
7. S.C. Tactile Localization					.45		.24
8. S.C. Per. Double Tactile Stim.						.57	.37
9. Imitation of Postures					.56		.51
10. Crossing Mid-line of Body					.51		.31
11. Bilateral Motor Coordination	.55				.37		.47
12. Right-left Discrimination				.38			.17
13. Standing Balance: Eyes Open				.61			.54
14. Standing Balance: Eyes Closed				.54			.45
15. Visual Discrim. Reversed Images	.47			.30			.41
16. Design Copying			.66				.64
17. S.C. Motor Accuracy Test			.31		.53		.45
18. Freedom from hyperactivity-distract.		.60					.39
19. Freedom from tactile defensiveness		.63					.42

A relationship previously identified (Ayres 1964, 1965) appeared among hyperactivity, distractibility, and defensive responses to tactile stimuli on Factor B.

All of the visual tests, with the exception of one requiring the visual discrimination of reversed (mirror) images, showed moderate to definite loadings in Factor C, defining this factor as one of visual perception.

Factor D bears some resemblance to the factor identified more clearly in the Q-technique analysis as deficit in postural and bilateral integration. In this instance the bilaterality appears not on motor tests, but on tests of right-left discrimination and a visual test that has a right-left element.

The motor tests delineated Factor E, with a loading on a test of tactile perception suggesting the relationship usually found between tactile perception and motor planning. Factor F appears to be concerned with somatosensory functions.

These factors must be considered in connection with the sample on which the data were gathered, <u>viz</u>., a group of children with learning problems sufficiently severe to necessitate special educational procedures but without the behavioral problems which would exclude them from public schools. These children also probably showed the effects of perceptual training often included in programs for those with learning disorders.

The question of the difference between factors emerging on the R and Q-technique factor analyses deserves some discussion. One of the main determinants, of course, is the difference in the type of tests included in each analysis. Many of the tests which yielded the most fruitful data in the Q analysis were not included in the R analysis because their value was not yet recognized. The differences also serve to remind investigators that interpreting neurological systems from statistical typologies may be far more involved than appears at this time.

Part Three

Objective

Part Three of the project tested the hypothesis that children, who are in special classes for educationally handicapped children and who receive sensorimotor training designed to enhance neurological integration, will show a significantly greater change in scores on perceptual-motor, language, and academic achievement tests than will children in a comparable classroom who receive, in place of sensorimotor training, the equivalent amount (in time and attention) of additional classroom instruction.

Procedure

The subjects of the experimental study were the same as those from whom data were gathered for the Q-analysis. During the first year of the study (1966-67), the 10 children in school district "A" were experimental subjects and 10 children in district "B" were control subjects. During the second year of the project, the assignment of children was reversed, 12 children in district "B" becoming the experimental group and 11 different children in district "A" the control group. The children in the two experimental classes were combined to make a sample of 22 experimental subjects; those in the two control classes were combined to make a sample of 21 control subjects. The teachers in each of the two school districts remained constant during the two years. Having half of the experimental and half of the control children taught by each teacher enabled control of the variables introduced by teachers. Seven of the children who were control subjects in district "B" the first year were retained in the same classroom and became experimental subjects the second year, making a total of 36 different individuals in the study. Inclusion of these 7 children in both the control and experimental groups constitutes a limitation of the study. Major characteristics of experimental and control groups at the beginning of the year are shown in Table 3.

At the beginning and near the end of each school year all subjects were given some of the Southern California Perceptual-motor Tests (numbers 1 through 11 in Table 4), the Illinois Test of Psycholinguistic Abilities (numbers 12 through 20 in Table 4), the Wepman Auditory Discrimination Test, the Gates-MacGinitie Reading Tests, and the Wide Range Achievement Test. Post-testing was done by examiners who were initially unfamiliar with which children constituted the experimental and control groups. One of the four examiners administering the post-tests learned through the children's comments which was the experimental and which the control group.

Table 3

Characteristics of Experimental and Control Groups*

		Experimental Group	Control Group
Number of subjects		22	21
Number of males		18	16
Number of females		4	5
Age in Months	Mean	94.2	98.0
	Standard deviation	12.0	12.8
WRAT: Reading	Mean standard score	83.2	81.7
	Standard deviation	9.9	7.7
WRAT: Arithmetic	Mean standard score	85.7	84.6
	Standard deviation	10.1	7.0
IQ: Mean		95.0	92.1
IQ: Standard deviation		12.1	10.3

*No differences between the experimental and control groups reached statistical significance.

Table 4

Initial and Mean Change in Test Scores of Experimental and Control Groups

	Initial Scores				Mean Change in Scores		Experimental Compared to Control
	Experimental		Control				
	Mean	St.D.	Mean	St.D.	Exper.	Cont.	
1. Visual Figure-ground	14.63	3.55	14.38	3.60	+2.50	+2.43	+0.07*
2. Kinesthesia	63.36	7.37	63.43	16.22	+4.00	+0.43	+3.57
3. Manual Form Perception	7.86	1.98	7.00	2.67	+1.00	+0.52	+0.48
4. Finger Identification	11.50	2.76	10.86	2.90	-0.18	-0.52	+0.34
5. Graphesthesia	10.14	4.11	10.19	3.84	16.23**	25.67**	-0.24*
6. Local. of Tactile Stimuli	77.91	5.86	77.81	6.40	+2.14	+1.86	+0.23
7. Imitation of Postures	10.13	4.65	10.62	4.93	+6.95	+6.67	+0.28*
8. Crossing Mid-line of Body	17.68	6.21	18.62	4.63	+4.16	+2.52	+1.66*
9. Bilateral Motor Coord.	7.00	2.98	8.62	3.94	+4.95	+2.71	+2.24*
10. Motor Accuracy	443.18	14.24	444.43	26.78	+8.09	+6.13	+1.96*
11. Ayres Space	41.55	8.71	39.05	10.79	+7.45	+5.24	+2.21*
12. Auditory Decoding	25.82	7.38	24.71	6.08	+0.68	+4.05	-3.37*
13. Visual Decoding	15.09	3.29	15.38	2.52	31.77**	22.76**	+8.66*
14. Auditory-vocal Assn.	19.64	3.77	19.43	3.22	+1.41	+1.38	+0.03
15. Visual-motor Assn.	16.91	3.05	17.24	5.30	+1.41	+1.24	+0.17
16. Vocal Encoding	20.09	7.35	19.81	9.22	+5.64	+3.91	+1.73
17. Motor Encoding	16.32	4.67	15.14	5.52	+2.59	+2.24	+0.35
18. Auditory-vocal Automatic	13.55	4.19	13.43	3.29	+2.05	+1.86	+0.19
19. Auditory-vocal Sequential	22.82	5.23	20.71	3.84	+1.55	+2.05	-0.50
20. Visual-motor Sequential	14.36	3.41	13.52	3.28	+1.05	+0.91	+0.14
21. Wepman Auditory Discrim.	23.64	4.15	22.33	4.21	+1.00	+0.67	+0.33
22. Gates-MacGinitie, vocab.	1.58	0.45	1.55	0.42	+3.50	+3.67	-0.17*
23. WRAT, Reading	31.77	8.63	31.85	3.72	+6.14	+6.38	-0.24
24. WRAT, Spelling	22.68	4.81	22.05	3.64	+3.09	+2.81	+0.28
25. WRAT, Arithmetic	20.45	4.24	20.38	4.35	+2.86	+1.81	+1.05*

** corrected change scores
* see text for explanation

Each child in the experimental group received developmental activities and/or sensory stimulation for approximately 40 minutes each school day for about 5 months. One experimental subject received therapy for only 3 months and one for 4 months. The remedial activity was based on the principles of recapitulating the sensorimotor developmental sequence and the utilization and normalization of brain mechanisms, especially those associated with the somatosensory and vestibular systems. The basic assumption was that perception and early academic learning are dependent, in part, on prior adequate development of sensory integrative processes. Most of the activities involved gross motion; no paper and pencil work was utilized. Working manipulatory puzzles or games occupied an average of 10 percent of the therapy time, but both experimental and control subjects received advanced perceptual training, including puzzles and games, in the classroom under the teacher's direction. The activities that constituted the independent variable of the study did not include language training.

Results

The mean and standard deviations of the initial test scores and the mean change or average difference per subject between pre- and post-test scores (change scores) are shown for both the experimental and control groups in Table 4. In the last column of the table the mean change of the experimental subjects is contrasted with that of the control subjects. The initial scores are the raw scores (usually the number of correct responses) on each test excepting test number 22. Since several different forms of the Gates-MacGinitie Reading Test were necessarily employed to meet the various reading levels of the children, the initial scores given in the Table are the reading grade level, but the mean change is based on the comparison of the pre- and post-test change in raw scores for each child. The latter method was preferred as a basis for the change score because several of the raw scores fell below grade levels given in the manual. Too few children were able to score above chance levels on the comprehension section of the Gates-MacGinitie test to justify its inclusion in the analysis.

The distribution of differences between pre- and post-test scores for each group was inspected and plotted to determine whether or not it was normal. A non-Gaussian distribution was obtained for tests 5 and 13. Normalization of the distribution was improved by a method advocated by Hovland, Lumsdaine and Sheffield (1949). A corrected change score for each individual was obtained by dividing the difference between 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. This method tends to make the actual change independent of the initial score.

Using computer program BMD07M (Dixon, 1965), a stepwise discriminant analysis was made of both the initial and change scores of the experimental and control groups. No F ratio was significant between the initial scores of the two groups on any test or on any combination of tests. The F ratio between the two groups' change scores on all 25 variables was not significant. In stepwise discriminant analysis, variables are entered into the analysis (and also removed) one at a time according to the degree to which they discriminate between the experimental and control groups. The process optimizes the difference between the two groups and allows the determination of those test scores most or least affected by sensory integrative activity. The first ten entries into the analysis (before removal of any of the variables) did yield a significant ratio ($P = < .05$) for each combination of tests. These tests are indicated in Table 4 by an asterisk. While the two groups cannot be considered to differ significantly statistically in terms of the experimental hypotheses, their analysis provides information pertinent to the problem. The group which showed the greater change is determined by inspection of the change scores. The order in which the tests were entered into the analysis reflects the degree to which the change score differentiated the groups. The order was numbers 12, 9, 25, 8, 11, 1, 22, 10, 5, 7. The hypothesis that developmental activity would increase perceptual, psycholinguistic and academic test scores as a whole was not supported. On one test, number 12, a significant ($P = < .05$) t-ratio indicates the probability that the control group gained more on the vocabulary test than did the experimental group.

Interpretation and Discussion

The contribution of this portion of the study lies less in its failure to support its experimental hypothesis than in analysis of its limitations and the possible influence of those limitations. Consideration of these factors may help clarify the essential problem and provide directional guides for further inquiry.

The experimental and control children were not and could not be matched on the neurodevelopmental deficit linked to the academic problem. The nature and types of deficits, their relation to reading and methods of identifying the type of disorder were and still are insufficiently defined to enable matching of children on the most pertinent variables.

The Q-technique factor analysis of these 36 subjects using a larger number of variables indicated the presence of two major types of neurodevelopmental disorder or syndromes related to reading problems in this group. One constellation of symptoms centered around auditory-language and sequencing deficits and the other included disorders in postural mechanisms and integration of function of the two sides of the body. The second syndrome was more closely related to academic deficits than were any of the other identified patterns of dysfunction. By chance, more of the clearest cases of language problems fell in the experimental rather than in the control group, whereas, of the 12 children with the most easily identifiable (judging by their factor loadings) and isolated problem with postural and bilateral integration, 7 were experimental subjects only, 2 were control subjects only, and 3 were control subjects the first year and experimental subjects the second year. It was the impression of the classroom teacher that these children had a particularly severe reading problem, but because of the nature of their problem, it was also they for whom the therapeutic program appeared to be most effective.

Inspection of the first ten tests which, when entered into the stepwise discriminant analysis along with other tests which maximized group differences, yielded a significant F ratio at the .05 level shows that the major gains of the control group over the experimental group were in the auditory-language functions, while the greater gains of the experimental over control group were in integration of function of the two sides of the body, visual perception and motor planning.

Discussion of the Project as a Whole

The products of this study can be classified into two domains: the statistical and the substantive. Current emphasis on scientific method as the most acceptable epistomological approach necessitated an experimental design with appropriate statistical analysis. Knowledge of a behavioral domain, however, must be well developed before experiments become the most productive method of furthering knowledge. Information about learning disorders is in the early descriptive-correlative stage. The fact that the sympton - learning disorder - rather than the condition causing the learning disorder remains the focus of most investigations indicates the elementary nature of organized knowledge about learning disorders. For these reasons the substantive aspect, supported by the statistical, of this project bears the richest rewards of the study.

The major contribution of this project has been the identification and clarification through the Q-analysis (along with considerable background knowledge of neurology) of one of the more important types of sensorimotor dysfunction interfering with learning, viz., deficit in postural and bilateral integration. Its treatment can now be made more specific, adding to the delineation of the independent variable in future experimentation. Identification of this syndrome and determination of tests which best differentiate it will assist in matching of subjects in future research.

The experimental hypothesis of the study was not supported, but the use of the stepwise discriminant analysis has indicated which dependent variables are most apt to be influenced by the independent variable. The second most important contribution of this project lies in its clarification of those parameters which must be better controlled to enable a more acceptable experiment. The possibility of precise experimentation, however, still lies in the distant future.

References

Ayres, A. J. Patterns of perceptual-motor dysfunction in children: a factor analytic study. Perceptual and Motor Skills, 1965, 20, 335-368.

Ayres, A. J. Tactile functions: their relationship to hyperactive and perceptual-motor behavior. American Journal of Occupational Therapy, 1964, 18, 6-11.

Dixon, W. J. (Ed.) Biomedical Computer Programs. Berkeley: University of California Press, 1965 and 1967.

Guilford, J. P. Preparation of item scores for the correlations between persons in a Q factor analysis. Educational and Psychological Measurement, 1963, 23, 13-22.

Head, H. Aphasia and Kindred Disorders of Speech, Volume I. Cambridge: University Press, 1926.

Hovland, C. I., Lumsdaine, A. A., and Sheffield, F. D. Experiments on Mass Communications. Princeton, New Jersey: Princeton University Press, 1949.

Kaiser, H. F. The varimax criterion for analytic rotation in factor analysis. Psychometrika, 1958, 23, 187-200.