Measuring the Effects of Neurodevelopmental Treatment on the Daily Living Skills of 2 Children With Cerebral Palsy

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This study examined the short-term effects of neurodevelopmental treatment (NDT) on the motor performance of daily living skills in 2 girls with cerebral palsy, aged 27 and 32 months. For 12 weeks, the subjects received treatment sessions consisting of NDT followed by play, or vice versa. After each treatment of play or NDT, the subjects were videotaped performing individually prescribed dressing activities. Trained raters, unaware of the type of treatment given, scored the videotapes on ordinally scaled dressing criteria. The results were not statistically significant for NDT or play for any criteria. The importance of this study is its development and exploration of refinements in single-subject research methods that show promise for use in the documentation of treatment outcomes. Such refinements include the use of functional activity as an evaluation tool and ordinal scales for the assessment of change.

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Neurodevelopmental treatment (NDT), the neurophysiological treatment approach for central nervous system dysfunction developed by the Bobaths (Bobath & Bobath, 1964), is widely used in the allied health professions to treat young children with cerebral palsy. Occupational therapists in particular describe one goal of NDT as providing foundational patterns for the learning of such self-care skills as feeding, dressing, and washing. Studies attempting to document NDT's effects, however, have been unable to validate this treatment approach. Little research has been conducted on the carryover effects of NDT to functional abilities.

Literature Review

Traditionally, studies attempting to substantiate the use of neurophysiologically based treatment approaches such as NDT have examined their long-term effects. Research designs can be descriptive designs, contrast designs, or control group designs. Researchers using descriptive designs to examine the efficacy of therapeutic intervention have usually demonstrated positive change as a result of intervention (Kong, 1966; Norton, 1975). Similarly, the few researchers using contrast designs to compare the effects of a neurophysiologically based treatment with the effects of more traditional programs such as functional treatment or passive range of motion have supported NDT (Carlsen, 1975; Scherzer, Mike, & Ilson, 1976).

Most researchers employing the more rigorous control group designs, however, have usually not demonstrated favorable outcomes in children as a result of NDT. Wright and Nicholson (1973) randomly assigned 47 children with spastic cerebral palsy, aged birth to 6 years, to treatment and no-treatment groups. After up to 12 months of therapy, the experimental and control groups had made similar gains in passive ankle dorsiflexion, hip abduction, and loss of primary automatic reflexes. Sommerfeld, Fraser, Hensinger, and Beresford (1981) supported Wright and Nicholson's (1973) findings in their study of 29 severely mentally retarded children with cerebral palsy. Harris (1981) examined the performance of 20 infants with Down syndrome on the Peabody (Folio & DuBose, 1974) and Bayley (1969) tests before and after either receiving NDT or participating in an infant learning program. She found no statistically significant difference in favor of NDT except in the attainment of individual treatment goals. Likewise, d'Avignon, Noren, and Arman (1981) found no statistically significant differences in preventing uncomplicated cerebral palsy in 30 infants randomly assigned to experimental (physical therapy based on Vojta's [1976] or Bobaths' [1967] methods) and control groups. Finally, Palmer et al. (1988) randomly assigned 48 infants to groups receiving either 12 months of physical therapy based on NDT or 6 months of physical therapy based on NDT preceded by 6 months of infant stimulation. Using standardized measures of motor and mental quotients, they found a significant difference in favor of the group receiving infant stimulation before NDT.

In response to the mixed results of earlier studies, DeGangi, Hurley, and Linscheid (1983) addressed the development of a reliable method of measuring the short-term effects of NDT in children with cerebral palsy. They said that this type of measurement may permit researchers to control for some methodological difficulties that plagued previous studies examining the long-term effects of NDT. DeGangi et al. stated that "if there is no carryover immediately following a treatment session, the positive effects of NDT are debatable" (p. 483). Furthermore, this approach reflected Harris's research (1981), which suggested that NDT treatment effectiveness may be better assessed with individualized measures associated with therapy goals than with standardized motor assessments.

DeGangi et al. (1983) replicated a single-subject design with 4 subjects receiving NDT and nonspecific play over a 5-week period. Pretest and posttest items designed to reflect qualitative changes in movement, postural tone, and reflex activity were administered during each treatment session and videotaped for later scoring by trained psychology students. Interrater reliability was high. No significant improvements, however, were consistently observed with either NDT or play for any subject. Although the results of the study did not validate NDT, the examination of the short-term (as opposed to the long-term) effects of NDT via a single-subject design emerged as a promising approach to the evaluation of the efficacy of NDT techniques.

In the present study, we employed methods similar to those used by DeGangi et al. (1983). Our objectives were to (a) improve the methodology used to measure the short-term effectiveness of NDT, including the use of individualized therapy goals as the dependent measures, and (b) measure the immediate carryover effects of NDT and play intervention on dressing skills. We sought to address problems identified in previous research by such authors as Erhardt (1983) and Magrun, deBenabib, and Nelson (1983). These problems were insensitivity of test measures, brief length of study, and use of unskilled raters to observe videotapes of children with cerebral palsy. First, we chose to measure the changes in the quality of dressing skills in children with cerebral palsy. This evaluation was designed to reflect individualized treatment goals and to upgrade data from a nominal to an ordinal level of measurement. Whereas the raters in DeGangi et al.'s study had to identify specific categories of behaviors as present or absent (nominal scale) or had to time behaviors, the raters in the present study described behaviors on 3- to 5-point scales (ordinal scale) or counted the number of behaviors. Second, treatment and measurement in the present study occurred for 12 weeks instead of 5 weeks. Third, we used raters with experience in observing children with cerebral palsy.

Method

Subjects

A single-subject design was repeated with 2 female subjects selected from the patient population of an experienced NDT-certified occupational therapist. These subjects demonstrated appropriateness for treatment by the NDT approach and normal or near-normal intelligence with no secondary disabilities. The subjects, aged 27 and 32 months, had spastic diplegic cerebral palsy. Subject 1 had limited shoulder girdle mobility and trunk rotation; poor sitting balance; increased extensor tone in the lower extremities; and increased flexion, pronation, and ulnar deviation in the upper extremities. Subject 2 had limited trunk rotation, neglect of the right side with limited weight shift over the right side, dyspraxia, and ataxia.

Procedure

Subject 1 received NDT once a week and Subject 2, twice a week, for 12 weeks. For six of these treatment sessions, each subject received 20–25 min of NDT and 20–25 min of play intervention and completed pretesting and posttesting. For all other sessions, each subject received NDT for 45 min. Subject 1 received a total of 390 min of NDT and Subject 2, 885 min, for 12 weeks. The order of the NDT and play treatments was alternated over the course of the study (see Table 1). Although we intended to administer NDT and play conditions alternately on Weeks 1–4, 6, 8, 10, and 12, we had to change our plans due to the subjects' illness and uncooperative behavior.

NDT for both subjects was administered by the same NDT-certified occupational therapist; play intervention was administered by the first author, an occupational therapy student. NDT involved specific therapeutic handling and positioning based on Bobath methods. General components of the NDT intervention included activities to normalize muscle tone and controlled movement in and out of developmental positions. A rigid program of activities for each subject was not used over the study period; rather, NDT handling, which incorporated play tasks, was used according to the child's response to therapy.

Play intervention involved spontaneous touch, encouragement to move, and interaction with the re-

Table 1
Treatment Schedule

Week No.	Subject 1 1st Treatment	Subject 1 2nd Treatment	Subject 2 1st Treatment	Subject 2 2nd Treatment
1	NDT	Play	—	—
2	Play	NDT	—	—
3	NDT	Play	NDT	Play
4	—	—	NDT	Play
5	—	—	—	—
6	Play	NDT	Play	NDT
7	—	—	—	—
8	NDT	Play	NDT	Play
9	—	—	—	—
10	—	—	Play	NDT
11	—	—	—	—
12	NDT	Play	NDT	Play

Note. NDT = neurodevelopmental treatment.

searcher. The child was encouraged to play with toys similar to those used by the NDT therapist, but the play situation was kept as child-directed as possible. The play condition did not require controlled handling in and out of developmental positions or specialized therapeutic equipment (e.g., bolsters or therapy balls) except as objects for play. Play activities included stringing beads, throwing and catching a ball, drawing on a blackboard while kneeling, and dressing a doll.

The services of the NDT-certified physical therapist offered by the center in which the study was conducted were available to both subjects during this study. In addition, the subjects' parents were allowed to continue any home treatment activities begun before the start of the study. These activities consisted largely of fine motor play and some range of motion exercises and did not involve the practice of the dressing skills used as test measures in this study. The treating therapist indicated that home treatment was not a large portion of the total treatment provided by the center, except as particular positioning eased the parents' ability to care for the child.

Data Collection

Each subject was given a pretest before each therapy session, a posttest immediately after the initial 20-min therapy session, and a posttest immediately after the second 20-min therapy session (see Table 1). For each subject, the tests encouraged the performance of specific dressing skills consistent with each child's level of dressing performance and the attainment of goals set by the treating occupational therapist. For Subject 1, appropriate test items, as determined by parental interview and clinical assessment, were (a) removal of a T-shirt with one arm free of one sleeve and (b) removal of a sock. For Subject 2, appropriate test items were (a) removal of a jacket and (b) removal of a sock.

All test items were administered by the occupational therapist providing NDT in the study. The sessions were videotaped for later scoring. For all tests, the subject was placed in a cube chair (a square, plastic chair with a back and armrests) facing the camera and given 60 sec from the start of cooperative behavior to complete each task. The methods of clothing removal were identical for all tests and were appropriate for each child on the basis of that child's current motor problems. The test administrator began each task using the same verbal and physical prompts for all pretests and posttests. As needed, the test administrator offered specific physical and verbal aids to minimize the child's frustration and maximize cooperation.

Four sets of measurement criteria were established for each dressing skill for each subject. Measurement criteria were intended to be objective measures of expected outcomes of NDT, as expressed in functional activity. Most measurement criteria were on a 3-, 4-, or 5-point scale that yielded ordinal data. Three criteria, however, required the raters to count the number of behaviors, thus generating interval-level data. See Table 2 for examples of the main types of ordinal scales and behavior counts used. Other criteria with the same kinds of measurement procedures included measures of shoulder girdle mobility, trunk rotation and sitting balance, spontaneous use of the upper extremity, extraneous body movement, and task initiation.

Occupational therapists experienced at observing children with cerebral palsy served as the raters. The raters first received verbal and demonstrated instruction in the measurement criteria. Individual raters were requested to score at least one test item on one measurement criterion and assign a rating independently. When viewing test items on videotape, the raters did not know whether the particular test session that they were viewing was pre- or posttest, or whether the test session occurred in the earlier or later weeks. Eleven therapists participated as raters, yielding 12 sets of matched scores (pretest, post-NDT, and postplay) from each measurement criterion for each test item. The 12 sets of matched scores resulted from 6 sets of pretest, post-NDT, and postplay scores from one rater plus 6 sets of pretest, post-NDT, and postplay scores from another rater for each measurement criterion. Each rater did not score all of the measurement criteria used in this study, but rather, only a few criteria according to his or her available time. The result was that the scores from two different raters were obtained for all of the measurement criteria.

Table 2
Sample Measurement Criteria for Pretests and Posttests

Criterion	Procedure
Separation of lower extremity	Indicate the maximum height to which the foot wearing the sock is lifted to reach hand during removal of sock. Score 0 if foot wearing sock is not lifted from near floor. Score 1 if foot is lifted to between floor and half the height of chair seat. Score 2 if foot is lifted to between half the height of seat and level of seat. Score 3 if foot is lifted to above level of seat.
Associated reaction of lower extremity	Indicate the presence of the greatest associated reaction in the opposite lower extremity while foot wearing sock is lifted to reach hand during sock removal. Score 0 if lower extremity extension results in loss of sitting balance and falling backward. Score 1 if tonal changes result in lower extremity extension lifting foot to half the height of chair seat. Score 2 if tonal changes result in lower extremity extension lifting foot 1–2 in. off floor. Score 3 if tonal changes result in toe and foot movements (e.g. toes curl, hallux extends, foot dorsiflexes). Score 4 if lower extremity is relaxed with foot on floor.
Functional shoulder mobility	Score 0 if shirt is not removed over the head. Score 1 if shirt is removed over the head with difficulty following assistance of shirt to over face. Score 2 if shirt is removed over the head smoothly and easily following assistance of shirt to over face. Score 3 if shirt is removed over the head with difficulty without assistance. Score 4 if shirt is removed over the head smoothly and easily without assistance.
Bilateral use of upper extremity	Describe the best use of each upper extremity during sock removal. Score 0 if left upper extremity alone removes sock while right upper extremity rests in lap or is otherwise not functionally used. Score 1 if left upper extremity alone removes sock while right upper extremity performs a stabilizing function (e.g., holds onto chair). Score 2 if both upper extremities remove sock by pushing down together using same functional movement. Score 3 if both upper extremities remove sock by pushing down in alternating movements.
Hand-to-foot coordination	Indicate the number of trials to remove sock from foot. One trial is one push or pull on sock that ends with the arrest of pushing or pulling movement, the release of grasp on sock, or both.

Results

Scores from two criteria were eliminated from the analysis because the videotape did not permit full viewing of the subject, which was needed to score a sufficient number of pretests and posttests. For each remaining measurement criterion, the G index of agreement was used to determine interrater reliability (Holley & Guilford, 1964). The G index yields an overall proportion of agreement based on the number of perfect matches among scores assigned by two raters. The reliability scores ranged from 0.50 to 1.00, with a mean proportion of agreement of 0.77 (see Table 3).

A comparison of improvement after NDT and after play was made for ordinal data with the Friedman

Table 3
Reliability of Measurement Criteria and Comparison of Improvements After Neurodevelopmental and Play Treatments*

Test Item	Measurement Criterion	G Index	Fr[a] Value	F^b Value
	Subject 1			
T-shirt	Functional shoulder mobility	0.60	0.00	—
	Shoulder abduction	0.60	1.23	—
	Sitting balance	0.70	—	0.13
	Associated reaction of lower extremity	0.90	0.18	—
Sock	Separation of lower extremity	0.90	0.20	—
	Trunk rotation	0.70	0.20	—
	Use of both upper extremities and sitting balance	0.90	2.60	—
	Associated reaction of lower extremity	1.00	0.44	—
	Subject 2			
Jacket	Task initiation	0.58	2.42	—
	Spontaneous use of right upper extremity	0.50	0.63	—
	Extraneous body movement	0.92	4.89	—
	Bilateral coordination of upper extremity	0.76	—	2.29
Sock	Bilateral use of upper extremity	0.92	1.42	—
	Hand-to-foot coordination	0.94	—	0.61

[a] Fr = Friedman test (Siegel, 1956) (critical value = 6.20).
[b] Critical value (α = .05; df between = 2; df within = 30) = 3.32.
* p = not significant.

analysis of variance by ranks (see Table 3). The Friedman test (Siegel, 1956) used the test statistic Fr to test the null hypothesis, which stated that median ranks of matched samples (pretest, post-NDT, and postplay) were the same. A modified Friedman test formula was used to correct for the effects of tied ranks among matched sets. Also, an analysis of variance (ANOVA) was used to compare the improvement after NDT and after play for the three measurement criteria yielding interval-level data. The ANOVA used the test statistic F to test the null hypothesis, which stated that the means of the pretest, post-NDT, and postplay groups were the same. As shown in Table 3, these analyses revealed no statistically significant differences among effects due to NDT and play for any criterion.

Ordinal and interval data were also analyzed for the effects of treatment order. We used a Wilcoxon rank sum test (Siegel, 1956) to compare interval scores from two periods, one in which NDT was the initial treatment condition and one in which play was the initial treatment condition. This test showed no significant differences ($p < .05$). Visual inspection of a graph of pretest and posttest scores from each measure over time was used to assess the effects of order for ordinal data. This visual inspection suggested no differences due to treatment order and revealed an increase in scores over time for measures of shoulder mobility (for Subject 1's T-shirt test) only.

Discussion

This study has expanded the existing single-system methodology for the measurement of the effect of NDT on children with cerebral palsy. Using individualized therapy objectives as outcome measures, we found that we could reliably measure qualitative changes in the dressing skills of children with cerebral palsy. We believe that the measurement of the effects of NDT on daily living skills is particularly relevant to the field of occupational therapy. Occupational therapists should be concerned that gains made in therapy are reflected in a child's increased ability to perform daily living tasks.

The overall results of this study agree with the findings of DeGangi et al. (1983). Neither study showed significant differences between the effects of NDT and play on functional activity. In consideration of the limitations of the present study, however, these results must be interpreted cautiously; they neither support nor discredit NDT as a treatment approach.

The measurement criteria used in earlier research were not sensitive enough to detect small changes occurring due to NDT. Thus, one purpose of the present study was to improve the methodology used to measure the effects of NDT. We enhanced test sensitivity by increasing the level of measurement from a nominal to an ordinal scale and by using individual treatment goals instead of standardized tests or developmental milestones. Perhaps, as recommended by DeGangi et al. (1983), future studies will use more sensitive computerized videotape analyses to measure small changes in angles of movement. Computerized analysis would enhance the level of measurement to a ratio scale, although it would require the researcher to relate resultant angles of movement to functional abilities.

A comparison of raw data from the present study with the DeGangi et al. (1983) study shows that in our study, post-NDT scores were frequently better than postplay scores, and fewer tied scores occurred. Although the number of tied scores remaining in the present study indicates that some rating scales failed to distinguish small differences between tied observations, the data suggest that an ordinal level of measurement may be more useful than categorical data for detecting changes due to NDT. Compared with the DeGangi et al. study, however, our study showed a decrease in overall reliability of measures with some ordinal scales.

Diminished interrater reliability of some measurement criteria is probably a function of insufficient rater training combined with the difficulties of making observations in small increments of ranges from videotape. Although the data analysis methods partially compensated for the raters' limited training by comparing their pretest and posttest scores individually, the differences between the raters may have obscured small effects due to NDT. Additional research is needed to determine whether human observers can detect from videotapes many of the subtle physical changes that occur due to NDT.

Another possible explanation for a lack of significant findings may relate to methods of statistical analysis. In reviewing the research on the effectiveness of NDT with pediatric clients, Ottenbacher et al. (1986) identified a small effect size of 0.31 due to NDT. This finding suggests that analysis may require many scored observations to detect statistically significant changes. Thus, we recommend replication of the present study with a larger sample or over a longer period of time.

Certainly, in view of the small effect size of NDT, an increase in the amount of NDT from the 390 or 885 min provided seems warranted. Perhaps if we had completed testing after the 45-min NDT sessions instead of after the 20–25-min sessions, we would have found differential treatment effects. Clinicians debate the length of treatment required to effect measurable changes in subjects with cerebral palsy. Treatment length is therefore a significant variable for future study.

A third consideration is that no significant differences were found between NDT and play because play was more like an additional treatment than like a control condition. Magrun et al. (1983) pointed out that "movement experiences in NDT and play are not mutually exclusive" (p. 848). Another limitation of the present study is that practical considerations demanded that the first author administer play intervention to both subjects. The first author may have unintentionally modeled techniques used by the NDT therapist, thus introducing bias in the play condition. Perhaps the contrast condition should involve developmental play or stimulation as provided by a non-NDT-trained discipline as well as a videotape of both play and NDT conditions for a closer comparison of experiences provided in each treatment.

Finally, like many previous studies, the present study is limited by its inability to withdraw NDT from its subjects. This study design was in part selected to eliminate a baseline or treatment withdrawal condition, thus enabling subjects to continue to receive occupational therapy through NDT. Furthermore, NDT-oriented physical therapy and home programming offered by the study center were not denied to the subjects. In this study, however, we question whether the minimal home treatment could sufficiently mask the gains observed on study measures. Additionally, the effects of physical therapy and home treatment as well as maturation were constant across all tests for each session. That is, posttests for each session were compared with regard to improvement to a pretest for that same session.

Summary

As a result of the present study, we recommend that researchers do the following:

- Continue to refine ordinal test measures, including pilot tests, to eliminate unreliable and nondiscriminating criteria.
- Use computerized videotape analysis to measure small changes in movement, as suggested by DeGangi et al. (1983).
- Train raters thoroughly in test criteria and use three ratings (versus two) for each observation to improve the analysis of reliability.
- Procure a large number of scored observations by increasing the length of the study, the number of treatments given, or both, to detect statistically significant changes.
- Provide longer NDT sessions.
- Use non-NDT-trained special educators to provide the play condition based on their own play and stimulation programs.
- Videotape both NDT and play conditions for closer comparison of treatments.
- Withhold NDT treatment provided in the home and by other members of the treatment team.

This study adds to a growing number of studies that have failed to demonstrate the efficacy of NDT. Perhaps the results of this study demonstrate the influence of the confounding factors to which this type of study is susceptible, such as an inability to withdraw NDT. More controlled research is needed to substantiate NDT as a method for the increased attainment of individual treatment goals. Future studies need to explore the relationship of these short-term outcomes and the long-term attainment of motor skills, functional gains, and deformity prevention. This study may also serve to remind occupational therapy practitioners of the value of play in the treatment of children with cerebral palsy as well as to reemphasize that treatment's primary goal is to increase functional ability. ▲

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