The Effect of a Sensory Integration Program on Academic Achievement, Motor Performance, and Self-Esteem in Children Identified as Learning Disabled: Results of a Clinical Trial

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Abstract

A multicenter clinical trial was conducted to evaluate the effect of sensory integration therapy on the academic achievement, motor performance, and

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self-esteem of learning disabled children who have sensory integrative dysfunction. A sample of 67 children was randomized into one of two groups: sensory integrative (SI) and perceptual-motor therapy (PM). The Woodcock-Johnson Psychoeducational Battery, the Bruininks-Oseretsky Test of Motor Proficiency, the Behavioral Academic Self-Esteem Rating Scale, and the Personality Inventory for Children were administered before therapy, after 6 months of therapy, and 3 months following cessation of therapy. Both the SI and PM groups improved on academic and motor measures. No group differences were detected on any measure. The implications of the findings and possible interpretations are discussed and future studies suggested.

Learning disabilities are being identified in a rapidly increasing number of children (Feagans, 1983) in spite of the fact that the literature in the field has long been filled with contradictions about definition, cause, and treatment. The controversies can be attributed, at least in part, to the long recognized fact that the learning disabled (LD) population is not a homogeneous one. Much work is being done to identify subgroups in LD and, eventually, the treatment approach most appropriate to each (Satz & Morris, 1981). At present, effective treatment remains elusive (Feagans, 1983).

Ayres (1969, 1972a, 1976, 1978) has suggested there is a subgroup of LD children who have sensory integrative dysfunction and who require specialized sensory integration (SI) therapy to fully benefit from special education. Ayres has developed a battery of tests to identify these children (1972b, 1975). Ayres and others have provided some evidence to support the use of SI programs with LD children (Ayres, 1972c, 1976, 1978; Ottenbacher, 1982). A large number of therapists (predominantly occupational therapists working with LD children) have incorporated Ayres' theory into their understanding of LD and have made SI therapy a major component of their treatment program (Yack, 1989).

Given the need to identify LD subgroups, the possibility that the SI approach can both identify a subgroup and provide a treatment approach specific to it is very exciting and invites research. The widespread adoption of SI programming demands research into its efficacy.

This study examined the effect of SI programming on the academic achievement, motor performance, and self-esteem of LD children with sensory integrative dysfunction. The study improved on previous studies in the area by:

(1) using a larger sample with a clearer definition and description of the sample;

(2) including a placebo group;

(3) using blind evaluation of outcome; and

(4) providing follow-up data.

Ayres views learning and behavior as the observable aspects of sensory integration, where SI is defined as the organization and processing of sensory stimuli required for the organism to make an adaptive response to the environment (Ayres, 1972a). The development of normal cognition is considered to depend on the adequate integration of the sensory systems, particularly the vestibular, tactile, and proprioceptive systems (Clark & Shuer, 1978).

SI theory suggests that the enhancement of SI can be achieved when the sensory modalities are used singularly, or in combination, to elicit an adaptive response. It is thought that when such activities are graded according to the child's motor skills and ability to tolerate sensory stimulation, an adaptive response is facilitated. This response helps to organize the nervous system.

Ayres' theory was formulated from existing evidence in neurobiology, phylogenetics, and growth and development. While there has been little attempt to systematically validate SI theory, one specific hypothesis emanating from SI theory and research, the vestibular dysfunction hypothesis, has been tested by independent groups. Ayres' theory placed a great deal of importance on the role of the vestibular system (Clark & Shuer, 1978). Indeed, in a 1978 study, Ayres concluded that it was some disorder in the vestibular system that significantly interfered with normal academic learning.

Servello (1982) found some evidence for vestibular-based dysfunction in some subgroups of LD children. However, he employed the Southern California Postrotary Nystagmus Test, prone extension posture, and standing balance as measures of vestibular-based functions. The validity of the first of these measures, as a test of vestibular function, has been questioned by some (Law & Polatajko, 1987; Polatajko, 1983; Royeen, Lesinski, Ciani, & Schneider, 1981), and the remaining measures are all *indirect*, not specific for vestibular dysfunction (Lee & Chasin, 1975). Further, Servello compared special education children to normal peers; thus, his study does not provide a direct test of the hypothesis.

Polatajko (1982) investigated vestibular function and its relationship to academic learning in a group of 40 normal children and 40 LD children. No evidence was found to support the vestibular dysfunction hypothesis (i.e., that vestibular dysfunction was related to academic problems). Polatajko concluded that the vestibular dysfunction hypothesis could not be accepted, the relationship between academic learning and vestibular function was weak, and, consequently, the use of SI therapy in the remediation of learning disabilities required careful study. A similar study by Brown et al. (1983) had the same results.

In another investigation of vestibular function, Polatajko and Sullivan (1987) have undertaken a preliminary study of body sway during upright standing among LD children. Upright posture is a product of the close interaction of the vestibular and proprioceptive systems. While sway differences between normal and LD children were observed, sway patterns suggested the differences were not due to vestibular dysfunction. Rather, the pilot data indicated that the differences in sway may be related to proprioceptive function. Servello's (1982) data could be interpreted to support this notion—indeed, so could much of the data frequently cited to support the vestibular dysfunction hypothesis (Polatajko, 1982).

According to SI theory, successful therapy should result in the normalization of sensory processing and, in turn, facilitate the normal acquisition of higher, dependent, cortical functions such as reading. The major support for SI therapy has been provided by outcome studies. Various outcome measures have been used to examine the effects of SI therapy on children identified as LD or at risk for LD. These include: dichotic listening (Kawar, 1973); changes in nystagmus or ocular fixation (Ottenbacher, Short, & Watson, 1979; Ottenbacher, Watson, Short, & Biderman, 1979); aspects of motor changes (Jenkins et al., 1982; White, 1979; Wilson, 1979); and language and academic changes (Ayres, 1972c, 1978; Ayres & Mailloux, 1981; d'Angelo, 1980; Grimwood & Rutherford, 1980; Wilson, 1979).

While all the studies cited above, including Ayres', suggest positive outcome, they suffer from numerous methodological flaws. A detailed review of Ayres' studies by Schaffer (1984) points to inadequate sampling and matching procedures, possibility of tester bias, and lack of control for placebo effect. Therefore, they cannot be considered to provide support for Ayres' theory. The remaining studies cited have similar problems, making reliable interpretation of their results impossible.

Carte, Morrison, Sublett, Uemura, & Setrakian (1984) carried out a careful replication of previous research on the effects of SI. No systematic effects on the dependent variables, related to perceptual processing and academic performance, were discernible. However, the sample of LD children was non-clinical and, therefore, did not reflect the child typically seen in therapy. Furthermore, the definition of LD was atypical, ".04 standard deviation discrepancy between the estimated level of intelligence and the level of academic achievement in either spelling, arithmetic, or reading (decoding) as measured by the WRAT"(Carte et al., 1984, p. 190). Finally, the mean age of the group (102.5 months) was above the ceiling (95 months) for the Southern California Sensory Integration Tests (SCSIT), the instruments used to identify sensory integrative dysfunction. Thus, the therapy may have been inappropriately applied. Again, the results are difficult to interpret.

Based on the foregoing review, one is forced to conclude that SI remains a promising, but invalidated, intervention technique—one that warrants careful examination.

Method

Design

Initially, a randomized, clinical trial using blind evaluation was designed to compare three interventions: sensory integration therapy (SI), perceptual-motor training (PM), and no intervention. However, the early subject accrual rate was somewhat problematic. Although large numbers of children were being referred to occupational therapy (OT), a considerable proportion were not entering the study. This seemed to occur for two reasons. First, parents were reluctant to enter their children in a trial where "no treatment" was a possibility. Given that no treatment is not a typical clinical recommendation after a diagnosis of sensory integrative dysfunction, and on the advice of epidemiology colleagues, the control group was dropped in May 1986. Accordingly, the study was reconstructed as a two-group trial; the control group data were treated as pilot data to be used for hypothesis generation. Thus, the specific research question to be addressed in this paper is:

> Is there a difference between the effects of a 6-month occupational therapy program using a SI program and one using a PM program in improving academic achievement, motor performance, and/or self-esteem in LD children with sensory integrative dysfunction?

The second factor proving problematic in the rate of accrual was the proportion of referred children being diagnosed as having a sensory integrative dysfunction. Since the percentage of children who met the SI criteria was considerably lower than expected, and since the rates differed greatly among centers, it was decided to investigate this phenomenon. The question was whether the observed differences were due to differences in types of referral or in diagnostic criteria used by the therapists. A double-blind study was conducted to investigate the consistency of diagnosis of SI dysfunction across therapists. The percentage agreement for the identification of SI dysfunction was 100%. Thus, it was concluded that differences in percentages of children across centers were due to the differences among centers in referral sources and types of children referred. No further action was taken on this issue.

Sample

The sample consisted of children who had been referred to occupational therapy for learning difficulties. Seven centers across southwestern Ontario participated in this trial. Children included in the trial:

1. were referred to OT for problems related to their learning disability, that is, poor gross and/or fine motor function, poor coordination, poor attention span;

2. were between 6 years and 8 years, 11 months at intake;

3. were identified as having a sensory integrative dysfunction, as determined by a therapist certified in the administration and interpretation of the SCSIT (Ayres, 1972b), the Southern California Postrotary Nystagmus Test (Ayres, 1975), and clinical observations;

4. were of normal intelligence (IQ $\geq$ 80) based on the Slosson Intelligence Test (Slosson, 1983);

5. had an academic delay of:

at least 6 months in reading, mathematics, and/or written language performance for the 6-year-olds, and at least 1 year in reading, mathematics, and/or written language performance for the 7- and 8-year-olds as measured by the Woodcock-Johnson Psychoeducational Battery (WJPEB) (Woodcock & Johnson, 1977);

or

a 1-standard deviation discrepancy between potential (IQ) and performance (academic skill); and

6. had parental consent.

Children were excluded from the trial if they:

1. demonstrated a neurological, sensory, or emotional disturbance (e.g., cerebral palsy, seizure disorder, hearing impairment, autism) diagnosed by a hospital team;

2. had received or were receiving SI therapy; or

3. demonstrated any medical contraindications to sensory integrative therapy (e.g., congenital heart problems) as determined from the medical history.

Intervention

The intent of the intervention model was to reflect the practice of SI therapy in a typical OT clinic. There was no attempt to simulate ideal conditions or to maximize dosage. The only restrictions were a mandatory termination of therapy after at 6-month period and randomly assigned group placement. Accordingly, both groups received 1 hour of therapy per week for 6 months, and then had a 3-month break from therapy before resuming any program.

The SI program used sensory modalities (e.g., scooter board, bolster swing) to elicit an adaptive motor response. Activities were graded according to the child's motor skills and ability to tolerate sensory stimulation.

The PM training used activities to increase PM function. These included table top activities, fine and gross motor activities, and eye-hand coordination tasks, but did not include any activities that were used in the sensory integration program.

To prevent cross-therapy contamination and ensure that the SI and PM treatments consisted of activities unique to each intervention, a treatment manual was developed at the outset of the study in consultation with the participating therapists. This manual, available upon request from the senior author, provided a comprehensive listing of activities typically used in OT and coded each as either an SI or PM activity. The therapists were restricted to activities outlined in the treatment manual. Further, the therapy sessions were recorded on specifically designed activity recording forms, and randomized checks by the investigators verified that therapy was within the treatment guidelines.

Process

Children referred to OT with learning difficulties were assessed by the therapist and the inclusion/exclusion criteria were checked. Parental consent was obtained and SI function was evaluated by a therapist certified in the administration of the SCSIT. If a SI dysfunction was identified, the research assistant (RA) administered the IQ test and the pre-test measures. The RA then verified all inclusion/exclusion criteria. Eligible children were stratified on two variables: severity of academic delay and center. Once stratified, children were randomly allocated to the treatment groups using a block randomization procedure. The RA reassessed the children at 6 and 9 months. Throughout the study, measures were taken to ensure that the RA was not aware of the group status of the children. As well, the RA had no previous knowledge of the study and was not an occupational therapist and, therefore, had no preconceived ideas about the study or expected results.

Outcome Measures

Academic ability, motor proficiency, self-esteem, and subjective assessment were measured at 6 and 9 months. The WJPEB (Woodcock & Johnson, 1977) was used to measure academic ability. The subtests included were: reading cluster, mathematics cluster, written language cluster (dictation and proofing), general knowledge cluster (science, social science, and humanities), preschool cognitive cluster, and perceptual speed cluster (spatial relations and visual matching). Results for the latter three subtests will not be reported in this paper.

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) (Bruininks, 1978) was used to measure motor skills. This test included a measure of gross motor ability and fine motor ability as well as an overall score of general motor ability.

The Coopersmith Behavioral Assessment of Self-Esteem (BASE) (Coopersmith & Ragnar, 1982) and the Personality Inventory for Children (Part I)-Revised (PIC) (Wirt, Lachar, Klinedinst, & Seat, 1984) were used as effective measures of self-esteem. Part I of the PIC is summarized by four factor scales: undisciplined/poor self- control, social incompetence, internalization/somatic symptoms, and cognitive development.

A subjective assessment was added at the request of the therapists involved in the study. An anecdotal recording form was completed by the therapists in consultation with the parents at the end of 6 months of therapy. (These data have not yet been analyzed and will not be discussed here).

Results

Sample Size

Overall, 111 children of the appropriate age who had been referred to OT and had been found to have a sensory integrative dysfunction were referred to the study for IQ and academic testing by the RA. Twelve percent of these children did not meet the IQ criteria and fourteen percent did not meet the academic criteria. The final study sample included 80 children. Through the process of random allocation, 13 of these were assigned to the control group (results to be discussed in a future paper), 35 to the SI group, and 32 to the PM group. Thus, the

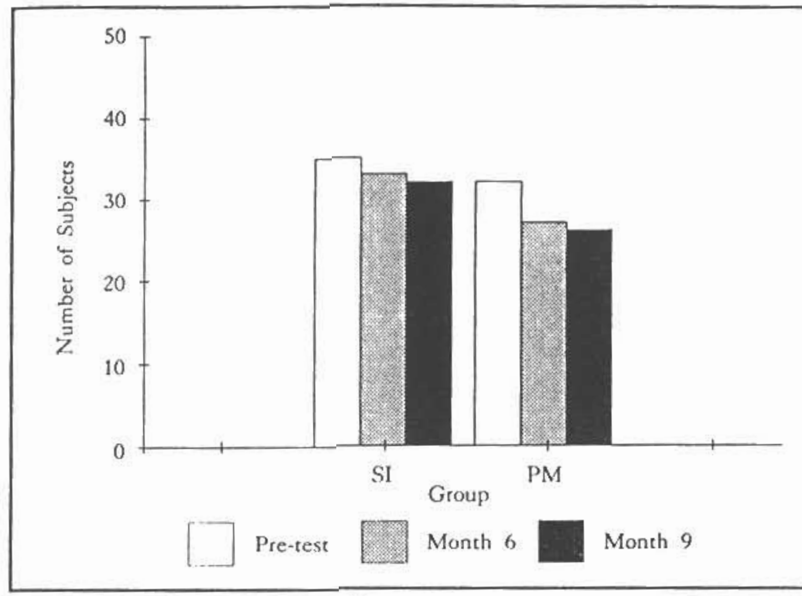

Figure 1. **Sample size decay for academic and motor measures for the SI and PM groups.**

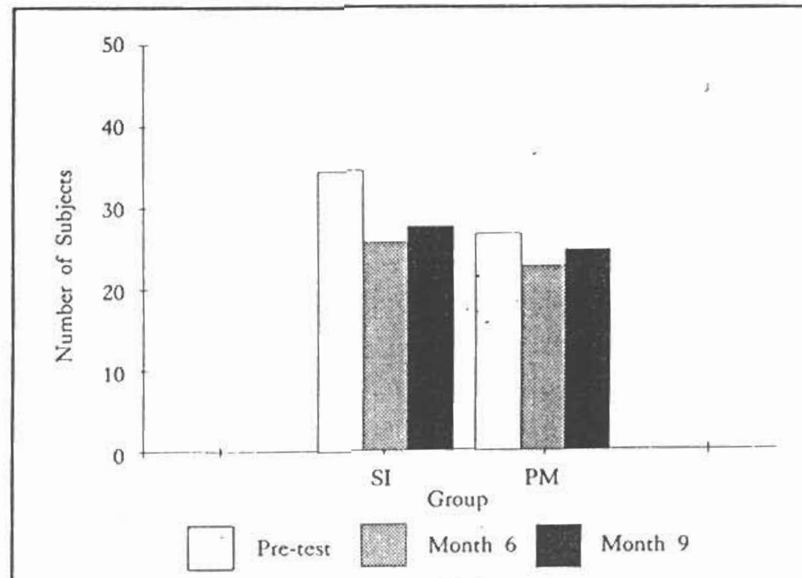

Figure 2. **Sample size decay for PIC for the SI and PM groups.**

results reported here are based on a total sample size of 67. The sample size decay was equivalent across groups and is presented in Figures 1,

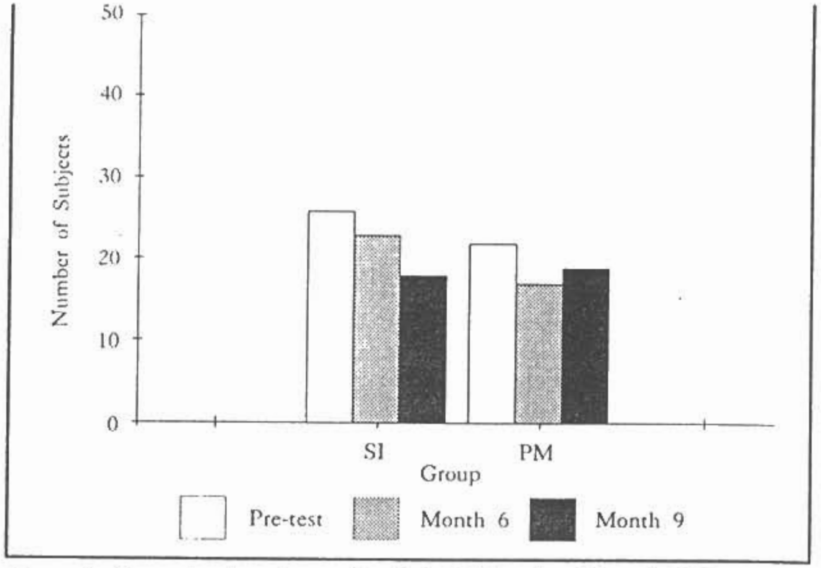

Figure 3. **Sample size decay for BASE for the SI and PM groups.**

2, and 3. Note the sample size decay for motor and academic variables was negligible. However, the decay for the self-esteem variables was more significant. This was due to the fact that administration was not under the direct control of the investigators. The self-esteem measures required teachers and parents to both self-administer the instrument and to send it into the project. Neither the parents nor, in particular, the teachers, were very compliant.

Sample Description

The sample consisted of 58 boys and 9 girls. This ratio coincided with expectations from the literature. The mean age for the sample was 7.4 years (88.8 months, SD = 10.7, range 71-109 months). There was no significant difference between the groups in either age or sex distribution.

As per the intake criteria, all the children had a normal IQ (group x = 98.6, SD = 14.7, range 80-137) and a significant academic delay. Overall, the sample was 10 to 12 months delayed in reading, mathematics, and written language (Table 1). Once again, there were no significant differences between groups.

Also as per intake criteria, all the children had some type of sensory integrative dysfunction. Eighty percent of the children presented with a motor delay. Overall, the sample was delayed by 1 year in motor function, with fine motor delays being greater than gross motor. This finding was well within expectations given a sensory integrative dysfunction was an inclusion criterion. There were no group differences.

Table 1
Sample Description

Group		IQ	$\bar{X}$ Age	Reading Age	Math Age	Written Age
Overall	67	98.60	7-4	6-5	6-6	6-4
SI	35	100.97	7-3	6-5	6-6	6-4
PM	32	95.68	7-6	6-5	6-5	6-4

In terms of self-esteem, 57% of the children had low self-esteem, as measured by the BASE, and only one child (2%) had high self-esteem. Again, this is not unexpected, given that the BASE represents academic self-esteem and that all the children were experiencing academic difficulties. On the PIC, the children performed within the normal range in three of the four factors: undisciplined, social incompetence, and internalization. On the cognitive development factor, the groups scored at a clinically significant level (2 standard deviations above the mean). Again, no group differences were noted. Only the treatment effects on BASE scores and the latter PIC factor are of any interest. These will be reported in this paper.

A more thorough description of the entire sample appears in Schaffer, Law, Polatajko, and Miller (1989).

Treatment Outcome

Figures 4, 5, and 6 show the mean group WJPEB cluster scores for reading, mathematics, and written language, respectively, at each of the three testing times relative to the standardization sample norms. Table 2 summarizes the data. As is evident from these figures, both groups showed significant improvement on all academic scales both at 6 months and 9 months.

Figure 7 shows the BOTMP composite score for motor performance for both groups at the three testing times. While this figure would suggest no change in performance, it should be noted that the BOTMP scores are age-adjusted; thus, no change suggests a growth rate similar to the standardization sample. This point is demonstrated by inclusion of the instrument standardization sample (normals) scores in Figure 7. Both groups either maintained the growth in motor performance

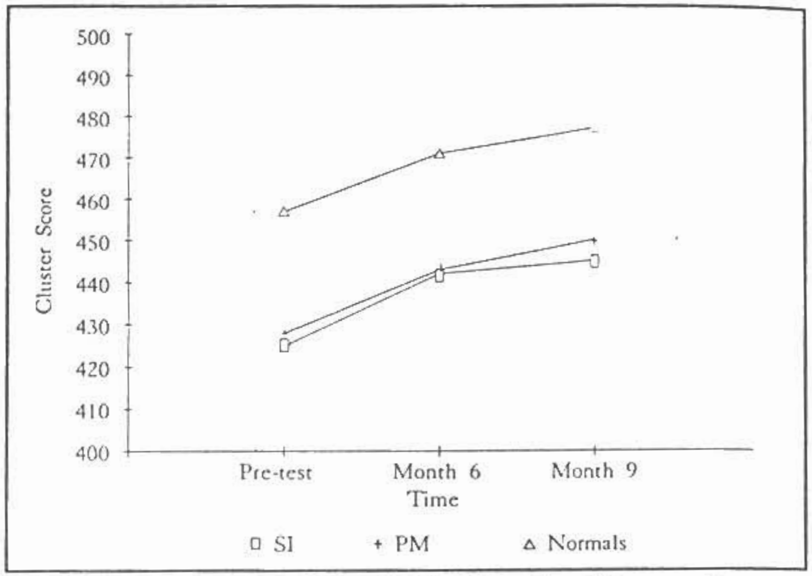

Figure 4. **Woodcock-Johnson Psychoeducational Battery Reading Cluster Scores for the SI and PM groups and the standardization sample (Normals).**

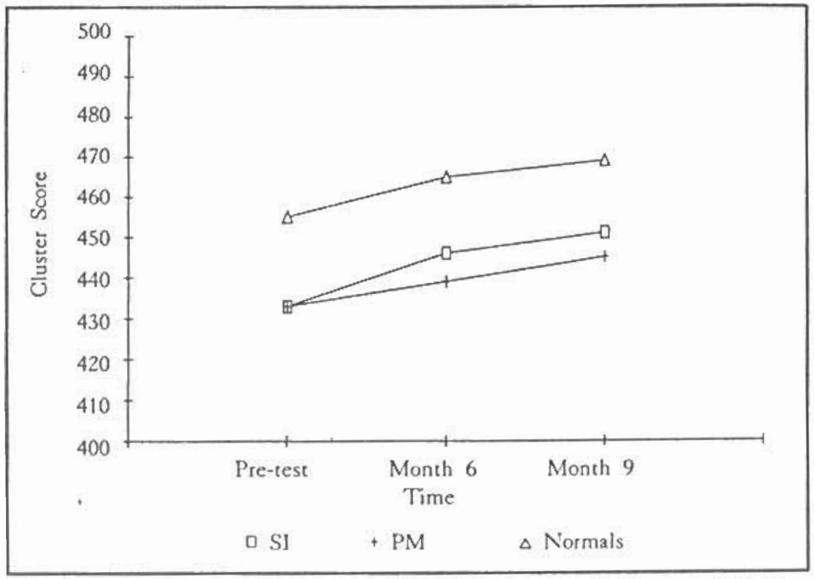

Figure 5. **Woodcock-Johnson Psychoeducational Battery Mathematics Cluster Scores for the SI and PM groups and the standardization sample (Normals).**

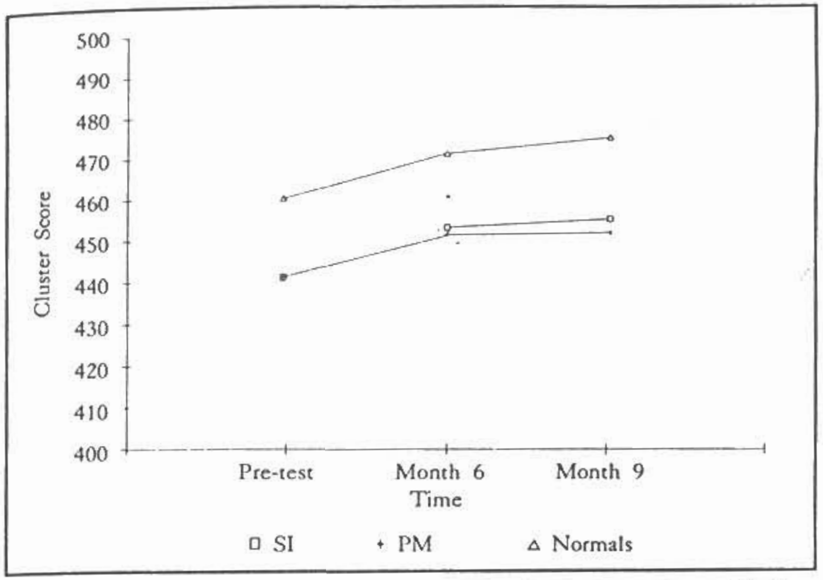

Figure 6. **Woodcock-Johnson Psychoeducational Battery Written Cluster scores for the SI and PM groups and the standardization sample (Normals).**

demonstrated by the standardization samples (i.e., actually improved in motor performance) or improved significantly over pre-test scores at 6 and 9 months.

In the area of self-esteem (Figures 8 and 9 and Table 3) the SI group showed significant improvements on the BASE both at 6 and 9 months None of the other measures showed any significant changes. The PM group showed no significant changes on any measure between pre- and post- or pre- and follow-up testing.

Group Differences

Academic. While all children improved, as is evident from Table 2, there were no significant differences between the SI group and the PM group in the amount of improvement in reading, mathematics, or written language ability immediately after treatment (at 6 months) or at follow-up (at 9 months). It should, however, be noted in the case of mathematics the p values (p = .054 at 6 months and .058 at 9 months) are very close to significance and, indeed, if a one-tailed test were used SI would be significantly better than PM

Mean Pre-test, 6-Month, and 9-Month Scores and (Standard Deviations) on Academic and Motor Measures for the SI and PM Groups and F(p)* Values for Group Differences

		Pre-test SI($n=35$) PM($n=32$)	6 Months SI($n=33$) PM($n=27$)	9 Months SI($n=32$) PM($n=26$)
	Academic Measures (WJPEB)			
Reading Cluster	SI	425.46 (27.88)	443.39 (31.83)	449.78 (30.90)
	PM	428.60 (30.82)	444.37 (30.91)	452.77 (27.20)
			F = .176 ($p=.677$)	**F = .117** ($p=.734$)
Mathematics Cluster	SI	434.11 (26.57)	447.70 (26.22)	453.69 (22.62)
	PM	434.28 (26.42)	442.33 (23.44)	448.85 (26.83)
			F = 3.893 ($p=.054$)	**F = 3.763** ($p=.058$)
Written Cluster	SI	441.57 (24.29)	455.55 (21.00)	459.31 (22.80)
	PM	441.28 (17.50)	451.89 (20.52)	454.00 (24.45)
			F = 1.012 ($p=.319$)	**F = 2.167** ($p=.147$)
	Motor Measures (BOTMP)			
Fine Motor	SI	32.20 (10.01)	34.49 (12.15)	35.94 (10.81)
	PM	30.44 (11.85)	32.48 (13.23)	31.77 (13.36)
			F = .071 ($p=.791$)	**F = 1.247** ($p=.269$)
Gross Motor	SI	43.97 (13.45)	44.12 (13.31)	45.41 (12.04)
	PM	43.22 (14.03)	44.15 (14.26)	43.12 (13.65)
			F = .048 ($p=.827$)	**F = .299** ($p=.634$)
Battery Composite	SI	87.17 (23.42)	89.82 (26.31)	93.19 (22.97)
	PM	85.78 (27.24)	89.18 (27.91)	87.65 (28.48)
			F = .003 ($p=.955$)	**F = .723** ($p=.399$)

WJPEB = Woodcock-Johnson Psychoeducational Battery
BOTMP = Bruininks-Oseretsky Test of Motor Proficiency
*Age, IQ, and Pre-test score used as covariates for each variable

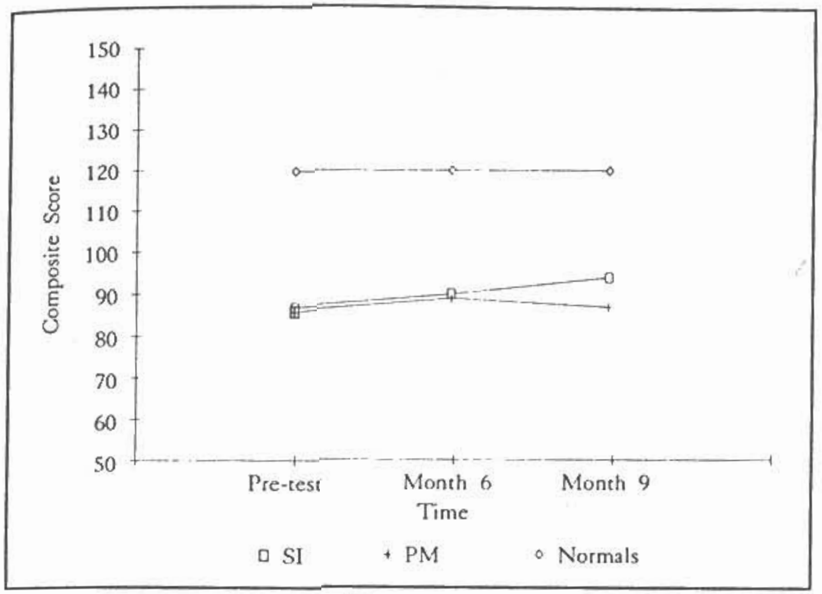

Figure 7. **BOTMP Battery Composite Scores for the SI and PM groups and the standardization sample (Normals).**

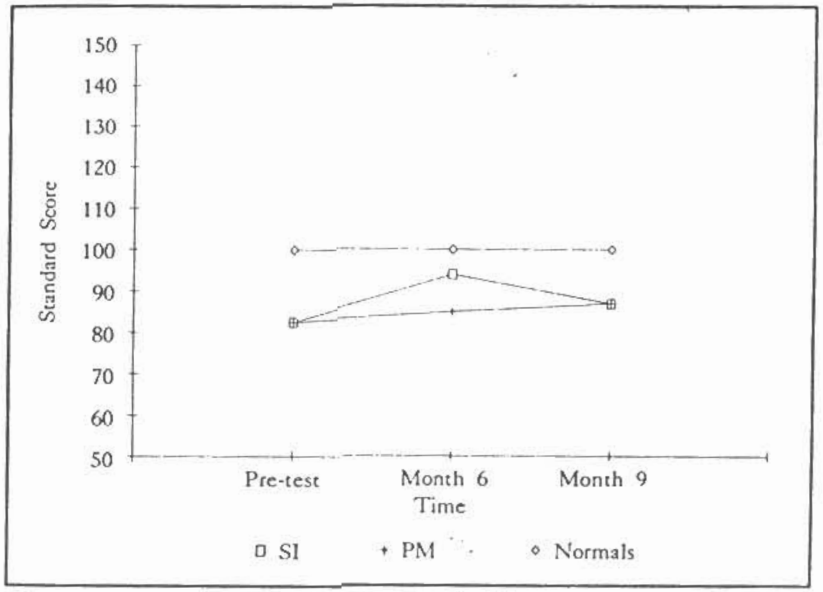

Figure 8. **BASE Standard Score for the SI and PM groups and the standardization sample (Normals).**

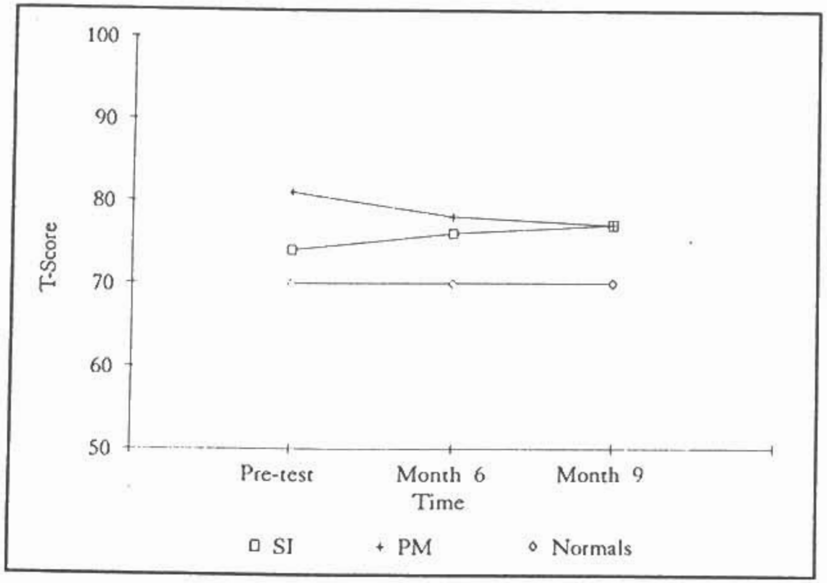

Figure 9. **PIC-F4 Scores for the SI and PM groups and the standardization sample (Normals).**

at improving mathematics, both immediately after treatment (at 6 months) and at follow-up (at 9 months).

Motor. There were no significant differences between the two groups in motor performance, on the Battery Composite Score (Figure 6) or on the fine motor or gross motor subtests at treatment post-test or at follow-up (Table 2).

Self-esteem. There were no significant differences between the groups at either 6 or 9 months (Table 3).

Discussion

In terms of overall outcome, both groups were noted to improve on academic and motor scales. Self-esteem, as measured by the BASE, showed significant improvement among the SI children; otherwise, no significant changes were noted in self-esteem. In terms of group differences, none were found between the effects of SI and PM treatment on reading, mathematics, written language, motor performance, or self-esteem in LD children with SI dysfunction.

The implications of the failure to find a differential effect for SI and PM could suggest that either therapy is equally effective in improving academic and motor performance in LD children with SI problems and that therapists may choose the approach they prefer. Indeed, the results

Table 3

Mean Pre-test, 6-Month, and 9-Month Scores and (Standard Deviations) on BASE and PIC-I for the SI and PM Groups and F(p)* Values for Group Differences

		Pre-test	6 Months	9 Months
Base		SI(n = 26) PM(n = 22)	SI(n = 23) PM(n = 16)	SI(n = 18) PM(n = 19)
Standard Score	SI	81.46 (15.69)	94.01 (15.91)	87.44 (15.17)
	PM	82.32 (12.54)	86.06 (11.19)	86.84 (13.23)
			F = .090 (p = .767)	F = .214 (p = .647)
PIC-I		SI(n = 35) PM(n = 27)	SI(n = 26) PM(n = 23)	SI(n = 28) PM(n = 25)
Cognitive Development	SI	74.14 (17.78)	76.31 (20.32)	76.82 (17.08)
	PM	80.93 (20.17)	78.39 (18.52)	76.60 (14.49)
			F = .842 (p = .364)	**F = 1.644** (p = .206)

*pre-test score used as the covariate

might suggest, as seems to be the clinical wisdom (Yack, 1989), that the two approaches can be used in combination. However the latter suggestion would require further testing because this study does not address that hypothesis. The results might even suggest that the distinction made between SI and PM tasks is artificial—an interpretation that may warrant discussion by the theoreticians.

On the other hand, the results of this study might be interpreted to suggest that neither approach has an effect on academic and motor performance and that the observed changes should be attributed to normal growth and development. Indeed, the groups did, on visual inspection (Figures 4 through 7), seem to improve at a rate comparable to the standardization sample. Actually, Figure 7 suggests that improvements in motor skills were larger than normal growth and development for both groups at 6 months and for the SI group at 9 months. While the "normal growth and development" interpretation can only be addressed with statistical inspection of the experimental changes relative to the "normal" changes (to be discussed in a future paper), it should be noted that maintaining normal growth and development is a significant outcome for these children. Both groups had significant academic and motor delays at the outset; that is, before treatment they did not experience normal growth and development.

Given a finding of no difference between two treatment approaches in any study, it is very difficult to distinguish between treatment effects and a variety of other possibilities including normal growth and development. In such a case, control group data become very important. As indicated above, pilot control data were collected in the early phases of this study. These data will be explored, keeping in mind the inherent limitations of the small sample size, and presented in future publications.

Whenever a study fails to find expected differences possible sources of error must be addressed, especially when, as is the case here, clinical impressions would suggest clinical gains were made. One important source of error could be the sample. The sample here was specifically chosen to be reasonably homogeneous (i.e., all the children had a learning disability and a sensory integrative dysfunction) and to reflect samples in other studies of SI effectiveness. Also, the groups did not differ significantly on any of the intake criteria or any of the pre-test measures. Nevertheless, the possibility exists that the sample was indeed not homogeneous in some unknown way. For example, inspection of change scores in motor performance indicates that exactly half of the children improved at a greater rate than the normal rate of growth and development while half improved at a slower rate, suggesting these children may be different. Efforts to describe the differences between these children have been explored and are reported in the accompanying paper, Law, Polatajko, Schaffer, Miller, & Macnab (1991).

Another source of error is power. While at the time of the study design power calculations indicated that a sample of 30 would be sufficient to detect real differences, post hoc calculations proved differently for some of the outcome measures. This discrepancy occured primarily because some of the outcome measures yielded larger variances than had been predicted, while the effect sizes were smaller than predicted. Further study with a larger sample is indicated.

A larger study would be particularly useful in the case of mathematics where group differences did reach significance using the typical two-tailed test, but did reach significance using a one-tailed test. If this finding could be replicated with a larger sample it would prove interesting. The majority of the SI literature relative to LD children addresses the language area and very little is known about the effect of SI on mathematics. This finding would be particularly interesting in light of the fact that mathematics alone seemed to be differentially affected by SI and PM. This poses an interesting theoretical quandary, that is, why mathematics and not reading? Are they processed differently? How and why should SI affect one and not the other? These questions should be investigated in future work.

With any study based on group design it must be recognized that individual differences in response to therapy may be masked by the group results. Thus, it is important to investigate individual differences in response to therapy. As already noted above, half of the children improved their motor performance at a rate greater than normal growth and development would dictate, while half did not. Indeed, visual inspection of the raw data indicate that a number of children made great gains in therapy while others deteriorated. Thus, it is important to determine which children are responsive to therapy and which are not so that therapy may be given appropriately.

Conclusion

The results of this study suggest that SI and PM, when administered for 1 hour, once a week, for 6 months, are equally effective in improving academic and motor performance in children with learning disabilities associated with SI dysfunction. Neither approach appears to affect self-esteem significantly. Finally, the results indicate that further study is necessary, particularly with respect to mathematics. Investigators in future studies should include larger samples, control groups, and designs that allow for the inspection of individual differences in responsiveness.

References

Ayres, A. J. (1969). Deficits in sensory integration in educationally handicapped children. *Journal of Learning Disabilities, 2*, 160-168.

Ayres, A. J. (1972a). *Sensory integration and learning disorders*. Los Angeles: Western Psychological Services.

Ayres, A. J. (1972b). *Southern California Sensory Integration Test Manual.* Los Angeles: Western Psychological Services.

Ayres, A. J. (1972c). Improving academic scores through sensory integration. *Journal of Learning Disabilities, 5*, 338-343.

Ayres, A. J. (1975). *Southern California Postrotary Nystagmus Test.* Los Angeles: Western Psychological Services.

Ayres, A. J. (1976). *The effect of sensory integrative therapy on learning disabled children: The final report of a research project.* Research report supported by Center for Studies in Sensory Integration Dysfunction and Valentine-Kline Foundation, Los Angeles.

Ayres, A. J. (1978). Learning disabilities and the vestibular system. *Journal of Learning Disabilities, 11*, 30-41.

Ayres, A. J., & Mailloux, Z. K. (1981). Influence of sensory integrative procedures on language development. *American Journal of Occupational Therapy, 35*, 383-390.

Brown B., Portnoy, G. H., Yingling, C. D., Herron, J., Galin, D., & Marcus, M. (1983). Dyslexic children have normal vestibular responses to rotation. *Archives Neurologica, 40*, 370-373.

Bruininks, R. H. (1978). *Bruininks-Oseretsky Test of Motor Proficiency.* Circle Pines, MN: American Guidance Service.

Carte, E., Morrison, D., Sublett, J., Uemura, A., & Setrakian, W. (1984). Sensory integration therapy: A trial of a specific neurodevelopmental therapy for the remediation of learning disabilities. *Journal of Developmental and Behavioral Pediatrics, 5*, (4), 189-194.

Clark, F. A., & Shuer, J. (1978). A clarification of sensory integration and its application to programming with retarded people. *Mental Retardation, 16*(3), 227-232.

Coopersmith, S., & Ragnar, G. (1982). *BASE-Behavioral Academic Self-Esteem.* Palo Alto, CA: Consulting Psychologists Press Inc.

d'Angelo, J. K. B. (1980). Effects of sensory integrative treatment on low-achieving college students. *American Journal of Occupational Therapy, 34*, 671-675.

Feagans, L. (1983). A current view of learning disabilities. *Journal of Pediatrics, 102*, (4), 487-493.

Grimwood, L. M., & Rutherford, E. M. (1980). Sensory integrative theory as an intervention procedure with grade one "at risk" readers. *The Exceptional Child, 27*, (1), 52-61.

Jenkins, J. R., Sells, C. J., Brady, D., Down, J., Moore, B., Carmen, P., & Holm R. (1982). Effects of developmental therapy on motor impaired children. *Physical and Occupational Therapy in Pediatrics, 2*, 12-28.

Kawar, M. (1973). The effects of sensorimotor therapy on dichotic listening in children with learning disabilities. *American Journal of Occupational Therapy, 27*, 226-231.

Law, M., & Polatajko, H. (1987). Diagnostic tests in occupational therapy: A model for evaluation. *Occupational Therapy Journal of Research*, 7, 111-122.

Law, M., Polatajko, H., Schaffer, R., Miller, J., & Macnab, J. (1991). The impact of heterogeneity in a clinical trial: Motor outcomes after sensory integration therapy. *Occupational Therapy Journal of Research, 11*, 177-189.

Lee, S. P., & Chasin, W. D. (1975). Otologic Assessment. In L. J. Bradford (Ed.), *Physiological Measures of the Audio-Vestibular System* (pp. 13-36). New York: Academic Press.

Ottenbacher, K. (1982). Sensory integration therapy: Affect of effect? *American Journal of Occupational Therapy, 36*, 571-578.

Ottenbacher, K., Short, M. A., & Watson, P. J. (1979). Nystagmus duration changes of learning disabled children during sensory integrative therapy. *Perceptual and Motor Skills, 48*, 1159-1164.

Ottenbacher, K., Watson, P. J., Short, M. A., & Biderman, M. D. (1979). Nystagmus and ocular fixation difficulties in learning disabled children. *American Journal of Occupational Therapy, 33*, 717-721.

Polatajko, H. J. (1982). A critical look at vestibular dysfunction in learning disabled children. *Developmental Medicine and Child Neurology, 27*, 283-292.

Polatajko, H. J. (1983). Sensory integration theory: Principles of treatment [film review]. *Canadian Journal of Occupational Therapy, 50*, (4), 145-146.

Polatajko, H. J., & Sullivan, T. (1987). Postural sway responses in learning disabled children: Pilot data. *The Occupational Therapy Journal of Research*, 7, 37-51.

Royeen, B. C., Lesinski, G., Ciani, S., & Schneider, D. (1981). Relationship of the Southern California Sensory Integration Tests. The Southern California Postrotary Nystagmus Test and clinical observations accompanying them to evaluations in otolaryngology, ophthalmology and audiology: Two descriptive case studies. *American Journal of Occupational Therapy, 35*, 443-450.

Satz, P., & Morris, R. (1981). Learning disability subtypes: A review. In F. J. Pirozzolo & M. C. Wittrock (Eds.), *Neuropsychological and Cognitive Reading.* New York: Academic Press.

Schaffer, R. (1984). Sensory integration therapy with learning disabled children: A critical review. *Canadian Journal of Occupational Therapy, 51*, (2), 73-77.

Schaffer, R., Law, M., Polatajko, H., & Miller, J. (1989). A profile of learning disabled children with sensory integrative dysfunction referred for occupational therapy. *Physical & Occupational Therapy in Pediatrics, 9*, 101-117.

Servello, M. B. (1982). Vestibular-based functions and behavior problems of children in special education and regular classes. *Perceptual and Motor Skills, 55*, 1289-1290.

Slosson, R. L. (1983). *Slosson Intelligence Test (SIT) and Oral Reading Test (SORT) for Children and Adults.* East Aurora, NY: Slosson Educational Publications.