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ABSTRACT

The effectiveness and theoretical validity of Neurodevelopmental Treatment (NDT), based on neuromotor development among nonhandicapped infants and young children, was investigated across seven cerebral palsied, severely handicapped children, ages 2 1/2 to 12 years. Results indicated that training had a statistically significant effect for four children, and the visual analysis suggested a training effect in the data of two of these four children. Theoretical relationships among abnormal tonic reflexes and normal motor patterns were not supported by the data. A nonparametric test was significant for the group when the means for baseline and training were used to represent the data, but not when the slopes were used in the analysis. Because results were not consistent across all children, it was suggested that future research focus on subject characteristics that may relate to the effectiveness of NDT. Additionally, recommendations were made regarding measurement systems for evaluating change, and strategies for investigating the NDT therapy package. (Author/CL)

FINAL REPORT

Evaluating Neurodevelopmental Theory and Training with Cerebral Palsied, Severely Handicapped Students

Doug Guess/Mary Jo Noonan

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ABSTRACT

Neurodevelopmental Treatment (NDT), based on neuromotor development among nonhandicapped infants and young children, is presently the most popular motor training approach with cerebral palsied children. Empirical data in support of NDT or other approaches to motor training, however, are lacking. In response to the absence of a data base, the theoretical basis and effectiveness of NDT was investigated across seven cerebral palsied, severely handicapped children, ages 2½ to 12 years. Results indicated that training had a statistically significant effect for four children, and the visual analysis suggested a training effect in the data of two of these four children. Theoretical relationships among abnormal tonic reflexes and normal motor patterns were not supported by the data. A nonparametric test was significant for the group when the means for baseline and training were used to represent the data, but not when the slopes were used in the analysis. Because results were not consistent across all children, it was suggested that future research focus on subject characteristics that may relate to the effectiveness of NDT. Additionally, recommendations were made regarding measurement systems for evaluating change, and strategies for investigating the NDT therapy package.

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CHAPTER I

INTRODUCTION

Cerebral palsy is a common physical handicap among severely handicapped children. It is a class of nonprogressive posture and movement disorders resulting from damage or malformation of the central nervous system (CNS) (Bax, 1964; Capute, 1974; Levitt, 1977; Vining, Accardo, Rubenstein, Farrell, & Roizen, 1976). The CNS coordinates sensory input yielding integrated motor responses (Fiorentino, 1972). Damage to the CNS results in delayed motor development that is characterized by tonic reflexes (atypical and persistent postures) and a deficiency in the normal generalized postural adjustment reactions of body alignment and balance (righting and equilibrium) that are necessary for the development of normal motor patterns (Bobath, B., 1948; Fiorentino, 1972; and Rushworth, 1971). A student with cerebral palsy, for example, may not be able to creep because the reciprocal pattern of arm and leg movements is prevented by a dominating tonic reflex causing the child's hips and knees to flex if the head and neck are extended. The child's movement is further hampered by the inability to make the necessary weight shifts (equilibrium responses) to maintain the all-four's creeping position when one extremity is moved (Bobath, K. & Bobath, B., 1967).

"Little's disease," as cerebral palsy was first identified, was initially described by William J. Little at a London medical conference in 1843 (Little, 1853). Little identified lesions or cavities in the cortex of the brain upon post-mortem exam of individuals with cerebral palsy. He also linked neonatal difficulty, particularly asphyxia, to symptoms of cerebral palsy (Little, 1853; Menkes, 1974). It is now established medically that brain-damage associated with cerebral palsy is due to prenatal etiological factors such as maternal viruses; defective development of the brain; perinatal difficulties such as anoxia due to premature separation of the placenta, awkward birth positions, or prolonged labor; prematurity; Rh incompatibility; and neo-natal factors of circulatory disorders, viruses, or bacteria (Bobath, K. & Bobath B., 1954; Cerebral palsy--Facts and Figures, 1973; Menkes, 1974). Wide disparity is found among statistics for this handicapping condition. Incidence estimates range from .6/1000 to 1/200 live births, with most estimates between 1/1000 to 2/1000 live births (Cerebral palsy--Facts and figures, 1973; Dekaban, 1970; Levitt, 1977; Marks, 1974; Dunsdon, 1960; Stephen, 1965; Mair, 1961).

Various treatment systems for cerebral palsy have been reported since the mid-1900's that can be characterized according to three types: orthopedic bracing and isolated muscle training (viz., Phelps, 1940; 1941; 1948); sensory stimulation providing experiences to the visual, auditory, tactile, olfactory, gustatory, and kinesthetic senses (viz., Kabat, 1947; Knott & Voss, 1956; 1968; Rood, 1956; 1962); and neuromuscular, stimulating the development and functioning of the CNS (viz., Bobath, B., 1948; 1967; Bobath K., 1980; Bobath, K. & Bobath, B., 1950; 1952; Doman, Spitz, Zucman, Delacato, & Doman, 1960; Doman, Taylor, & Thomas, 1969; Fay, 1946; 1954; LeWinn, 1969).

All three types of treatment are currently in use; however, there is little evidence available to support or refute the theories and techniques of the systems (Barrera, Routh, Parr, Johnson, Arendshort, Goolsby, & Schroeder, 1976; Levitt, 1977; Martin & Epstein, 1976). As stated by Martin & Epstein (1976), "The best known therapeutic 'schools' in cerebral palsy typically rely on semiobjective, anecdotal case reports or simple outcome studies . . . .These studies may indicate that something did or did not work, while failing to isolate the effective treatment variables" (p. 285).

Purpose

The efficacy of a popular neuromuscular approach to the treatment of cerebral palsy, neurodevelopmental training (NDT) (Bobath, B., 1948; 1953; 1954a; 1954b; 1954c; 1954d; 1955; 1967; Bobath, K., 1959; 1980; Bobath K. & Bobath B., 1950; 1952; 1954; 1955; 1967; 1976) and its theoretical hypotheses in the training of motor behaviors among severely handicapped children with cerebral palsy have not been empirically verified. NDT is based on the theory of neurological maturation that describes the functions of developing areas of the brain and the implications of these functions for the process of motor development.

As an attempt to replicate the normal process of neurological development within cerebral palsied individuals, NDT focuses on two objectives: 1) the prevention or control (i.e., "inhibition") of movement or posture to prevent abnormal reflexes, and 2) stimulation and guidance (i.e., "facilitation") of postural reactions permitting the sensations of normalized motor behavior. Developmental milestones such as head control or sitting are not directly taught, although their acquisition is among the objectives of treatment.

Three research questions concerning the effectiveness of NDT were addressed in this study:

1. Do postural reactions improve as a result of neurodevelopmental training?

in the asymmetrical tonic neck reflex?

3. Do improvements in postural reactions correspond to an increase in head erect and rolling motor patterns that are not directly trained?

A secondary purpose of this study was to demonstrate an empirical evaluation of a therapy approach in three ways. First, important techniques of the therapy, the facilitation of postural reactions in conjunction with reflex inhibiting positioning, were operationalized to establish an isolated treatment variable. Second, a single subject design was selected for this research in order to analyze directly the effects of training among individual subjects (Baer, Wolf, & Risley, 1968; Hersen & Barlow, 1976). Martin and Epstein (1976) explained that single subject research would be more appropriate than group design, "because of the organic and behavioral variability in cerebral palsy" (p. 288). And third, measurement procedures of sensory/motor skills developed by the University of Kansas Early Childhood Institute (Guess, Rues, Warren, & Lyon, Note 1; Guess, Rues, Warren, Lyon, & Janssen, Note 2; Guess, Rues, Warren, Janssen, Noonan, Esquith, & Mulligan, Note 3) were used to measure head erect and rolling behavior sensitively and quantitatively. The measures do not require subjective qualitative judgments to score performance and slight changes within a skill can be monitored.

REVIEW OF LITERATURE

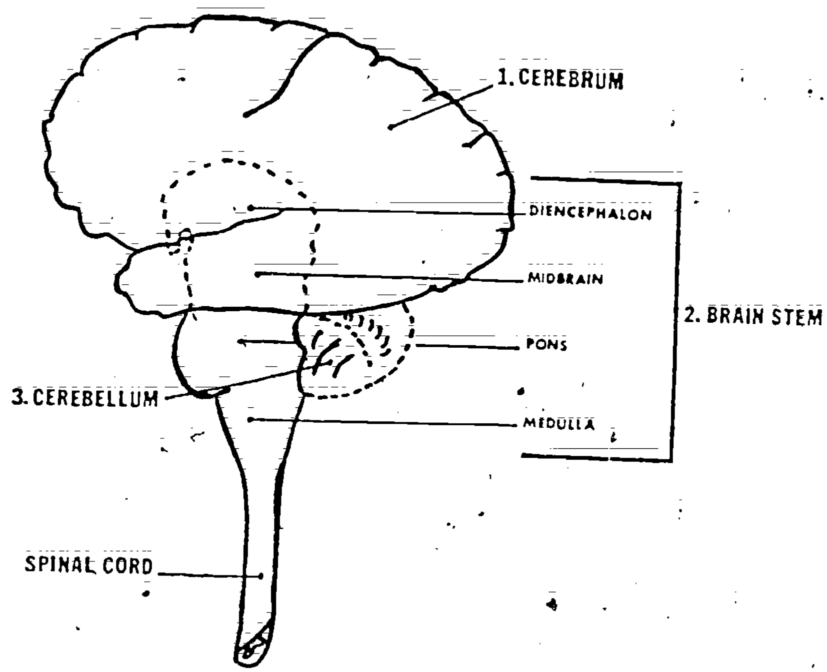
An overview of neuromotor development among nonhandicapped and cerebral palsied young children is presented because of its importance and implications to questions addressed in this study. Theory, treatment procedures, and research data of the three major therapy approaches are then briefly described to provide a framework for interpreting the more detailed presentation of NDT and the general state of the art in the treatment of cerebral palsy.

Neuromotor Development

"The development of the motor skills closely parallels and is dependent on the physical maturation of the nervous system" (Sukiennicki, 1971, p. 128). "Neuromotor development," therefore, refers to the sequential growth and sophistication of the central nervous system (CNS) and its close association to motor performance among normally developing infants (Molnar, 1974). The dependent relationship of motor behavior to the nervous system was initially established through experimentation with lower vertebrates and studies of humans with CNS damage (McGraw, 1943). Cortical maturation (i.e., growth and development of the CNS), and corresponding motor achievements were described by referencing the CNS structures of the spine, the brainstem (including the midbrain), the cerebellum, and the cerebrum (covered by the cerebral cortex) (see Figure 1) (Capute, Accardo, Vining, Rubenstein, & Harryman, 1978; Fiorentino, 1963; Sukiennicki, 1971). The order in which the structures of the brain mature ontogenetically was found to be the same as the phylogenetic

Figure Caption

Figure 1. The central nervous system. In the development of the normal infant, the system matures in ascending order: spinal cord, cerebellum, brainstem (including the midbrain), and cerebrum (or cortex).


1. CEREBRUM
DIENCEPHALON
MIDBRAIN
2. BRAIN STEM
PONS
3. CEREBELLUM
MEDULLA
SPINAL CORD

[illegible] Sukiennicki, 1971). Reflexive patterns (to be described later) were identified as characteristic of specific maturational or functioning levels of the CNS and shown to be the basis of the tonal, postural, and voluntary qualities of motor responses (Magnus, 1926; Sherrington, 1906).

The Newborn Infant

Maturity of the central nervous system. Neurological research indicates that CNS development is incomplete at birth (Conel, 1939; Dekaban, 1970; McGraw, 1943; Sukiennicki, 1971). Physiologically, the appearance of the newborn's brain indicates that the lower centers of the brain are more mature than the cortex (Dekaban, 1970). Conel (1939) has noted that the texture is gelatinous instead of firm. Cell size, number, and arrangement; and cortex width, layers, and stage of mylenation, provide additional evidence that the cortex does not contribute appreciably to the control of motor responses in the neonate (McGraw, 1943).

Reflex activity. CNS control in the newborn is predominantly from the midbrain (or "subcortex") and the reflexes typifying motor behavior are characteristic of the brainstem. According to Sukiennicki (1971), "early primitive reflexive responses reflect the relatively underdeveloped state of the nervous structures and the domination of the lower center" (p. 129). Neonatal reflexes include automatic responses of sneezing, coughing, and yawning; localized behaviors such as rooting, sucking, grasping and stepping; and larger, total-body patterns of the Moro and tonic reflexes (Gillette, 1969; McGraw, 1943; Mysak, 1963; Rushworth, 1971).

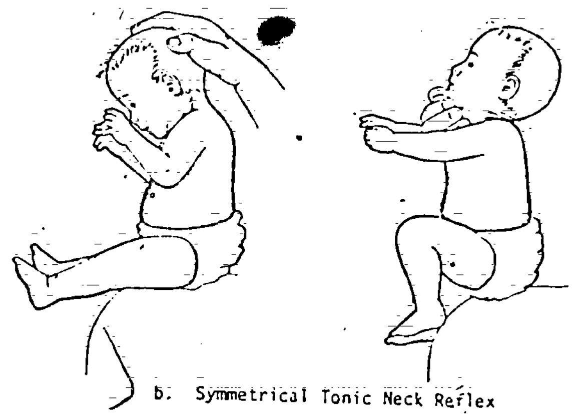
Tonic reflexes, the asymmetrical tonic neck (ATNR), symmetrical tonic neck (STNR), and tonic labyrinthine (TLR), are also referred to as "static" postural reflexes and are in response to the position of the head and body in space, and/or the position of the head in relation to the body (Dergassies, 1977; Magnus, 1926) (see Figure 2). Muscle tone throughout the body is affected by the reflexes (Wright, 1945). A nonhandicapped infant will demonstrate tonic reflexes somewhat variably from birth to two months until four to twelve months of age (Dergassies, 1977; Fiorentino, 1973; Mysak, 1963; Rushworth, 1971). None of the reflexes are obligatory; the infant is not bound to the posture of a reflex. Many authors have commented on the difficulty in discerning a clear, unambiguous TLR because it is typically seen in postures that also elicit the STNR and ATNR (Dekaban, 1970; Mysak, 1963). The inability to observe the TLR in isolation has led to some disagreement concerning its presence among nonhandicapped infants (Bobath, K., 1980; Capute et al., 1978).

Muscle tonus and posture. "By tone in skeletal muscle is meant a state of reflex contraction which is concerned with maintaining position or posture. The distribution and degree of this contraction among the various muscles of the body are related to the attitude adapted by the animal and also to the extent to which the nervous system is intact" (Wright, 1945, p. 582). Resting muscles tend to resist stretching and instead, have a slight, constant firmness and tension. Movement is accommodated by adjustments in tone throughout the muscles in the body (Gillette, 1969; Holt, 1965). Characteristically, the neonate has a great deal more tone than a year-old child or an adult. The resulting newborn posture is a predominantly flexed position in both prone and supine (Fiorentino, 1972).

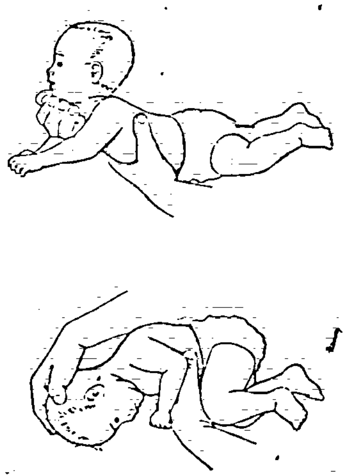
Figure Caption

Figure 2. Topography of tonic reflexes in children with cerebral palsy.

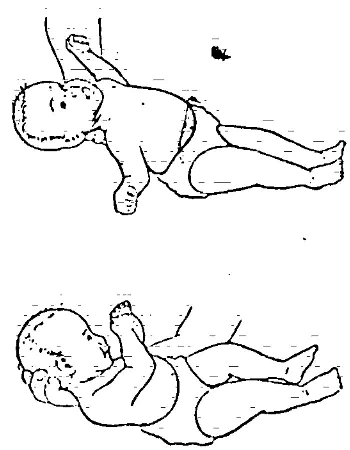
a. Asymmetrical Tonic Neck Reflex



b. Symmetrical Tonic Neck Reflex



c. Tonic Labyrinthine Reflex (prone)



d. Tonic Labyrinthine Reflex (supine)

Development of the Infant

Fiorentino (1963) describes primitive reflexes as essential; the infant's response to them is preparatory for progressive development through motor milestones. During approximately the first 15 months following birth, however, the cortex matures and develops dominating and inhibitory control over the subcortex (Capute et al., 1978; Fiorentino, 1972; Gillette, 1969; McGraw, 1943; Rushworth, 1971). Reflexes that typify neonatal motor behavior are gradually replaced (or integrated) by more refined and selective cortically-controlled behavior mediated by the interaction of the cortex, basal ganglia and cerebellum (Fiorentino, 1973). McGraw (1943) contrasts the reflexive behaviors of the newborn with those of the developing infant as "more stereotyped and limited, whereas cortical behavior is plastic and manifests a diversity of patterns and response" (p. 10). With cortical maturation, the infant develops the postural reflex reactions of righting and equilibrium (alignment and balance responses) and engages increasingly in more purposeful voluntary behavior as coordinated and complex motor patterns develop (e.g., crawling) (Bobath, K., 1980; McGraw, 1943; Sukiennicki, 1971). Righting reactions align the head and neck with the trunk, align the trunk with the limbs, and maintain a midline position of the head (Fiorentino, 1973; Gillette, 1969). For example, a baby rolls in the direction of a passive head turn or, if carried at an angle, maintains a midline position of the head. Equilibrium reactions compensate rather than establish alignment in response to changes in the center of gravity to maintain a balanced posture (Fiorentino, 1972; Mysak, 1963; Sukiennicki, 1971). In sitting, for instance, equilibrium reactions allow a child to lean while reaching for objects without falling over.

The development of righting reactions begins at birth. At five to six months, equilibrium reactions are evident. A gradual and progressive integration of the righting reactions with the newly-developing equilibrium reactions then begins and is completed between three to five years of age (although Fiorentino, 1973, reports that righting reactions disappear) (Bobath, K., 1980; McGraw, 1943; Mysak, 1963). As summarized by Fiorentino (1972), the infant "develops from a being with mass movements of symmetrical synergies dominated by lower centers of primitive reactions to a child with a highly complex, integrated nervous system under cortical control with its volitional postural refined patterns of movement" (p. 60).

Neuromotor Development among Infants with Cerebral Palsy

Cerebral palsy occurs when there is damage to, or a lesion of, the young infant's immature cortex. There is an absence of CNS integration and the lower centers of the brain maintain control of motor behavior (Bax, 1964; Bobath, B., 1948; Fiorentino, 1972; Levitt, 1977; Sukiennicki, 1971). "This means that the lesion acts on an immature brain, interfering with its normal process of maturation and with its normal orderly development" (Fiorentino, 1972, p. 3). The resulting motor development is abnormal and neither typical of subcortical nor cortical behavior of a nonhandicapped infant.

In the presence of cerebral palsy, the primitive reflexes persist indefinitely and are not dominated by cortically controlled behaviors as in the development of the nonhandicapped infant. Additionally, the child with cerebral palsy may be "obligated" and unable to move out of a reflexive posture (Fiorentino, 1972; Rushworth, 1971). Pathological tonic reflexes are described by Dergassies (1977) as "immediate, constant, rapid, and inexhaustible," in contrast to their presence among nonhandicapped infants in which they are "slow, inconsistent, incomplete, and appear only after a very long latency" (p. 151).

Tonic reflexes as they characterize cerebral palsy were first described by Magnus and DeKleijn in 1918 (Dergassies, 1977; Magnus, 1926; Menkes, 1974; Wright, 1945). Magnus and DeKleijn observed the ATNR, STNR, and TLR in response to head turning among decerebrate animals, animal preparations in which the brainstem was surgically transected through the midbrain. Motor behavior of decerebrate animals is completely under the control of the brainstem. According to Bobath, K. (1980), "tonic" is a combination of the two terms "tone" and "static" that are descriptive of the increased muscle tightness (spasticity) and restricted movement qualities of the posturing. Sherrington (1906) referred to the resulting clinical picture as "decerebrate rigidity," descriptive of the extreme hypertonicity of the muscles.

Abnormal tonic reflexes in children with cerebral palsy constrain movement and impede development. Associated muscle tone is either hypotonic (decreased tone), hypertonic or spastic (increased tone), or fluctuating (Capute et al., 1978; Fiorentino, 1972; Sukiennicki, 1971). The pathological reflexes and tone result in postures that are incompatible with and inhibit more cortically mature righting and equilibrium reactions and are counterproductive to achieving voluntary, normal motor patterns (e.g., rolling, sitting, crawling, etc.) (Bobath, K., 1980; Campbell, Green, & Carlson, 1977; Fiorentino, 1972; Levitt, 1977; Utley, Holvoet, & Barnes, 1977). Postures typical of cerebral palsied children are awkward body positions that are frequently asymmetrical (e.g., the trunk may be laterally curved) and/or comprised of "associated reactions" (e.g., when one hand opens, the other hand opens).

Summary of Neuromotor Development

As cortical maturation occurs in the normal infant, subcortical reflexes decrease; normal postural reactions of righting and equilibrium (body alignment and balance responses) develop and allow for voluntary coordinated motor patterns (e.g., rolling, sitting, etc.). If cerebral palsy is present, cortical maturation does not occur, the subcortex maintains control of motor behavior, and tonic reflexes (ATNR, STNR and TLR) persist and are abnormal. Lacking cortically dominated control of motor behavior, cerebral palsied children do not develop the postural reactions of righting and equilibrium that are required for learning more complex, coordinated motor patterns.

Treatment Approaches to Cerebral Palsy

There are at least three types of approaches to the treatment of cerebral palsy: orthopedic, sensory stimulation, and neuromotor. None of the approaches are presently dismissed as nonbeneficial, however, the neuromotor approach seems to be the most preferred approach with some aspects of the orthopedic and sensory stimulation approaches included (Banus, 1971).

Orthopedic Approach

Throughout the 1940's and 1950's an orthopedic management system for the treatment of cerebral palsy was the primary approach to treatment and has sometimes been referred to as the traditional approach (Phelps, 1940; 1941; 1948). W. M. Phelps was an orthopedic surgeon who adapted and expanded on the conventional treatment techniques of poliomytis for individuals with cerebral palsy (Gillette, 1969). Therapy in the orthopedic system includes fifteen modalities or methods of isolated and group muscle training (e.g., massage, active assisted motion, resisted motion, etc.). Braces, splints, surgery, and drugs may be prescribed to correct deformities, facilitate muscle relaxation or contraction, or inhibit uncontrolled movement due to fluctuating muscle tone (Gillette, 1969; Levitt, 1977; Marks, 1974).

Research on orthopedic therapy. Crosland (1951) reported the results of a study to evaluate the effectiveness of the orthopedic treatment system. Based on a developmental checklist of 128 motor skills, all 34 cerebral palsied children in the study, ages 5 to 11 years, improved. Length of treatment was the only factor related to the amount of improvement. Children receiving 2-3½ years of therapy progressed an average of 31 skills on the checklist, and those receiving less than one year of treatment acquired an average of only nine new skills. Results of the study are difficult to interpret because there was no control or comparison group and the students were selected because they appeared "to offer the possibility of a good response to treatment" (Crosland, 1951, p. 92). The most significant limitation of the study was the total absence of a description of treatment. Neither the time spent in treatment nor the "traditional" techniques used by the physical and occupational therapists were reported.

A study by Zuck and Johnson (1952) was conducted with 36 subjects to determine if intelligence or type of cerebral palsy were related to success with an orthopedic approach to therapy. Results were presented graphically and compared to a normal rate of development transposed as a slope of 1.0. After ten months of treatment, all subjects showed progress; however, the rate of development did not change for all. Subjects with spasticity (increased muscle tone) progressed at a faster rate than subjects with athetosis (fluctuating muscle tone), and subjects with IQ scores above 70 improved more than those with IQ scores below 70. Even though changes in rate of development were noted for some subjects, the authors suspected, "that many of these children would do as well without formal treatment" (p. 118). As in the Crosland (1951) study, results are inconclusive because treatment was only described vaguely as "group therapy" of three hours per day. Additionally, the validity of describing normal motor development as a fixed rate is unknown and questionable.

Another attempt to identify children with cerebral palsy that were most likely to benefit from orthopedic therapy was reported in 1959 by Ingram, Withers, and Speltz. Sixty children were treated for 3 to 36 months, and 40 of them showed progress. The authors attributed the failure of 20 subjects to improve to mental retardation, emotional immaturity, or the severity of the cerebral palsy. Results were based on performance related to a developmental checklist constructed by the authors. Only mildly affected subjects were selected for treatment, and twelve were excluded from the study after 16 months of treatment without evidence of progress. Selection problems, lack of experimental control, and the omission of a methods description preclude any conclusion from the results.

One investigation of orthopedic treatment employed a comparison group (Paine, 1962). Treatment of 103 children for at least five years led the author to conclude that children mildly affected with cerebral palsy would learn to walk with better gaits and have less contractures. Additionally, children with spastic cerebral palsy would be less likely to have surgery prescribed if their treatment was initiated prior to age two.

Although the study by Paine (1962) included a group of "totally untreated" children, the make-up of the comparison group differed from the experimental group so as to bias the study in favor of the experimenta group. Children were included in the comparison group rather than the experimental group if they were unlikely to benefit from treatment, or if the children's parents were not interested in the program.

Treatment was described in much greater detail than the previously reported studies of Crosland (1951), Zuck and Johnson (1952), and Ingram et al. (1959), but it is still not possible to determine the exact treatment program received by each child. It was reported that the method of treatment varied, but included "stretching exercises, 'muscle training,' attempts to teach patterns of movement and range of motion of individual joints, and also functional training directed at walking and the use of hands for daily self care, writing, etc." (Paine, 1962, p. 606).

Sensory Stimulation Approach

Proprioceptive neuromuscular facilitation. Tactile and kinesthetic/proprioceptive experiences are the main focus of the sensory stimulation approaches to the treatment of cerebral palsy. Isolated muscle training from the orthopedic approach is included, but, bracing, surgery and drugs are not recommended. Kabat (1947), and later, Knott and Voss (1956; 1968) advocated proprioceptive neuromuscular facilitation (PNF) therapy (Gillette, 1969; Levitt, 1977; Marks, 1974; Sukiennicki, 1971). Spiral and diagonal movement patterns resembling the alignment of the body's muscle fibers are utilized to stimulate the proprioceptors (nervous tissue relaying the sensation of movement to the brain), and in turn, stimulate the brain's motor cortex (Marks, 1974; Sukiennicki, 1971). Other PNF techniques, touch, auditory, and visual stimulation, stretch, pressure, resistance, icing, and the use of tonic and righting reflexes, are included to reinforce normalized responses of the neuromuscular system (Levitt, 1977; Marks, 1974).

Rood. Rood's (1956; 1962) sensory stimulation approach is very similar to PNF, but places a greater emphasis on following the normal progression of muscle and motor development. Stimulation of the sensory receptors is sequential and intensive with repetition. In addition to PNF techniques, squeezing, vibration, brushing, stroking, and neutral warmth are applied to activate or inhibit movement (Sukiennicki, 1971). Proprioceptive stimulation to muscle groups is differentiated according to two types of muscles: light work and heavy work muscles. Both tonic and postural reflexes are encouraged within the therapy program. Studies investigating the effectiveness of PNF or Rood's sensory stimulation approaches were not found in the literature.

Neuromotor Approach

Fay, Doman-Delacato. In the 1940's Fay developed a program for treatment of cerebral palsy aimed at stimulating the growth of the CNS (1946; 1954). Repetitive passive movement or "patterning" of the locomotion patterns associated with the child's level of neurological development and the associated level of phylogenetic development is the primary focus of treatment (Sukiennicki, 1971). Patterning "follows the successive stages of locomotion adopted by animals in the ascending evolutionary scale, beginning with the simplest reflex-wiggling of the fish, and progressing through amphibian crawling, reptilean creeping, and finally to primate erect walking" (Gillette, 1969, p. 52). Spasticity is relaxed through repetitive movements referred to as "unlocking reflexes" and abnormal tonic reflexes are utilized to initiate motion for the passive patterning (Levitt, 1977). For additional stimulation of CNS development, the therapy program includes restricting the intake of fluids and providing the child with opportunities to breath carbon dioxide-rich oxygen (Gillette 1969).

During 1956 and 1957 the Doman-Delacato therapy system was developed to expand the treatment program of Fay (Doman et al., 1960; Gillette, 1969; Sukiennicki, 1971). Treatment includes up to 22 different procedures organized around five principles of therapy: sensory stimulation, programming the brain (tactile sensitization and training hemispheric dominance), immediate responding, functional cognitive responding, and increased circulation, oxygen, and nutrients to the brain (Sukiennicki, 1971). Therapy is carried out daily for an average of five hours.

Research on Doman-Delacato approach. Doman and his colleagues have reported results from two evaluation studies of their therapy program. In the first study (Doman et al., 1960), 76 children, ages one to nine years, received an average of 11 months of treatment. In addition to an individually prescribed therapy, the 56 nonwalking children were required to be prone on the floor when not receiving their program (except for caregiving time). An assessment of mobility skills according to 13 levels indicated that mobility improved a mean of 4.2 levels. None of the children failed to improve and 11 children learned to walk independently. No differences in progress were noted in relation to age.

In a second study of brain-injured children (3 months to 22 years of age) who had completed one year of treatment, 290 of the 335 children showed improvement (Doman et al., 1969). Rate of neurological growth was determined by the Doman-Delacato Profile (Doman et al., 1969) prior to treatment "using neurological age as one variable and chronological age as another," and compared to the rate of growth during treatment (p. 217). Both of these group studies lacked an experimental design and precise definitions of the therapy programs, so it is not possible to identify the treatment program itself as the causative factor. Additional there is no basis to assume that the rate of neurological development is constant as suggested in the evaluation of therapy, and even more importan there is no evidence that the Doman-Delacato Profile is a valid measure of neurological development.

Neurodevelopmental theory and training. Neurodevelopmental theory (Bobath, B., 1948; 1953; 1954a; 1954b; 1954c; 1954d; 1955; 1967; Bobath, K., 1959; 1980; Bobath, K. & Bobath, B., 1950; 1952; 1954; 1955; 1967; 1976) was derived from neurological research describing normal cortical maturation and its function (Bobath, K. & Bobath, B., 1952; Fulton, 1943; McGraw, 1943; Monrad-Krohn, 1938; Wright, 1945). The theory predicts that training cortically controlled postural reactions (righting and equilibrium) will result in a decrease in subcortically controlled reflexes (ATNR, STNR, and TLR) and improvement in the development of coordinated motor patterns (e.g., rolling, sitting, crawling, etc.) (Bobath, B., 1948; 1967; Bobath, K., 1959, 1980; Bobath, K. & Bobath, B., 1967; 1976). The theory is consistent with neurological development as it occurs in the normal infant; when cortical maturation occurs, postural reactions of righting and equilibrium are evident, subcortical reflexes diminish, and head control, sitting, rolling, crawling, and increasingly more complex motor behaviors develop (Bobath, K., 1980; McGraw, 1943).

There are two basic strategies in NDT: 1) "inhibit" subcortical reflexes (stabilize and control posture and movement to normalize muscle tone and prevent abnormal reflexes), and 2) "facilitate" (stimulate, guide, and assist) postural reactions (Bobath, K., 1980; Bobath, K. & Bobath, B., 1967). NDT is the only treatment approach to cerebral palsy that advocates the inhibition rather than utilization of primitive reflexes (Bobath, K. & Bobath, B., 1952). Carrying a cerebral palsied child in a flexed sitting position, with the knees and hips bent and the shoulders forward, is an example of "inhibiting" an ATNR or STNR. Neither reflex can occur because extension (straightening) of the arms, trunk, and legs is prevented (Bobath, B., 1948; Bobath, K., 1980). As an example of facilitation, an equilibrium reaction may be stimulated by lying a child on a tilt board (a board that can be rocked from side to side) and helping the child to move as necessary to maintain balance as the board is slowly tilted. Normal motor patterns are not directly trained, although their achievement is the ultimate objective of NDT. Essentially, NDT seeks to replicate the normal process of neurological development in the cerebral palsied child by providing experiences with normalized posture and movement (Bobath, 1980).

Research on NDT. Several studies have investigated the efficacy of NDT. Woods (1964) and Kong (1966) reported the outcome of NDT according to gains made in ambulation. Woods investigated "Bobath treatment" among 478 children and found that ineducable children with spastic cerebral palsy made little or no progress. Educable children with either spastic paraplegia (only legs affected) or athetosis (fluctuating muscle tone) made the most progress, with 91 of 118 children learning to walk. Kong (1966) reported on 69 children that began therapy within their first year of life. Therapists demonstrated NDT techniques and taught caregivers to be daily interventionists. After one to four years of treatment the 53 children with minimal cerebral palsy developed a normal gait, 9 with mild cerebral palsy learned to walk (two children used support), and of the 7 children moderately and severely affected, one learned to walk.

Wright and Nicholson (1973) used a control and comparison group to investigate NDT among 47 cerebral palsied children. The children were divided into four age groups (birth to 5 months, 6 to 11 months, 12 to 17 months, and 18 months and older). Equivalent numbers of children from each age group were randomly assigned to one of three groups: 1) NDT for 12 months, 2) no NDT for 6 months; NDT for the next 6 months, and 3) no NDT for 12 months. Gains in head control and rolling skills were the only differences between the groups and were in favor of the 12-month treatment group. Developmental progress and a diminishing of primitive reflexes occurred for all children regardless of the type or severity of cerebral palsy.

Carlsen (1975) compared NDT to a motor training approach emphasizing fine motor and self-help skills. Twenty cerebral palsied children, ages one to five were matched for motor development level and randomly assigned to a treatment condition. NDT, the "facilitative condition," was broadly defined as, "directed toward developing sensory organization, postural stability, and controlled movement" (p. 271). Training was carried out one hour two times per week for six weeks. Parents were also encouraged to implement home-training using the activities demonstrated during therapy. Results of pre- and post-measures on the Bayley Scales of Infant Development (Bayley, 1969) and the Denver Developmental Screening Test (Frankenburg & Dodds, 1969) suggested that NDT was more effective than the other training condition.

Two case studies of NDT reported developmental progress as a result of training. A study with three severely/multiply handicapped children ages three and four years was reported by Norton (1975) in which 10 to 15 minutes of training was conducted daily by the mothers. All children showed improvement based on pre- and post-measures of equilibrium and righting reactions, and on observations of "increasingly complex behaviors" (including such items as postural reactions, voluntary play, response to sound, and motivation). Tyler and Kahn (1976) described a therapy program for one child. NDT was defined as "working on" proper positioning for feeding (seated on the mother's lap), independent play (sidelying), and sleeping (sidelying). Improvements were noted in normal muscle tone and movement, head and trunk control, and righting reactions.

Three investigations of physical therapy with young cerebral palsied children used NDT in conjunction with techniques from other approaches. Footh and Logan (1963) combined isolated muscle training and bracing from the orthopedic approach with NDT in the training of 73 children, ages 10 months to 5 years. After one year of a ½-hour weekly therapy program in which the parents were taught training techniques, children under age three made larger gains than the older children. Factors of IQ, prior physical therapy treatment, and amount of physical therapy (determined by the number of therapy sessions during the year-long study) were not related to gains.

Mysak (1963) reported the development and results of a reflex therapy program based primarily on NDT with contributions from Fay (neuromotor patterning), Kabat (PNF), and Rood (sensory stimulation). In a pilot study with seven children ages 14 months to 11 years, and a replication study with nine children, all improved with treatment.

A comparison group was included in an experimental study by Scherzer, Mike, & Ilson (1976) of NDT and some procedures from Fay and Rood. Twenty-two children under 18 months of age were randomly assigned to the comparison or treatment group and received therapy twice a week for up to two years. The comparison group's therapy consisted solely of passive range of motion exercises. Therapy for the treatment group was described as, "tailored to fit the individual needs of a child," and included, "positioning and movement to inhibit abnormal reflexes or motor patterns and to facilitate more mature motor development" (Scherzer et al., 1976, pp. 48-49). Parents were trained to implement the treatment at home. The experimental group, children of normal intelligence, and older children showed the greatest improvement.

Each NDT study reported improvement for all children who received treatment. Progess was assessed according to gains in ambulation (Kong, 1966; Woods, 1964; Norton, 1975; Scherzer et al., 1976; Tyler & Kahn, 1976; Wright & Nicholson, 1973), postural reactions (Mysak, 1963; Norton, 1975; Tyler & Kahn, 1976), and standardized tests (Carlsen, 1975). As in the results reported from the orthopedic and Doman-Delacato studies, consistent findings of subject variables related to the amount of progress (e.g., age, IQ, amount of treatment, severity of cerebral palsy, etc.) were not evident.

Results from the NDT studies reviewed cannot be generalized or replicated for at least three reasons. First, most of the research lacked experimental control. Three of the six group studies (Footh & Logan, 1963; Kong, 1966; Woods, 1964) did not include a control or comparison group, and the single subject studies (Mysak, 1963; Norton, 1975; Tyler & Kahn, 1976) were conducted as case studies rather than in the framework of a single subject research design. It is not possible, therefore, to attribute developmental gains to the therapy rather than maturation or some other factor. Second, none of the method sections included operationalized definitions of therapy. And third, the reliability and validity of the measures of progress are unknown (only Carlsen, 1975, reported results based on standardized measurement).

Summary

Normal neurological development is a process of orderly maturation of the CNS occurring primarily during the first 15 months of life. Maturation of the CNS yields cortical dominance in the control of motor behavior. Cortically controlled behavior is characterized by righting and equilibrium reactions that are critical components of voluntary coordinated motor patterns (e.g., head control, rolling, sitting, crawling, etc.). Reflexes associated with the subcortically controlled motor responses of the young infant are inhibited as a result of cortical development.

Children with cerebral palsy have brain damage that impedes CNS maturation. Pathological tonic reflexes persist and constrain the acquisition of the postural reactions of righting and equilibrium, and thereby, the normal development of motor skills.

Three general approaches have been followed in the treatment of cerebral palsy: orthopedic, sensory stimulation, and neuromotor. NDT, a neuromotor approach, is the only approach based on CNS development as it occurs in nonhandicapped children. Research investigations of the various systems of therapy have all reported child progress. A lack of experimental control, the failure to operationalize therapy procedures, and vague outcome measures, however, have limited any statements regarding the efficacy of the intervention techniques. Currently, there is no empirical evidence to refute or support any of the approaches to the treatment of cerebral palsy.

CHAPTER III

METHOD

Facilitation of righting and equilibrium postural reactions was operationalized as the treatment variable for seven severely handicapped children with cerebral palsy. Using a multiple baseline design, the effectiveness of training postural reactions was investigated. Additionall an abnormal reflex (ATNR) and a coordinated motor pattern (head erect or rolling) were probed throughout the study to evaluate their theoretical relationship to postural reactions. NDT theory postulates that as righting and equilibrium reactions are acquired, primitive tonic reflexes diminish and coordinated motor patterns develop.

Subjects

Four girls and three boys ages 2 to 12 years were included in this study. All children were enrolled in Lawrence and Kansas City area preschool and elementary school classes for severely/multiply handicapped children. After the study was approved by the University Advisory Committee on Human Experimentation, the following criteria were used for subject selection:

a) medical diagnosis of cerebral palsy;

b) gross motor developmental level at or below seven months (assessed by Denver Developmental Screening Test, Frankenburg & Dodds, 1969);

c) clear and consistent demonstration of an asymmetrical tonic neck reflex (ATNR), symmetrical tonic neck reflex (STNR), or tonic labyrinthine reflex (TLR) (score of 3+ at least 7 of 10 trials, assessed with Primitive Reflex Profile, Capute et al., 1978); and

d) approval of training objectives by the child's physical or occupational therapist.

A gross motor level at or below seven months was included in the selection criteria because it precludes the achievement of the intervention targets (righting and equilibrium reactions). The ATNR was the only consistent reflex observed when subjects were selected. Table 1 summarizes the demographic characteristics of the children in this study.

Subject 1. Sam, a 2 year 1 month old male, was the youngest subject. At birth, labor and delivery were prolonged, he needed resuscitation, and was placed in the hospital's neonatal intensive care unit following heart failure. He had his first seizure at 8 days of age. When the study began, Sam was able to hold his head up in prone or sitting, sit independently for several minutes (although he could not attain sitting without assistance) and crawl on his stomach short distances by pulling himself forward with his arms. Socially, he recognized and responded positively to familiar persons. He understood simple directions, could reach and grasp desired objects, and was just beginning to imitate sounds within his repertoire. Between sessions 59 and 77, Sam had heelcord surgery (the casts were removed before he returned to school and the study).

Subject 2. Janet, a 3 year 4 month old female, was seizuring at birth and reportedly seizured almost continuously for the first four months of life. She was the most severely handicapped child in the study. Janet slept frequently, and typically did not raise her head in prone, move a limb voluntarily, or interact in anyway with people or objects in her environment. Occasionally, however, she did respond to movement or sound by crying or smiling. Following session 91 Janet was

Table 1

Demographic Characteristics of Subjects

Subject	Sex	Age at Beginning of Study	Diagnosis	Medication	Denver Developmental Screening Test Motor	Denver Developmental Screening Test Overall
1 (Sam)	M	2 yrs. 1 mo.	spastic quadriplegia seizure disorder	phenobarbitol tegretol	6 mos.	7 mos.
2 (Janet)	F	3 yrs. 4 mos.	spastic quadriplegia seizure disorder microcephaly	phenobarbitol	1 mo.	1 mo.
3 (Charlie)	M	5 yrs. 3 mos.	spastic quadriplegia seizure disorder	none	3 mos.	4 mos.
4 (Loretta)	F	3 yrs. 2 mos.	hypotonic quadriplegia	none	5 mos.	24 mos.
5 (Kathy)	F	3 yrs. 3 mos.	hypotonic quadriplegia seizure disorder	none	2 mos.	4 mos.
6 (Marilyn)	F	12 yrs. 1 mo.	spastic quadriplegia seizure disorder scoliosis	phenobarbitol	2 mos.	3 mos.
7 (Matt)	M	4 yrs. 4 mos.	spastic quadriplegia	phenobarbitol	2 mos.	6 mos.

hospitalized for several days with a respiratory infection and a fever that rose to 108°F accompanied by grand mal seizures. Although she returned to school for a few days, she was hospitalized again with similar symptoms and malnutrition (treated with a gastrostomy). Due to poor health, her participation in the study was discontinued.

Subject 3. Charlie, a 5 year 3 month old male, had perinatal anoxia. At the beginning of the study he was able to lift and maintain his head up for several seconds in prone while propping on his forearms. Charlie had very little head control when sitting, however, and did not reach for objects from any position. In spite of his severe physical limitations, Charlie was very attentive to his environment, discriminated strangers from familiar persons, and showed favoritism among familiar persons.

Subject 4. Loretta, a 3 year 2 month old female, had respiratory distress following a prolonged labor at birth. When the study began, she was able to lift her head and maintain head control for a short time in prone and sitting, and was just beginning to maintain a sitting position independently for several seconds. Although she was not able to crawl, she could roll to a desired destination. Loretta was the only subject able to talk. Her language skills were approximately at age level; she initiated and participated in conversations with peers and adults, followed directions, commented on past and future events, and laughed at simple jokes. She was clearly the highest functioning subject in the study.

Subject 5. Kathy, a 3 year 3 month old female, was born postmature at 42 to 43 weeks gestation and had seizures at the age of 12 hours. She received intensive therapy and patterning of the Doman-Delacato approach for approximately a year. Therapy was discontinued when her family moved to the Kansas City area and enrolled her in a special education preschool program a few weeks before the study began. When evaluated at the beginning of the study, Kathy was only able to lift her head momentarily in prone or supported sitting. She had minimal reach and grasp skills, but was quite responsive socially. She frequently smiled at familiar persons, sometimes cried when family members left the room, and attended to persons and events in her environment.

Subject 6. Marilyn, a 12 year 1 month old female, was the oldest child in the study. She was born breech with apparently no other complications until she had a cerebral aneurysm at 10 days of age. When the study began, Marilyn had a severe scoliosis and contractures of her knees, hips, and left elbow and wrist. She was able to lift her head momentarily in prone or supported sitting but did not reach for objects nor visually track them. Marilyn did respond positively, however, by smiling or laughing when people spoke to her in a friendly tone, if music of a particular recording artist was played, or if she was put through movement activites.

Subject 7. Matt, a 4 year 4 month old male, had an unremarkable birth history. At the beginning of the study he was able to maintain head control in prone when propped on his forearms for a short time. Matt could sit long-legged with support, could maintain grasp of an object, and was just learning to reach for objects. Contractures of both elbows and wrists limited his physical skills. He was socially very alert, discriminated strangers from familiar persons, and laughed easily during play.

Setting and Equipment

The study was conducted at five preschool and elementary school sites in the Lawrence and Kansas City area (see Table 2). The elementary school classrooms were for severely multiply handicapped children and were located in special education wings of public elementary schools. All three preschool sites were university-sponsored programs. Table 2 also delineates the persons who carried out the study at each site. At a site where more than one trainer participated, the trainers alternated sessions (Subjects 3 and 6) or implemented training for at least six consecutive weeks (Subjects 1, 2, and 5).

Baseline and training took place in each child's classroom during the morning school hours except for Subject 4, Loretta, who received training in her school's occupational therapy room after school hours. A carpeted area or therapy mat approximately 12 X 12 feet (6.36 X 6.36 m) served as the training setting and the following equipment was used:

a) a firm plastic therapy ball, barrel, or carpeted barrel, 36 inches in diameter (91.44 cm, ball commercially available from Preston Corporation #PC 2764 A);

b) an adult-size straightback chair without arms;

c) a stopwatch; and

d) if rolling was probed, two elastic bands to fit the child's waist and chest (see Appendix 4 for dimensions and directions for construction).

Responses Measured

Three variables were monitored throughout the study: postural reactions (equilibrium, parachute, and righting), the ATNR, and a coordinated motor pattern (head erect or rolling). Ten consecutive trials of each postural reaction were measured each session (i.e., daily, Monday through Friday). The ATNR and head erect or rolling were probed,

Table 2

Settings and Types of Personnel Serving as Trainers for Each Subject

Subjects	Setting	Trainer(s)
1 (Sam) 2 (Janet)	special education preschool	1 OT undergraduate student 1 PT undergraduate student 2 PT graduate students
3 (Charlie)	elementary school SMH class	1 teacher 2 paraprofessionals
4 (Loretta)	occupational therapy room	1 research assistant
5 (Kathy)	special education preschool	1 teacher 1 OT, SMH graduate student
6 (Marilyn)	elementary school SMH class	1 teacher, SMH graduate student 2 paraprofessionals
7 (Matt)	special education preschool	1 SMH graduate student

rather than measured each session, to reduce the possibility of reactive effects from repeated measurement (see Table 3).

A session schedule was given to each trainer indicating the sessions in which probes were to be taken and the order in which the postural reactions were to be trained (see Figure 3). To guard against an order effect in training, the daily sequence of equilibrium, parachute, and righting training was randomized for each subject. The session schedule was utilized by recording each date that a session was conducted in the left hand column without regard for days missed due to illness or other absenteeism.

Postural reactions. The equilibrium, parachute (another equilibrium reaction), and righting reactions are responses of balance and body alignment that are essential, according to neurodevelopmental theory, for the development of coordinated motor patterns (Bobath, B., 1948; Bobath, K., 1980; Bobath, K. & Bobath, B., 1967). The three postural reactions monitored and trained in this study were defined as follows:

a) equilibrium reaction - The student is seated cross-legged, in ring-sitting, or long-legged, on the floor facing a mirror, and supported by the trainer at the upper trunk. When gently tipped to one side (about 45°) the subject's arm (of the side to which the subject was tipped) will extend and the trunk will tilt towards the opposite side within five seconds (see Figure 4a).

b) parachute reaction (an equilibrium reaction) - The student is prone on a therapy ball and supported by the trainer at the hips. As the student is gently rolled forward until he/she is one arm's length from the floor, the student's arms will extend outward beyond the head, and the hands will open and extend toward the floor within five seconds (see Figure 4b).

c) righting reaction (head righting) - The trainer is seated on a chair and the student is supported under the arms and seated on the trainer's lap. Both are facing the mirror. When the student is gently tipped to one side (about 45°), the student will maintain or regain a midline head position within five seconds (see Figure 4c).

Table 3

Responses Measured; Type and Frequency of Measurement

Responses Measured		Types of Measurement	Frequency of Measurement
Postural Reactions (all three for each student)	Equilibrium Parachute Righting	Scale: 0-3 10 trials each, totaled (90 points possible) (see Table 3)	Each session
Tonic Reflex Probe	Asymmetrical Tonic Neck	Scale: 0-4+ 10 trials (see Appendix A)	Every third session
Coordinated Motor Pattern Probe (one for each child)	Head Erect	Head turn frequency, Head lift frequency, Longest duration Cumulative duration (see Appendix B)	Every fourth session
	Rolling	Degrees rotation (see Appendix C)	

Figure Caption

Figure 3. Training schedule followed by each trainer. The date was recorded in the left column, and the information in each column across form the date indicated if a reflex or motor probe was to be conducted that day, and specified the order in which postural reaction training was to be conducted.

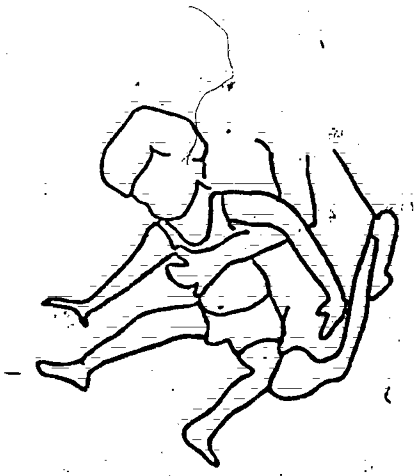
Subject 1 ____________

TRAINING SEQUENCE

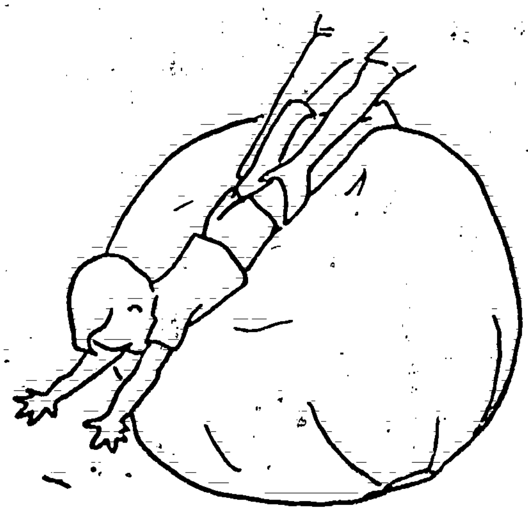
Date	Session	Reflex Probe	Motor Pattern Probe	Training Order
____	1			parachute, equilibrium, righting
____	2			equilibrium, parachute, righting
____	3	x		equilibrium, righting, parachute
____	4		x	righting, parachute, equilibrium
____	5			parachute, righting, equilibrium
____	6	x		righting, equilibrium, parachute
____	7			equilibrium, parachute, righting
____	8		x	parachute, equilibrium, righting
____	9	x		righting, parachute, equilibrium
____	10			equilibrium, righting, parachute
____	11			parachute, righting, equilibrium
____	12	x	x	righting, equilibrium, parachute
____	13			righting, equilibrium, parachute
____	14			equilibrium, parachute, righting
____	15	x		equilibrium, righting, parachute
____	16		x	righting, parachute, equilibrium
____	17			parachute, equilibrium, righting
____	18	x		parachute, righting, equilibrium
____	19			parachute, righting, equilibrium
____	20		x	equilibrium, righting, parachute
____	21	x		righting, equilibrium, parachute
____	22			parachute, equilibrium righting
____	23			righting, parachute, equilibrium
____	24	x	x	equilibrium, protective, righting

Figure Caption

Figure 4. Stimulus positons for training the three postural reactions.



a. Equilbrium Reaction



b. Parachute Reaction

c. Righting Reaction

Each postural reaction was scored on a scale from 0 to 3, "total assistance" to "independent," and recorded on a training data sheet (see Figure 5). The scoring indicated the "level of assistance" needed by the subject to respond as each reaction was defined. Table 4 describes the levels of assistance and scoring for each postural reaction.

Measurements obtained for the ten trials of each reaction (alternating to the left and right side for equilibrium and righting) were totaled and presented as one score per session per subject. Scores from the three postural reactions were totaled because the responses do not occur in complete isolation of one another. The situations described above to elicit each postural reaction would prompt other postural reactions as well. For example, if a student was sitting on the floor and tipped to one side, the upper trunk and shoulders would raise toward the opposite side (equilibrium). Additionally, it would be expected that the head would maintain or reposition to midline, a righting reaction. A score of 90 points was possible for each session (10 trials X 3 possible points X 3 postural reactions). Appendix A contains a sample of a completed data sheet.

<u>Tonic reflex</u>. The ATNR is a subcortical (cortically immature) motor response that interferes with normal motor responses. It was assessed by a probe every third session. ATNR probes taken throughout the study were measured with procedures from the <u>Primitive Reflex Profile</u> included in Appendix B (Capute et al., 1978).

An ATNR is illustrated in Figure 1 and was defined as follows:

> When the child is supine he may be seen to lie with head turned to one side with extension of extremeties on that side (chin side), and flexion of the contralateral extremities (occiput side). This may also be noted in sitting; it is often described as the "fencer" position. (Capute et al., 1978, p. 38)

Figure Caption

Figure 5. Data sheet for recording five sessions of postural reaction responses. The number corresponding to the level of assistance required in each trial was written in the space provided under the numbers from 1 to 10. Scores were totaled for each reaction and recorded in the T column; the total score for all three reactions was recorded in the TT column; and the interobserver reliability was recorded in the R% column.

DATA SHEET 1
Training

Student ______________ Trainer ______________ Week # ______

Date		1	2	3	4	5	6	7	8	9	10	T	TT	R%
	equilibrium													
	parachute													
	righting													
	equilibrium													
	parachute													
	righting													
	equilibrium													
	parachute													
	righting													
	equilibrium													
	parachute													
	righting													
	equilibrium													
	parachute													
	righting													

Table 4

Levels of Assistance Training; Scoring and Definitions of Levels

Postural Reactions	Score/Level	Training Procedures
Equilibrium	3/Independent	No assistance given; the student's arm on the side to which he/she was tipped will extend and the trunk will tilt toward the opposite side.
	2/Cue	The trainer says, "Catch yourself," and/or taps the student's upper arm (on the side to which the student was tipped).
	1/Prompt	The trainer extends the student's arm (on the side to which the student was tipped).
	0/Put Through	The trainer extends the student's arm (on the side to which the student was tipped) and tilts the trunk in the opposite direction of the tip.
Parachute (equilibrium)	3/Independent	No assistance given; the student's arm will extend beyond the head and the hands will open and extend to the floor.
	2/Cue	The trainer says, "Reach for the floor," and/or gently taps on the student's upper arm.
	1/Prompt	The trainer extends the student's arm forward and opens the student's hands, or touches them to the floor.
	0/Put Through	The trainer extends the student's arms forward, opens the student's hands, and touches them to the floor.
Righting	3/Independent	No assistance given; the student will maintain or regain a midline head position.
	2/Cue	The trainer says, "Pick up your head," and/or gently taps the side of the student's head.
	1/Prompt	The trainer lifts the student's head half-way to midline position.
	0/Put Through	The trainer lifts the child's head to midline position.

Scoring ranged from "0" ("absent", reflex did not occur) to "4+" ("obligatory," reflex maintained longer than 30 seconds) and was recorded on the ATNR data sheet (see Figure 6). An example of a completed data sheet is included in Appendix C.

Coordinated motor pattern. Quantitative assessment procedures were used to probe the coordinated motor patterns of head erect and rolling (Foshage, Note 4; Rues, Note 5; Day, Rues, & Lehr, Note 6; Fritzshall & Noonan, Note 7). Head erect assessment procedures (see Appendix D), measuring the frequency of head turns and head lifts, the longest duration, and the cumulative duration of head erect, were used as the motor pattern probe for children with very poor head control skills (Subject 2, Janet; Subject 5, Kathy; Subject 6, Marilyn; and Subject 7, Matt). The remaining children (Subject 1, Sam; Subject 3, Charlie; and Subject 4, Loretta) were probed with the degrees of trunk rotation measure from the rolling assessment procedures (see Appendix E). Head erect and rolling data sheets are presented in Figures 7 and 8, respectively. A sample of a completed data sheet for head erect is in Appendix F and for rolling is in Appendix G.

Training Procedures

One component of NDT, facilitating postural reactions, was conducted for each subject by a trainer each daily session (i.e., Monday through Friday). A four-step "levels of assistance" strategy (Lynch, Flanagan, & Pennell, 1977; Child Progress Monitoring System, Note 8; and described in studies by Banerdt & Bricker, 1978; Horner & Keilitz, 1975; O'Brien & Azrin, 1972), sequenced from independent with no intervention from the trainer to total assistance with complete physical guidance from the trainer, was used to operationalize "facilitation" as the training procedure for this study (see Table 4). Levels of assistance training

Figure Caption

Figure 6. Data sheet for recording ATNR probes for five probe sessions. Trials were alternated to the right and to the left sides.

DATA SHEET 2
Tonic Reflex Probe

Student ______________________ Trainer ______________________

Date		Trials 1	2	3	4	5	Reliability
____	left	___	___	___	___	___	
	right	___	___	___	___	___	____
____	left	___	___	___	___	___	
	right	___	___	___	___	___	____
____	left	___	___	___	___	___	
	right	___	___	___	___	___	____
____	left	___	___	___	___	___	
	right	___	___	___	___	___	____
____	left	___	___	___	___	___	
	right	___	___	___	___	___	____

Figure Caption

Figure 7. Data sheet for recording one session of a head erect probe. Head turns and head lifts were tallied; each duration greater than 2 seconds was listed and the logest duration was circled; and the durations listed in the third column were summed and recorded in the fourth column. Upper extremity weight bearing was not assessed.

NAME: BIRTHDATE: DATE:

OBSERVER(S): SETTING: RELIABILITY:

Code:
- ↑ - no arm support
- √↑ - props on one forearm, other arm no support
- √√ - props on forearms
- √| - props on forearm and one extended arm
- || - props on extended arms
- R - right arm
- L - left arm

HEAD ERECT DESCRIPTORS				UPPER EXTREMITY WEIGHT BEARING DESCRIPTORS							Reliability
Head Turns	Head Lifts	Duration: Longest Head Lift	Cumulative Duration: Head Erect or	R ↑ L ↑	R ↑ L √	R √ L ↑	R √ L √	R √ L |	R | L √	R | L |	
Total											

Figure Caption

Figure 8. Data sheet for recording one session of a rolling probe. The degrees of trunk rotation was circled under the second column; the body part leading the roll and the amount of mobility was not assessed.

Measurement of the Rolling Response from Prone, Supine, and Sidelying

Name ______________________ Evaluator ______________

Date ______________________ Observer ______________

Descriptors

P - prone S - supine SL- sidelying	R - right L - left	O - orange (0-11.25°) B - blue (11.25-22.5°) R - red (22.5-45°) W - white (over 45°)	SH - shoulder PE - pelvis R - reliability

Trial	Trunk Rotation	Body Part Leading Roll	Mobility	R
P over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
P over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL R to S)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
P over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
P over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL L to S)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL R to P)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL L to P)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
	R ____	R ____	R ____	

Mean R per session ____

was selected because it parallels the descriptions of facilitation techniques in the NDT literature (e.g., Bobath, K. & Bobath, B., 1967) and yet is a fairly standardized training procedure in the education of severely handicapped children.

Daily sessions consisted of ten trials for each of the three postural reactions. Each trial began at the independent level (3). If the child failed to respond within five seconds, the trainer provided the next level of assistance, a verbal cue (2). Training continued in the same manner throughout the remaining levels of assistance; if no response occurred within five seconds of the stimulus, training moved to the next level. When a correct response occurred at any level, verbal and social praise was given and training proceeded to the next trial at the independent level of assistance.

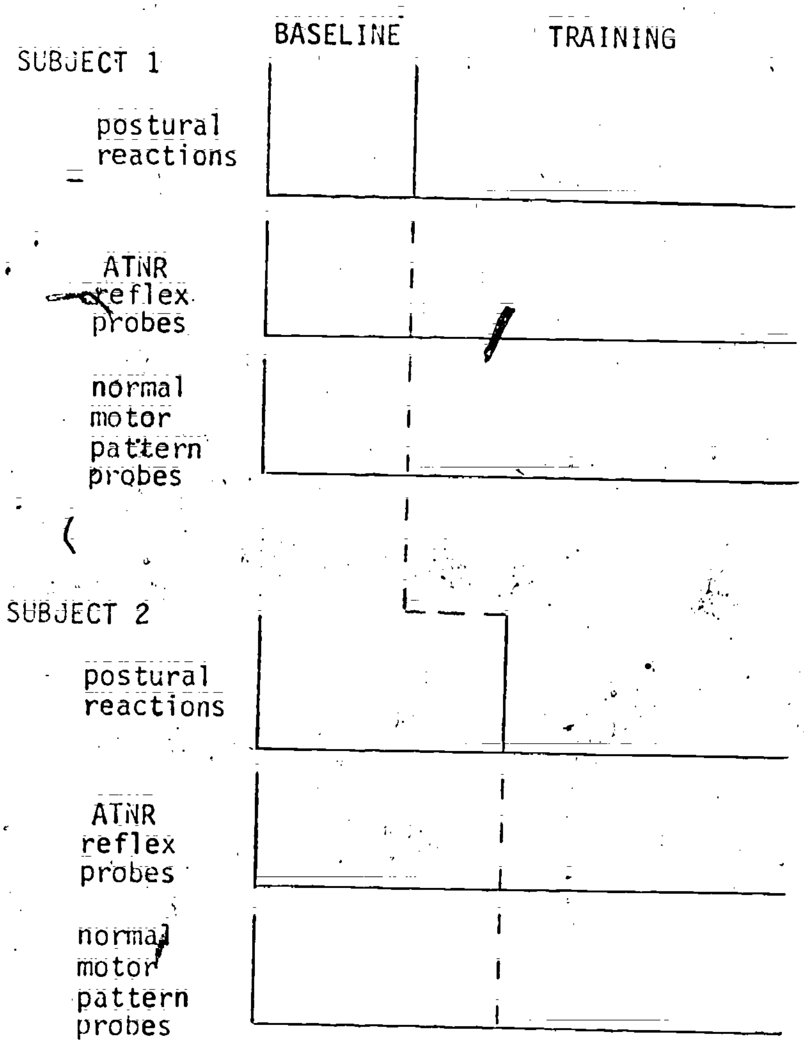
Experimental Design

A multiple baseline design (Baer, Wolf, & Risley, 1968; Hersen & Barlow, 1976; Sidman, 1960) across two subjects was replicated three times (see Figure 9). Subject 7 (Matt) was not included in a multiple baseline because the subject he was paired with was excluded early in the study due to poor school attendance.

Baseline. The baseline was the initial condition. Opportunities to respond for the postural reactions were given only at the independent level of assistance; responses at the other levels of assistance would have constituted training. Two scores were possible for each trial: "3" for an independent correct response, and "0" for no response, or an incorrect response. Probes of the ATNR and head erect or rolling were conducted according to the procedures specified in Appendix B, D, and E, respectively. Verbal and social praise were given noncontingently and for cooperation during the baseline condition.

Figure Caption

Figure 9. Multiple baseline across two subjects; postural reactions were trained for each subject, and the ATNR and a motor pattern were monitored with probes. (The design was replicated twice.)


BASELINE
TRAINING
SUBJECT 1
postural reactions
ATNR reflex probes
normal motor pattern probes
SUBJECT 2
postural reactions
ATNR reflex probes
normal motor pattern probes

Baseline was terminated for the children in the first legs of the multiple baselines (and Subject 7) when the postural reaction data were stable and a minimum of three data points were collcted for the ATNR and coordinated motor pattern probes (a minimum of twelve sessions). Baseline was terminated and training was introduced to the remaining children when the training condition data of the child each was paired with stabilized, or when a trend in the data was clearly evident.

Training. Once the training condition was introduced, neurodevelopmental "facilitation" of postural reactions was conducted each session as described on page 44; the training procedure was directed at improving equilibrium, righting, and parachute reactions.

Reliability

Interobserver reliability data for each subject were collected on the postural reaction measures approximately once a week, and at least twice during the study for the probes (ATNR and coordinated motor patterns). If more than one trainer was used, reliability was taken at least twice with each trainer across each measure. The investigator served as the reliability observer.

Reliability was calculated separately for each postural reactions, reflex, and motor patterns probe. Postural reaction and ATNR reliability scores were obtained by dividing the total number of agreements by the number of agreements plus disagreements, and multiplying by 100:

$$\frac{\text{total agreements}}{\text{agreements + disagreements}} \times 100.$$

Directions for computing reliability for the coordinated motor patterns are included in the procedures for measuring head erect and rolling in Appendix D and E.

Data Analysis

Results were evaluated by using both within-subjects and group analyses of the data. The major portion of the analysis, within-subject comparisons, was accomplished by using visual analysis, descriptive statistics, and a nonparametric test and correlation coefficient. A group comparison of the baseline condition to the training condition was made using a nonparametric test with means and with slopes.

Within-subject. Postural reaction and probe (ATNR and coordinated motor patterns) results were graphed for the visual analysis of the data (Parsonson & Baer, 1978) (see Figure 9). Least squares regression lines calculated with the TI 55 Texas Instrument hand calculator were fitted separately to the baseline and training data to assist in the interpretation of the results.

Baseline and training conditions were then compared for differences of level and trend in the data. Each of the three repeated multiple baseline designs and results from Subject 7 were evaluated for a systematic replication of training effects across each subject. The mean, standard deviation, and the slope of the regression line were reported as descriptive statistics to aid in the visual evaluation.

ATNR and coordinated motor pattern probes were each correlated with the postural reaction data of the training condition within subjects. Kendall's Tau (Bruning & Kintz, 1977; Conover, 1971) was calculated for the coefficient of correlation.

The Mann-Whitney U-Test (Bruning & Kintz, 1977; Conover, 1971) was run to compare the baseline and treatment conditions for each subject. Difference scores, rather than obtained scores were used for this analysis. The scores were derived by the following procedure:

a) The least squares regression line was fitted to the baseline data and extended through the training data;

b) The point on the regression line corresponding to the x-value of each observed score in the baseline and training conditions was obtained using the following formula:

$$Y = bX + a$$

where b is the slope of the baseline regression line, and a is the y-intercept of the line;

c) Each calculated point was then subtracted from the obtained score that corresponded to its x-value to derive a difference score.

If there was no training effect, the difference scores in the baseline and training conditions were essentially the same.

Group. A Wilcoxon Signed Ranks Test (Bruning & Kintz, 1977; Conover, 1971) was run to compare baseline and training conditions for the group. The test was run twice: the first time, the means of each condition for each subject were used as the data; and the second time, the slopes of the regression lines in each condition were used.

CHAPTER IV

RESULTS

Reliability

Mean interobserver reliability scores across sessions for each child are listed in Table 5. Across children, mean reliability ranged from 88.3% to 100% for postural reactions, from 76.7% to 100% for the ATNR probes, and from 76.5% to 100% for the motor probes. Mean reliability scores for each postural reaction measure across subjects were all above 97%, and total mean reliability across subjects and postural reactions was 98.2%. For the reflex and motor probes, mean reliability scores across subjects were all greater than 94%. Appendix H contains the interobserver reliability scores for each subject per measure and per session.

Within-Subject Data Analyses

A visual analysis of the data is presented first for each subject (see Figures 10 through 20). Baseline and training conditions were compared with reference to level and trend of the data. Descriptive statistics were used to aid in these analyses. Results in the training condition were then compared to the probe data for similar or contrasting effects. Finally, the overall effect of training on the postural reactions was evaluated across the seven subjects (see Figure 21).

Two nonparametric statistical analyses are described for each subject (Bruning & Kintz, 1977; Conover, 1971). A Mann-Whitney Test with difference scores (derived from the actual scores and the corres-

Table 5

Mean Reliability Scores Across Sessions by Measure for Each Child

Subject	Postural Reactions				Probes		
	Equilibrium	Parachute	Righting	Overall	ATNR	Head Erect	Rolling
1 (Sam)	97.3	98.3	88.3	95.1	96		89.6
2 (Janet)	100	100	100	100	100	100	
3 (Charlie)	100	100	100	100	96		100
4 (Loretta)	97.3	94.5	96.4	96.3	100		92.5
5 (Kathy)	94.2	100	97.5	97.8	100	76.5	
6 (Marilyn)	100	100	100	100	76.7	100	
7 (Matt)	100	100	98.7	99.7	100	100	
Mean per Measure Across Subjects	98.4	99	97.3	98.2	95.5	94.1	94

ponding points on the regression line from the baseline condition) was used to compare the baseline and training conditions of each subject. Kendall's Correlation Coefficient (tau) was calculated to compare the postural reaction data to each set of probe data during the training condition.

<u>Subject 1 (Sam) and Subject 2 (Janet)</u>. Figure 10 illustrates fairly low, slightly variable, and relatively stable postural reaction scores for Sam (Subject 1) during the baseline condition. A slight, but immediate increase in level of the postural reaction data occurred when the postural reaction training condition began. During baseline, the mean level of total points was 8.25, whereas in training it was greater at a mean of 22.52 points. Additionally, the trend of the regression line fit to the data changed from a downward slope of -.20 during baseline, to an upward slope of .22 during training. Variability was much greater in the training condition and yielded a standard deviation of 10.79, compared to a baseline standard deviation of 2.89.

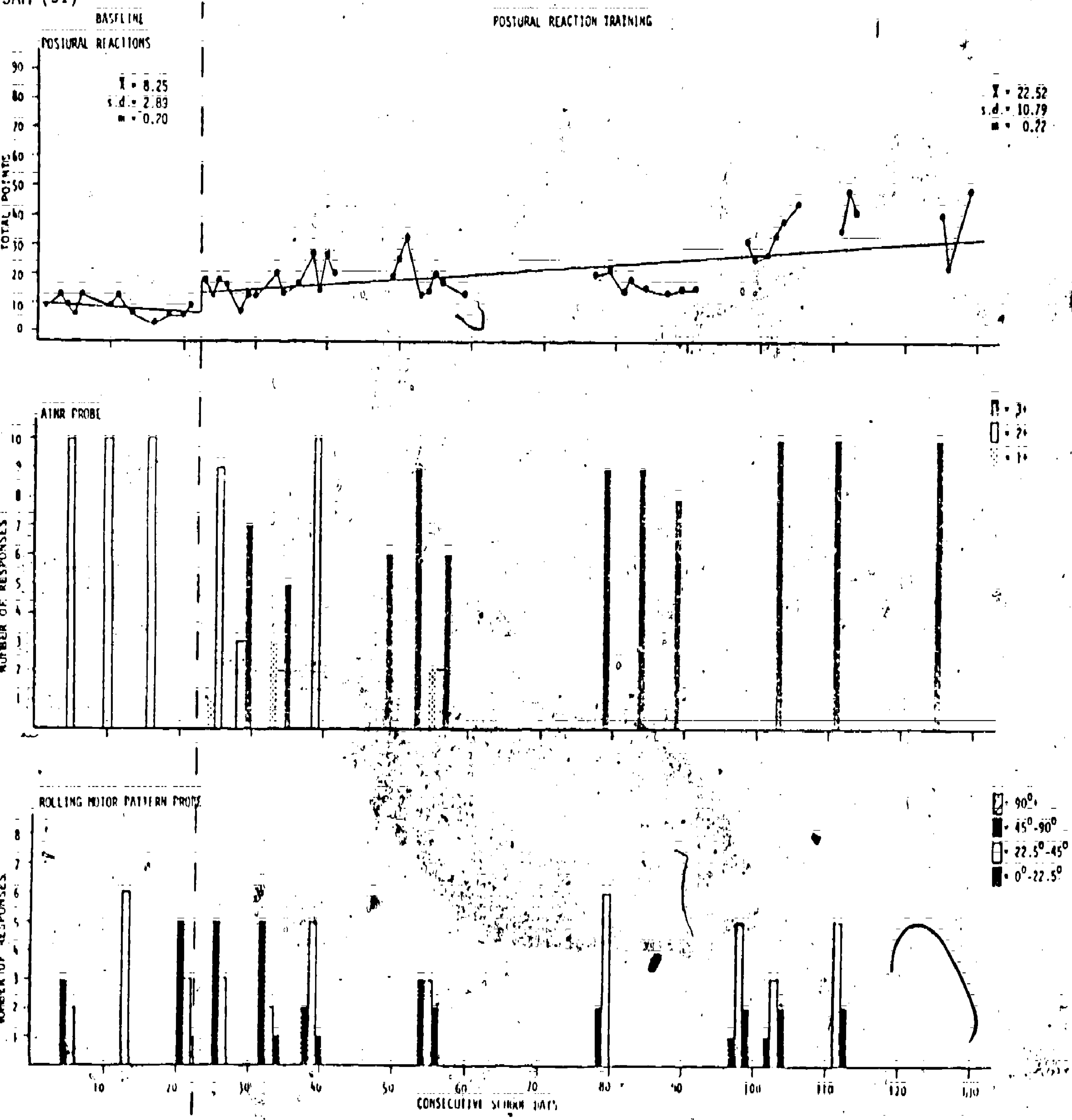
Figure 11 presents the postural reaction data separately for the equilibrium, parachute, and righting reactions for Sam. All three behaviors increased in level, variability, and trend. Most of the improvement occurred in the equilibrium response.

ATNR probe scores increased in intensity over the course of the study (see Figure 10). Initially, consistently high levels of 2+ (partial reflex posture) were recorded. Following session 60, however, 2+ responses no longer occurred, and 3+ scores (full reflex posture, but not obligatory) were noted with increasing frequency. The improvement in postural reactions were accompanied by an increase in the level of ATNR responses.

Figure Caption

Figure 10. Postural reaction, ATNR probe, and motor pattern probe data for Sam (Subject 1) and Janet (Subject 2) across sessions.

SAM (S1)



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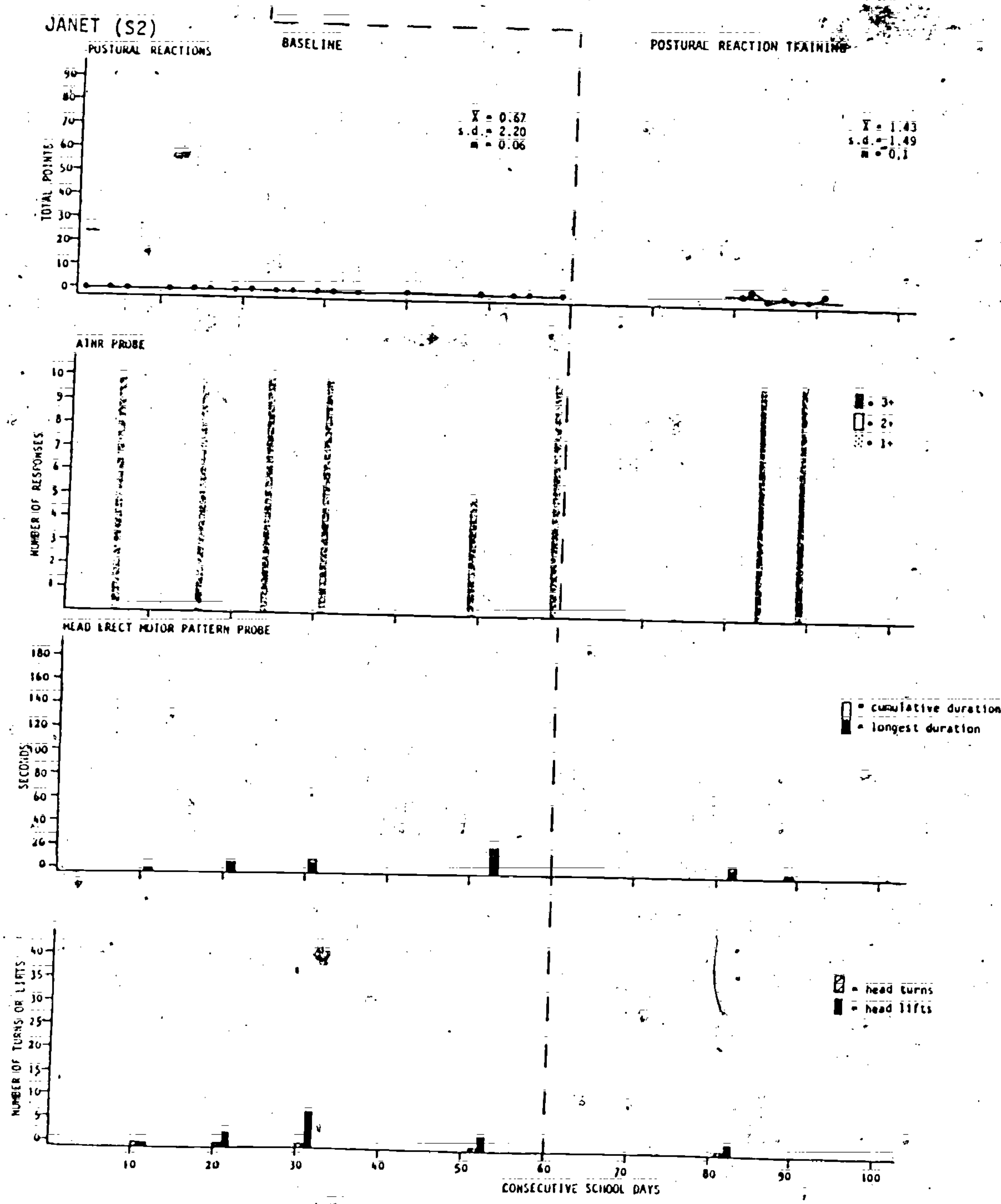

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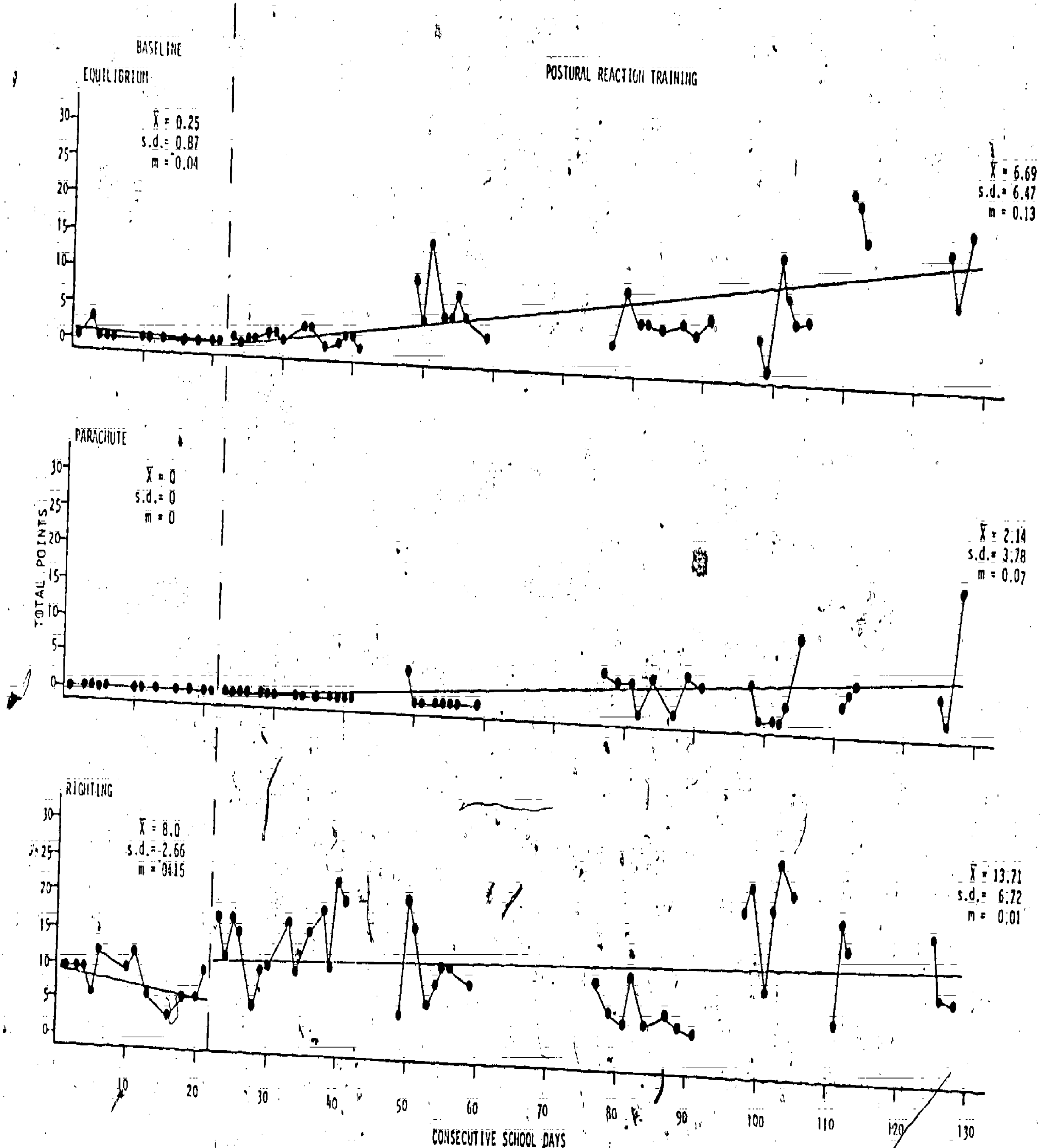
Figure Caption

Figure 11. Individual postural reaction data for equilibrium, parachute, and righting responses across sessions for Sam (Subject 1).


BASELINE
EQUILIBRIUM
POSTURAL REACTION TRAINING
X̄ = 0.25
s.d. = 0.87
m = 0.04
X̄ = 6.69
s.d. = 6.47
m = 0.13
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 2.14
s.d. = 3.78
m = 0.07
TOTAL POINTS
RIGHTING
X̄ = 8.0
s.d. = 2.66
m = 0.15
X̄ = 13.71
s.d. = 6.72
m = 0.01
CONSECUTIVE SCHOOL DAYS

Degrees of trunk rotation measured in the rolling motor pattern probe increased slightly throughout training (see Figure 10). Zero degrees - 22.5° of trunk rotation was recorded for five of the eight rolling trials in each of the first two probes during the training condition. Following those first two training probes, 22.5° - 45° of trunk rotation was the more frequent and consistent response. The highest frequency of 22.5° - 45° rotation was 6, but this same frequency was also noted during baseline.

A Mann-Whitney Test (see Table 6) produced a z-score of -5.10, significant at the .05 level using a two-tailed test. Kendall's Tau (see Table 7) correlating the ATNR probes with the corresponding training scores were all less than ±.39. Tau for 0° - 22.5° rolling rotation was relatively high at -.73, but much less for 22.5° - 45° (tau = .12) and 45° - 90° (tau = .52).

Janet's postural reaction data were at zero or close to zero throughout baseline (see Figure 10). Sessions 63 and 65 were the only sessions in which she scored above zero, 11% of the sessions. In training, mean total points increased from a baseline level of .67 to a training level of 1.43, and Janet scored above zero 57% of the sessions. Trends in the data for both conditions were very slight; the regression line through the baseline data had a slope of .06 and the line through training had a slope of -.01. Variability was negligible in both postural reaction baseline and training conditions.

Postural reaction data are presented in greater detail for Janet in Figure 12. Baseline and training conditions had consistently lower scores for the equilibrium response; however, all responding greater than a score of zero occurred during training. There was no change in

Table 6

Mann-Whitney U-Test
Comparing Postural Reaction Baseline to Treatment

Subject	z-Score
1 (Sam)	-5.10*
2 (Janet)	NA
3 (Charlie)	NA
4 (Loretta)	4.75*
5 (Kathy)	-5.10*
6 (Marilyn)	5.68*
7 (Matt)	-.99

*Significant at .05 level.

Table 7

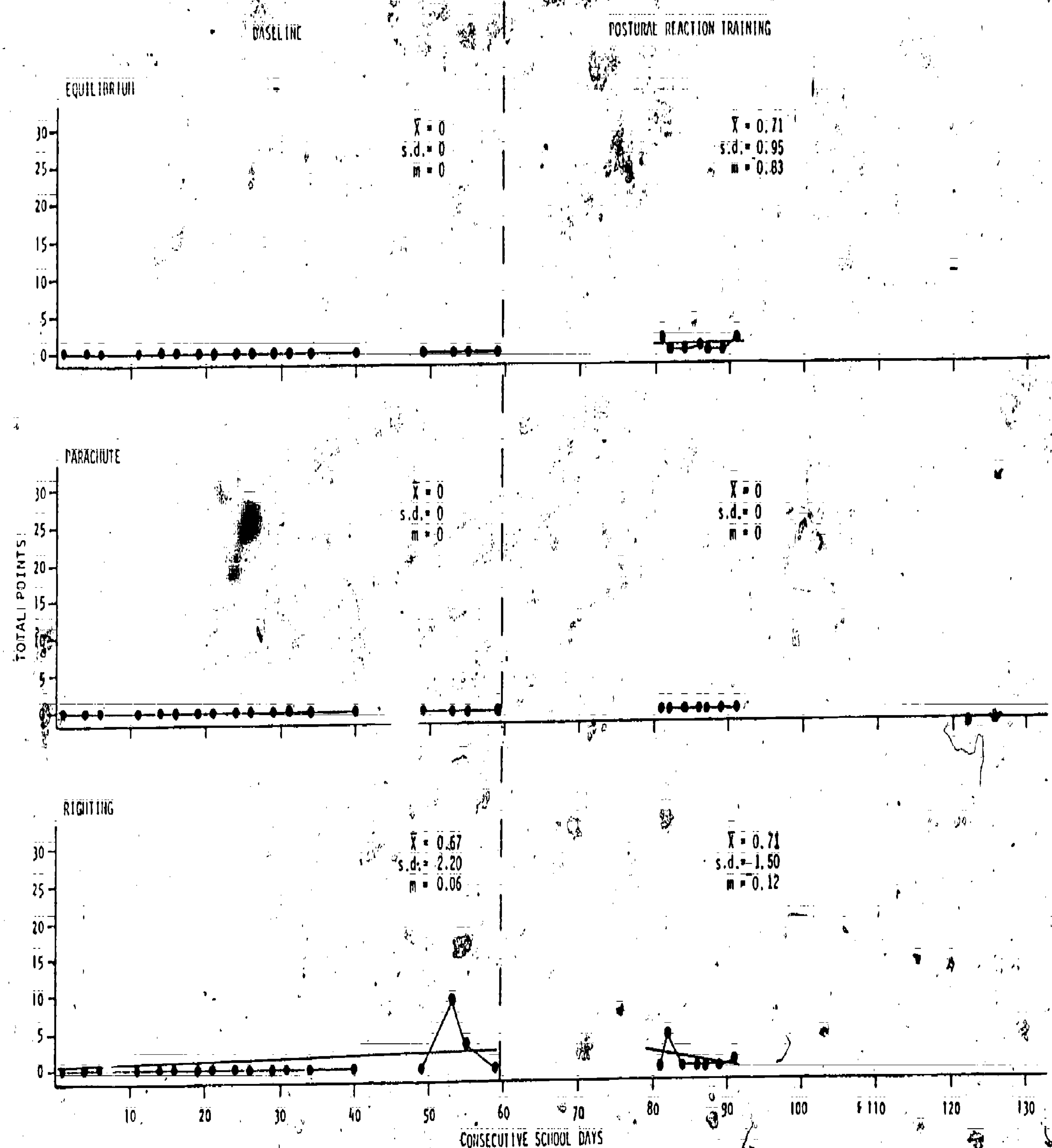
Kendall's Rank-Order Correlation Coefficient (Tau)

Comparing Postural Reaction Training to the ATNR Probes and Training

Subject	ATNR Probe Scores			Rolling Rotation Scores				Head Erect Scores	
	3+	2+	1+	0-22.5°	22.5°-45°	45°-90°	90°+	Cumulative Duration	Lifts
1. (Sam)	.36	-.39	-.17	-.73	.12	.52			
2. (Janet)									
3. (Charlie)	.08			-.06	.31	-.06	-.31		
4. (Loretta)				.82	-.82				
5. (Kathy)								.52	.17
6. (Marilyn)	.15	-.15	-.[illegible]					.39	.67
7. (Matt)								.60	.22

Figure Caption

Figure 12. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Janet (Subject 2).


BASELINE
POSTURAL REACTION TRAINING
EQUILIBRIUM
X̄ = 0
s.d. = 0
m = 0
X̄ = 0.71
s.d. = 0.95
m = 0.83
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
RIGHTING
X̄ = 0.67
s.d. = 2.20
m = 0.06
X̄ = 0.71
s.d. = 1.50
m = 0.12
TOTAL POINTS
CONSECUTIVE SCHOOL DAYS

the parachute reaction during the study; all baseline and training scores were zero. The only points scored during baseline were scored for the righting reaction just prior to implementing the training. The highest score in the training condition for righting was less than the highest score (9) recorded in the baseline condition.

ATNR probes remained relatively stable at 3+ (full reflex posture, but not obligatory) throughout the study except for session 48 when 3+ occurred five times and no measurable response was observed for the other five trials of that session (see Figure 10). This lower ATNR score occurred just previous to the two postural reaction baseline sessions in which total points were greater than zero.

Head erect motor pattern probes in Figure 10 indicated very low levels of head erect duration, head turns, and head lifts. Levels of behavior were slightly higher during baseline with 21 seconds as the longest duration and longest cumulative duration, and 6 head lifts as the greatest frequency of head lifts or head turns during the recording period of 180 seconds.

The Mann-Whitney test was run to compare Janet's postural reaction baseline and treatment scores, but the lack of variance in the baseline data distorted the test. Therefore, the z-score from that test was not included in Table 6. As a substitute analysis, a chi-square test (Bruning & Kintz, 1977; Conover, 1971) was run to determine if the probability of the number of scores higher than zero in the baseline condition in comparison to the treatment condition was greater than chance. Chi-square with 1 degree of freedom and Yates' correction (because some expected cell frequencies were less than 10) was equal to 3.6 and was not significant at the .05 level for a two-tailed test. Kendall's Tau was not determined for comparing the postural reaction training data to either of the probes because there were not enough probe data for the computations.

Subject 3 (Charlie) and Subject 4 (Loretta). In Figure 13, Charlie's postural reaction baseline was stable at zero for all sessions. Shortly after the training condition began, two scores greater than zero were recorded (session 39 and 40), and during approximately the last third of the training, several scores greater than zero were recorded (from session 83 to the end of training). The highest total score recorded during training was 3. The mean total points, standard deviation, and slope of the regression line were all very low: .20, .57, and .01, respectively.

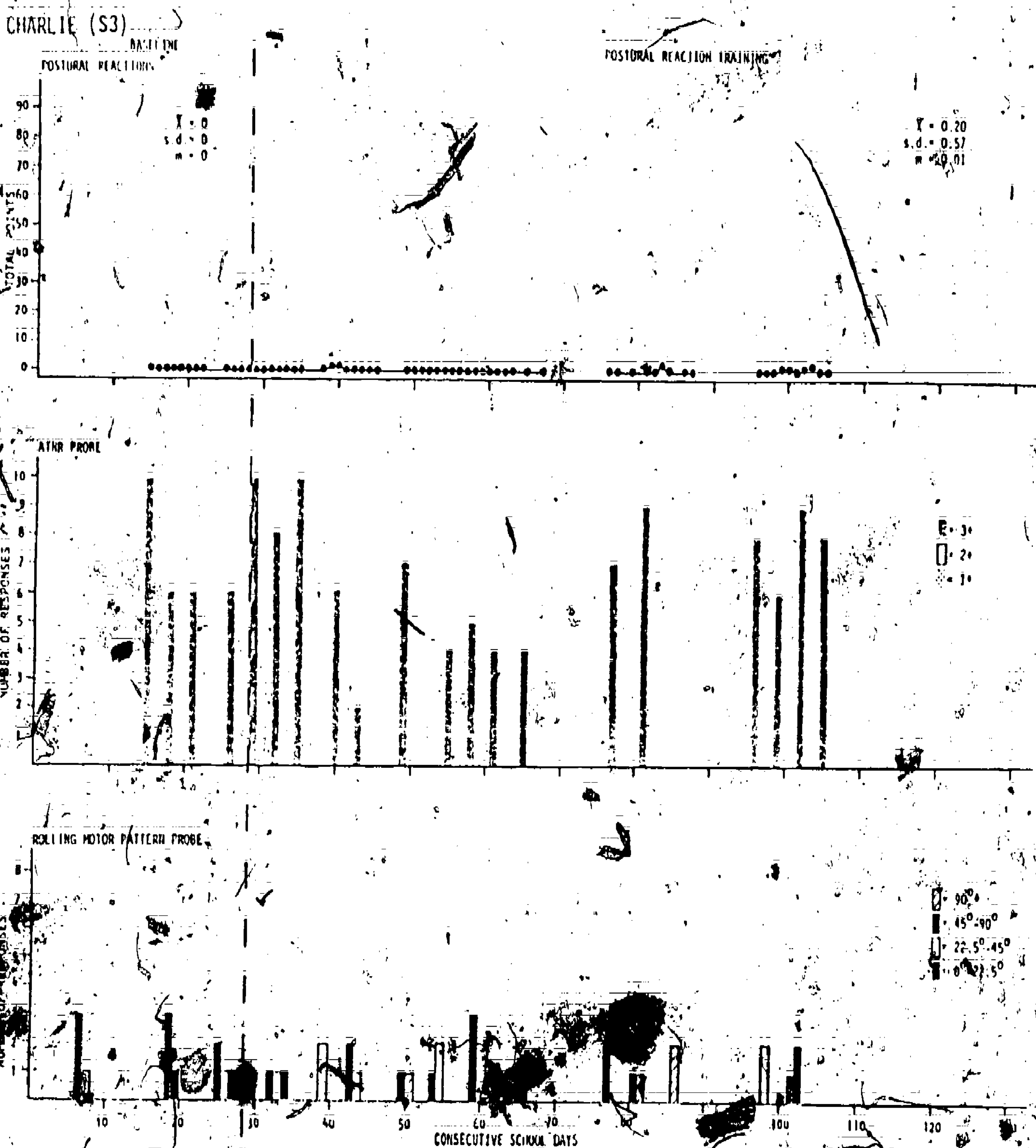
Figure 14 shows that only one score greater than zero occurred in training for the equilibrium reaction (session 39). Total points for the parachute reaction remained at zero across training sessions. Most of the low variability noted among Charlie's postural reaction training data in Figure 13 was found in the righting reaction data displayed in Figure 14.

Probe data for the ATNR were variable and no trend in the data was evident for Charlie (see Figure 13). Only scores of 3+ (full reflex posture, but not obligatory) were recorded and they ranged in frequency from 2 to 10 per probe session. The variability of the reflex data did not appear to related to the variability of the postural reaction data.

Rolling rotation measured as Charlie's motor pattern probe was fairly stable (see Figure 13). All responses occurred at a frequency of 3 or less. Zero degrees - 22.5° rotation decreased, while 22.5° - 45° and 90°+ rotation increased slightly across baseline and training sessions.

Figure Caption

Figure 13. Postural reaction, ATNR probe, and motor pattern probe data for Charlie (Subject 3) and Loretta (Subject 4) across sessions.



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LORETTA (S4)

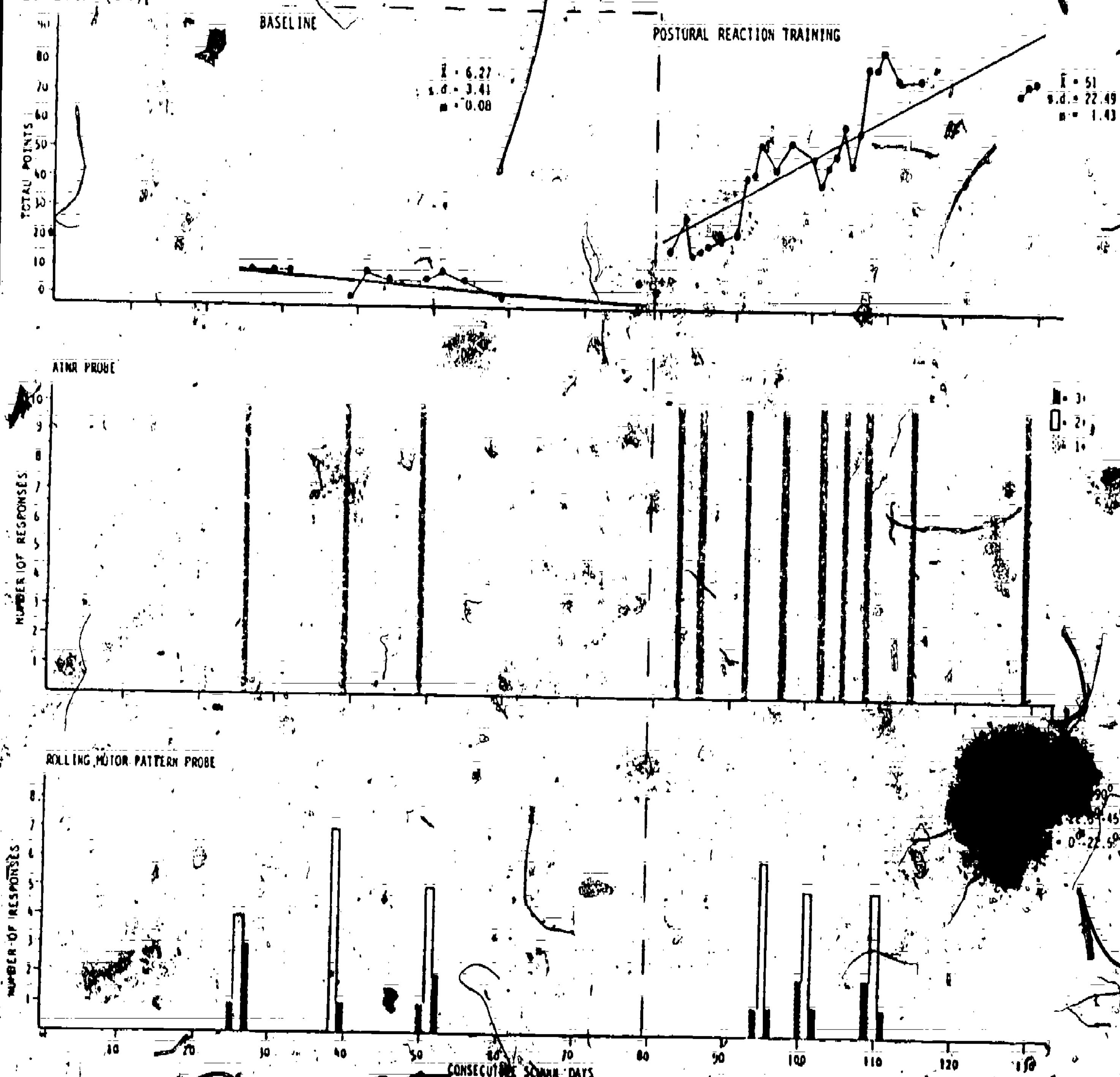

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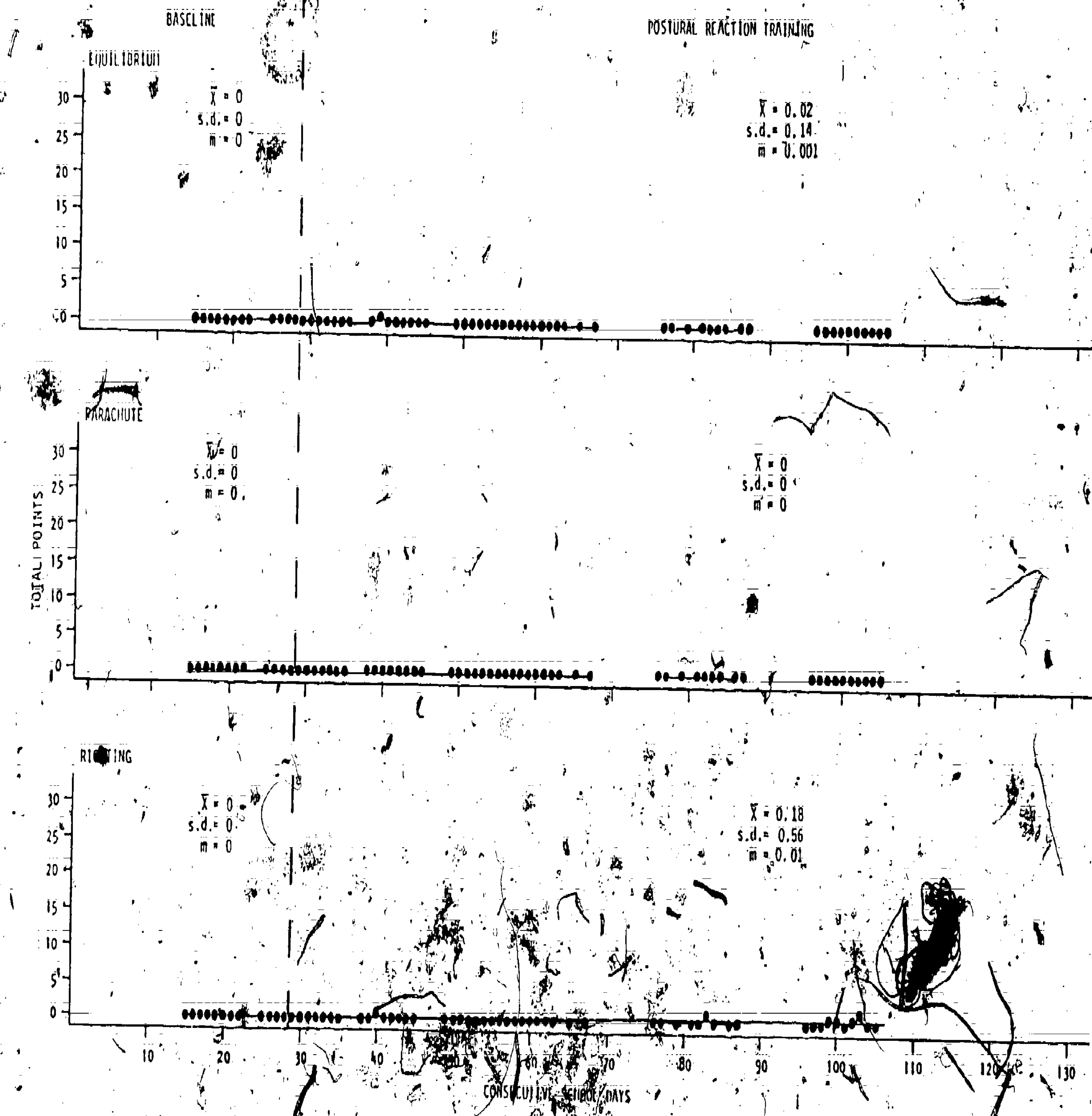
Figure Caption

Figure 14. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Charlie (Subject 3).


BASELINE
POSTURAL REACTION TRAINING
EQUILIBRIUM
X̄ = 0
s.d. = 0
m = 0
X̄ = 0.02
s.d. = 0.14
m = 0.001
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
TOTAL POINTS
RIGHTING
X̄ = 0
s.d. = 0
m = 0
X̄ = 0.18
s.d. = 0.56
m = 0.01
CONSECUTIVE SCHOOL DAYS

There was no obvious relationship between the postural reaction data and the rolling motor pattern probes.

The Mann-Whitney Test was not reported for Charlie in Table 6 for the same reason it was not reported for Janet (Subject 2); the result of the test was distorted due to the lack of variance in the baseline data. A chi-square with 1 degree of freedom and Yates' correction yielded a test statistic of .72 that was not significant at the .05 level for a two-tailed test; the probability of the scores greater than zero occurring in the training condition was no better than chance.

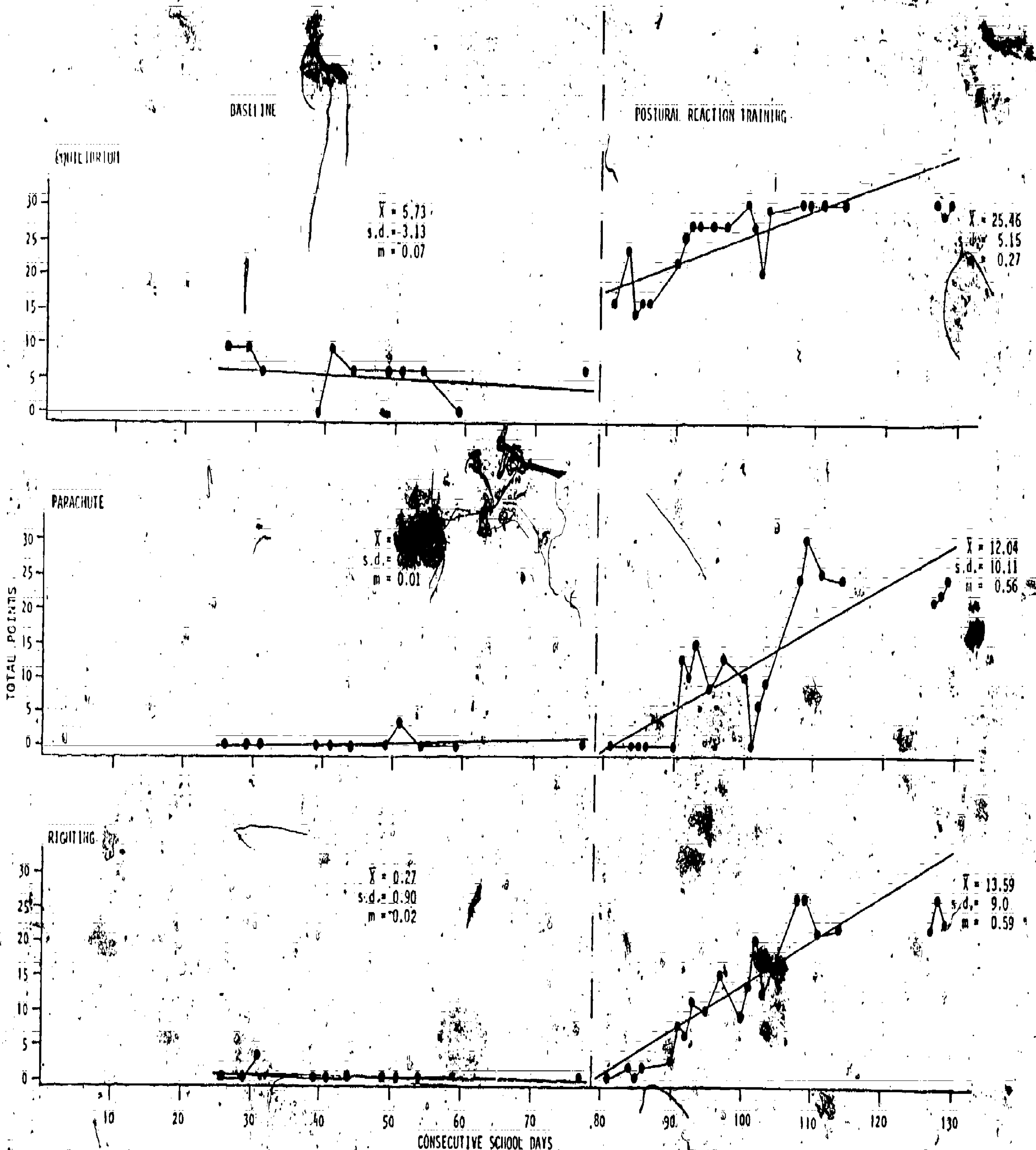
Low correlation coefficients resulted from comparing postural reaction training data to the ATNR probes and the rolling probes. Tau was equal to .08 for the frequency of the 3+ ATNR probe (the only ATNR level scored by Charlie), and tau ranged from -.06 to .31 across the four rolling rotation scores (see Table 7).

A gradually decreasing baseline (m = -.08) with a mean of 6.27 characterized the postural reaction data for Loretta (Subject 4) (see Figure 13). Training data, in contrast, increased at a slope of 1.43 described by the regression line, and ranged from a score of 15 (session 84) to almost the total points possible with a score of 80 (session 103). The training condition mean total points was 51. Variability was also greater during training (s.d. = 22.49) than in baseline (s.d. = 3.41).

Figure 15 illustrates that Loretta's scores for the equilibrium reaction were typically greater than zero during baseline and rose very quickly in the training condition. Parachute and righting reactions were predominantly at zero during the baseline condition and increased more gradually than the equilibrium reaction. All three postural reac-

Figure Caption

Figure 15. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Loretta (Subject 4).



BASELINE
POSTURAL REACTION TRAINING
PARACHUTE
RIGHTING
X̄ = 5.73
s.d. = 3.13
m = 0.07
X̄ = 25.46
s.d. = 5.15
m = 0.27
m = 0.01
X̄ = 12.04
s.d. = 10.11
m = 0.56
X̄ = 0.27
s.d. = 0.90
m = 0.02
X̄ = 13.59
s.d. = 9.0
m = 0.59
TOTAL POINTS
CONSECUTIVE SCHOOL DAYS

AVAILABLE

tions, however, reached the level of total possible points or were very close to it.

Scores from the ATNR probe were stable at 3+ (full reflex posture, but not obligatory) with a frequency of 10 responses throughout baseline and training (see Figure 13). This stability did not show a relationship to the increasing trend that occurred in the postural reaction training data.

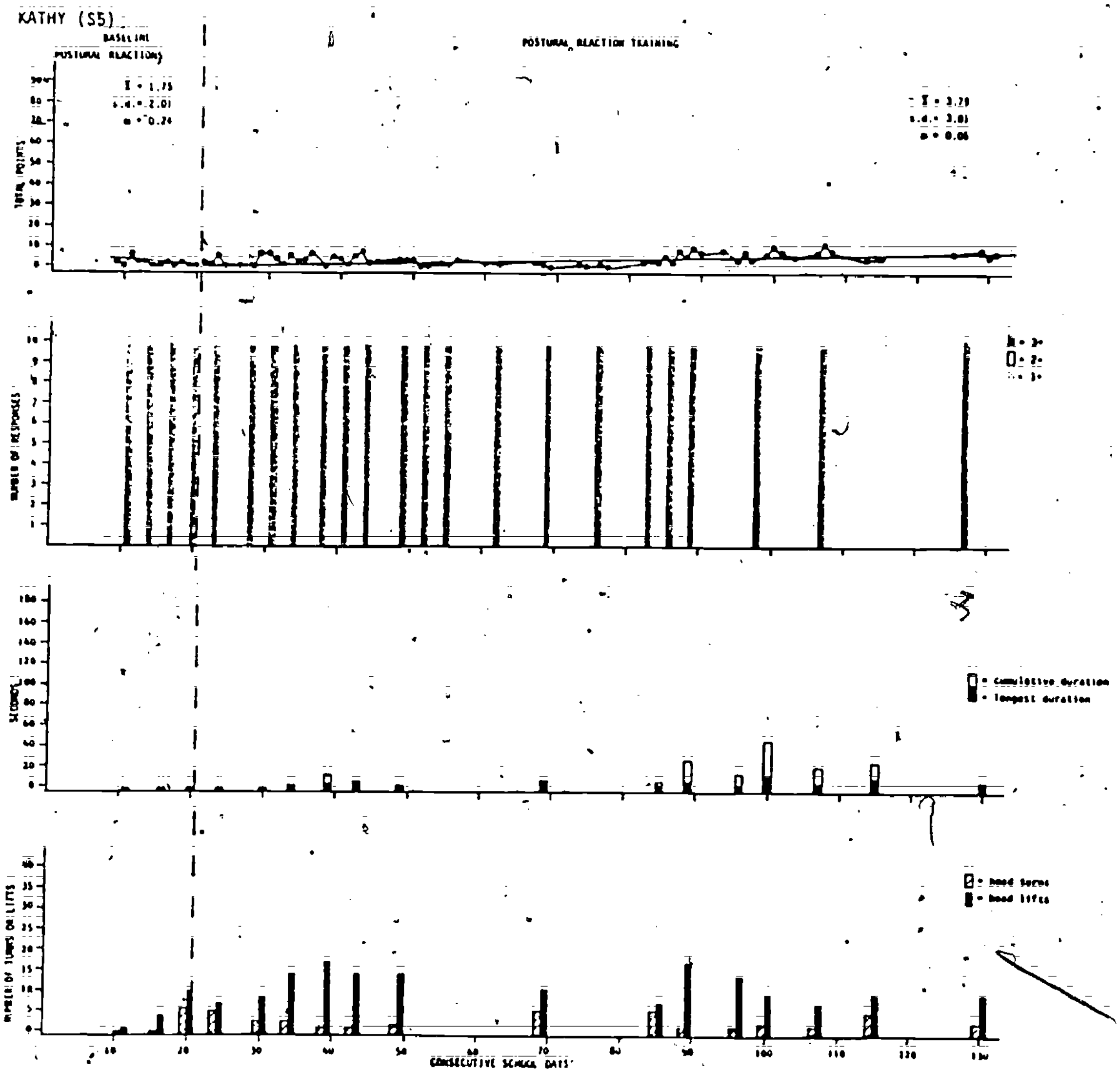
Degrees rotation in rolling changed slightly during the course of the study (see Figure 13). Zero degrees - 22.5° rotation increased one increment, and the greater amounts of rotation, 22.5° - 45°, and 45° - 90°, each decreased. The overall degrees of rolling rotation was assessed to be slightly less during training than during baseline.

As seen in Table 6, a z-score of 4.75, significant at the .05 level with a two-tailed test, was calculated with a Mann-Whitney Test comparing the postural reaction baseline to training. Kendall's Tau could not be used to describe the relationship among the postural reaction training data and the ATNR probes because there was no variance in the probe data. Likewise, tau was not derived for comparing postural reaction training and 45° - 90° rolling rotation. Tau was equal to .82 and -.82 respectively for 0° - 22.5° rotation and 22.5° - 45° rotation (see Table 7).

<u>Subject 5 (Kathy) and Subject 6 (Marilyn)</u>. In Figure 16, Kathy's postural reaction baseline data remained less than 10 points (with a mean of 1.75) and had a regression line with a gradually decreasing trend ($m = -.24$). When training began there was an immediate, but slight, increase in level and variability. The mean (3.79) and standard deviation (3.01) of the postural reaction training condition were both

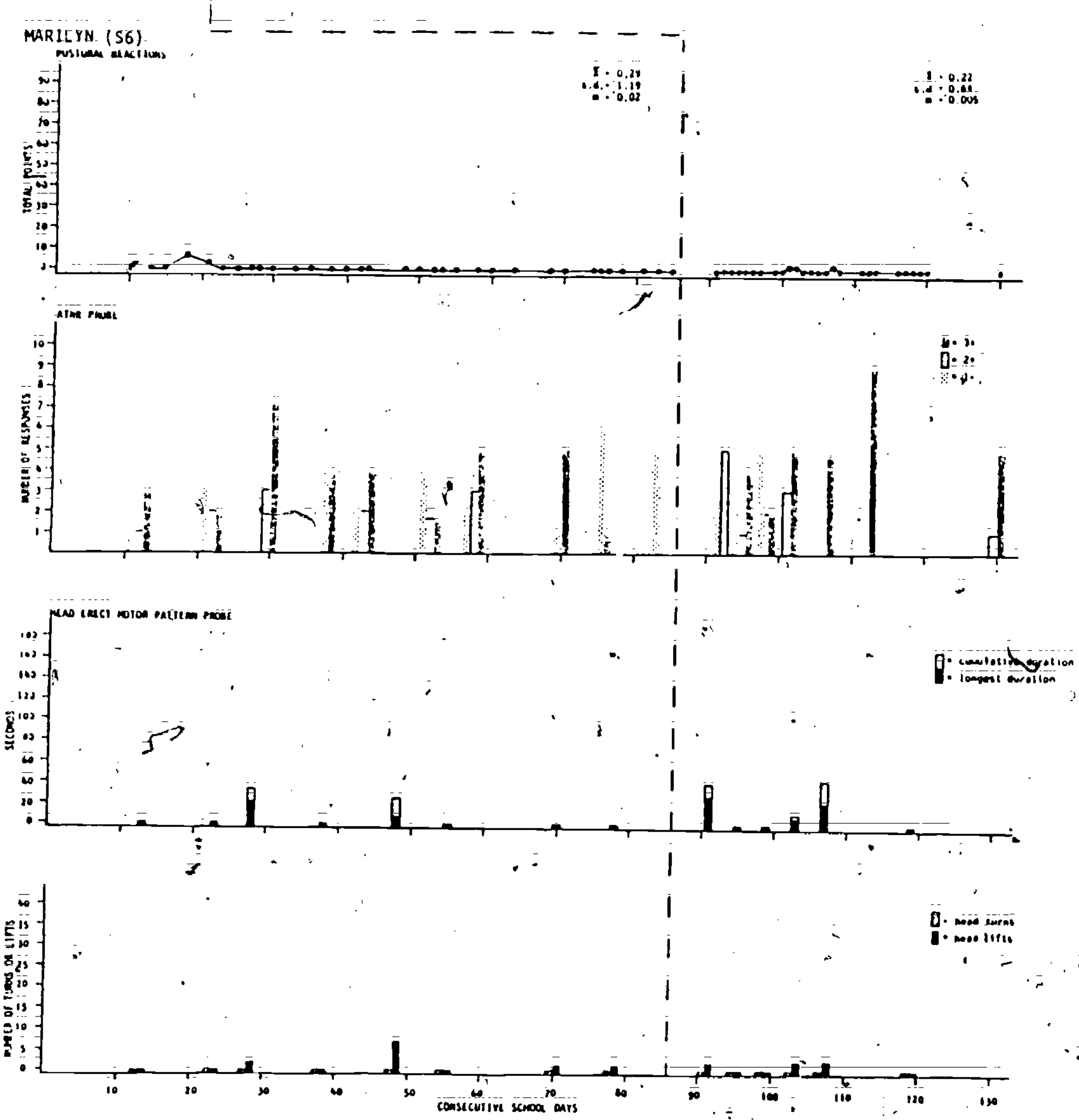
Figure Caption

Figure 16. Postural reaction, ATNR probe, and motor pattern probe data for Kathy (Subject 5) and Marilyn (Subject 6) across sessions.



KATHY (S5)
BASELINE
POSTURAL REACTIONS
POSTURAL REACTION TRAINING
TOTAL POINTS
CONSECUTIVE SCHOOL DAYS

(cont.)



greater than the corresponding statistics for the baseline condition ($\bar{X}$ = 1.75; s.d. = 2.01). Additionally, the negative slope of the regression line in baseline changed to a positive one in training, although it still remained very slight (m = .05).

Postural reaction data broken down into the three reactions of equilibrium, parachute, and righting are presented for Kathy in Figure 17. Equilibrium was stable at zero throughout baseline, and increased slightly in level and trend immediately when the training was introduced. Total points decreased to near baseline level midway through training (sessions 50 through 81), but the training condition finished off with an increasing trend (sessions 82 through 131). Total points for the parachute reaction were at zero throughout all sessions of baseline and training. Righting reaction data accounted for all the variability during the postural reaction baseline. Data followed a decreasing trend during the righting baseline and a slightly increasing trend in the training condition.

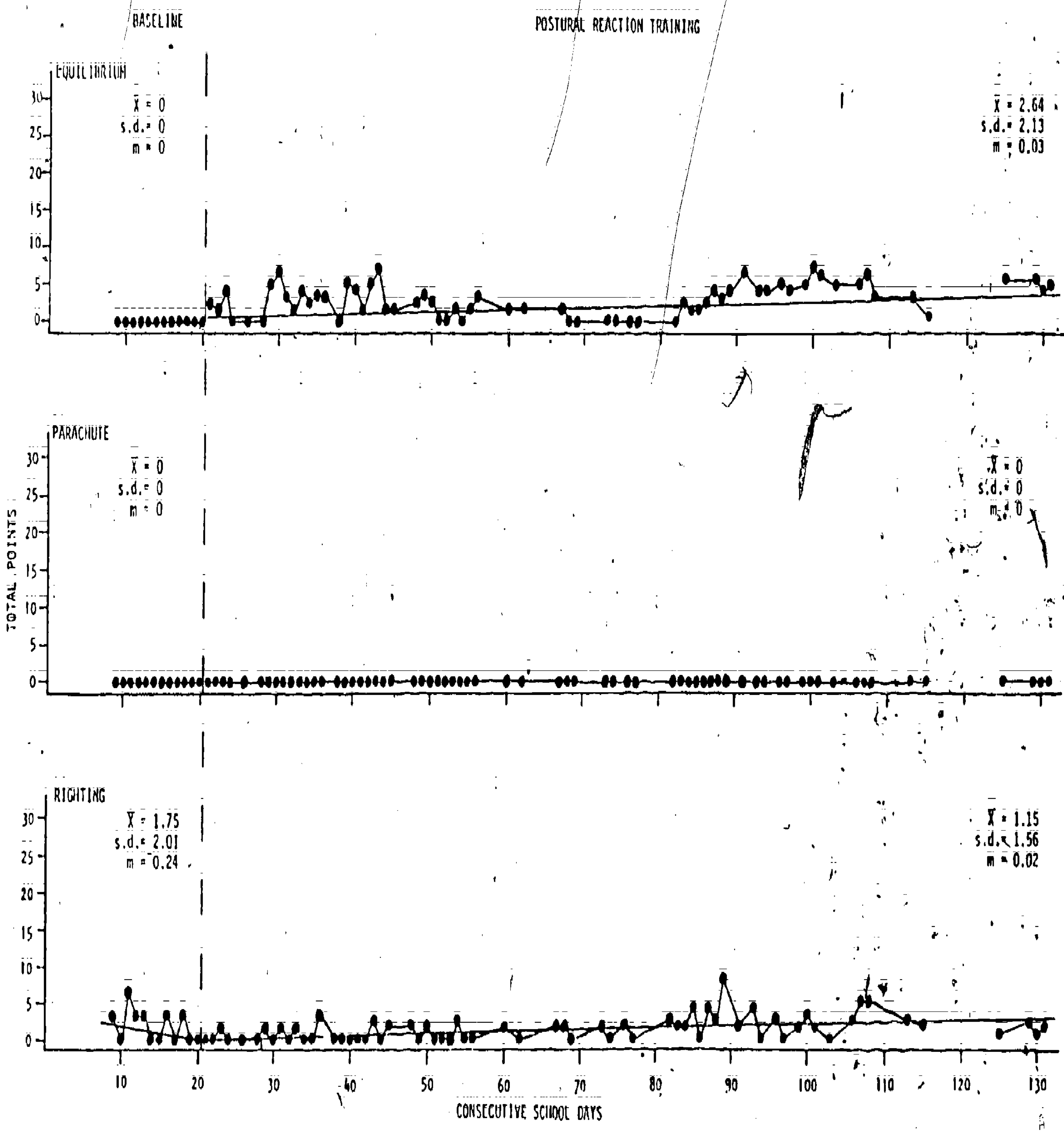
Probes of the ATNR were consistent at ten 3+ responses (full reflex posture, but not obligatory) for each probe session (see Figure 16). The complete lack of variability in reflex data did not correspond to the variability of the postural reaction data during the training condition.

In Figure 16, longest head erect duration, cumulative duration, and head lifts increased during training until session 100, after which all three decreased. The increase followed by a decrease did not relate to the trend of the postural reaction data.

A Mann-Whitney z-score of -5.10 was obtained for Kathy (see Table 6). Kathy's training condition was significantly different than baseline

Figure Caption

Figure 17. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Kathy (Subject 5).


BASELINE
POSTURAL REACTION TRAINING
EQUILIBRIUM
X̄ = 0
s.d. = 0
m = 0
X̄ = 2.64
s.d. = 2.13
m = 0.03
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
RIGHTING
X̄ = 1.75
s.d. = 2.01
m = 0.24
X̄ = 1.15
s.d. = 1.56
m = 0.02
TOTAL POINTS
CONSECUTIVE SCHOOL DAYS

at the .05 level for a two-tailed test. Kendall's Tau was not used to correlate the ATNR probes with the postural reaction training data because the probe data were without variance. Correlating head erect with postural reaction training data, tau for cumulative duration was equal to .52 and for head lifts tau was equal to .17.

Postural reaction data were at zero for Marilyn, except for sessions 18 and 21 (see Figure 16). The baseline trend was negative and minimal (m = .02). Training was very similar to the baseline condition with three data points greater than zero and a regression line slope of -.005.

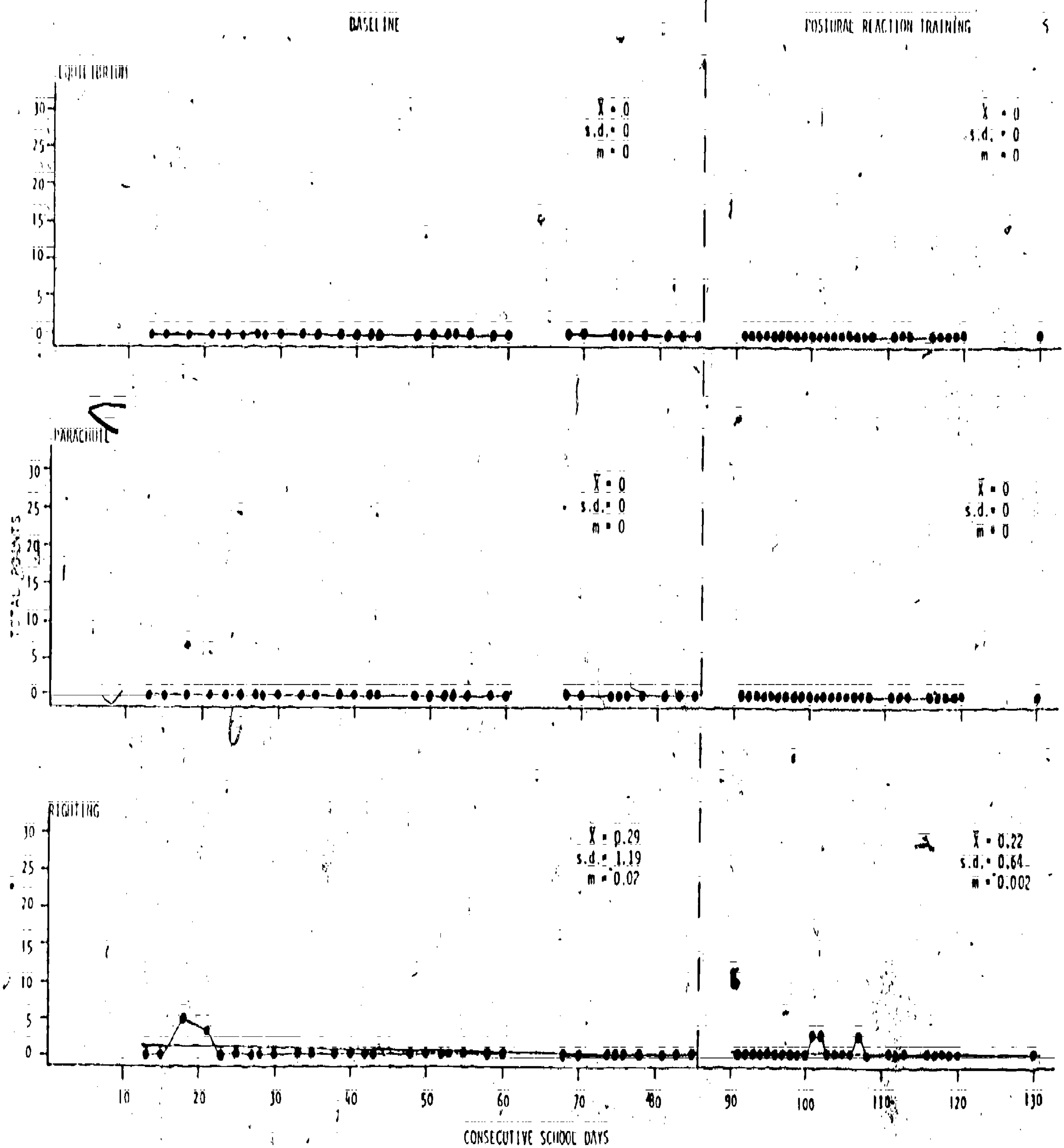
Figure 18 indicates that all points scored in the postural reaction data occurred for the righting response. The highest score during baseline was 6 points, and the highest score during training was 3 points.

ATNR scores were highly variable (see Figure 16). Marilyn scored several 1+ responses (increased tone, no change in posture) up until session 98, after which the 1+ score was absent. The scores of 2+ (partial reflex posture) and 3+ (full reflex posture, but not obligatory) occurred variably; 2+ ranged from a frequency of 1 to 5, and 3+ ranged from 1 to 9. Variability in the reflex probes did not relate to the relatively stable data of the postural reaction training condition.

Head erect behaviors were also variable throughout the study (see Figure 16). All levels of responding were low, and head erect behaviors frequently did not occur during the probe sessions. The longest cumulative duration of head erect was 44 seconds out of a possible 180 seconds (session 107), and 7 was the largest number of head lifts recorded during a 180-second probe (session 48).

Figure Caption

Figure 18. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Marilyn (Subject 6).



BASELINE
POSTURAL REACTION TRAINING
EQUILIBRIUM
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
TOTAL POINTS
RIGHTING
X̄ = 0.29
s.d. = 1.19
m = 0.07
X̄ = 0.22
s.d. = 0.64
m = 0.002
CONSECUTIVE SCHOOL DAYS

Marilyn's z-score from the Mann-Whitney Test was 5.68, significant at the .05 level for a two-tailed test (see Table 6). For Kendall's Rank-Order Correlation Coefficient (see Table 7), calculated to compare postural reaction training data to the ATNR probes, tau was equal to .15 for 3+, -.15 for 2+, and -.73 for 1+. Kendall's Tau was .39 for head erect cumulative duration and .67 for head lifts.

Subject 7 (Matt). Postural reaction baseline data were stable at a mean of 14.25 for Matt (see Figure 19). During the training condition, the variability gradually increased (s.d. = 5.22) as the trend rose (m = .32). Mean total points for postural reactions during training was 19.23, slightly higher than the baseline mean.

Figure 20 illustrates that the baselines of the equilibrium and parachute reactions were both stable at zero. Equilibrium scores remained at zero throughout training, whereas, parachute data increased until session 40, after which it decreased and eventually returned to zero level. Righting reaction data were stable but somewhat variable during baseline with a mean of 14.25 and a standard deviation of 2.26. The data were stable following the initiation of treatment until session 38 when the trend began to rise somewhat sharply.

A 3+ score (full reflex posture, but not obligatory) at a frequency of 10 responses was consistent throughout baseline and training for the ATNR probe (see Figure 19). The stable probe did not relate to the gradually increasing trend of the postural reaction training data.

Head erect data were variable and without an obvious trend throughout the study (see Figure 19). Cumulative duration reached 180 seconds (session 41) and the longest duration was 40 seconds (session 56). Head turns were infrequent, and the greatest number of head lifts was 20 (session 41).

Figure Caption

Figure 19. Postural reaction, ATNR probe, and motor pattern probe data for Matt (Subject 7) across sessions.

MATT (S7)

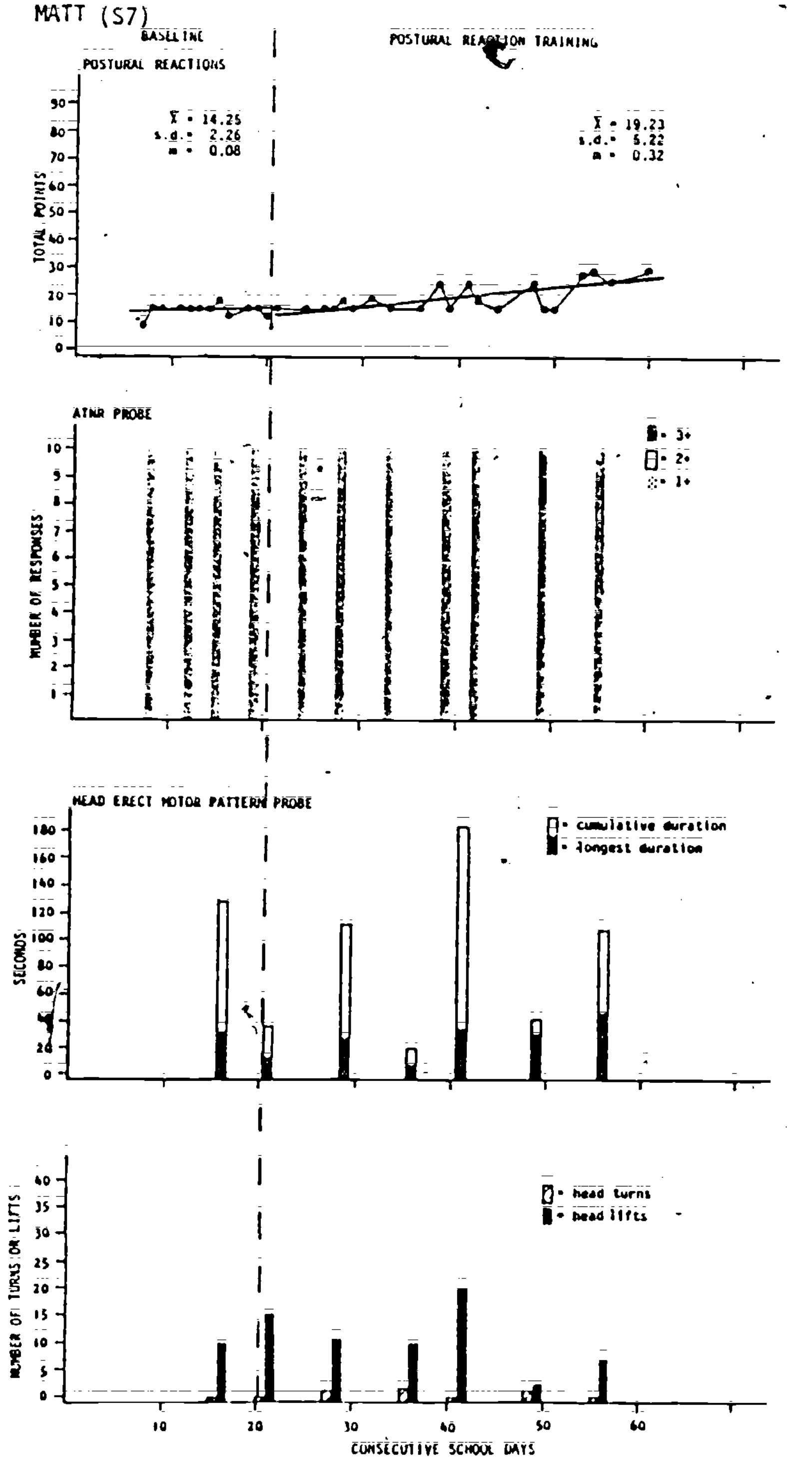


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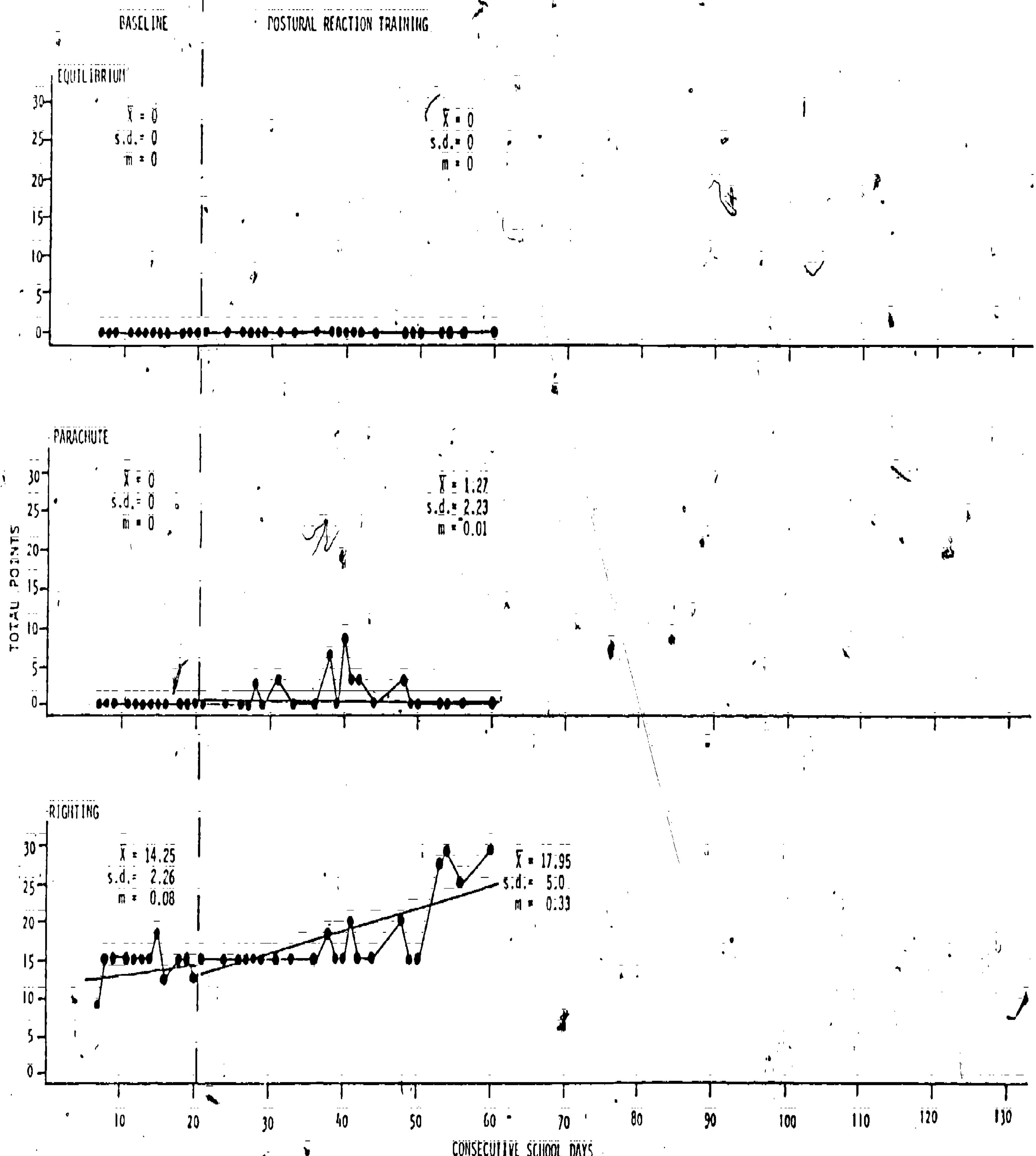
Figure Caption

Figure 20. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Matt (Subject 7).


BASELINE
POSTURAL REACTION TRAINING
EQUILIBRIUM
X̄ = 0
s.d. = 0
m = 0
X̄ = 0
s.d. = 0
m = 0
PARACHUTE
X̄ = 0
s.d. = 0
m = 0
X̄ = 1.27
s.d. = 2.23
m = 0.01
TOTAL POINTS
RIGHTING
X̄ = 14.25
s.d. = 2.26
m = 0.08
X̄ = 17.95
s.d. = 5.0
m = 0.33
CONSECUTIVE SCHOOL DAYS

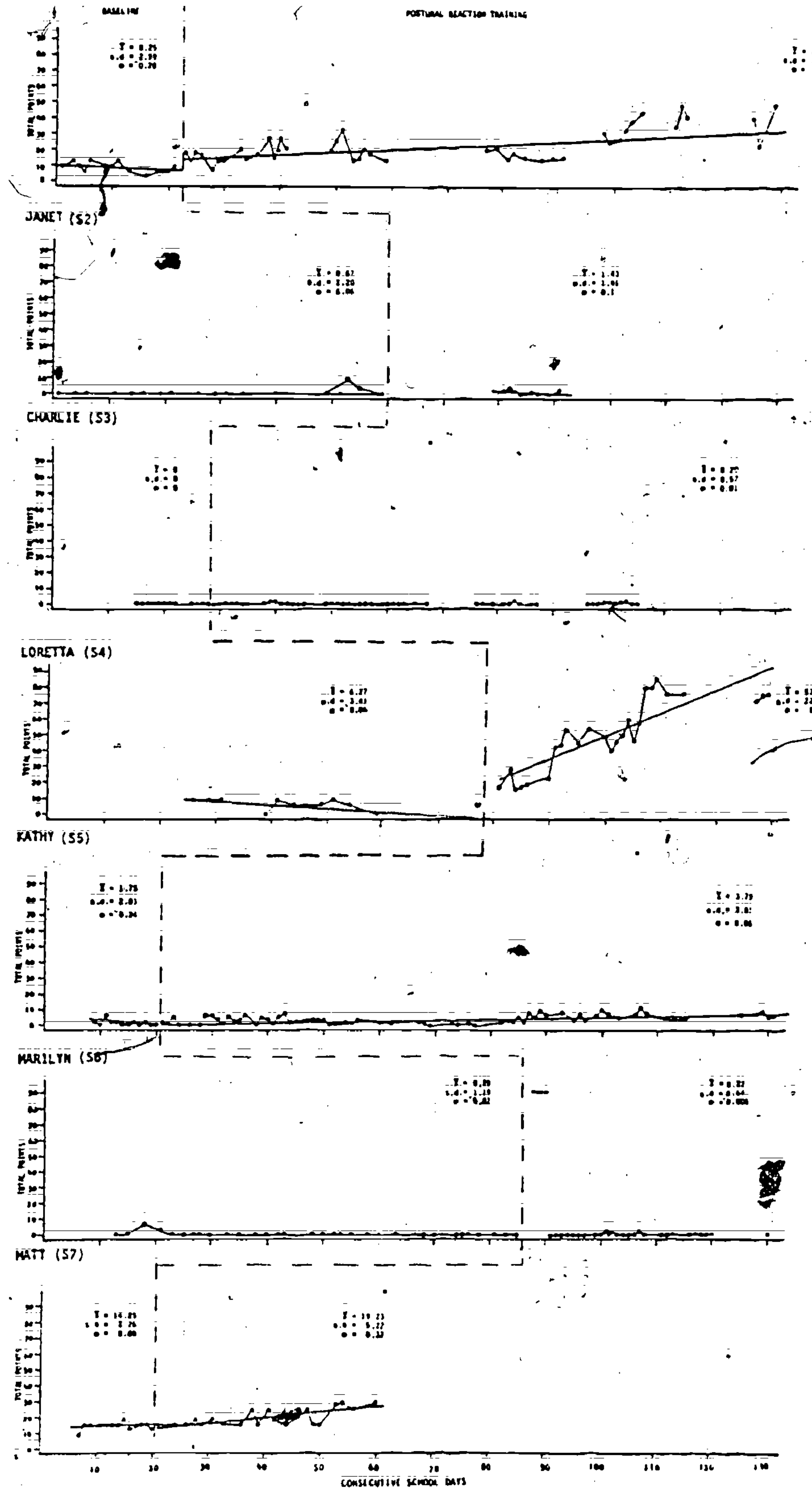
In comparing the baseline to the training condition for the postural reactions, the Mann-Whitney z-score was -.99, not significant at the .05 level for a two-tailed test (see Table 6). Kendall's Tau was not used to correlate the ATNR probes to postural reaction data because the probe data were without variance. Tau for postural reactions and cumulative duration of head erect was .60, and for head lifts was .22 (see Table 7).

Overall postural reaction results. Figure 21 displays the postural reaction baseline and training data across all seven subjects. All baseline conditions were relatively stable with standard deviations ranging from 0 (Charlie, Subject 3) to 3.41 (Loretta, Subject 4). Baseline trends were either negative, or if positive, very slight with regression line slopes no greater than .08 (Matt, Subject 7). Mean total points were greater in the training condition than during baseline for all subjects except Janet (Subject 2) and Marilyn (Subject 6). Marilyn was the only subject with a negative trend for the regression line fit to the postural reaction training data.

Sam (Subject 1) and Loretta (Subject 4) showed the most marked contrasts in comparing training to baseline (visually). The training conditions of the remaining children (Janet, Subject 2; Charlie, Subject 3; Kathy, Subject 5; Marilyn, Subject 6; and Matt, Subject 7) were not clearly different from their baseline conditions. The Mann-Whitney nonparametric analysis of variance test, however, yielded significant z-scores for four of the seven children, Sam (Subject 1), Loretta (Subject 4), Kathy (Subject 5), and Marilyn (Subject 6) (see Table 6).

Figure Caption

Figure 21. Postural reaction data across sessions for all seven children.



BASELINE
POSTURAL REACTION TRAINING
TOTAL POINTS
JANET (S2)
CHARLIE (S3)
LORETTA (S4)
KATHY (S5)
MARILYN (S6)
MATT (S7)
CONSECUTIVE SCHOOL DAYS

Group Data Analysis

The Wilcoxon Signed Ranks Test (Bruning & Kintz, 1977; Conover, 1971) was run to compare the baseline and training conditions of the postural reaction data across all seven subjects. Using the means as the scores representing the baseline and training conditions for each subject, the test statistic T was equal to 2 and significant at the .05 level for a two tailed test. The Wilcoxon test was also run with the slopes of the regression lines, and T was equal to 3. At the .05 level for a two tailed test, 3 was not significant; however, it was significant at the .10 level.

DISCUSSION

Reliability Results

Interobserver reliability for all subjects for postural reactions was quite high. Most disagreements occurred when the reliability observer (the investigator) was not positioned optimally and the view of one side of the subject and trainer was partially obscured. Without a clear frontal view, the observer occasionally missed the physical prompt (level 1) as it followed the cue (level 2). It was rarely difficult to see when the child exhibited the target response at a particular level of assistance, and no one specific postural reaction was any more difficult to score and agree upon than another. The similar mean reliability scores across measures and subjects for postural reactions supported this conclusion.

Agreement for the ATNR measure overall was high. It was fairly low, however, for Marilyn (Subject 6). Marilyn demonstrated the most variability among the children in the reflex probe, and the constractures of her left elbow and wrist contributed to the difficulty in scoring. The teacher serving as Marilyn's trainer commented that she was reluctant to score a response according to assessment procedures when the observed posture seemed to be more a function of the orthopedic condition of Marilyn (i.e., her contractures and severe scoliosis) rather than what she understood to be the response associated with a tonic reflex.

Head erect probes were observed with 100% reliability for three of the four children for which the behavior was measured. For two of those three children with 100% reliability, the ease of reliability was due to a very low level or absence of responding (Janet, Subject 2; Marilyn, Subject 6). Matt (Subject 7), the other child with perfect reliability, sometimes had long durations of head erect behavior, but the frequency of head lifts was low. Responses to be agreed upon, therefore, were few. In contrast, the low reliability of head erect measurement for Kathy (Subject 4) was related to a higher frequency of head lifts and very low cumulative duration of head erect. Kathy's head lifts were of a low height, quick in succession, and it was difficult to determine when her chin was or was not in contact with the surface of the mat. Rolling rotation reliability was the lowest overall mean reliability score, but it was well within the upper range of interboserver agreement obtained in the reliability study in the development of the assessment tool (Fritzshall & Noonan, Note 7).

Overall, interobserver reliability indicated that measurement and data recording were not a problem in this study. Agreement on all measures was reasonable in relation to the behaviors recorded.

Performance Results

A visual analysis suggested that the results for Loretta (Subject 4) and Sam (Subject 1) demonstrated a treatment effect of improved postural reactions, with particular clarity in Loretta's case. Although the change in level and trend in Sam's data were not as dramatic as in Loretta's, the effect was immediate. Additionally, the first three of four data points in Sam's training data were of a higher level than any of the data points in baseline.

Due to the developmental nature of the postural reaction skills, one could reasonably extrapolate and extend the baseline trend through at least several months prior to the collection of baseline data. Essentially, the baseline data were representative of a long history of behavior that was equivalent to, if not greater than, the duration of the training condition. Interpreting baseline in this manner suggested that Sam's training condition may have been of greater clinical significance than might be assumed at first glance.

The conclusion of clinical significance was supported by the statistical significance of the effect for both children. It may be important to note that both children showed obvious improvement across all three postural reactions, whereas the other five children each had one or more postural reactions in which they showed stable zero-level responding throughout the entire training condition.

Kathy (Subject 5) and Marilyn (Subject 6) each had slight differences in comparing baseline to training; differences that yielded statistical significance, yet visually did not appear to be convincing. During the training condition, Kathy's data were eratic with an initial increase in variability, followed by a period of decreased variability and lower-level responding, and then followed again by an increase in variability and level of response. The lack of a consistent trend during training made a weak case for suggesting that the lower level and variability of baseline represented a different set of responses than those during training. The statistical significance for Kathy and Marilyn's data may be explained by the nature of the nonparametric analysis of variance test that is based on the rank-order of the data without regard for the actual magnitude of the scores.

Adopting the same rationale for extending Sam's (Subject 1) baseline back over several months prior to training for Matt's baseline (Subject 7), the training effect was, perhaps, of more clinical importance than it first appeared. It is doubtful that the increased variability apparent from Session 47 on would have been present in a longer baseline representing more of Matt's history. The effect is still weaker than that seen in Sam (Subject 1) and Loretta (Subject 4) because the change in Matt's behavior was not immediate. But, relative to the history represented by the baseline data, the lag of nine training sessions prior to the change in the trend of the data may not have been a long enough lag to discount a relationship between the change in behavior and the treatment variable. Furthermore, it was not surprising to see a lag before a subsequent behavior change because a depressed rate of motor development is characteristics of cerebral palsied, severely handicapped children. The immediacy of the effects observed in Sam (Subject 1) and Loretta (Subject 4) were surprising to this investigator and possibly were indicative of a sensitive measurement system.

Clinically, training had no effect for Janet (Subject 2), Charlie (Subject 3), Kathy (Subject 5) and Marilyn (Subject 6). All four children had near zero-level responding throughout the entire study.

One subject characteristic may have been related to the results; the most improvement occurred in the two highest-level children, socially and intellectually. Both of the children were quite severely physically handicapped, but they were the only two children who showed evidence of purposeful and goal-directed motor behavior. These behaviors did not necessarily indicate that the cerebral palsy of these children was less severe than of the other children, but more likely represented an interaction effect of social and intellectual behavior with motor behavior. Two NDT studies, Scherzer, Mike, and Ilson (1976) and Woods (1964), also suggested that intelligence may be a related factor, but Footh and Logan (1963) found no relationship between IQ and improvement. No other demographic characteristics seemed to be related to the results.

Only Sam (Subject 1) had a visually-apparent trend in ATNR data during the training condition with the reflex increasing in strength from predominantly 2+ to 3+ scores. Interestingly, the correlation coefficients were relatively low. The reason for the low statistical association may have been that the low and high points within the variability of each set of data were not temporally synchronized.

The stable ATNR responses of 3+ at a frequency of 10 for Janet (Subject 2), Loretta (Subject 4), Kathy (Subject 5), and Matt (Subject 6) bore no discernable relationship to postural reactions because they were without variance. The fact that "no change" occurred for both the reflex and postural reaction data for Janet did not seem to indicate any dependence between the behaviors. The "no change" in ATNR for the other three children corresponded to a possible slight postural reaction training effect for Kathy, a moderate effect for Matt, and a strong effect for Loretta.

Charlie (Subject 3) and Marilyn (Subject 6) each had a great amount of variability in the reflex response. The only obvious interpretation of the results for Charlie's ATNR is that there was no change in the behavior, and the variability was unrelated to the low variability in the postural reaction data of the training condition. Marilyn had the greatest variability with unstable responses across the reflex scores as well as the frequency of each score. Although the 1+ ATNR score was correlated quite highly with the postural reaction data, the postural reactions did not show any clinically significant change, so it is difficult to consider the correlation to be very meaningful. Additionally, with as many correlations as were calculated, it is not unlikely that the one high ATNR correlation may have occurred simply by chance.

Motor probe findings were neither consistent within and across the head erect and rolling probes, nor across time and in relation to the postural reaction training data. Rolling rotation data trends were unique for each child who received that motor pattern probe. The slight increase in Sam's rotation was moderately related to the increase in postural reaction training data by visual analysis and with tau for 0°-22.5° rotation (tau = -.73) and 45°-90° rotation (tau = .52). Charlie's rolling data across sessions showed a slight increase in total degrees rotation, but the changing trends of the rolling response did not relate to the stability of the training data. Apparently, slight improvement in rotation was not dependent upon improvement in postural reactions. For Loretta's rolling data, the high correlations for 0°-22.5° rotation and 22.5°-45° rotation indicated that the amount of rotation decreased as the postural reaction data increased. The high correlations should be interpreted conservatively, however, because the coefficients may have been inflated since only three scores went into the calculation of each (i.e., the probability of three scores occurring in a ranked order from highest to lowest or lowest to highest is much greater than for a sample of a larger number).

Very little head erect data were actually collected because the behaviors occurred at low levels for Janet (Subject 2), Kathy (Subject 5), and Marilyn (Subject 6). There was no relationship among head erect and postural reaction data to comment upon for Janet and Marilyn because there were virtually no responses for either behavior, unless the absence of responding in both cases was to be considered meaningful. Perhaps if a greater range in the amount of head erect responding had been covered in this study, the absence of behavior would be interpretable. A moderately high correlation among Marilyn's postural reactions and head lifts (tau = .67) may have reflected the temporal association of slight increases in both of the behaviors. The correlation is interesting, but clinically insignificant with such low-level behavior; Marilyn was barely responding in either case.

Kathy's low level head erect behavior had identifiable trends. Visually, the higher levels of head erect behaviors corresponded to the higher levels and increased variability in the postural reaction data. A tau equal to .52 for cumulative head erect duration moderately supported this analysis. The relationship was not particularly convincing, however, because head erect behaviors decreased near the end of data collection, but postural reaction scores did not. Matt (Subject 7) demonstrated much more head erect behavior than the other three children, but visually there were no trends evident in the data. Tau for the cumulative duration data (.60) suggested that the behavior may have increased as the postural reactions improved. It is unfortunate that it was not possible to collect more data for Matt to see if this correlation would have continued.

One study reviewed in the literature (Wright & Nicholson, 1973) reported results of decreased tonic reflexes and improved head erect and rolling behaviors as a result of NDT. Additionally, Norton (1975) found positive changes in equilibrium, righting and complex behaviors, as did Tyler and Kahn (1976) with righting and head control. These results were not replicated in the present study. No speculation can be made explaining the discrepancy among results since measurement procedures were not specified and NDT was not operationalized.

Group results. Mean level responding for postural reactions was significantly different for training in comparison to baseline. Significant results were not found in comparing the baseline and training conditions using the slopes of the regression lines, although the test statistic was close to significance ($p < .10$). Statistical significance for means was not of obvious clincial significance. The ranks-test was not sensitive to the magnitude of the differences between baseline and training conditions. But, the fact of statistical difference may have prompted a second look at the postural reaction data across subjects. Five of seven subjects had higher means (however slight) during training than in baseline. That was interesting and perhaps suggestive that those occasional responses in the predominantly zero-level training data indicated the very beginning of a training effect.

Summary of performance results. Postural reaction improvements were only clearly demonstrated by Sam (Subject 1) and Loretta (Subject 4), the two intellectually and socially highest-functioning children in the study. Although two other children in addition to Sam and Loretta (Kathy, Subject 5 and Marilyn, Subject 6) had statistically significant results suggestive of a treatment effect, only Sam and Loretta's data were of clinical significance. ATNR and motor pattern probe data were not clearly related to postural reaction data. Individual relationships noted were of little meaning due to the overall low level of the responses, or they were not replicated with any other subject. Group results of statistical significance between postural reaction baseline training means must be interpreted conservatively because the ranks test was not sensitive to the magnitude of change, and clinical significance was slight.

Major Research Questions

Do postural reactions improve as a result of neurodevelopmental training? Results did not indicate that postural reaction training, one component of NDT, was effective in improving those behaviors for all the severely handicapped children in the study. Only two of the seven children showed a clear change in behavior, however, the change did seem to be directly related to the onset of the training condition. It was not surprising that the other five children did not show improvement; gains in behaviors across all performance domains have been extremely slow for all of them. All five of these children had little, if any, voluntary movement and were either extremely hypotonic or hypertonic, and two of them had joint contractures. It may be that for children so severely handicapped, six months of training for approximately 30 minutes per day represented a relatively insignificant intervention. Postural reactions may indeed improve with training for some cerebral palsied children, but it has not been shown effective for all children and it is not known if a quantitative increase in the treatment variable would yield improvements for a greater portion of those children that receive treatment.

Do improvements in postural reactions correspond to a decrease in the asymmetrical tonic neck reflex? The results for Sam (Subject 1) and Loretta (Subject 4), the only two children who showed improvements in postural reaction responses, indicated that the ATNR did not decrease in relation to postural reaction improvement. Sam's ATNR increased and his atypical relfex became stronger. Loretta's ATNR remained the same at a high 3+ level even though she made dramatic gains in the postural reactions during training. These results suggested that learning postural reactions may have been independent of the presence of the ATNR.

It is also possible that inferring the strength of the ATNR by measuring its frequency and topography was not entirely valid. Both Loretta and Sam had been observed to routinely "use" their ATNR within their voluntary and goal-directed motor responses. A more functional evaluation of the relationship of the topography of the ATNR to the child's motor repertoire might have yielded different results.

Do improvements in postural reactions correspond to an increase in head erect and rolling motor patterns that are not directly trained? Loretta showed the most improvement in postural reaction responses, but her rolling did not improve. The decrease in the greater degrees of rotation and the increase in the lesser degrees of rotation suggested that she was rolling with increasingly more spasticity; the quality of rolling got worse. It may be that rolling mobility was more easily achieved if Loretta "used" her hypertonicity, a reasonable hypothesis for a child who was generally quite hypotonic.

Sam did improve slightly in rolling rotation as postural reactions improved. The dependent relationship is questionable, however, because Charlie (Subject 3) also showed slight improvement in rolling rotation, but his postural reactions did not improve.

The data for evaluating this question are limited because only two children showed improvement in postural reactions. Rolling rotation data for Sam and Loretta did not support a relationship between rolling and postural reactions. Head erect data cannot be used to discuss this question because the data showed very little change within subjects, and postural reactions improved only slightly or not at all.

Secondary Purposes of Study

Operationalization of therapy as a treatment variable. Levels of assistance training was a reasonable operationalization of NDT facilitation because it resembled descriptions of NDT in the literature as guidance and assistance to perform a response (cf. Bobath, K. & Bobath, B., 1954) and was easily standardized as a procedure. The literature has also described facilitation as providing stimulus situations in which the target response would be expected (cf. Bobath, B., 1955). This definition was the operationalized baseline condition. In effect, the study was a comparison of two facilitation treatment conditions across subjects. The repeated measurement in the baselines indicated that simply providing the opportunity for the response was not an effective treatment. A third, more complex description of facilitation was also found in the NDT literature (cf. Bobath, K. & Bobath, B., 1976). Facilitation of postural reactions was described to be contingent on the child's responses in such a manner that it would require subjective judgements by the trainer throughout each session, and could be a very different treatment across sessions and across children. Using this third description of NDT would have made it very difficult to evaluate the results of a study in any meaningful way.

Kazdin and Wilson (1978) pointed out that operationalizing a therapeutic treatment is actually an analogue study, since it only resembles the clinical treatment being investigated. While it is recognized that an analogue study's results may, therefore, be of more limited generalizability, operationalization of a treatment is critical if its efficacy is to be evaluated. As explained by Kazdin and Wilson,

> An "analogue" study usually focuses upon a carefully defined research question under well-controlled conditions. The purpose of the investigation is to illuminate a particular process or to study an intervention that may be of importance in actual treatment. (p. 159)

<u>Application of single subject research design</u>. Multiple baseline design was appropriate to the study and the research questions. It allowed for an analysis of individual child behavior and clinical significance of the results for each child and in relation to the statistical significance of one of the two group tests.

The developmental nature of postural reactions could have rationalized a multiple probe design (Horner & Baer, 1978) in lieu of the long baselines of the traditional multiple baseline design. Extensive repeated measurement throughout baseline was opted for instead to guard against the hypothesis of reactivity from repeated measurement. Loretta's (Subject 4) improvement in postural reactions at the point when treatment was initiated, and subsequent to a decreasing baseline trend, was a good example of results that did not appear to have been confounded by a testing effect.

The quantity of data and the close look at each child's behavior afforded by the single subject design enhanced the overall contribution of this study in the evaluation of NDT.

Application of quantitative sensory/motor measurement. In reviewing the literature, it became apparent that there was a need to measure precisely "how much" improvement occurred in the child's motor skills as a result of training. Previous studies have simply reported "improvements" of a particular behavior (i.e., head erect or walking) (cf. Kong, 1966; Wright & Nicholson, 1973). Other studies used developmental checklists that were most often unpublished, probably nonstandardized, and were unlikely to be sensitive enough to detect changes within a motor skill (cf. Crosland, 1951; Ingram, Withers, & Speltz, 1957). The quantitative assessment procedures used in this study (Foshage, Note 4; Rues, Note 5; Day & Lehr, Note 6; and Fritzshall & Noonan, Note 7) provided a precise description of the amount of change for head erect and rolling and was sensitive to changes within each skill.

Limitations and Implications

Two measurement limitations were noted by the investigator in the course of data collection. First, the lack of opportunities to score 1's and 2's during baseline may have deflated the baseline level and inflated the apparent difference between the baseline and treatment conditions. To allow for scores of 1's and 2's during baseline, however, would have been to provide training. If measurement was only taken at the independent response level, much of acquisition would not have been evident in the data. It seems that the limitation is inherent if the data collected describe the level of assistance required in training.

The second measurement limitation is related to the first. In observing the children's responses throughout the study, it was noted that they frequently approximated a response, and sometimes did so at the independent level of assistance. The data recording procedures were not sensitive to these responses, but instead, recorded "teacher-behavior" required for the child to respond as the target behaviors had been operationalized. It might have been more useful to have monitored the effects of levels of assistance training by coding critical dimensions of the children's responses at the independent level of assistance. For example, acquisition of equilibrium may have been followed by coding the position of the arm (flexed or extended), the position of the hand in relation to the floor (palm up or palm down), and whether the hand was fisted or open, as the critical dimensions of the response. A master's thesis is currently being conducted to compare the sensitivity of levels of assistance measurement and behavior coding in levels of assistance training (Phillips, Note 8). If coding the critical dimensions of the behavior was as sensitive or more sensitive than noting the level of assistance required, a more accurate measure of baseline behavior may have been obtained.

Operationalizing facilitation of NDT for postural reactions as described in this study may not represent "NDT" as used by some interventionists. Social validation with therapists and teachers who have taken the NDT training course and/or claim to use NDT routinely in their intervention procedures should be undertaken in future research of this type.

It might not have been reasonable to expect NDT limited to postural reaction training to affect ATNR or motor pattern responses. This study should be viewed as the first step in a a constructive treatment strategy (McFall & Marston, 1970), and the ATNR and motor pattern responses should be monitored as additional components of NDT are added to the treatment package in the validation process. A parametric treatment strategy (Kazdin & Wilson, 1978) would also be a logical follow-up to this study. An increase in the quantity of the treatment component could yield clinically significant results across more children.

Future research, then, should focus on a single subject design which allows for some evaluation of subject characteristics as they relate to the training effect. The measurement component should be sensitive to levels of skill acquisition, but independent of the training strategy. And finally, future research should build on this initial study following either a constructive treatment strategy or parametric treatment strategy.

CHAPTER VI

SUMMARY

A review of the literature on motor training for cerebral palsied children suggested that three theoretical/treatment approaches have characterized the intervention efforts: orthopedic, sensory stimulation, and neuromotor. None of the approaches have been empirically validated in relation to theory or methods of training. Research studies investigating the various approaches to motor training lacked experimental control, failed to operationalize the treatment techniques, and reported results according to vague outcome measures.

A component of neurodevelopmental training (NDT), a popular neuromotor approach based on neurological development among nonhandicapped infants was operationalized as the treatment variable using a multiple baseline design in this study. Postural reactions of righting and equilibrium were trained across seven cerebral palsied, severely handicapped children, ages 2½ to 12 years. A visual analysis of the results, supported by a nonparametric statistical test, indicated that the postural reaction responses of two children improved significantly as a result of training. Additionally, the statistical analyses yielded significance among baseline and treatment conditions for two other children. Reflex and motor probe data did not appear to be related to the postural reaction training. In the group analyses, a significant difference was found in a test of baseline and treatment means, however, the same test was not significant when slopes were used in the comparison. It was concluded that postural reaction training may be effective for some children, but clearly not for all. Tonic reflexes did not appear to constrain the acqusition of postural reactions, and the acquisition of postural reactions did not appear to influence the development of head erect or rolling motor patterns.

It was recommended that future research follow up with single subject designs using matched subjects to identify the subject characteristics related to the effectiveness of training; investigate sensitive measurement strategies independent of the training strategy; and build upon this initial data base with a constructive or parametric approach to evaluating the NDT therapy package.

Reference Notes

1. Guess, D., Rues, J., Warren, S., & Lyon, S. Quantitative assessment of motor and sensory/motor acquisition in handicapped and nonhandicapped infants and young children, Vol. I: Assessment procedures for developmental milestones. (ECI Document No. 255) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1980.

2. Guess, D., Rues, J., Warren, S., Lyon, S., & Janssen, C. Quantitative assessment of motor and sensory/motor acquisition in handicapped and nonhandicapped infants and young children, Vol. II: Interobserver reliability results for the procedures. (ECI Document No. 257) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1981.

3. Guess, D., Rues, J., Warren, S., Janssen, C., Noonan, M. J., Esquith, D., & Mulligan, M. Quantitative assessment of motor and sensory/motor acquisition in handicapped and nonhandicapped infants and young children, Vol. III: Replication of the procedures. (ECI Document No. 258) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1982.

4. Foshage, K. J. Procedures for measuring head control. In D. Guess, J. Rues, S. Warren, & S. Lyon, Quantitative assessment of motor and sensory/motor acquisition in handicapped and nonhandicapped infants and young children, Vol. I: Assessment procedures for developmental milestones. (ECI Document No. 255) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1980.

5. Rues, J. P. Quantitative measurement of head erect in the prone and supported sitting position in nonhandicapped infants. In D. Guess, J. Rues, S. Warren, C. Janssen, M. J. Noonan, D. Esquith, & M. Mulligan, Quantitative assessment of motor and sensory/motor acquisition in handicapped infants and young children, Vol. III: Replication of the procedures. (ECI Document No. 258) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1982.

6. Day, P., Rues, J., & Lehr, D. Procedures for measuring rolling. In D. Guess, J. Rues, S. Warren, & S. Lyon, Quantitative assessment of motor and sensory/motor acquisition in handicapped and nonhandicapped infants and young children, Vol. I: Assessment procedures for developmental milestones. (ECI Document No. 255) Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1980.

7. Fritzshall, J. D. & Noonan, M. J. A replication study: Quantitative assessment of rolling behavior in handicapped and nonhandicapped infants and children. Kansas Research Institute for the Early Childhood Education of the Handicapped. Lawrence, Kansas, University of Kansas, 1982.

8. *Child progress monitoring system*. Unpublished manuscript. Debbie School Programs. Mailman Center for Child Development, Miami, Florida, University of Miami, 1977.

9. Phillips, E. (untitled), Unpublished master's thesis, University of Kansas, in preparation.

References

Baer, D. M., Wolf, M. M., & Risley, T. R. Some current dimensions of applied behavior analysis. Journal of Applied Behavior Analysis, 1968, 1, 91-97.

Banerdt, B. & Bricker, D. A training program for selected self-feeding skills for the motorically impaired. AAESPH Review, 1978, 3, 222-229.

Banus, B. S. (Ed.). The developmental therapist. Thorofare, N.J.: Charles B. Slack, 1971.

Barrera, M. E. C., Routh, D. K., Parr, C. A., Johnson, N. M., Arendshort, D. S., Goolsby, E. L., & Schroeder, S. R. Early intervention for biologically handicapped infants and young children: A preliminary study with each child as his own control. In T. D. Tjossem (Ed.), Intervention strategies for high risk infants and young children. Baltimore: University Park Press, 1976.

Bax, M. C. D. Terminology and classification of cerebral palsy. Developmental Medicine and Child Neurology, 1964, 6, 295-297.

Bayley, N. The Bayley scales of infant development. New York: Psychological Corporation, 1969.

Bobath, B. The importance of the reduction of muscle tone and the control of mass reflex action in the treatment of spasticity. Occupational Therapy and Rehabilitation, 1948, 27, 371-383.

Bobath, B. Control of postures and movements in the treatment of cerebral palsy. Physiotherapy, 1953, 39, 99-104.

Bobath, B. A study of abnormal postural reflex activity in patients with lesions of the central nervous system--I. Physiotherapy, 1954, 40, 259-267. (a)

Bobath, B. A study of abnormal postural reflex activity in patients with lesions of the central nervous system--II. Physiotherapy, 1954, 40, 295-300. (b)

Bobath, B. A study of abnormal postural reflex activity in patients with lesions of the central nervous system--III. Physiotherapy, 1954, 40, 326-334. (c)

Bobath, B. A study of abnormal postural reflex activity in patients with lesions of the central nervous system--IV. Physiotherapy, 1954, 40, 368-373. (d)

Bobath, B. The treatment of motor disorders of pyramidal and extra-pyramidal origin by reflex inhibition and facilitation of movements. Physiotherapy, 1955, 41, 146-153.

Bobath, B. The very early treatment of cerebral palsy. Developmental Medicine and Child Neurology, 1967, 9, 373-390.

Bobath, K. The neuropathology of cerebral palsy and its importance in treatment and diagnosis. The Cerebral Palsy Review, 1959, 8, 13-33.

Bobath, K. Neurophysiological basis for the treatment of cerebral palsy. Philadelphia: Lippincott, 1980.

Bobath, K. & Bobath, B. Spastic paralysis: Treatment of the use of reflex inhibition. The British Journal of Physical Medicine, 1950, 13, 121-127.

Bobath, K. & Bobath, B. A treatment of cerebral palsy: Based on the analysis of the patient's motor behavior. The British Journal of Physical Medicine, 1952, 15, 107-117.

Bobath, K. & Bobath, B. Treatment of cerebral palsy by the inhibition of abnormal reflex action. British Orthoptic Journal, 1954, 11, 88-98.

Bobath, K. & Bobath, B. Tonic reflexes and righting reflexes in the diagnosis and assessment of cerebral palsy. Cerebral Palsy Review, 1955, 16(5), 4-10.

Bobath, K. & Bobath, B. The neurodevelopmental treatment of cerebral palsy. Physical Therapy, 1967, 47, 1039-1041.

Bobath, K. & Bobath, B. Cerebral palsy, In P. H. Pearson & C. E. Williams (Eds.), Physical therapy services in the developmental disabilities. Springfield, Ill.: Charles C Thomas, 1976, 31-185.

Bruning, J. L. & Kintz, B. L. Computational handbook of statistics. Glenview, Illinois: Scott, Foresman and Company, 1977.

Campbell, P., Green, K., & Carlson, L. Approximating the norm through environmental and child-centered prosthetics and adaptive equipment. In E. Sontag (Ed.), Educational programming for the severely and profoundly handicapped. Reston, Virg.: The Council for Exceptional Children, 1977, 300-320.

Capute, A. J. Developmental Disabilities: An overview. Dent. Clin. N. Am., 1974, 18, 557-577.

Capute, A. J., Accardo, P. J., Vining, E. P. G., Rubenstein, J. E., & Harryman, S. Primitive reflex profile. Baltimore: University Park Press, 1978.

Carlsen, P. N. Comparison of two occupational therapy approaches for treating the young cerebral-palsied child. American Journal of Occupational Therapy, 1975, 29, 268-272.

Cerebral palsy--Facts and figures. New York: United Cerebral Palsy Association, Inc., 1973.

Conel, J. L. The postnatal development of the human cerebral cortex. Vol I: The cortex of the newborn. Cambridge, Mass.: Harvard University Press, 1939.

Conover, W. J. Practical nonparametric statistics. New York: John Wiley & Sons, 1971.

Crosland, J. H. The assessment of results in the conservative treatment of cerebral palsy. Archives of Diseases in Childhood, 1951, 26, 92-95.

Dekaban, A. Neurology of early childhood. Baltimore: Williams & Wilkins, Co., 1970, 1-49.

Dergassies, S. S. Neurological development in the full-term and premature neonate. New York: Exerpta Medica, 1977.

Doman, R. J., Spitz, E. B., Zucman, E., Delacato, C. H., & Doman, G. Children with severe brain injuries. Journal of the American Medical Association, 1960, 174, 257-262.

Doman, R. J., Taylor, R. G., & Thomas, E. W. Brain injury as a diagnosis and the results of treatment in 335 brain injured children. In J. M. Wolf (Ed.), The results of treatment in cerebral palsy. Springfield, Ill.: Charles C Thomas, 1969, 213-220.

Dunsdon, M. I. Cerebral palsy. Educational Research, 1960, 3, 37-50.

Fay, T. Problems of rehabilitation in patients with cerebral palsy. Delaware Medical Journal, 1946, 18, 57-60.

Fay, T. Basic considerations regarding neuromuscular and reflex therapy. Spastics Quarterly (III), 1954.

Fiorentino, M. R. Reflex testing methods for evaluating CNS development. Springfield, Ill.: Charles C Thomas, 1963.

Fiorentino, M. R. Normal and abnormal development: The influence of primitive reflexes on motor development. Springfield, Ill.: Charles C Thomas, 1972.

Fiorentino, M. R. Reflex testing methods for evaluating C.N.S. development, Springfield, Ill.: Charles C Thomas, 1973.

Footh, V. K., & Logan, K. L. Measuring the effectiveness of physical therapy in the treatment of cerebral palsy. Journal of the American Physical Therapy Association, 1963, 43(12), 867-873.

Frankenburg, W. K. & Dodds, J. B. Denver developmental screening test. Denver: University of Colorado Medical Center, 1969.

Fulton, J. F. Physiology of the nervous system. Great Britain: Oxford University Press, 1943.

Gillette, H. E. Systems of therapy in cerebral palsy. Springfield, Ill.: Charles C Thomas, 1969.

Hersen, M. & Barlow, D. H. Single case experimental designs. New York: Pergamon Press, 1976.

Holt, K. S. Assessment of cerebral palsy. London: Lloyd-Luke (Medical Books), Ltd., 1965.

Horner, R. D. & Baer, D. M. Multiple-probe technique: A variation of the multiple baseline. Journal of Applied Behavior Analysis, 1978, 11, 189-196.

Horner, R. D. & Keilitz, I. Training mentally retarded adolescents to brush their teeth. Journal of Applied Behavior Analysis, 1975, 8, 301-309.

Ingram, A. J., Withers, E., & Speltz, E. Role of intensive physical and occupational therapy in the treatment of cerebral palsy: Testing and results. Archives of Physical Medicine and Rehabilitation, 1959, 40, 429-438.

Kabat, H. Studies on neuromuscular dysfunction. II: New principles of neuromuscular reeducation. Permanente Foundation Medical Bulletin, 1947, 5, 3.

Kazdin, A. E. & Wilson, G. T. Evaluation of behavior therapy: Issues, evidence, and research strategies. Lincoln, Nebraska: University of Nebraska Press, 1978.

Knott, M. & Voss, D. E. Proprioceptive neuromuscular facilitation. New York: Hoeber, 1956.

Knott, M. & Voss, D. E. Proprioceptive neuromuscular facilitation: Patterns and techniques (2nd Ed.). New York: Harper and Row, 1968.

Kong, E. Very early treatment of cerebral palsy. Developmental Medicine and Child Neurology, 1966, 8, 198-202.

Levitt, S. Cerebral palsy. In J. Cash (Ed.), Neurology for physiotherapists. Lippincott, 1977, 266-287.

LeWinn, E. B. Human neurological organization. Springfield, Ill.: Charles C Thomas, 1969.

Little, W. J. On the nature and treatment of the deformities of the human frame: Being a course of lectures delivered at the Royal Orthopaedic Hospital in 1843 with numerous notes and additions. London: Longman, Brown, Greene, & Longman, 1853.

Lynch, V., Flanagan, K., & Pennell, O. Implementing data collection and charting conventions: Let me count the ways, Part 1. In N. G. Haring (Ed.), The experimental education training program: An inservice program for personnel serving the severely handicapped. Seattle, Wash.: University of Washington, 1977, 111-128.

Mair, A. Incidence, prevalence, and social class. In J. L. Henderson (Ed.), Cerebral palsy in childhood and adolescence. Edinburgh: E. & S. Livingston, 1961, 15-21.

Magnus, R. Some results of studies in the physiology of posture. Lancet, Sept. 1926, 531-536.

Marks, N. C. Cerebral palsied and learning disabled children. Springfield, Ill.: Charles C Thomas, 1974.

Martin, J. E. & Epstein, L. H. Evaluating treatment effectiveness in cerebral palsy: Single subject designs. Physical Therapy, 1976, 56, 285-294.

McFall, R. M. & Marston, A. R. An experimental investigation of behavior rehearsal in assertive training. Journal of Abnormal Psychology, 1970, 76, 295-303.

McGraw, M. B. The neuromuscular maturation of the human infant. New York: Hafner Press, 1943.

Menkes, J. H. Textbook of child neurology. Philadelphia: Lea & Febiger, 1974.

Molnar, G. E. Motor deficit of retarded infants and young children. Archives of Physical Medicine and Rehabilitation, 1974, 55, 393-398.

Monrad-Krohn, G. H. Clinical examination of the nervous system. Great Britain: H. K. Lewis, 1938.

Mysak, E. D. Principles of reflex therapy approach to cerebral palsy. New York: Teachers College, Columbia University, 1963.

Norton, Y. Neurodevelopment and sensory integration. American Journal of Occupational Therapy, 1975, 29, 93-100.

O'Brien, F. & Azrin, N. H. Developing proper mealtime behaviors of the institutionalized retarded. Journal of Applied Behavior Analysis, 1972, 5, 389-399.

Paine, R. S. On the treatment of cerebral palsy: The outcome of 177 patients, 74 totally untreated. Pediatrics, 1962, 29, 605-616.

Parsonson, B. S. & Baer, D. M. The analysis and presentation of graphic data. In T. R. Kratochwill (Ed.), Single subject research: Strategies for evaluating change. New York: Academic Press, 1978, 101-166.

Phelps, W. M. The treatment of cerebral palsies. Journal of Bone and Joint Surgery, 1940, 22, 1004-1012.

Phelps, W. M. Factors influencing the treatment of cerebral palsy. Physiotherapy Review, 1941, 21, 136-138.

Phelps, W. M. Let's define cerebral palsy. Crippled Children, 1948, 26, 3-5.

Rood, M. S. Neurophysiological mechanisms utilized in the treatment of neuromuscular dysfunction. American Journal of Occupational Therapy, 1956, 10, 220-224.

Rood, M. The use of sensory receptors to activate, facilitate, and inhibit motor response, autonomic and somatic in developmental sequence. In C. Sattely (Ed.), Approaches to treatment of patients with neuromuscular dysfunction. (Study Course VI Third International Congress, World Federatin of Occupational Therapists) Dubuque, Iowa: William C. Brown, Co., 1962.

Rushworth, G. On postural and righting reflexes. In C. B. Kopp (Ed.), Readings in early development, Springfield, Ill.: Charles C Thomas, 1971, 6-20.

Scherzer, A. L., Mike, V., & Ilson, J. Physical therapy as a determinant of change in the cerebral palsied infant. Pediatrics, 1976, 58, 47-52.

Sherrington, C. S. The integrative action of the nervous system. New Haven: Yale University Press, 1906.

Sidman, M. Tactics of scientific research: Evaluating experimental data in psychology. New York: Basic Books, 1960.

Stephen, E. Cerebral palsy and mental defect. In A. M. Clarke & A. D. B. Clarke (Eds.), Mental deficiency: The changing outlook (2nd Ed.). London: Methuen, 1965.

Sukiennicki, D. A. Neuromotor development. In B. S. Banus (Ed.), The developmental therapist. Thorofare, N. J.: Charles B. Slack, 1971, 125-208.

Tyler, N. B. & Kahn, N. A home treatment program for the cerebral palsied child. American Journal of Occupational Therapy, 1976, 30, 437-440.

Utley, B. L., Holvoet, J. F., & Barnes, K. Handling, positioning, and feeding the physically handicapped. In E. Sontag (Ed.), Educational programming for the severely and profoundly handicapped. Reston, Va.: Division of Mental Retardation, Council for Exceptional Children, 1977, 279-299.

Vining, E. P. G., Accardo, P. T., Rubenstein, J. E., Farrell, S. E., & Roizen, N. J. Cerebral palsy: A pediatric develomentalist's overview. American Journal of Disease in Children, 1976, 130, 643-649.

Woods, G. E. The outcome of physical treatment in cerebral palsy. Cerebral Palsy Review, 1964, 25(5), 3-9, 15.

Wright, S. Applied physiology. Great Britan: Oxford University Press, 1945.

Wright, T. & Nicholson, J. Physiotherapy for the spastic child: An evaluation. Developmental Medicine and Child Neurology, 1973, 15, 146-163.

Zuck, F. N. & Johnson, M. K. The progress of cerebral palsy patients under inpatient circumstances. The American Academy of Orthopoedic Surgeons, 1952, 9, 112-118.

APPENDIX A

Sample of Completed Training Data Sheet

DATA SHEET 1
Training

Student Sam Trainer W.V. Week # 6

Date		1	2	3	4	5	6	7	8	9	10	T	TT	R%
10/29/81	equilibrium	0	0	0	1	0	0	0	0	0	0	1		
	parachute	0	0	0	0	0	0	0	0	0	0	0		
	righting	2	1	0	1	0	3	2	3	0	3	15	16	✓
11/2/81	equilibrium	0	0	1	0	0	0	0	1	0	0	2		
	parachute	0	0	0	0	0	0	0	0	0	0	0		
	righting	0	2	0	0	0	0	0	0	0	3	5	7	✓
11/3/81	equilibrium	0	0	1	0	0	0	0	0	0	1	2		
	parachute	0	0	0	0	0	0	0	0	0	0	0		
	righting	2	3	0	0	2	0	3	0	0	0	10	12	✓
11/4/81	equilibrium	0	0	0	0	0	0	0	0	0	1	1		
	parachute	0	0	0	0	0	0	0	0	0	0			
	righting	2	3	0	2	0	3	0	0	0	1	11	12	93%
11/9/81	equilibrium	0	0	0	0	0	0	0	1	0	2	3		
	parachute	0	0	0	0	0	0	0	0	0	0	0		
	righting	2	1	1	2	2	2	2	2	1	2	17	20	✓

APPENDIX B

ATNR Assessment Procedures
(Capute et al., 1978, pp. 38-40)

ASYMMETRICAL TONIC NECK REFLEX

Description

When the child is supine he may be seen to lie with head turned to one side with extension of the extremities on that side (chin side), and flexion of the contralateral extremities (occiput side). This may also be noted in sitting; it is often described as the "fencer" position.

Technique

The child is placed supine. He is first observed for active head turning and subsequent extremity movement. The head is then passively turned (through 180°) alternately to each side for 5 sec. This is repeated five times on each side. If no movement is noted, the head turning is repeated and changes in tone are observed. Consistent tone changes must be felt in at least two extremities for the reflex to be scored as present.

Grading

0 Absent

1+ With passive head rotation, no visible response, but increased extensor tone noted in extremities on chin side or increased flexor tone on occiput side. (Active movement may elicit visible response.)

2+ With passive movement of the head, visible extension of extremities on chin side or flexion on occiput side is noted. (In some babies the visible component will be limited to flexion/extension of the fingers.)

3+ Passive head movement produces full (180°), if transient, extension in the extremities on the chin side or more than full (90°), flexion of extremities on the occiput side. (The upper extremities of some babies with a positive tonic labyrinthine reflex will start from a position of flexion, and therefore only slight visible movement will cause them to be scored 3+.)

4+ Obligatory (more than 30 sec) extension of extremities on chin side or flexion of extremities on occiput side.

APPENDIX C

Sample of Completed ATNR Data Sheet

DATA SHEET 2
Tonic Reflex Probe

Student *Charlie* Trainer *M.S.*

Date		Trials 1	2	3	4	5	Reliability
12/17/81	left	3+	0	0	3+	0	
	right	3+	0	0	3+	0	____
12/23/81	left	3+	3+	0	0	3+	
	right	0	0	0	3+	0	____
1/19/82	left	3+	3+	3+	3+	0	
	right	3+	3+	3+	0	0	100%
1/25/82	left	3+	3+	0	3+	3+	
	right	3+	3+	3+	3+	3+	____
2/15/82	left	3+	3+	3+	3+	3+	
	right	3+	3+	3+	0	0	____

APPENDIX D

Head Erect Assessment Procedures
(Foshage, Note 4; Rues, Note 5)

Procedures for Measuring
<u>Head Erect</u>

by

Kathleen J. Foshage[1]

[1]The procedures reported in this study were taken from a master's thesis conducted by Kathleen J. Foshage that was submitted to the Department of Special Education at the University of Kansas in October, 1978.

Measuring Head Control

Areas for measuring three critical forms of head erect behavior have been described earlier in figure 1. They include: (1) head erect in the prone position; (2) head erect in a supported sitting position; and (3) maintenance of head erect while being "pulled-to-sit" and reclined-to-supine".

Head Erect in the Prone Position

These procedures are designed to measure the frequency and duration of the child's head raises when he is placed on his stomach. The position of the child's arms when his head is raised is also measured.

Materials and Equipment

A data sheet, cumulative stopwatch, and pencil are necessary. Two types of reinforcers for head erect behavior are recommended; manipulatables and consumables.

Manipulatable. Identify the child's preferred toys. Request the child's parents (or teachers) to provide information on which type of stimulation (i.e., food, vibration, touch, etc.) will elicit and maintain a functional response from the child. If no preference information is available, present a variety of objects to the child and determine his preferred ones. The child may demonstrate preference by fixating on an object, or reaching for it, or otherwise responding positively to its presentation. Periodically probe the child's interest in other objects to determine if the initial objects remain the child's preferred ones. Potentially reinforcing objects include:

1. Visually interesting toys with bright colors and moving parts: rotating lamps, mobiles, flashing lights, t.v. etc. These items allow head

erect to be measured in a variety of positions.

2. Auditorily stimulating toys, such as music boxes, bells, and "See and Say," that can be activated when the child's head is appropriately erect.

3. A vibrator that can be applied to any part of the body except the neck (to avoid stimulating extensor muscles).

Consumable. Foods and liquids may be used to reinforce head erect behavior. Liquids can be placed in a squeeze bottle with a spout so that a few drops can be dispersed into the child's mouth when the child's head is raised. Use foods that can be given immediately and eaten easily and quickly (e.g., M & M's).

Observational Settings

Conduct measures of head control in the prone position (and the other two positions) in both structured and unstructured settings.

Structured observations. Make these observations when head control is a treatment goal. Their purpose is to assess the child's ability to display head erect behavior when an attempt is made to specifically elicit this response. No verbal cues are to be given. Without giving any verbal cues, attempt to gain the child's attention by holding a toy within his visual field, and then moving it to the midline position. This may elicit an attempt by him to raise and turn his head to the midline position to see the object. If a sound-producing toy is used, manipulate it so it sounds only when the child lifts his head.

Unstructured observations. These observations should take place during an activity that regularly occurs. Their purpose is to assess the child's ability to display head erect behavior under natural conditions without the aid of a specific prompt. These may include activities where head erect behavior (in a prone position) is a prerequisite to the activity, but not the goal of training (e.g., reach and touch program, visual tracking, etc.). These observations may be taken in the home or treatment setting. Place the child on a floor or table. Make the toys available 12-18 inches in front of him in the midline of his body. Adjust the observations to the child's fedding and sleeping schedule to avoid drowsiness or hunger, and do not attempt to specifically elicit the response.

Positioning the Child

1. Place the child prone (on stomach) on a floor, mat, or table.
2. Flex his elbows and place his hands on either side of the head.
3. Extend, abduct, and externally rotate the legs.

If the child places his hands or fingers in his mouth, remove and reposition them directly above his shoulders on either side of the head. If he attempts to roll over, stop and reposition him. If abnormal muscle tone develops during the observation, reposition the child but do not stop the observation. Abnormal tone is indicated by scissoring of the arms and/or legs, and/or hyperextension of the neck.

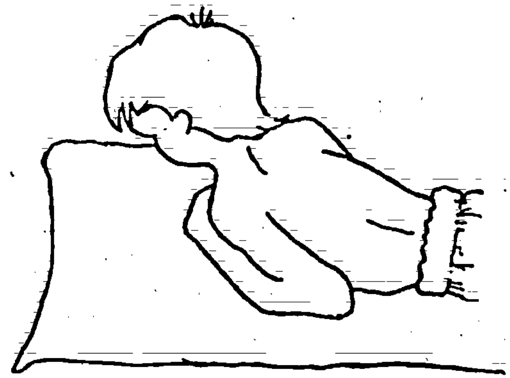
Behavior Definitions

The terms defined below describe positions of the head and arms during the measurement procedure. These positions are illustrated in Figure 2.

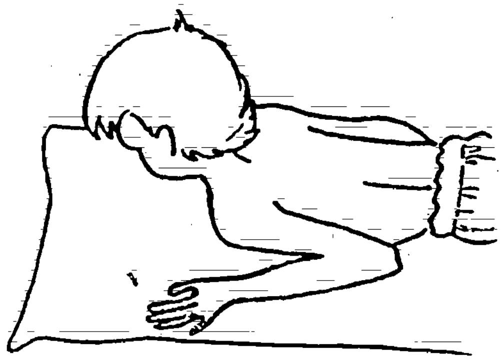
1. Head bob. The head is raised and remains up less than or equal to 5 sec before contacting a supporting surface.

2. Head erect. When no part of the head or neck (chin to clavicle) is touching the supporting surface. If the head rests on or touches the arms when they are being used as supports, head erect is not occurring.

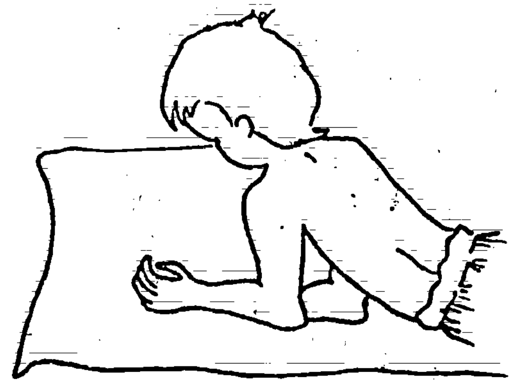
a. Head bob



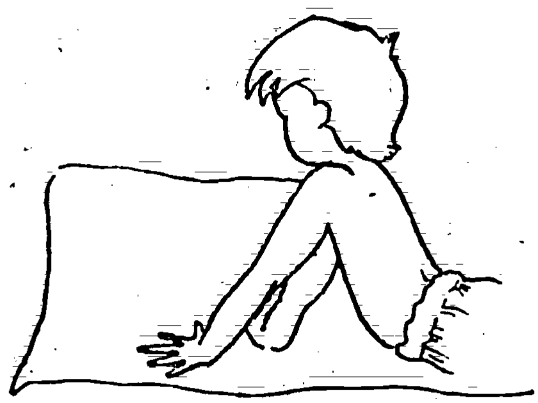
c. Head up without forearm support



b. Head erect



d. Head erect with forearm props



e. Head erect with extended arm props

Figure 2. Illustrations of the head and arm positions

3. Head up without arm support. The head is raised and remains up longer than 5 sec before contacting a supporting surface, with an elbow angle of less than 90°.

4. Head erect with forearm props. The head is raised and remains up more than 5 sec with one arm elbow angle more than 90° and other arm not touching a supporting surface. This excludes any arm raising behavior involved in rolling over that can be prevented by the examiner.

5. Head erect with extended arm props. The head and chest are raised and remain up longer than 5 sec with no part of the arm touching a supporting surface. Only the hands are touching the surface.

Combinations of these arm positions can occur. One arm may be in one position and the other in a different position. Score these "combinations" on the data sheet also.

Measurement Procedures

Take frequency and/or duration measures of head erect behavior. To determine which measure to use (Schedule A or Schedule B described below) perform an initial observation session. Observe the child for 3 min and record the cumulative duration of all head erect behavior. Do not record arms positions during this preliminary step. If the cumulative duration of head erect is less than 60 sec, observe the child using Schedule A. If the total is greater than or equal to 60 sec, observe the child using Schedule B.

Observation Schedule A. Use this schedule with children who sustain head erect behavior for less than 60 sec of the 3 min initial observation. First place the child in the starting position and observe him for 3 min, allowing the stopwatch to run continuously. During this time record his head erect behavior using the position abbreviations shown on the data

Name: ______________ Location: ☐ Home ☐ School

Date: ______________ Setting: ☐ Structured

Age: ______________ ☐ Unstructured

Examiner: ______________ ☐ Group ☐ Individual

Time: ________ Start ________ Stop

Code: B - bob

+ - no arm support

√+ - props on one forearm, other arm no support

√√ - props on forearms

√ - props on one forearm, other arm is raised

√/ - props on one forearm and one extended arm

// - props on extended arms

/ - props on one extended arm, other arm is raised

Responses or Trials	Duration	Arm Position(s)
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		
9.		
10.		
11.		

Figure 3. Data sheet for measuring head erect in the prone position.

HE25

sheet in Figure 3. This self-explanatory data sheet is required to observe on both schedules. If the child raises his head longer than 5 sec, record the duration of this head raise (in seconds) and note the position of the child's arms.

Observation Schedule B. Follow this schedule with children who sustain head erect behavior for 60 sec or longer during the initial observation.

First place the child on his stomach and present the stimulus. If the child does not raise his head in 30 sec, end the trial and record a zero on the data sheet. If the child does raise his head within 30 sec, time and record the duration of the response (including the position of the arms). Beginning when the head raises above the supporting surface. If abnormal tone is observed during the probe trials (to be described), stop the session, record the time, and reposition the child. (Mark an asterisk on the data sheet next to the appropriate trial to indicate that the trial was interrupted.) To begin each trial, reposition the child and again present the stimulus. Conduct a minimum of 5 to 10 trials. Use the same data sheet as required in Schedule A.

During head lifts, the stimulus may be moved horizontally to maintain the child's eye contact or vertically to prompt the child to raise his head higher. If the child lowers his head, but does not touch the supporting surface, hold the stimulus at this level and slowly raise it.

Change from the 3 min observation periods to the discrete trial measure (Schedule A to B) when the child maintains a head erect position for 60 sec during a 3 min period. To use this criteria sum only occurrences of head erect greater than 5 sec in length.

Data Analysis

It is suggested that two measures of head erect be tabulated. These are (1) number of head bobs per minute; and (2) duration of the longest head erect response per 3 min observation.

Head bobs/minute. In observation Schedule A, the number of head bobs are recorded during the observation period. This includes head raises of less than 5 seconds. A head bob per minute frequency can be tabulated by dividing the total number of head bobs during each 3 min session by three.

$$\frac{\text{total head bobs/session}}{3} = \text{\# of head bobs/minute}$$

Tabulate this rate by session for the child.

Duration. In observation Schedules A and B, the duration of head erect behavior is recorded. Using either schedule, the longest occurrence of head erect behavior for each session can be determined.

Graph the data for both head bobs/minute and the longest duration of head erect on the same scale. Indicate on the left horizontal axis head bobs/minute; on the right horizontal axis record longest duration of head erect behavior per observation period. Then use this graph to follow the transition between head bobs and the increased duration of head erect behavior for the child.

Head Erect in the Supported Sitting Position

The procedures are designed to measure the frequency and duration of the child's head raises while he is seated in the examiner's lap.

Materials and Equipment

Appropriate data sheets, a cumulative stopwatch, table, and chair are needed. A modified sheet of plexiglass (described below) is also required. This apparatus is also used in measuring head erect in the "pull-to-sit" and "recline-to-supine" positions.

Measurement frame. A 2' x 2' sheet of plexiglass (or use blackboard of the same dimensions) is necessary. Using ¼" wide tape, divide the plexiglass into three trisections (30° angles). Number the trisections 1, 2, and 3 with 1 encompassing the length of the bottom edge, 2 in the middle, and 3 encompassing the length of the vertical edge (see Figure 4).

If you desire a portable unit, cut a groove just wide enough to allow the plexiglass (or blackboard) to fit in a board 3" x 4". A hole can be drilled through the top and a leather strip inserted to be used as a handle. The portable unit must be divided into trisections after it is fitted into the wooden groove since the support board will raise the plexiglass (or blackboard) off the surface slightly.

Foot blocks. If it is necessary to raise the examiner's knees to provide a horizontal base of support for the child, construct foot blocks from telephone books, cardboard bricks, etc.

Reinforcers. The same reinforcers used to consequate head erect behavior in the prone position can be used for head erect behavior in the supported sitting position.

Observational Settings

Structured observation (see p. HE21). In this setting have a second examiner provide visual or auditory stimulation by holding interesting objects at or above the child's eye level to encourage the child to maintain head erect behavior.

Unstructured observations (see p. HE21). Provide no additional visual or auditory stimulation. Seat the child where he can observe ongoing activity in the room.

Positioning the Child

Implement the initial positioning and movement of the child as follows:

1. Remove all clothing from the upper part of his body.

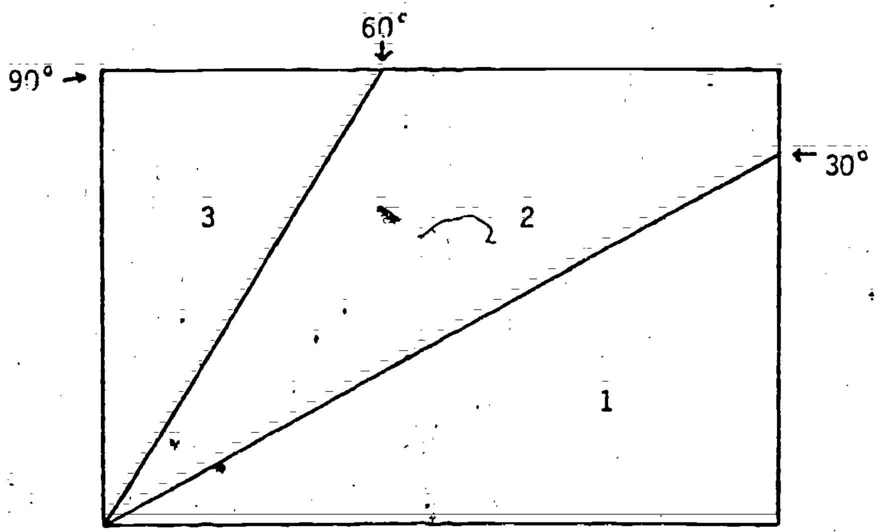


Figure 4. Trisection device.

2. Place the trisection device on the table.

3. Place the chair of appropriate height parallel to the trisection device. The height of the chair and the table must be coordinated so the child's waist is even with the bottom edge of the trisection device when the child is seated on the examiner's lap facing the same direction as the examiner. Use foot blocks, if necessary, to raise the examiner's knees so that her hips and knees form a horizontal line.

4. Position the vertical edge of the trisection device containing Trisection 3 so that it bisects the child's trunk into front and back halves as shown in Figure 5.

5. Support the child at the waist if he is able to maintain his trunk in a vertical position for 30 sections. Support him at the shoulders to maintain the vertical trunk position if he cannot voluntarily maintain this position for 30 seconds. Do not allow the child's head to touch the examiner's chest.

Behavior Definitions

Head erect behavior is scored when no part of the head (excluding hair) is lower than 60° (i.e., below the third trisection); the child's neck is not hyperextended, and the entire head has not moved beyond the vertical edge of the trisection device (90° edge).

Measurement Procedures

Frequency and duration measurements are made of head erect behavior in the supported sitting position. To determine which measure to use, position and observe the child for 3 min initially. During this period, record the duration of the behavior using a cumulative stopwatch according to the definition given above. Make sure a second person provides visual or auditory stimulation by holding objects at or above the child's eye level.

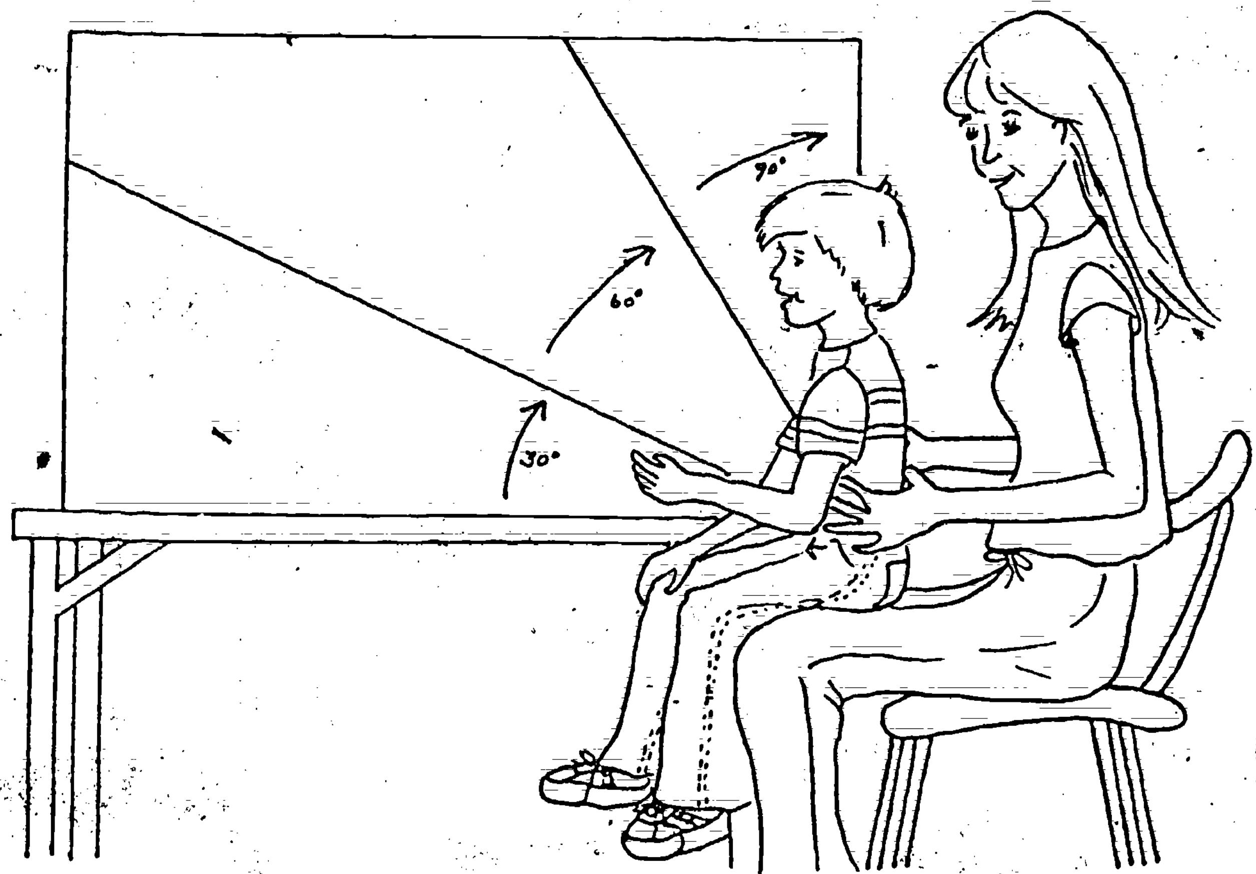


Figure 5. Correct position for measurement in supported sitting.

If the child holds his head erect for 25 or more cumulative seconds during the 3 min period, use a duration measure for all subsequent observations. If the child does not maintain head erect for 25 cumulative sec or more during the observation, use a frequency measure for subsequent observations.

Duration. To measure duration, start the stopwatch when no part of the child's head (excluding hair) is below the 60° line on the trisection device and when the head is not hyperextended. Stop the watch when any part of the head (excluding hair) falls below the 60° line, when the neck hyperextends, or when the entire head moves beyond the vertical (90°) edge of the trisection device.

Frequency. To measure frequency, record a response occurrence each time the child's head moves above the 60° line on the trisection device, when the neck is not hyperextended, and when the head is not beyond the vertical (90°) edge of the trisection device.

Record responses on a data sheet like that presented in Figure 6.

Data Analysis

Frequency. Tabulate the number of times during the 3-min period in which the child's head raises above the 60° line on the trisection device. Then calculate frequency per minute by dividing the total responses by three. Graph these data by observation session, as described in the prone position.

Duration. For each session determine the longest time that the child maintained the head erect position. Alternatively, tabulate the total time per session that the child's head was erect.

Graph the data by observation session, as described in the prone position.

Head Erect in the Supported Sitting Position

Name: ________________ Location: Home School
Age: ________________ Setting: Structured
Examiner: ________________ Unstructured
Observer: ________________ Support: Shoulders
Observation Time: ________ Waist
Frequency-Duration
Head Erect (circle one)

Date: ________________ Location: Home School
Examiner: ________________ Setting: Structured
Observer: ________________ Unstructured
Observation Time: ________ Support: Shoulders
Frequency-Duration
Head Erect (circle one)

Date: ________________ Location: Home School
Examiner: ________________ Setting: Structured
Observer: ________________ Unstructured
Observation Time: ________ Support: Shoulders
Frequency-Duration Waist
Head Erect (circle one)

Date: ________________ Location: Home School
Examiner: ________________ Setting: Structured
Observer: ________________ Unstructured
Observation Time: ________ Support: Shoulders
Frequency-Duration Waist
Head Erect (circle one)

Figure 6. Recording head erect in the supported sitting position.

Head Erect in the Pull to Sit and Recline to Supine Position

The procedures described for these positions are intended to measure the angle of the child's head in relation to his body while he is being pulled to a sitting position and while he is being lowered back to a supine position.

Materials and Equipment

Required materials include a data sheet, the trisection device described in the previous section and the following special materials.

Velcro band. A velcro (3/4" wide) strip long enough to fit around the largest child's chest just under the arms.

Velcro loop. Cut 10 small pieces of velcro (1" x ½") from the soft (fuzzy) portion. Use these to secure the surgical tape to the opposite piece of velcro previously secured across the child's chest.

Tape. Cut strips of surgical tape (#1535 - 1" x 10 yds, 3M Micropore brand surgical tape) in strips long enough to reach from the middle of the child's chin to the velcro band around the child's chest plus one inch. Wrap one end of the tape around the velcro loop and adhere it to itself (see Figure 7).

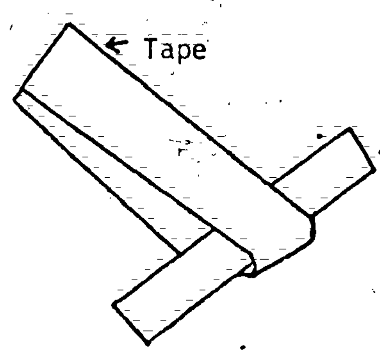


Figure 7. Velcro loop and tape.

Headrest. Use sandbags on both sides of the child's head to maintain a midline position when the child is prone, or use a commerically available headrest (removed from a wheelchair) for the correct positioning.

Reinforcers. The same reinforcers used in measuring head erect in the prone position and supported sitting position are sufficient.

Observational Settings

Structured observations (see p. HE21). These measurements should be taken twice weekly during the implementation of a pull-to-sit and recline-to-supine treatment program, or at different times of day to avoid fatiguing the child. Five trials (pull-to-sit and recline-to-supine) should be performed. A toy may be placed on the examiner's head or shoulder (attached by velcro) to encourage the child to raise his head.

Unstructured observations (see p. HE21). Place the trisection device on a diaper changing table to record data as the child is reclined prior to having a diaper changed and as the child is pulled to sit after being changed. Similar situations that the child normally encounters may be substituted. A minimum number of trials is not required.

Positioning the Child

To position the child, implement the following procedures:

1. Place the trisection device on the floor or on a table.
2. Remove all clothing from the upper part of the child's body.
3. Place the velcro band around the child's chest directly under his arms as shown in Figure 8. Tighten the band after it is in place by adjusting the two points of adherence, one under each arm.
4. Fasten one end of the tape around the velcro loop and back onto itself. Center the velcro loop, with tape already attached, on the front of the band.

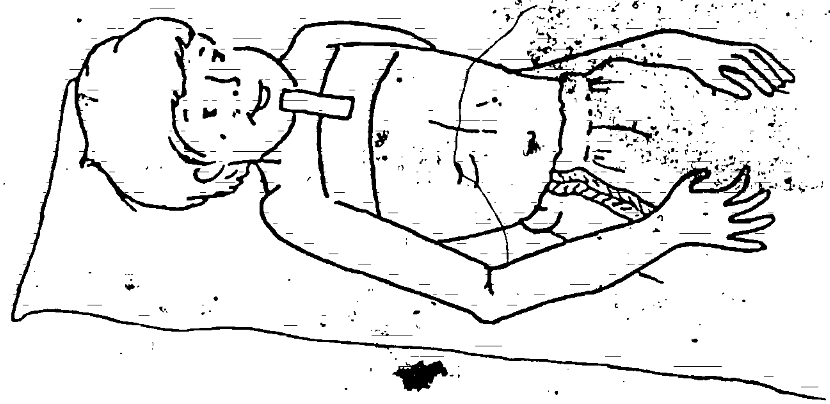


Figure 8. Correct placement of velcro loop and tape.

5. Place the child in a supine position parallel to the trisection device, so that his waist is even with the vertical end of the device. His head must be flat on the floor and maintained in midline with a headrest if necessary as shown in Figure 9.

6. Attach the free end of the tape to the middle of the child's chin so that there is no slack. Note: Attach the tape while child's mouth is in its usual position. For example, if his mouth is usually open, attach the tape while it is open. If the mouth is open during pull to sit and recline, but not at other time, hold the child's mouth open to attach the tape.

7. Flex the child's knees and place his feet flat on the floor. To maintain this position the examiner may have to externally rotate and flex his/her knee and place the child's flexed knees over his/her calf.

Behavior Definitions

Score head erect behavior for each trisection as the child is pulled from the supine to the sitting position, and lowered back from the sitting to the supine position. Score head erect behavior only if the following two conditions are met: (1) the tape remains attached, and (2) the head is not resting on the child's chest.

Measurement Procedures

As the child is being pulled to sit, or reclined, record the number of trisections in which his head remains erect. Conduct five trials of pull to sit and five of recline to supine. Implement the procedures described below.

1. Use either the child's hands or shoulders as a point of contact for the pull-to-sit and recline maneuver. Base this on the child's ability to assist with his arms in the maneuver. That is, if the child can assist

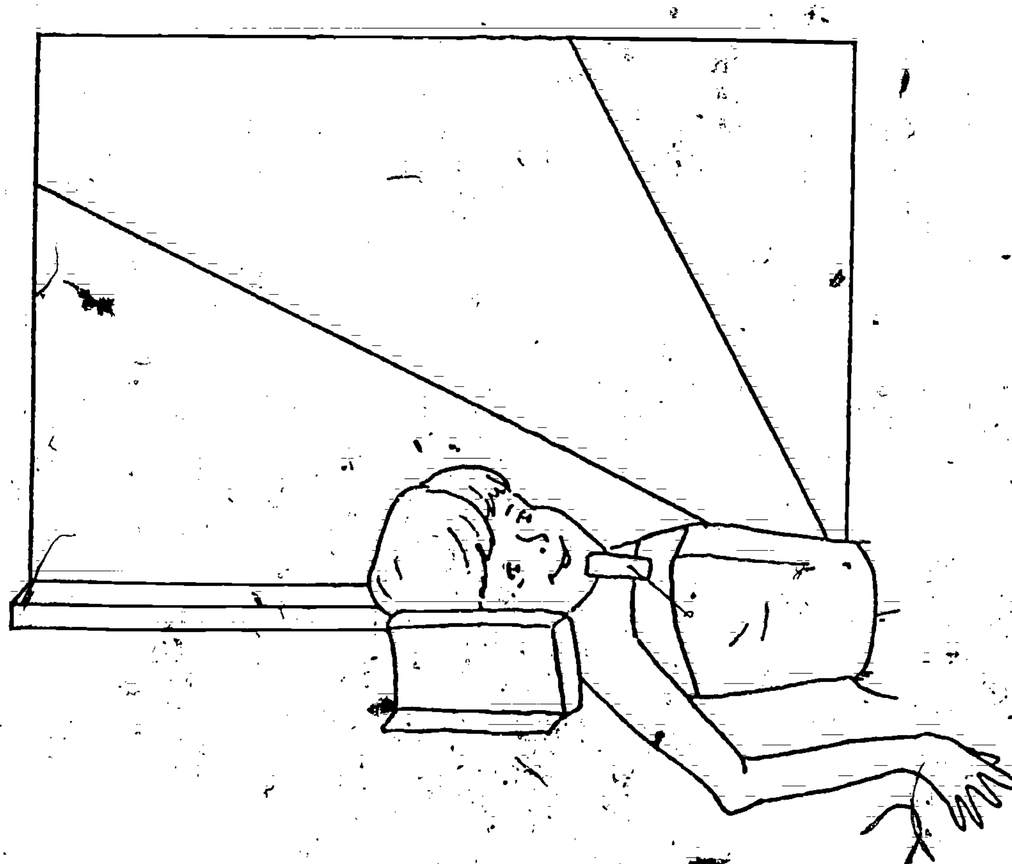


Figure 9. Correct body alignment with the trisection device.

in pulling, grasp the child's hand prior to the trial. If there is none, or only minimal contraction present, use the shoulders as the point of contact instead. In this case, fold the child's arms across his chest and then place one hand on each shoulder.

2. To conduct a trial, pull the child to the sitting position then lower him/her back to the supine position. To start the trial, first instruct the child to "sit up," then grasp him at the appropriate place (hands or shoulders), and pull him straight up into the sitting position. Then place the child's head in the midline position prior to beginning the movement back to the supine position. When moving back to the supine position, grasp the child at the appropriate place (hand or shoulders) and lower him to the floor.

3. Regulate the duration of a trial by counting 1 sec per trisection so that the ascent and descent each requires 3 seconds.

4. Have a second examiner record the trisections in which the child demonstrates head erect behavior and in which trisections he does not.

5. Use three symbols for recording the data: (1) (+) head is erect; (2) (-) head is not erect; (3) (0) tape is detached. The head is defined as erect if the tape is attached and the child's head is not resting on his chest. For each trisection that this occurs, the observer marks a plus (+) on the data sheet (see Figure 10) for the appropriate trisection. When the tape detaches, the observer records the trisection number (1, 2, or 3) corresponding to the posterior part of the child's ear. The observer marks a (0) for this trisection and marks the previous trisection appropriately (+). For example, if the tape detaches at 30°, then trisection 1 is marked (+) and trisection 2 is marked (0) on the ascent (pull-to-sit). If the tape detaches at 30° on the descent, trisection 2 is marked (+) and trisection

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1 is marked (0). Any trisections moved through after the tape has detached are marked (-) along with any trisections in which the child's head is resting on or near his chest.

6. Conduct five trials each of pull-to-sit and recline-to-supine. Provide brief rests between trials as needed.

Data Analysis

Tabulate the data for the pull-to-sit and recline poisitons by recording, for each trial, the number of trisections in which head control was observed (+). Each trial requires that six scores be recorded. These include three scores (each trisection) as the child is pulled to a sitting position, and three scores (each trisection) as the child is lowered back to the supine position. Since five trials (pull-to-sit and recline) are administered in a session, a total of 30 scores are recorded. These scores can be converted to a percent correct for the session by dividing the total number of correct (+) by 30 and multiplying by 100. Data can be graphed across sessions to show the percent of head control.

Location:	Home	School	Name: ______
	Structured	Unstructured	Date: ______
	Group	Individual	Age: ______
			Examiner: ______

Time: _____ Start _____ Stop   Time: _____ Start _____ Stop

	Pull to Sit					Recline					
	Trisection						Trisection				
Trials	1	2	3	Hands	Shoulders	Trials	3	2	1	Hands	Shoulders
1						1					
2						2					
3						3					
4						4					
5						5					

Figure 10. Date sheet for measuring head erect in the pull to sit and recline positions.

A REPLICATION STUDY:

Quantitative Measurement of Head Erect in the Prone and Supported Sitting Position in Nonhandicapped Infants[1]

by

Jane Purcell Rues

[1]The procedures and data reported in this study were taken from a Doctoral dissertation by Jane Purcell Rues that was submitted to the Department of Special Education, University of Kansas, in 1981.

Overview of Measurement Procedures

Volume I, Assessment Procedures for Selected Developmental Milestones pages HE19-HE42, described procedures used by Foshage (1978) in the original head erect study. The procedures in the original study measured head erect in prone, pull to sit and recline, and supported sitting. Volume II, pages HEI-HE18 present the performance and reliability results from the original study.

Measurement Procedure Revisions

Head erect behaviors in two positions, prone and supported sitting, were selected for revision and longitudinal replication. The original procedures for measuring head erect in the prone position included two observation schedules: Schedule A which was primarily a frequency measure, and Schedule B which was a duration measure. Schedule A required a 3 minute observation session: the responses (i.e., head bobs emitted by the child) constituted the number of trials during the 3 minute timing. The duration of head lifts and arm positions were recorded if the head was raised longer than 5 seconds. Schedule B included a series of discreet trials (minimum of 5 and maximum of 10) in which duration of the head lift and the position(s) of the arms were recorded.

The transition between these two system (i.e., from 3 minute observation periods to 5 to 10 trials) was made when the child maintained a head erect position for 60 seconds during a 3 minute period. Only durations of head erect greater than 5 seconds were added together to get this number.

The revised measurement procedure combined components of Observation Schedule A and Observation Schedule B. The 3 minute observation session was maintained and the code was adapted to allow for simultaneous recordings of the following behaviors: frequency of head turns and lifts, duration of longest head lift, cumulative duration of head erect, and frequency of arm positions. The descriptor, head turns, represented an addition to the code. When the cumulative duration of head erect behavior equalled 160 seconds on 2 out of 3 sessions, the duration measure was then applied to the descriptor, extended arm props. The focus in the 3 minute observation session was then directed at measures of frequency of extended arm props, cumulative duration of extended arm props and frequency of arm positions.

The data sheet was changed to accommodate the above revisions and can be used to measure the behaviors (i.e., head erect and extended arm props) sequentially, simultaneously, or independently. The imposed ceiling of 3 minutes on cumulative duration of head erect and extended arm props far exceeds the duration measures specified in the standardized and nonstandardized assessments previously reviewed.

The original procedure for measuring head erect in support sitting involved two measures (frequency or duration). A specified criterion determined when the observer changed from a frequency measure to a duration measure. The revised procedure combined both measures allowing for simultaneous recordings of frequency of head erect in a 3 minute observation session. This revision was made in an effort to systematically collect data on emergence and acquisition in a nonhandicapped population. Additions to the data sheet were also necessary in the provision of external support to the infant in the supported sitting position. A sequence of support positions from cephalo to caudal (shoulder to pelvis) was defined and included in an effort to quantify the emergence and acquisition of this skill in the nonhandicapped sub-

jects. The initial criterion for change in the provision of external support to the subject (i.e., maintenance of the vertical position for 30 seconds) resulted in a too abrupt decrease in support for nonhandicapped subjects.

APPENDIX E

Rolling Assessment Procedures
(Day, Rues, & Lehr, Note 6; Fritzshall & Noonan, Note 7)

Mobility

Procedures for Measuring Segmental Rolling

by

Paula Day[1], Jane Rues and Donna Lehr

[1] The procedures reported in this study were taken, in part from a master's thesis conducted by Paula Day that was submitted to the Department of Special Education at the University of Kansas in 1980.

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Selecting the Target Behaviors

Information obtained from the assessment instruments and developmental research was used to identify descriptors of rolling behaviors that were amenable to quantitative measurement procedures. It has been clearly shown that rolling progresses through several stages. As Gessell (1934) noted an infant's first step towards the achievement of an erect posture is through the use of rotational components during rolling. All current assessments lack any clear measurement of the emergence of rolling. Specific scales define rolling as the ability to roll independently from a supine to a prone position. By limiting their measurement to the absolute of nonoccurrence or occurrence, these scales have little value in identifying the emergence of rolling or its variuos component stages.

In order to objectively determine the stage of development in rolling behavior for a child, target behaviors were selected that measured the various components of rolling. These target behaviors are segmental rolling from a supine, prone and sidelying positioning and rolling mobility.

Developing the Measurement and Observation Procedures

Emergence, quality and mobility aspects of rolling is discussed according to seven major headings: (a) Specification of Behavior; (b) Materials and Equipment; (c) Observational Settings; (d) Conditions for Observing; (e) Providing Cues to the Child; (f) Measuring Rolling; and (g) Specification for Taking Measures of Reliability.

The Specification of Behavior section provides a description of the behavior to be measured and the types of measurement procedures utilized.

The Materials and Equipment section includes the materials needed for the child and those required by the observer to measure the behavior. When applicable, information is given on how the materials should be arranged in the environment.

The Observational Settings section specifies the locations for administration of the assessment.

The Conditions for Observing section provides descriptions of the initial positioning procedures of the child as well as other positioning procedures used in the assessment. Specifications for observer positioning are also described.

The section [illegible] Providing Cues to the Child, defines not only what cues to use, but how and when they should be presented.

The section on Measuring Rolling includes definitions of rolling and other terms related to these behaviors. There is a more detailed explanation in this section of the type of recording procedures used as well as descriptions for the beginning and ending of a trial.

The Specification for Taking Measures of Reliability section provides criteria for reliability measures as well as information on how reliability measures are taken and calculated. The formula for determining the agreement among observers is included.

Measuring Segmental Rolling in Prone, Supine and Sidelying Positions

Specification of Behavior

In the positions of prone, supine and sidelying the child's response is observed and then recorded in terms of the following: 1) degrees of independent rolling, 2) degrees of trunk rotation, and 3) duration of movement.

Materials and Equipment

A data sheet (Figure 1), pencil, stopwatch and reinforcing objects are used. A carpeted floor area, free of obstacles is required. Additionally the preparation and use of the following additional equipment is required.

Rolling Prone to Supine
Supine to Prone

Name: Examiner:

Date: Observer:

Observation Length: Reliability:

Descriptors:

P - prone position
S - supine position
SL - sidelying position

R - right
L - left
A - verbal
B - visual

Trial	Initial Position	Stimulus Direction	Degrees Body Rotation	Degrees Rolled	Duration	Reliability
1	P	R				
2	P	R				
3	P	R				
4	P	L				
5	P	L				
6	P	L				
7	S	R				
8	S	R				
9	S	R				
10	S	L				
11	S	L				
12	S	L				
13	SL R	P				
14	SL R	S				
15	SL L	P				
16	SL L	S				

Figure 1. Rolling Data Sheet.

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Elastic Band #1. Cut a three-inch wide elastic strip to a length of one-half inch longer than the measurement of the child's hips (positioned directly below the umbilicus). First, place a mark one-fourth inch from each end of the elastic strip. Then divide the remaining band into four equal sections by color coding each quadrant. The quadrants are further divided into two equal parts by drawing a single black line (See Figure 2a).

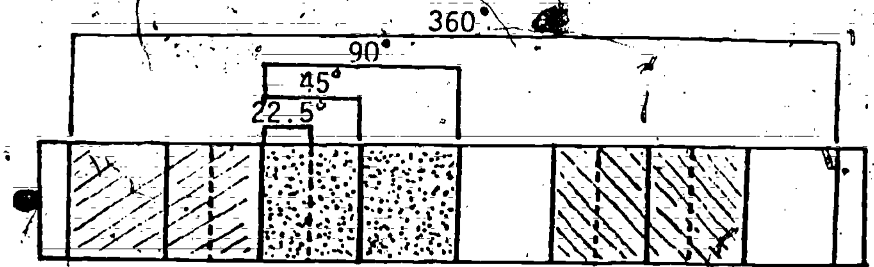
The inside quadrants of red and blue and outside quadrants of white and green are further divided into equal parts by black dotted lines. The elastic strip is then sewn together one-fourth inch from raw edges to form a circular band. Each colored section represents 90°, the dividing line in each section indicates 45° and the dotted sections represent 22.5°. The total band represents 360° (See Figure 2b).

Elastic Band #2. Cut a one-inch wide strip of elastic to a length of one-half inch longer than the measurement around the child's chest (using the nipple line as a reference point). Divide the elastic strip and construct the band following the directions for Band #1.

The examiner should identify preferred toys for each child. Parents usually can provide this information. If no information is available, the examiner should present a variety of objects and observe the child to determine if the items are preferred. The child may demonstrate preference for an object by looking at it, reaching for it, etc.

Some examples of commonly reinforcing agents and how they are used are: visually interesting toys with bright colors and moving parts can be used to stimulate the child to visually follow the object.

Auditorily stimulating toys such as music boxes, bells, etc. are used to encourage rolling by allowing the child to visually follow the adults face or roll toward a preferred person.



a. Elastic strip 1

b. Elastic strip 2

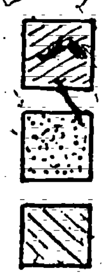


Figure 2. Elastic Band #1 and #2

Observational Settings

The measurements should be taken in a structured situation where the child's degrees of rolling and body rotation can easily be observed. These can occur either at home or at school. The child needs to be viually and/or socially alert.

The structured observation setting employed a second examiner who provided visual or auditory stimulation by holding interesting objects to the side and above the childs head to encourage rolling.

Conditions for Observing Segmental Rolling in Supine

Initial Positioning Procedures. The child is placed on his back with head in midline and trunk straight. The elastic bands are positioned comfortably around the child as seen in Figure 3. Place child in a supine, prone or sidelying position and slip the band around his hips and chest. Positioning of the Band #1 needs to be directly below the umbilicus with the bands seam centered on the umbilicus. Band #2 should be directly over the nipple line and corresponding to colors in Band #1. The bands should be tight enough to remain securely in position but not so tight as to create or constraint movement or cause discomfort.

Positioning Procedures. In the supine position, six trials are taken, 3 to the child's right side and three to the child's left side. Once the child was positioned and bands correctly placed, the trials would begin procedure for each trial consisted of the following steps:

1) Begin stopwatch.
2) The examiner says or signs "roll", then gains the child's attention by moving toy in visual field to designate side.
3) Observe trunk rotation by noting difference in band markings. Stationary band versus moving band.

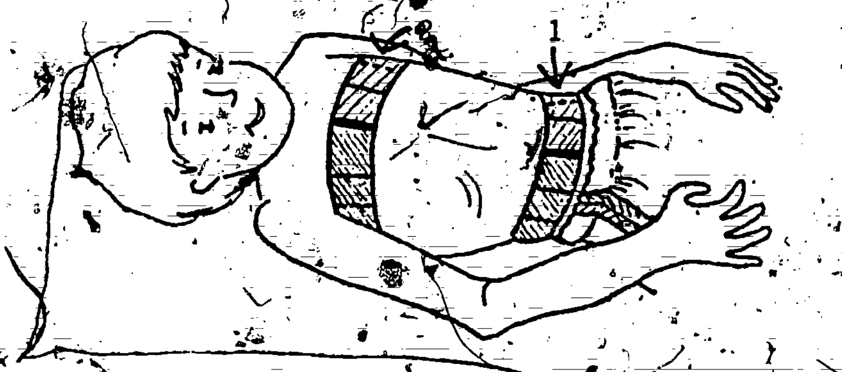


Figure 3. Positioning of Bands 1 and 2.

4) Periodically activate toy and verbally encourage child to roll.

5) Stop timing if no movement occurs after 30 seconds.

6) If child makes any movement, timing is countinued until he rolls to either prone or rolls back to supine. A child who rolls to sidelying from supine but then retuns to the supine position will be given credit for rolling to sidelying or 90°.

7) If child independently rolls he is reinforced with verbal praise and a brief opportunity to play with the toy.

8) Observations are then recorded according to descriptions previously defined.

Providing Cue to the Child

Additional data sheet descriptors that require further explanation are the use of prompts. Two prompts can be used simultaneously. The verbal cue "roll" and visual and/or auditory stimulus were used to encourage rolling. These are recorded on the data sheet as A (verbal) or B (visual) or A and B. The presentation of the stimulus are specified for each trials on the data sheet. In the prone position if a stimulus direction was designated as right this indicated the toy was initially held on the child's right side and slightly above his head to encourage rolling.

Measuring Segmental Rolling in Supine Position

After presentation of the stimulus (on child's right or left side, depending on corresponding trial number) observations are made on degrees of independent rolling and degrees of trunk rotation. The degree a child independently rolls is measured by observer Band #1. The side of the child was designated as the initial reference point. If a child rolls from supine to sidelying. This would represent 90° of independent rolling. Rolling from supine to prone equals 180° and rolling from supine to supine would equal 360°. The colored bands help to visualize and measure smaller increments of independent rolling.

To observe and measure the degrees of trunk rotation, the examiner needs to look at both bands and observe the difference in alignment between the stationary and moving body part. Again, the initial reference point is the side. For example, if the child initiates rolling through his left hip by flexing left leg over his trunk and allowing the rest of his body (shoulders and head) to follow, the moving body part would be the left hip (band #1) and the stationary body part being the shoulders (band #2). During this rolling behavior the examiner would observe a distinct difference in alignment between the bands, the white section of band #1 (moving part) would be corresponding to the blue section of band #2 (stationary part). (See Figure 4). The measurement of degrees would be determined by how far the moving band differed from the stationary band. If the white section of band #1 moved to the dotted line a representation of 225° of body rotation would be indicated. If rotation continued and the white section moved to the solid black line, 45° of body rotation would be noted.

The greatest amount of rotation noted during a single trial is recorded.

A duration measure is recorded following each trial.

<u>Conditions for Observing Segmental Rolling in Prone</u>

<u>Initial Positioning Procedures.</u> The child is placed on his stomach with head in midline and trunk straight. The elastic bands are positioned comfortably around the child and in accordance with previous descriptions.

<u>Positioning Procedures.</u> In the supine position, six trials are taken, three to the child's right side and three to the child's left side. Once the child was positioned and bands correctly placed, the trials would

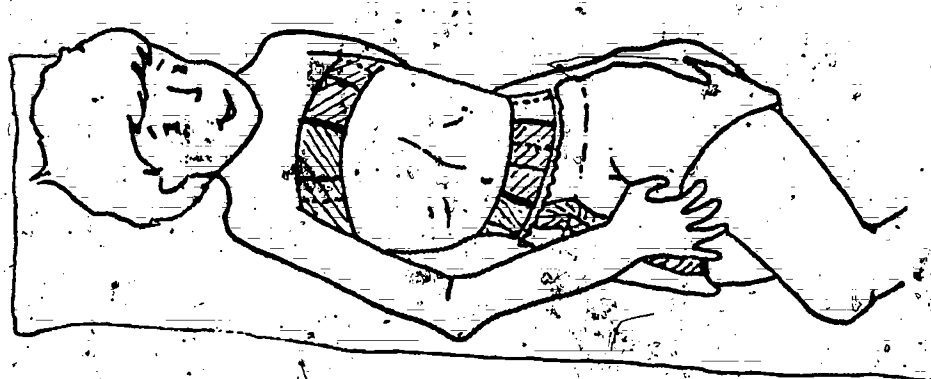


Figure 4. Observation of rotation.

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begin procedure for each trial consisted of the following steps:

2) The examiner says or signs "roll", then gains the child's attention by moving toy in visual field to designate side.

3) Observe trunk rotation by noting difference in band markings. Stationary band versus moving band.

4) Periodically activate toy and verbally encourage child to roll.

5) Stop timing if no movement occurs after 30 seconds.

6) If child makes any movement, timing is countinued until he rolls to either prone or rolls back to supine. A child who rolls to sidelying from supine but then retuns to the supine position will be given credit for rolling to sidelying or 90°.

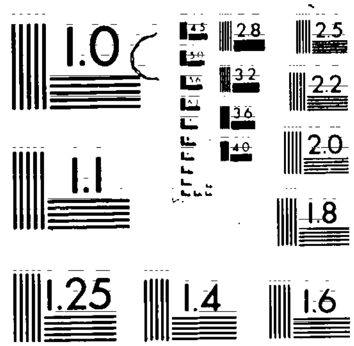
7) If child independently rolls he is reinforced with verbal praise and a brief opportunity to play with the toy.

8) Observations are then recorded according to descriptions previously defined.

Measuring Segmental Rolling in Prone

After presentation of the stimulus (on child's right or left side, depending on corresponding trial number) observations are made on degrees of independent rolling and degrees of trunk rotation. The degree a child independently rolls is measured by observing Band #1. The side of the child was designated as the initial reference point. If a child rolls from supine to sidelying. This would represent 90° of independent rolling. Rolling from supine to prone equals 180° and rolling from supine to supine would equal 360°. The colored bands help to visualize and measure smaller increments of independent rolling.

To observe and measure the degrees of trunk rotation, the examiner needs to look at both bands and observe the difference in alignment between


1.0
2.8
2.5
3.2
2.2
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6

the stationary and moving body part. Again, the inital reference point being the side. For example, if the child initiates rolling through his left hip by flexing left leg over his trunk and allowing the rest of his body (shoulders and head) to follow, the moving body part would be the left hip (Band #1) and the stationary body part being the shoulders (Band #2). During this rolling behavior the examiner would observe a distinct difference in alignment between the bands, the white section of Band #1 (moving part) would be corresponding to the blue section of Band #2 (stationary part) (See Figure 4). The measurement of degrees would be determined by how far the moving band differed from the stationary band. If the white section of Band #1 moved to the dotted line a representation of 225° of body rotation would indicated. If rotation continued and the white section moved to the solid black line, 45° of body rotation would be noted. The greatest amount of rotation noted during a single trial is recorded. A duration measure is recorded following each trial.

Conditions for Observing Segmental Rolling in Sidelying

Initial Positioning Procedures. The child is positioned on his right or left side depending on the trial number. In the initial sidelying position the child's head should be slightly flexed forward with trunk straight. The elastic bands are positioned comfortably around the child in accordance with previous descriptors. Once a trial begins repositioning should not be necessary.

Positioning Procedures. In the sidelying position, trials are 2 in the prone position and 2 in the supine position (1 on left side and 1 on right side). Continue to follow same procedures as outlined for the supine position.

Specification for Taking Measures of Reliability

Movement recordings. Reliability percentages for the degrees of body rotation, degrees independently rolled and time elapsed from the start to the end of each trial are recorded separately. Measures of duration are considered in agreement if scores are within five seconds of each other. For each session across all trials, the number of agreements and the number of disagreements for the three categories are tallied, using the following formula to determine reliability scores:

$$\frac{\text{\# of agreements}}{\text{\# of agreements and disagreements}} \times 100$$

Calculating the mean reliability scores for each session consists of adding the reliability percentages for each trial and dividing by the total number of trials.

Measuring Rolling Mobility

Specification of Behavior

Measurement of rolling mobility, which is rolling prone to supine and supine to prone as a means of locomotion, consists of recording the number of complete rolls and maximum degrees of body rotation. The distance the child travels as well as the time it takes to travel are also measured.

Materials and Equipment

The two elastic bands used to measure segmental rolling are employed for rolling mobility. In addition to the bands distance markings need to be established. For this procedure masking tape approximately three feet long is needed for a starting point as well as a stopping point. The first piece of tape is placed on the floor or mat and the second piece is applied 10 feet from the starting point. A third piece of tape is then placed horizontal between the two vertical strips (See Figure 5). The horizontal piece of tape is marked at six inch increments for accurate distance measurements.

Similar objects, toys, or food used for segmental rolling may be utilized.

A stopwatch, data sheet for "Rolling Mobility" (Figure 6), and a pencil are the other required items.

Observation Setting

The measurement for rolling mobility should be taken in a structured situation where the childs' frequency of complete rolls and degrees of body rotation can easily be observed. The child needs to be visually and/or socially alert. Also, if the child cries or seizures during a trial, the trial should be discontinued and resumed later. Once a trial begins re-positioning should not be necessary.

The structured observation setting employes a second examiner who provides visual or auditory stimulation by holding interesting objects to the childs side.

Condition for Observing Rolling Mobility

If the child independently rolls both from prone to supine and supine to prone in any of the trails on the data sheet "Rolling Prone to Supine-Supine to Prone" then data should be taken on rolling mobility.

Positioning procedures. The child is positioned in either the prone or supine position which have been specified on the

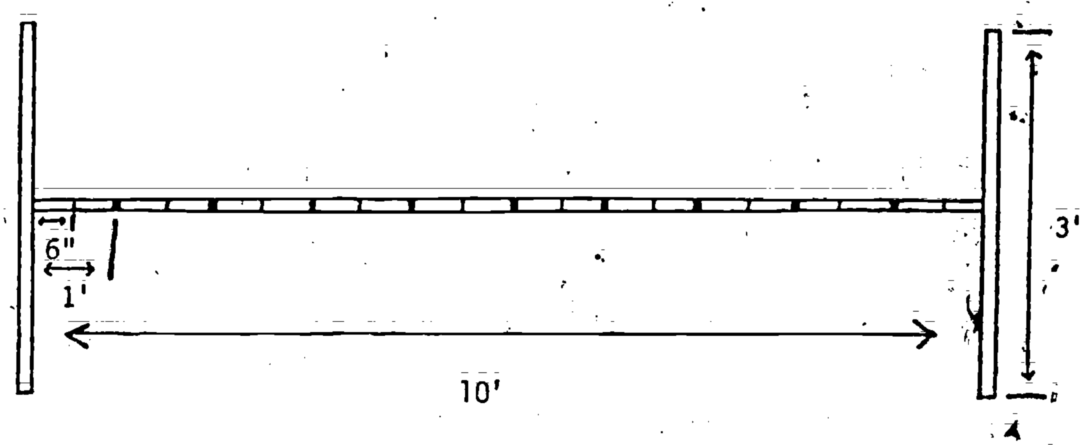


Figure 5. Distance Markers.

Rolling Mobility

Name: Examiner:

Date: Observer:

Observation Length: Reliability:

Descriptors:

P - prone position
S - supine position
SL- sidelying position

R - right
L - left

Trial	Initial Position	Direction of Roll	# of Complete Rolls	Duration	Degrees of Body Rotation	Distance Rolled	Reliability
1	P	R					
2	P	R					
3	P	L					
4	P	L					
5	S	R					
6	S	R					
7	S	L					
8	S	L					
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

Figure 6. Rolling Mobility Data Sheet

data sheet. Specification of the initial position includes the direction of the roll. For example when administering Trial #1 the child is placed in the prone position with the right shoulder resting on the starting tape (Figure 7). The direction of the roll is defined as the arm over which the child initially rolls.

Position of observer. The observer is positioned on either side of the horizontal piece of tape. The most beneficial position is to kneel or stand up so that measures are easily visable.

Providing Cues to the Child

The only cues utilized to encourage rolling are visually, auditorily or, tactily stimulating objects or toys which are presumed to be reinforcing to the child. The item(s) selected is/are placed 2-3 feet from the child and are activated throughout the trial. If the child progresses forward toward the item(s), then the item(s) is/are placed further away until the two minute trial is completed.

Measuring Rolling Mobility

Description of the behavior. Rolling mobility is defined as a complete 360° roll from either the supine or prone position.

Type of measurement used. The type and frequency of rolling is procured by recording the degrees of body rotation and the number of complete rolls.

When recording the number of complete rolls the observer counts one complete roll if the child rolls from either supine to supine or prone to prone, depending on the initial psotion. Partial credit is also measured. For example, if the child initially begins a trial in the supine position and rolls as follows: supine-prone-supine-prone

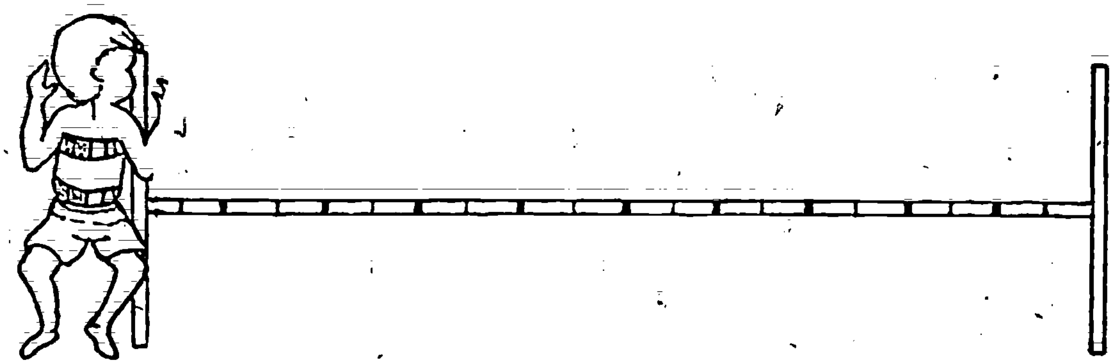


Figure 7. Initial position.

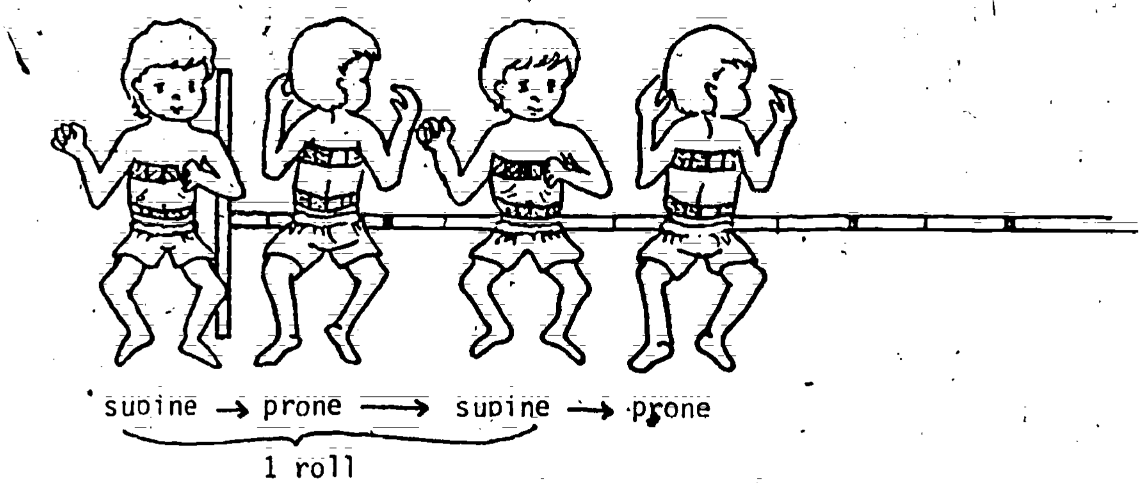
then his total number of complete rolls for the trial would be one and one half (see Figure 8).

The degrees of body rotation is measured as indicated in the segmental rolling procedures by observing the difference in alignment between the stationary and moving bands (Figure 9). The largest amount of degrees noted during a single trial is the recorded measure. For instance, if a child independently rolls three times during a trail with the first roll showing 0° body rotation, second roll 22.5° body rotation and the third roll with 45° of body rotation, the 45° measure would be recorded.

The distance the child rolls is also recorded on the data sheet. The observer places a piece of tape adjacent to the shoulder resting on the starting tape prior to beginning the trial. After the trial is terminated a second piece of tape is placed adjacent to the shoulder furtherest from the starting point. The observer determines the distance traveled by measuring the distance between these two points marked by tape (Figure10).

The time needed to travel the distance of six feet is recorded on the data sheet. However, if the child does not travel six feet, then two minutes (the total length of trial) is recorded in the time column. After the distance traveled and duration have been determined then the rate of locomotion is calculated by dividing the distance traveled by the time.

Beginning of trial. The child is positioned either in prone or supine with the predetermined direction established. After the child is initially positioned measurement commences with the presentation of preferred objects or toys. The stopwatch begins at the same time.



rolling: supine-prone-supine-prone

scored: 1½ total rolls.

Figure 8. Counting rolls.

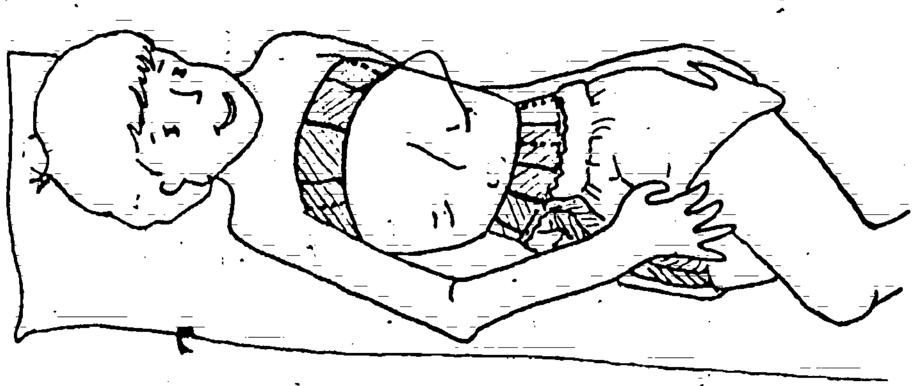


Figure 9. Measuring degrees of rotation.

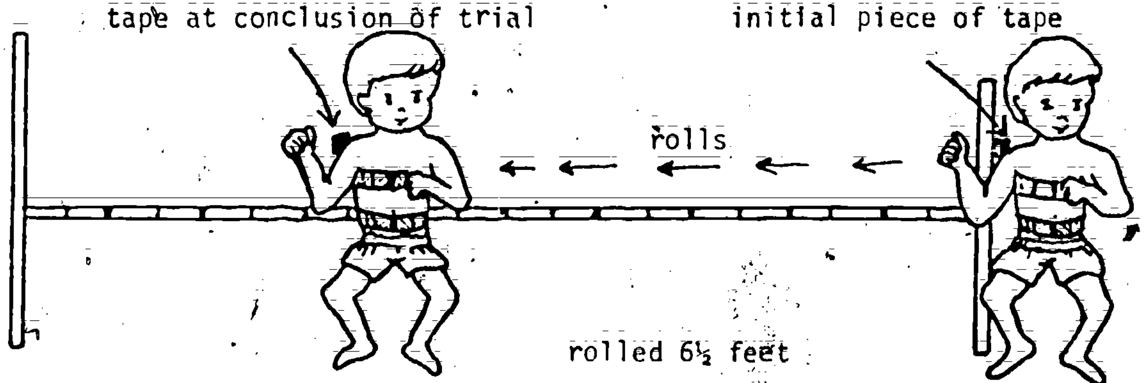


Figure 10. Measuring distance.

Termination of trial. The end of the trial is determined when the child travels the distance of six feet or at the expiration of two minutes, whichever comes first.

Specifications for Taking Measures of Reliability

Reliability precentage for the number of complete rolls, degrees of body rotation, distance rolled and time elapsed from the beginning to the end of each trial are recorded separately. The initial position and direction of the roll are specified on the data sheet. Measures of duration are considered in agreement if the scores are within 5 seconds of each other. For each session across all trials, the number of agreements and the number of disagreements for the four categories are tallied, using the following formula to determine reliability scores:

$$\frac{\text{\# of agreements}}{\text{\# of agreements and disagreements}} \times 100$$

Calculating the mean reliability scores for each session consists of adding the reliability percentages for each trial and dividing by the total number of trials.

Quantitative Assessment of Rolling Behavior in Handicapped and Nonhandicapped Infants and Children[1]

by

Jill D. Fritzshall

and

Mary Jo Noonan

[1]The procedures and data reported in this study were taken from a Master' Thesis by Jill D. Fritzshall that was submitted to the Department of Special Education, University of Kansas, 1982.

A complete description of the measurement procedures used in this study is found in pages M(R)1 to M(R)25 of Volume I, Assessment Procedures for Selected Developmental Milestones. In the original study, segmental rolling was observed from prone, supine, and sidelying and specific measures were taken on degrees of body rotation, degrees rolled, and duration of each trial. If a child was able to roll from prone to supine and supine to prone, then a different data sheet was used in order to record rolling mobility. Rolling mobility was defined as the use of rolling as a means of locomotion, and specific measures were taken on the degrees of body rotation, number of complete and partial rolls made, distance rolled, and duration of the trial. The measurement of rolling distance was made by placing masking tape in a horizontal line across the carpet which was marked in six-inch increments. The child was expected to roll along this tape so that his/her rolling distance could be determined.

Three revisions were made in the selection of target behaviors. Since during the replication it was rare for a child to roll in a straight line along the masking tape, distance measurements were not taken. Rather, the number of complete and partial rolls, specific to a quarter of a roll, were taken as an adequate measure of rolling mobility. "Rolling mobility" was added as a descriptor to the "Segmental Rolling" data sheet while "Degrees Rolled" was eliminated. Thus, the same data sheets now entitled "Measurements of the Rolling Response from Prone, Supine, and Sidelying" (see Figure 1), were used with each child, regardless of the ability to roll from prone to supine and supine to prone.

P-prone
S-supine
SL-sidelying

R-right
L-left

O-orange (0-11.25° rotation)
B-blue (between 11.25° and 22.5° rotation)
R-red (between 22.5° and 45° rotation)
W-white (over 45° rotation)

SH-shoulder
PE-pelvis

R-reliability

Trial	Trunk Rotation	Body Part Leading Roll	Mobility	R
P rolling over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
P rolling over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
(SL R to S)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
P rolling over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
P rolling over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
(SL L to S)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
S rolling over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/3 21/2 23/4 3 rolls	
S rolling over R	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL R to P)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S rolling over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
S rolling over L	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	
(SL L to P)	O B R W	SH PE	less than 1/4 roll 1/4 1/2 3/4 1 roll 11/4 11/2 13/4 2 rolls 21/4 21/2 23/4 3 rolls	

R________ R________ R________ Mean R/Trial________

Figure 1. Data Sheet

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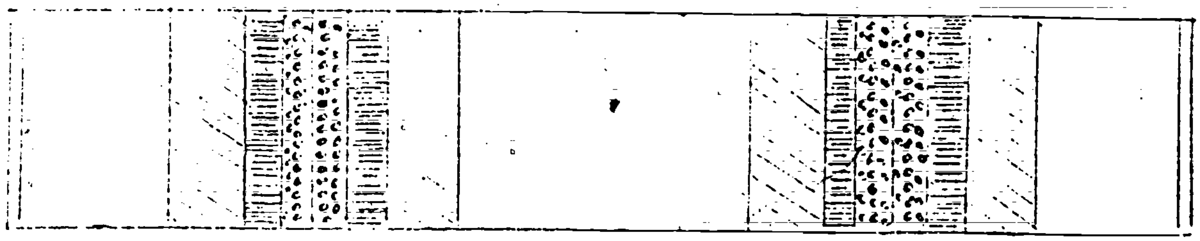
determine the duration of each trial. Because they gave an auditory cue when stopped and started, it was believed to be impossible to obtain a valid reliability measure of this descriptor. More significantly, it was difficult to simultaneously facilitate a rolling response (often by holding a toy in one hand), observe that response, and operate a stopwatch. This was particularly true when it was necessary to keep an eye on the stopwatch for the first 30 seconds of a trial in order to eliminate that trial if the child failed to make a rolling response. Thus, "Duration" as a descriptor was eliminated. Instead, a timer was set before each trial which then lasted 60 seconds or until the child made three consecutive rolls in the same direction, whichever came first.

Finally, the body part leading the roll was added as a descriptor to the data sheet. The addition of this descriptor would permit a systematic analysis of the body part initiating the roll (i.e., shoulder vs. pelvis) in both handicapped and nonhandicapped subjects.

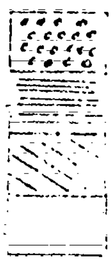
Two procedural changes were made during the replication. First, the number of trials per session was reduced by approximately one-half. The number of trials taken from prone and from supine changed from six to four in an attempt to prevent the child from fatiguing. In addition, sidelying trials (eight possible per session) were only used if a child failed to make at least a half of a roll in a particular direction from prone or supine.

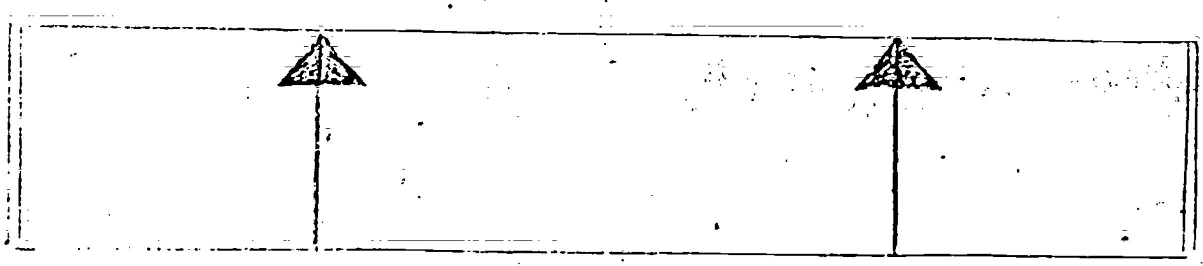
Second, the observation period for degrees of trunk rotation was more specifically stated in the procedures used during the replication than in the original study. In the original study, the maximum degrees the experience of this investigator that: (1) it was extremely difficult to observe the two elastic bands during an entire trial without physically moving into the child's rolling space or visually distracting the child by hovering over him or her; and (2) the maximum degrees of trunk rotation most frequently occurred during the first quarter of a roll. Thus, it was decided that the observation period for trunk rotation would be during the first quarter of the first roll that the child made during each trial.

One change was made in the measurement systems used to record the rolling response. Elastic band #1, placed on the nipple line and used to determine degrees of trunk rotation, was color coded to show 0°, 22.5°, 45°, 90°, and 360° increments, in the original study. Degrees of trunk rotation were recorded in these figures. During the process of replication, however, the degrees of trunk rotation almost invariably fell somewhere between those exact figures, and their use on the data sheet was felt to be inaccurate. Therefore, exact measurements were replaced by a series of short ranges of degrees of trunk rotation. For example, "0°" was replaced by "between 0° and 11.25°" of trunk rotation. In increasing order, the ranges were "between 11.25° to 22.5°," "between 22.5° and 45°" and "more than 45°." Changes in the design of the band reflect these revisions (see Figure 2). For the sake of convenience, a change was also made in the design of elastic band #2, placed at the level of the umbilicus. The original study had color coded elastic band #2 in the same increments as elastic band #1. During the replication, the colors on elastic band #2 were replaced by arrows at specified points. Degrees of trunk rotation were determined by the misalignment



Elastic band #1





Elastic band #2.

Figure 2. Elastic bands for rolling.

between the arrows and discreet points on elastic band #1. By using arrows instead of colors on elastic band #2, the construction time was cut by approximately one-half.

A second replication was initiated in which an additional revision was made. Those people who observed and recorded the rolling response (the evaluator and another observer) were no longer involved in facilitating the response. Another person was used during each session to encourage the child to roll. This person did not record the rolling response, but functioned as a facilitator only. Except for this change, the methods used during the second replication were identical to those used during the first.

APPENDIX F

Sample of Completed Head Erect Data Sheet

NAME: Kathy BIRTHDATE: — DATE: 12/1/81

OBSERVER(S): C.H. SETTING: Classroom RELIABILITY: 87.5%

Code: ↑ - no arm support

√↑ - props on one forearm, other arm no support

√√ - props on forearms

√| - props on forearm and one extended arm

|| - props on extended arms

R - right arm
L - left arm

HEAD ERECT DESCRIPTORS				UPPER EXTREMITY WEIGHT BEARING DESCRIPTORS							Reliability
Head Turns	Head Lifts	Duration: Longest Head Lift	Cumulative Duration: Head Erect or	R L ↑ ↑	R L ↑ √	R L √ ↑	R L √ √	R L √ |	R L | √	R L | |	
11	~~||||~~ ~~||||~~ ||||	3									
Total 2	14	3	3								

APPENDIX G

Sample of Completed Rolling Data Sheet

Measurement of the Rolling Response from Prone, Supine, and Sidelying

Name *Loretta* Evaluator *D. D.*

Date *11/17/81* Observer *M.J.*

Descriptors

P - prone
S - supine
SL - sidelying

R - right
L - left

O - orange (0-11.25°)
B - blue (11.25-22.5°)
R - red (22.5-45°)
W - white (over 45°)

SH - shoulder
PE - pelvis
R - reliability

Trial	Trunk Rotation	Body Part Leading Roll	Mobility				R
P over R	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
P over R	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
(SL R to S)	O B R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
P over L	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
P over L	O B (R) W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
(SL L to S)	O B R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
S over R	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
S over R	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
(SL R to P)	O B R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
S over L	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
S over L	O (B) R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
(SL L to P)	O B R W	SH PE	less than 1/4 roll				
			1/4	1/2	3/4	1 roll	
			11/4	11/2	13/4	2 rolls	
			21/4	21/2	23/4	3 rolls	
	R *100%*	R ____	R ____				

Mean R per session ____

APPENDIX H

Interobserver Reliability Scores for Each Subject per Measure and per Session

Reliability Scores by Measure for each Session for Sam (Subject 1)

Sessions	Postural Reactions				Probes	
	Equilibrium	Parachute	Righting	Overall	ATNR	Rolling
5	100	100	90	97.7		100
11	100	100	100	100		
21					100	87.5
23	100	100	70	90		
30	100	100	80	93.3		
33	100	100	80	93.3		100
59	100	100	100	100		
79	100	100	100	100	100	87.5
80	100	100	80	93.3		
89	80	80	90	83.3	80	
103	100	100	90	97.7	100	87.5
112	90	100	100	97.7		75
125					100	
126	90	100	80	90		
Mean per [Me]asure Across Sessions	97.3	98.3	88.3	95.1	96	89.6

Reliability Scores by Measure for each Session for Janet (Subject 2)

Session	Postural Reactions: Equilibrium	Postural Reactions: Parachute	Postural Reactions: Righting	Postural Reactions: Overall	Probes: ATNR	Probes: Head Erect
1	100	100	100	100		
11	100	100	100	100	100	100
21	100	100	100	100		100
59	100	100	100	100	100	
81	100	100	100	100		
86	100	100	100	100		
89	100	100	100	100	100	100
Mean per Measure Across Sessions	100	100	100	100	100	100

Reliability Scores by Measure for
each Session for Charlie (Subject 3)

Session	Postural Reactions: Equilibrium	Parachute	Righting	Overall	Probes: ATNR	Rolling
19	100	100	100	100		
26	100	100	100	100	80	
29	100	100	100	100	100	100
35	100	100	100	100	100	
39	100	100	100	100		100
51	100	100	100	100		
54	100	100	100	100		100
59	100	100	100	100		
77	100	100	100	100	100	
83	100	100	100	100		
87	100	100	100	100		
102	100	100	100	100	100	100
Mean per Measure Across Sessions	100	100	100	100	96	100

Reliability Scores by Measure for each Session for Loretta (Subject 4)

Session	Postural Reactions				Probes	
	Equilibrium	Parachute	Righting	Overall	ATNR	Rolling
26	100	100	100	100	100	
29	90	100	100	97.7		
31					100	
39						100
51	100	90	100	97.7		87.5
54	80	100	100	93.3		
59	100	100	100	100		
77	100	100	100	100		
81	100	100	100	100		
91	100	90	90	93.3		
101						75
102	100	90	100	97.7	100	
107	100	90	80	90		
110						100
114	100	80	90	90	100	
Mean per Measure Across Sessions	97.3	94.5	96.4	96.3	100	92.5

Reliability Scores by Measure for each Session for Kathy (Subject 5)

Session	Postural Reactions: Equilibrium	Parachute	Righting	Overall	Probes: ATNR	Head Erect
14	100	100	100	100	100	
21	100	100	100	100		
23	100	100	100	100	100	
24						89.7
30	100	100	100	100		71.1
38	100	100	100	100	100	
49	100	100	100	100		87.5
53	100	100	100	100		
73	100	100	90	97.7		
84	80	100	100	97.7		
86	80	100	100	93.3	100	
88	100	100	90	97.7		
100	70	100	90	86.7		57.8
Mean per Measure Across Sessions	94.2	100	97.5	97.8	100	76.5

Reliability Scores by Measure for
each Session for Marilyn (Subject 6)

Session	Postural Reactions				Probes	
	Equilibrium	Parachute	Righting	Overall	ATNR	Head Erect
25	100	100	100	100		
30	100	100	100	100	80	
38	100	100	100	100	70	100
43	100	100	100	100	70	
50	100	100	100	100		
58	100	100	100	100	60	
70	100	100	100	100	90	100
74	100	100	100	100		
85	100	100	100	100		
92	100	100	100	100	90	
98	100	100	100	100		
101	100	100	100	100		
113	100	100	100	100		
119	100	100	100	100		100
Mean per Measure Across Sessions	100	100	100	100	76.7	100

Reliability Scores by Measure for each Session for Matt (Subject 7)

Session	Postural Reactions: Equilibrium	Parachute	Righting	Overall	Probes: ATNR	Head Erect
7	100	100	90	97.7		
8	100	100	100	100	100	
14	100	100	100	100		
21	100	100	100	100		100
26	100	100	100	100		
38	100	100	100	100		
49	100	100	100	100	100	100
53	100	100	100	100		
Mean per Measure Across Sessions	100	100	98.7	99.7	100	100