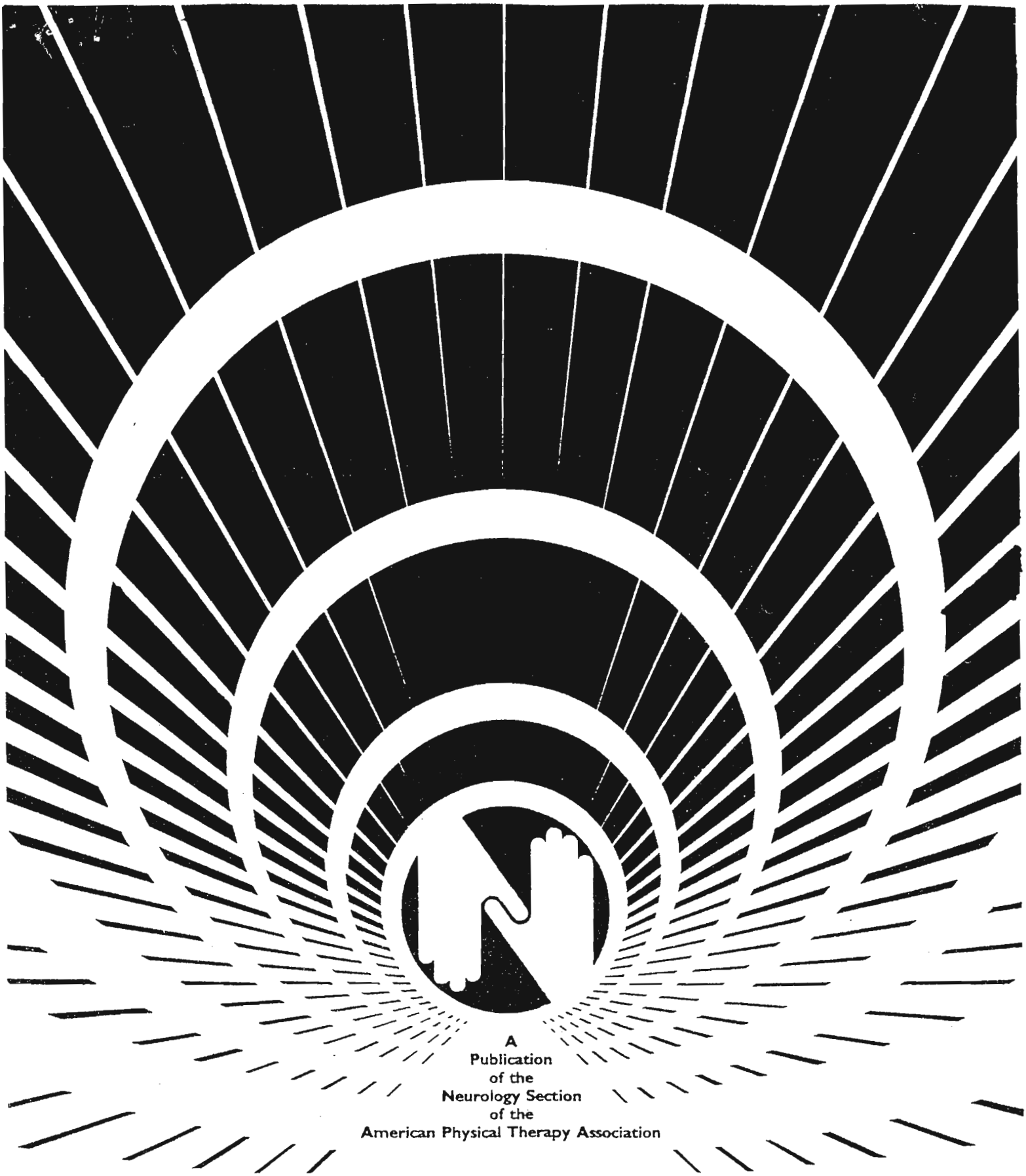

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NEUROLOGY REPORT

USE OF NEUROTRANSMITTER MODULATION TO FACILITATE SENSORY INTEGRATION

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Use of neurotransmitter modulation to facilitate more normal motor, sensory, and perceptual functions has been a topic of laboratory research for several years. Iversen's article in Scientific American's THE BRAIN published in 1979 (1) presents an excellent synopsis of the scope and clinical implications of neurotransmitter research available in the late 70's. More current studies reported by Wurtman (2) and Raskin (3) clarify the role of various neurotransmitter substances, specifically Serotonin, and GABA in the modification of sensory and motor functions.

Modification of neurotransmitter substances may be accomplished in several ways. Injections of laboratory animals and application of minute amounts of electrical current administered transcranially, have been the methods of choice according to historical accounts. We were made aware of this novel approach to modification of motor functions by local referring physicians. With the approval of the Institutional Review Board of our local rehabilitation hospital, we chose to use transcranial applications with a small portable unit. The unit selected provided 1 milliamp of current and was felt to be the most non-invasive way to obtain the desired results. The particular unit used was designed by the Pain Suppressor Labs, Inc. of Elmwood Park, New Jersey. Their unit was known to increase levels of Serotonin and GABA in transcranial applications(4), and was acknowledged for this use by federal authorities.

We were extremely encouraged by the findings of our first pilot study reported by Joan Malden(5), which cited the reduction of spasticity and an increase in the rate of motor learning in children receiving transcranial application of the unit in ten minute dosages, twice daily in conjunction with their regularly scheduled therapies. Of particular interest to us was our clinical observations of a significant increase in attentive behaviors, bilateral use of the upper extremities, hand function, and ocular motor control that occurred with regularity for most of the youngsters using the units. Their resulting pattern of behavior was strikingly similar to the clinical result obtained from use of a sensory integrative approach to treatment. In short, we felt that the increased levels of Serotonin that attended transcranial application of the NTM was facilitatory to processes of sensory integration at brain stem, midbrain, and cortical levels. Since most of the clients in the former study were infants and preschoolers for whom no standardized measures of attention, visual perception, or hand function could be obtained, a decision to include only primary school aged children through and young adults in the study was made. Our purpose was to determine whether or not a detailed large scale investigation of the effects of NTM on sensory integrative processes would be justified.

MATERIALS AND METHODS

A small sample size was chosen to initiate this Pilot Study. Our initial objective was to investigate the possibility of functional correlations existing between transcranial applications of NTM and daily living skills. Due to a lack of clinical evidence from related rehabiltation fields, a small sample size was chosen to initiate this Pilot Study.

A total of 16 patients were included in the study. Ages ranged from 5 to 25 years old. Diagnoses of all patients reflected neurological involvement ranging from Minimal Cerebral Dysfunction to Cerebral Palsy, Spastic Quadriplegia. The socio-economic backgrounds of the patients ranged from lower middle to upper classes, and included all major ethnic groups. Because of our desire to quantify any improvement in perceptual function, only patients with intelligence testing within borderline,. normal, and superior ranges were included in this study.

GROUPING

The patients were then evaluated and divided into three groups. Those who were receiving Physical Therapy, but not Occupational Therapy were grouped together as Group 1. The patients in Group 1 received consultative Occupational Therapy services only at the conclusion of the initial evaluation. At this time, specific recommendations were made regarding therapeutic exercises and/or activities that should be performed on a daily basis to aid in remediation of the perceptual deficits shown by the pre-test measures. In addition, patients in group 1 were given a Neurotransmitter Modulator (NTM) unit to use twice daily, and were instructed in its' application. Patients who would

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benefit from Occupational Therapy, as determined by physicians prescription and therapists' evaluation were then randomly grouped into two further groups. The patients in Group 2 received Occupational Therapy weekly, and a home program, and a home program to be carried out daily but no NTM. The patients in Group 3 received Occupational Therapy weekly and a daily home program. They also were given a NTM unit, and instructed in its' application twice daily.

INSTRUMENTS

Two subtests from the Southern California Sensory Integration Tests(6) and two subtests from the Jebsen Hand Function Test (7) were chosen for use in the evaluation procedures. The design copying subtest of the SCSIT was chosen because as a paper and pencil test it combined measure of fine motor skill, motor planning, and spatial perception. These skills subserve form and space perception as well as praxis(8). The Motor Accuracy subtest of the SCSIT, in its' revised form was chosen because it allows for a quantifiable measure of fine eye-hand coordination, as well as a clinical measure of ocular motor control.

The card Turning subtest from the ebsen, which simulates page turning, was chosen as a representative sample of a daily living task that emerges fairly early in the development of hand function skills (9). This was a task that could be accomplished with minimal patterns of gross grasp and wrist rotation normally available at the 18 month level of development. The Simulated Feeding subtest of the Jebsen was chosen as a representative sample of a higher level hand function task that emerges later on in the developmental continuum. In addition, these subtests also had good test-retest validity.

Procedure All participants received and initial evaluation consisting of a developmental gross motor assessment and the four subtest previously described. All tests were administered as specified by their protocols. In addition, four participants were randomly selected for videotape analysis so that a longitudinal record of their progress could be maintained. All participants were then grouped as previously described. A decision was made early on in the development of the study not to include a placebo group. The nul result of placebo effect in use of transcranial application of the NTM unit had already been documented during our prior study of thirty handicapped youngsters (10). In order to assure compliance with the experimental design, contact with parents or significant others was maintained throughout the duration of the study. Two retests were conducted at six week intervals. For those clients whose retest results seemed unduly contaminated by social factors (holiday and birthday celebrations resulting in not enough sleep, gorging on sweets, ets) a third retest session was scheduled and the final score was substituted for the contaminated score.

During the course of the study, therapists involved in treatment of patients in Group 1 were not appraised of test results. Parents of clients in Groups 2 and 3 who specifically requested feedback about test results were told that these would be shared at the conclusion of the study.

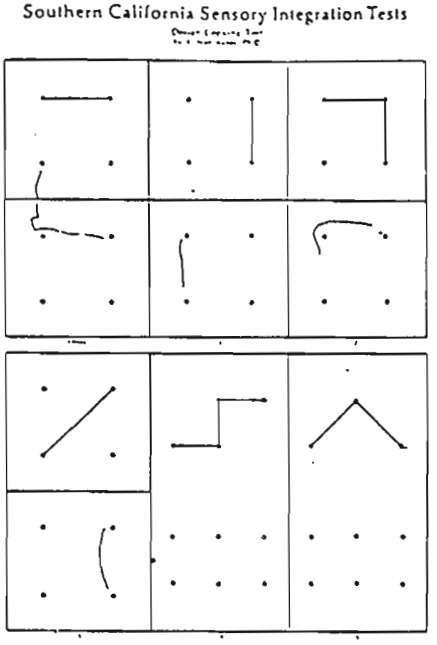
The patients in groups 2 and 3 received regularly scheduled occupational therapy treatments. Treatment sessions lasted between 30 and 40 minutes each and tended to be divided into traditional sensory integrative and table top activities. The sensory integrative portions of treatment involved use of a large gymnastic ball to stimulate the vestibular apparatus and subcortical motor patterns of body righting, reciprocity among the extremities, and tonic stabilization. A climbing apparatus, and use of a "Sit 'n Spin" were also used to stimulate more normal patterns of response to temporospatial orienting functions. The table top portion of each treatment session included chalkboard activities, task oriented clay play for both unilateral and bilateral hand functions, and use of assorted manipulatives to stimulate development of bilateral reciprocal hand functions. Specific patterns of grasp and prehension were rehearsed through use of developmental toys. Constructional items were also used to encourage exploration of emerging spatial, motor sequencing, pattern duplication, and manipulative skills. In addition, as with all other patients involved in Occupational Therapy at our facility, the daily home program specifying use of particular pieces of equipment was reviewed weekly. Most of the patients spontaneously requested use of our library of equipment which was developed to encourage compliance and to discourage resistance to the home program on the part of the child. Activities that would tend to replicate tasks included in the formal assesments were specifically avoided.

Raw data was reported on the protocol sheets provided in the SCSIT kit, and also on specially prepared data sheets. Upon conclusion of the study, the data was tabulated and graphed to asist in its' interpretation.

RESULTS

Our original decision regarding the use of a small sample was based upon a somewhat predetermined view that although differences found might have clinical significance, little statistical significance would be found. Upon conclusion of this study, we had reason to regret this original decision, Our results were based upon such a small sample size, that although clinical significance was apparent, a broader array of statistical differences among the groups was found by applying the T-Test (11). Design Copying: We considered the data from both clinical and stastical viewpoints. Clinically, we were impressed by the emergence of improved visuospatial skills during the initial six weeks of the study in the groups that were receiving use of the NTM. For example, figure 1-A shows the production of a 5.7 year old child with spastic right hemiplegia at the pretest trials. Figure 1-B shows her production at the first post test, taken six weeks later. We were impressed with the rate of improvement in terms of directionality and spatial organization.

Fig. 1-A



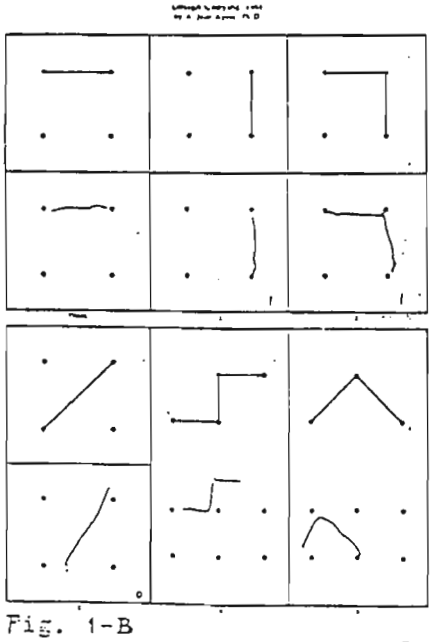


Fig. 1-B

A review of the spread sheet showing the pretest and post test scores of patients in groups 1, 2, and 3 (see fig. 1-C) was initially conducted for differences among the groups. It was noted that the percentage of change in design copying scores for patients in group 1 who used NTM, but no occupational therapy, averaged 59%. The percentage was determined by subtracting the pretest scores from the post test scores and then dividing the result by the pretest score. Although some patients in this group showed no change, the individual percentages of change were then averaged to determine a group average. The average percentage of change for group 2 who used occupational therapy, but no NTM, was determined in the same way. The average percentage of change in this group was 35%. The average percentage of change for group 3 (NTM with O.T.) was also determined in the same manner. The average percentage of change in group 3 was 88%. The graph in Figure 1-D shows this result. Statistical analysis showed a difference between Group 2 and group 3 (TT-6.672, p-.001). Both groups received occupational therapy, but Group 3 received occupational therapy and transcranial application of the NTM unit twice daily.

Motor accuracy: Examination of the raw test data showed a tremendous imporvement in the overall fluidity and continuity of line with patients in groups 1 and 3. The common factor among the two groups was the transcranial use of the NTM unit. For example, improvement in the overall smoothness and continuity of line can be seen by comparing Figure 2-A with figure 2-B. Figure 2-A shows the production of 5.8 year old child with Cerebellar Ataxia obtained during the pretest trials. Figure 2-B shows his production at the first post test, taken six weeks later.

NTM Pilot Design Copying Test

(a) Student	(b) Diagnosis	(c) C.A.	(d) Design Copying Pre Test	(e) Standard Score Mn -1 to +1	(f) Design Copying Post Test	(g) Standard Scores Mn -1 to +1	(h) Diff. (f-d)	(i) % Chg. (h/d)
Group #1								
Laura M.	Spas. Quad.	5.70	0	-1.80	2	- .70	2	2.00
Oscar M.	Spas. Heal.	21.11	11	-2.30	15	- .80	4	.36
Maria B.	Spas. Quad.	25.00	6	-3.80	6	-3.80	0	0.00
Tammy A.	Spas. Quad.	14.40	13	-1.40	13	-1.40	0	0.00
Averages Grp#1		16.55	8	-2.33	9	-2.23	2	.39
Group #2								
Rachel M.	M.C.D.	6.50	10	- .10	13	- .80	3	.30
Thomas M.	M.C.D.	7.10	9	-1.00	13	- .20	4	.44
Christopher M.	M.C.D.	7.30	14	- .20	13	- .20	-1	- .07
Christopher D.	M.C.D.	5.10	7	- .30	12	.70	5	.71
Averages Grp#2		6.70	10	- .40	9	- .13	4	.35
Group #3								
Matthew M.	Hypotonia	5.11	2	-1.40	6	- .70	4	2.00
Kevin M.	M.C.D.	9.20	8	-2.70	11	-1.80	3	.38
Jason L.	Spas. Quad.	10.50	3	-4.50	6	-3.80	3	1.00
Jennifer O.	Spas. Heal.	6.60	4	-2.00	6	- .30	2	.50
Nicholas L.	Cereb. Ataxia	5.90	4	-1.00	6	- .70	2	.50
Averages Grp#3		9.50	4	-2.32	6	-1.46	3	.88

Figure 1-C

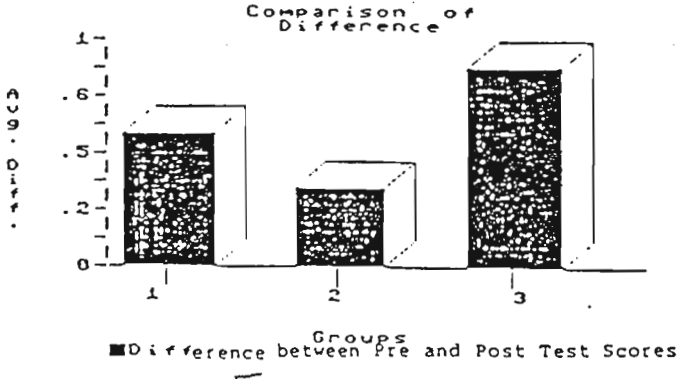


Figure 1-D

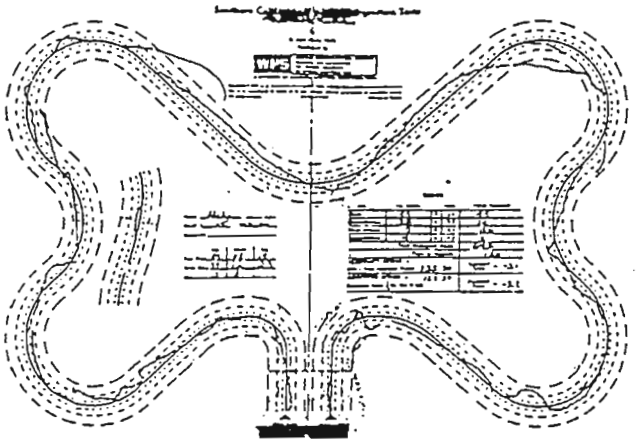


FIGURE 2-A

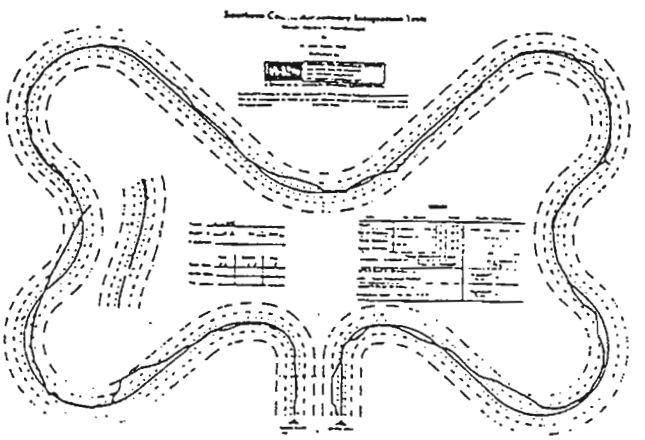


FIGURE 2-B

A review of the spread sheet showing the results of the Motor Accuracy Tests revealed a statistical difference between Group 2 and Group 3 in both upper extremities. (T-11.064, p-«.001) Again, both groups received occupational therapy, but Group 3 received occupational therapy and transcranial applicaton of the NTM unit. Little difference was noted between Group 1 and Group 2. This finding tended to support our supposition that neither use of NTM nor occupational therapy alone would produce so great a difference as seen when both forms of treatment are used together. In addition, clinical factors, such as the overall assthetic quality of kinetic melody, showed meaningful change in groups 1 and 3 as the study progressed.

Card Turning Test The data collected from this test was tabulated according to patterns of dominance among the patients. Although all patients showed improvement in their scores by a decrease in the amount of time required to complete the test, not all groups improved at the same rate or in the same manner. The percentage of change with patients in group 1, who used NTM but no occupational therapy, averaged 43% in their dominant hands and 21% in their non dominant hands. The patients in group 2 who used occupational therapy but no NTM, averaged a 15% change in their dominant hands, but a 45% change in their non dominant hands. The greatest percentage of change in both hands was found in group 3 who used NTM and occupational therapy. The patients in this group averaged 53% change in their dominant hands, and 68% change in their non dominant hands, (see figure 3). Statistical analysis showed that the greatest difference occurred between group 2 and group 3 in the post test scores with the non-dominant hand. (T-10.752, p-.001) Both groups received occupational therapy, but Group 3 received occupational therapy and transcranial application of the NTM unit.

NTM Pilot Card Turning Test

(a) Student	(b) Diagnosis	(c) Card Turn. Pre Test Dominant Upper Ext.	(d) Card Turn. Post Te Dominant U/E	(e) Diff. (c-d)	(f) % Chg. (e/c)	(g) Card Turn. Pre Test Non-dominant U/E.	(h) Card Turn. Post Te Non-dominant U/E	(i) Diff. (g-h)	(j) % Chg. (i/g)
Group #1									
Laura M.	Spas. Quad.	30	9	21	.70	66	45	21	.32
Oscar M.	Spas. Hemi.	5	4	1	.20	36	39	-3	- .08
Maria El.	Spas. Quad.	9	6	3	.33	21	16	5	.24
Tammy R.	Spas. Quad.	8	4	4	.50	9	4	5	.56
Averages Grp#1		13	6	7.25	.43	33	26	7	.21
Group #2									
Rachel W.	M.C.D.	11	8	3	.27	16	10	6	.38
Thomas W.	M.C.D.	10	7	3	.30	13	6	7	.54
Christopher M.	M.C.D.	8	5	3	.38	11	8	3	.27
Christopher O.	M.C.D.	6	8	-2	- .33	15	6	9	.60
Averages Grp#2		9	9	1	.15	14	7	6	.45
Group #3									
Matthew M.	Hypotonia	18	14	4	.22	16	9	7	.44
Kevin H.	M.C.D.	14	3	11	.79	26	2	24	.92
Jason L.	Spas. Quad.	14	7	7	.50	16	9	7	.44
Jennifer O.	Spas. Hemi.	8	5	3	.38	184	21	163	.89
Nicholas L.	Cereb. Atax.	41	9	32	.78	37	11	26	.70
Averages Grp#3		19	8	11	.53	56	10	43	.68

Figure 3

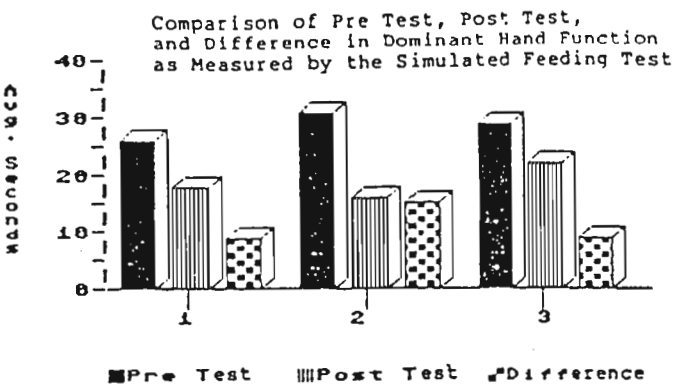


Figure 4-A

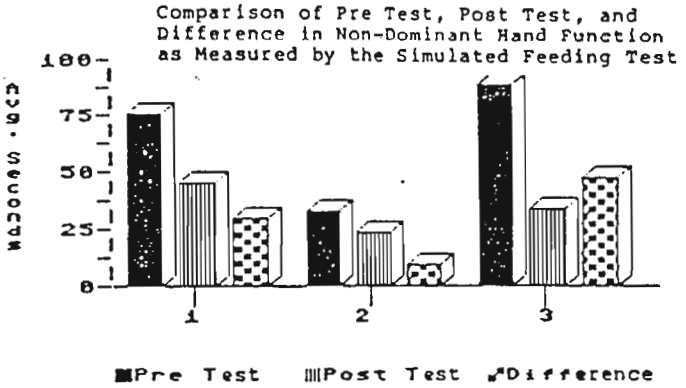


Figure 4-B

Simulated Feeding: The data collected from this test was also tabulated according to patterns of dominance among the patients. Again, while all patients showed improvement, not all groups demonstrated the same rate of change. As shown by Figure 4-A, the patients in group 2, who used occupational therapy but no NTM, showed the greatest difference between pre and post test measures in their dominant hands. The patients in group 3, who used both occupational therapy and NTM, showed the greatest difference between pre and post test measures in their non dominant hands (see Figure 4-B). Analysisi of the data from this test showed that the greatest statistical difference occurred in use of the non-dominant hand between group 2 and group 3 (T-14.499, p-«001) Both groups received occupational therapy, but group 3 received occupational therapy and transcranial application of the NTM unit.

DISCUSSION

The averaged group scores showed impovement in all of the areas tested to some degree. However, review of the spread sheets tended to show group trends and patterns which we felt were significant. When looking to see which group consistently tended to show the greatest rate of imporvement through all of the measures, it was obvious that group 3 who used both occupational therapy and NTM, had fared the best. This group tended to surpass the rate of improvement of the other groups by approximately 30% in Design Copying, and by greater than 20% in the non-dominant extemity and 10% in the dominant extremity in the Card Turning and Simulated Feeding Tests.

The results shown by the Design Copying Test were totally unexpected. When the scores were tallied, it could be seen that those clients in groups 1 and 3 who used the NTM Unit and who had initially been classed as having moderate impairment according to their standard scores,. moved to within normal limits in this skill in twelve weeks. This result, in our experience, usually would have required a minimum of 12 months of therapeutic intervention to achieve. Because the processes involved in performance of the Design Copying test also subserve math and reading competencies, we felt this result might have particular significance in treatment of the Learning Disabled.

analysis of the hand function tests also revealed trends that we felt were of clinical significance. We were primarily looking for patterns of improvement in both dominant and non dominant hand function because skill in self care requires bilaterality to some extent. In the developmentally lower task of simulated page turning as evaluated by the Card Turning Test, the averaged results of group 3, who used both occupational therapy and NTM, showed significant improvement in function of both upper extremities. In the developmentally higher task of Simulated Feeding, all groups showed significant gains in use of both upper extremities, including patients in group 1 who received no occupational therapy. We felt that the data in group 1 might have been skewed shomewhat because the average age of patients in this group turned out to eight years greater than the average age of patients in groups 2 and 3. Again, much greater improvement was seen in the groups using the NTM unit than in the group that received traditional occupational therapy alone.

The results shown by the Motor accuracy test were very obvious in terms of clinical judgement. The raw data produced by the groups using the NTM unit began to show a remarkable smoothness in overall production in the two post tests that simply was not apparent in the tests of the group that received occupational therapy alone. It seemed to us that the patients in groups 1 and 3 had improved in their ability to simultaneously monitor the dynamic internal changes occuring within proprioceptors located in muscles of the eyes, neck, trunk, and upper extremities, while motor planning in anticipation of changes that were likely to be required. This result showed improvement in the

ability to simultaneously integrate influences arising from cerebellar, reticular, basal ganglion, and cortical centers. We were impressed with this result because simultaneity is a factor of great significance in working with patients with Learning Disabilities, Cerebral Palsy, and other types of Central Nervous System dysfunction. (12) It is also, quite often, difficult to achieve.

CONCLUSION

The implications of the results of this study show a clear need for a larger, mor detailed investigation of the use of NTM as an adjunct to treatment in the facilitation of sensory integration processes. As a group, Cerebral Palsied children whose program included transcranial application of the NTM unit, showed significant gain in motor functions of their dominant extremities. This improvement was carried over into functional daily living skills. As a group, their visuospatial skills showed a more rapid increase in level of organization than could be anticipated with conventional treatment alone. This result may also have particular relevance to the treatment of children with Learning Disabilties, where visua-spatial skills are frequently impaired.

In conclusion, the results obtained when the NTM unit was applied did tend to parallel those obtained through use of an extensive course of sensory integrative treatment. However, when occupational therapy was applied in conjunction with transcranial application of the NTM unit, the results were more uniformly predictable, affected both dominant and nondominant upper extremities, and occurred at a much faster rate than heretofore possible. We found that those patients who 1- used the NTM unit, and 2- whose scores showed moderate impairment during pre test trials, improved to within normal limits in a 12 week period. We feel these findings were remarkable.

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