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ABSTRACT

Three studies that applied quantitative procedures to measure motor and sensory/motor acquisition among handicapped and nonhandicapped infants and children are presented. In addition, a study concerning the replication of the quantitative procedures for assessing rolling behavior is described in a fourth article. The first study, by C. Janssen, "An Application Study: Validation of Quantitative Measurement Procedures to Assess Visual Fixation Skills in Handicapped and Nonhandicapped Infants and Young Children," used the visual fixation procedures to assess the emergence of this skill among nonhandicapped infants; it also observed interactions between mothers and infants related to visual fixation skills. The second study, "Evaluating Neurodevelopmental Training and Theory with Cerebral Palsied, Severely Handicapped Students," by M. Noonan, used quantitative assessment procedures to help evaluate neurodevelopmental training. The third study, by D. Cook and J. Rues, "The Effects of Vestibular Stimulation and Social Reinforcement on Speech and Motor Behaviors in Multiply Handicapped Preschoolers," used head erect measurement procedures to evaluate effects of vestibular stimulation and social praise on the speech and motor behavior of preschool children with severely/multiply handicapping conditions. The fourth study, by J. Fritzshall and M. Moonan, "A Replication Study: Quantitative Assessment of Rolling Behavior in Handicapped and Nonhandicapped Infants and Children," provided a detailed analysis of the rolling behavior of three handicapped children and one nonhandicapped infant. (SEW)

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Quantitative Assessment of Motor and Sensory/Motor Acquisition in Handicapped and Nonhandicapped Infants and Young Children

VOLUME IV

APPLICATION OF THE PROCEDURES

by

Doug Guess
Jane Rues
Steve Warren
Cynthia Janssen.
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QUANTITATIVE ASSESSMENT OF MOTOR AND SENSORY/MOTOR ACQUISITION IN HANDICAPPED AND NONHANDICAPPED INFANTS AND YOUNG CHILDREN

VOLUME IV

Application of the Procedures[1]

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Table of Contents

INTRODUCTION

The present Volume IV is a continuation of three earlier documents pertaining to the development of quantitative procedures to measure motor and sensory/motor acquisition among handicapped and nonhandicapped infants and children.

The original procedures of measurement were presented as Quantitative Assessment of Motor and Sensory/Motor Acquisition in Handicapped and Nonhandicapped Infants and Young Children (Volume I): Assessment Procedures for Selected Developmental Milestones.

A second document, Quantitative Assessment of Motor and Sensory/Motor Acquisition in Handicapped and Nonhandicapped Infants and Young Children (Volume II): Interobserver Reliability Results for the Procedures, presented the interobserver reliability results separate from the quantitative measurement procedures described in the first volume, and was distributed as ECI Document No. 257 in April, 1981.

A third document, Quantitative Assessment of Motor and Sensory/Motor Acquisition in Handicapped and Nonhandicapped Infants and Young Children (Volume III): Replication of the Procedures, presented longitudinal replication studies for the original procedures described in Volume I. Volume III was distributed as ECI Document 258 in March, 1982.

The present Volume IV includes three studies that have applied the measurement procedures. The first study, reported by Janssen, used the visual fixation procedures to assess the emergence of this skill among nonhandicapped infants. This study also observed interactions between mothers and infants related to visual fixation skills. A second study, reported by Noonan, used quantitative assessment procedures to help evaluate neurodevelopmental training with cerebral palsied, severely handicapped children.

A third investigation, reported by Cook and Rues, used head erect measurement procedures to evaluate effects of vestibular stimulation and social praise on the speech and motor behavior of preschool children with severely/multiply handicapping conditions.

These three studies, and several others currently in progress, serve to demonstrate how the quantitative assessment procedures can be used to provide reliable and sensitive measures of motor and sensory/motor acquisition among handicapped infants, and among handicapped infants and children who are provided with direct intervention programs in classroom settings. These types of application studies are a direct result of the accumulated research reported in the earlier volumes, and culminate in a technology to more accurately assess motor and sensory/motor acquisition and performance among handicapped and nonhandicapped infants and children.

A fourth study reported in this volume by Fritzshall and Noonan is a replication of the quantitative procedures for assessing rolling behavior. This study was not completed in time for inclusion in Volume III that contains other replication studies of the original (Volume I) assessment procedures.

AN APPLICATION STUDY:

Validation of Quantitative Measurement Procedures to Assess Visual Fixation Skills in Handicapped and Nonhandicapped Infants and Young Children

by

Cynthia M. Janssen

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[1] The procedures and data reported in this study were taken from a Doctoral dissertation by Cynthia M. Janssen that was submitted to the Department of Special Education, University of Kansas, in March, 1982.

Introduction

There is a national commitment to identify and provide early intervention for severely/multiply handicapped children. However, as Guess, Rues, Warren, and Lyon (Note 2) noted, the current technology for serving these children lags far behind the commitment to provide services. This is particularly apparent in the area of assessment.

The problems with and limitations of traditional assessment procedures for this population have been established in the literature (Edwards and Edwards, 1970; Mira, 1977; Roberts, Bondy, Mira, and Cairns, 1978; ~~Switzky~~, Woolsey-Hill, and Quoss, 1979; and Guess et al., Note 2). These problems include: 1) the unique characteristics severely/multiply handicapped individuals bring to the testing situation, 2) normative developmental data are not available for the severely handicapped population, 3) the wrong type of information is often collected, 4) operationally defined and quantifiable behaviors are missing, and 5) assessment items are not sensitive to emergence and incremental changes of behavior.

A group of researchers at the University of Kansas (Guess et al., Note 2) have attempted to address these problems of assessment by developing quantitative procedures to measure motor and sensory/motor growth in nonhandicapped and handicapped (especially severely/multiply handicapped) infants and young children. Critical behaviors that normally develop in the first year of life were identified and procedures which include operational definitions of responses and specifications of measurement techniques and conditions were developed for each identified behavior. These procedures were then tested with handicapped and nonhandicapped infants and young children across observers to determine inter-observer reliability and they were replicated over time to determine the stability of the measurements.

One of the important skill areas of sensory/motor development in the first year is that of visual orientation. A rudimentary form of visual fixation appears a few hours after birth (Ling, 1942) and by the fourth month, the visual-motor system reaches functional maturity (White, Castle, and Held, 1964). Therefore, one of the critical behaviors for which quantitative procedures were developed was visual fixation. These procedures were found to be reliable across observers (Eye and Janssen, Note 1) and over time (Janssen, Note 3). However, the procedures needed validation on nonhandicapped infants to determine, if, in fact, development of visual fixation was being measured.

The primary purpose of this study then, was to validate on nonhandicapped infants, assessment procedures which were developed to measure visual fixation in handicapped infants and children. This validation was an attempt to determine if the procedures: 1) detected acquisition of visual fixation skills, 2) were sensitive to emergence and incremental changes of visual fixation behavior, and 3) reflected the infants' actual visual fixation skill level in the first four months of life.

Once handicapped infants and young children have been appropriately assessed, there still remains the need for early intervention services. For several reasons this is especially important in the area of visual skill development. Visual fixation is a skill that reaches functional maturity by the age of four months in nonhandicapped infants (Ling, 1942; White, Castle, and Held, 1964; and Stern, 1977). Various researchers have hypothesized that visual fixation is important for future language acquisition in that it enhances joint attention (Bruner, 1975 and Collis and Schaffer, 1975), provides experience in turn taking (Stern, 1974 and Bruner, 1977), and is an elementary form of conversation (Trevarthen, 1977 and Fafouti-Milenkovic and Uzgiris, 1979). Other researchers point out that visual attending relates to optimum development in that it allows opportunities for interaction with and reinforcement from caregivers (Brazelton, Koslowski, and Main, 1974 and Bruner, 1977) and provides infants with a means to begin to control their external environment (Brazelton and Tronick, 1980).

It follows that educators need to know how the acquisition of visual behavior in handicapped infants relates to the development of other behavior and how best to enhance that development in order to provide appropriate early intervention services to handicapped infants and young children. It has been documented in the literature that there are only a few studies on factors influencing the development of handicapped infants (Sameroff and Chandler, 1975 and Vietze, Abernathy, Ashe, and Faulstich, 1978) and even fewer studies specifically addressing the relationship of visual skills to development in handicapped infants (Jones, 1977 and Berger and Cunningham, 1981).

As a result of this deficiency, the secondary purpose of this study was to collect pilot data using a methodology for studying mother/infant interactions to determine how nonhandicapped infants' development of visual and vocal behavior in the first four months of life is related to their mother's visual and vocal behavior. These data can then be compared to data from future studies using the same methodology with handicapped or at-risk infants and their mothers.

Methods

Observations were made of mother/infant pairs in their homes once every one to two weeks under two conditions: the Assessment condition and the Interaction condition.

Subjects

The subjects for this study included four nonhandicapped infants and their mothers. The mothers were selected on the basis of their due dates, so that all four babies would be approximately the same ages while observations were made. In all four cases, there were no indications prior to, during, or subsequent to delivery to suggest that the infants might be at-risk for any handicapping conditions. All four mother/infant pairs were first observed when the infant was two weeks of age, and thereafter observations were made every one to two weeks up to and including the 20th week of age. All four subjects were female.

Assessment Condition

A complete description of the measurement procedures for the Assessment Condition in this study is found in pages VO (F) 1 to VO (F) 13 of Volume I, Assessment Procedures for Selected Developmental Milestones. Procedures were developed to measure the frequency, duration, and mean duration of visual fixations of preferred objects when the child was in a sitting, prone, or sidelying position (see Figure 1 for data sheet). Visual fixation was considered to occur when the student's eyes were directed toward the stimulus for at least one second. A 3' x 3' plexiglass grid (Figure 2), divided into nine sections, was used to determine placement for presentation of stimulus items: centered directly in front of the child, right of center, left of center, centered up from child, up to the right, up to the left, centered down from child, down

A	B	C
D	E	F
G	H	I

Name: Examiner:

Date: Reliability-Frequency:

Start time: Duration:

Condition: Fixation Assessment

Trial	Stimulus	Section	Frequency	Duration	X Duration	Reliability
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						

Figure 1: Assessment condition data sheet.

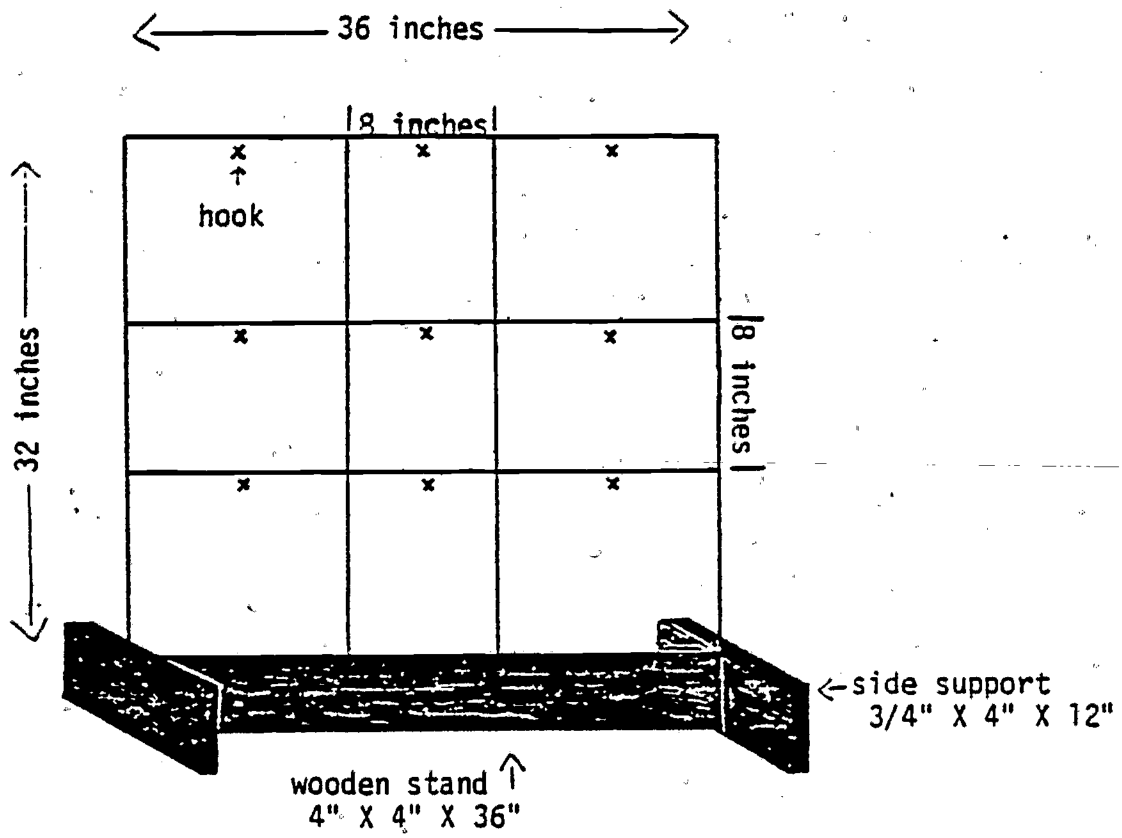

Figure 2: Plexiglass grid.

to the right, and down to the left. Fixation on objects in each of these grid positions was tested at two distances from the child: grid 6"-12" from child and grid 18"-24" from child. In the original study, it was reported that the distance of the grid did not significantly affect either the child's performance or the reliability, therefore one distance, grid 12"-18" from child, was used in this study.

For each trial the grid was placed directly in front of the infant with the examiner directly in front of the infant and grid in order to clearly view the infant's eyes. A trial began when the stimulus object was presented and the infant was instructed to look. The trial ended after 15 seconds had elapsed. The frequency and cumulative duration of visual fixations with the stimulus object was recorded. A mean duration score was then computed by dividing the cumulative duration by the frequency for each grid section. In the original study each student was tested in at least two of the three positions: sitting, sidelying, or prone. However, for purposes of this study each infant was tested sitting in her mother's lap.

<u>Interaction Condition</u>

The procedures used under the Interaction condition were developed in order to obtain observations of specific infant and mother behavior while the infant and mother were engaged in an interaction with one another. This observation of mother/infant interaction provided visual data on the infant to be used in comparing performance on the fixation assessment. It also provided data for studying the relationship between specific infant and mother behaviors.

<u>Materials and equipment</u>. Materials used during observation of the mother/infant dyad were data sheets (see Figure 3), pencils, and the

Name: Examiner: Objects: 1___

Date: 2___

Condition: Mother/Infant Interaction

Lap	Start time:	Reliability:
1		
2		
3		
4		
5		

Crib/floor	Start time:	Reliability:
1		
2		
3		
4		
5		

Infant seat	Start time:	Reliability:
1		
2		
3		
4		
5		

Figure 3: Interaction condition data sheet.

same two preferred objects of the infant selected by the mother and used in the Assessment condition.

Equipment necessary included a cassette tape recorder with three five-minute tape recordings of four-second intervals and two earphones and jacks which fit the tape recorder.

Observational settings. Three separate five-minute samples of behavior of the mother/infant dyad were observed. These samples were in three settings: infant held in the mother's lap, infant seated in an infant seat, and infant lying on the floor or in a crib. The three settings were chosen since these have been found to be the three most frequent situations that an infant experiences (Freedle and Lewis, 1977).

Positioning. The mother and infant were positioned such that the distance of the mother's face from the infant's face ranged from touching to no further than 36" apart, regardless of setting. However, when the infant was positioned in the mother's lap, the range was obviously restricted from that which could be obtained when the infant was observed either in the infant seat or crib/floor setting. The examiner(s) was positioned either standing or sitting next to and as close to the mother and infant as possible in order to see both the infant's and mother's eyes.

Description of the behavior. The behavior observed during the Interaction condition fell into three categories: infant visual behavior, infant vocal behavior, and mother behavior. Specific behaviors within these three categories were both mutually exhaustive and mutually exclusive. Mutual exhaustiveness refers to the capability of any of the behaviors within a category to cover the range of all possible behaviors that might occur in that category. This is accomplished by including a code which is used when one of the specified behaviors is occurring in that category (the "√" codes). The behaviors are mutually exclusive when only one behavior within a category can be occurring at any one time.

The description of each behavior within the three categories and the corresponding codes for each were modified from codes designed by Linn (Note 4), Vietze et al. (1978), and Yarrow, Pederson, and Rubenstein (1977):

1 - Infant Visual Behavior

11 - Infant's eyes are directed toward the mothers face for at least one second.

12 - Infant's eyes are directed toward one of the two designated stimulus objects for at least one second.

13 - Infant's eyes are directed toward the other designated stimulus object for at least one second.

1√ - Infant's eyes are directed at none of the above.

2 - Infant Vocal Behavior

21 - Infant produces voiced sounds which do not indicate discomfort or distress. Excluded are burps, sneezes, hiccups, and non-vocal sounds accompanying breathing or swallowing.

22 - Infant produces voiced sounds which indicate discomfort or distress. This includes fussy or cry sounds accompanied by corners of the mouth turned down and eyes wrinkled.

2√ - Infant engages in neither of the above.

3 - Mother behavior

31 - Mother produces sounds, words, or a series of sounds or words directed toward the infant when the infant is the primary focus of the mother's attention. Included are baby-talk, singing, humming, laughing, whistling, and adult speech. Excluded are coughs and sneezes.

32 - Mother's eyes are directed toward the infant's face or any part of the infant's body, hair, clothing, etc.

33 - Mother produces sounds, words or a series of sounds or words directed toward the infant and mother's eyes are directed toward the infant.

3√ - Mother engages in none of the above behaviors.

In addition to the above behaviors, the objects used during the interaction were described according to the following code:

1 - Object has no movement or sound.

2 - Object has no movement, but with sound.

3 - Object has movement, but no sound.

4 - Object has movement and sound.

Directions to mothers. At the initiation of data collection for this study the examiner informed each mother of the purposes of the study, the conditions for observation, and her role in each condition. The specific instructions given the mother included only the following:

1) "Your face should be no further than 36" from the baby's face during each 5-minute sample."

2) "Try to interact with your baby as naturally as you would if you were not being observed."

3) "The two objects used during the assessment are available for you to use in any way you choose during the three 5-minute samples."

Procedures for measurement. The order in which observations were made of the three settings for each session was predetermined randomly. Data were collected only when the infant was awake and alert; therefore it was not always possible to get measurements in each of the three settings. Prior to initiation of observations in the three settings, the heading information on the data sheet was filled in. The specific procedures for each setting were as follows:

1) The infant, mother, and examiner(s) were positioned as previously described. The examiner wore an earphone connected from the recorder to her ear.

2) The tape recorder was activated. When the examiner heard the tone for each interval, she recorded three two-digit code numbers corresponding to the observed behavior: one number which described the infant's visual behavior, one which described the infant's verbal behavior, and one which described the mother's behavior during that interval. The observer was proficient enough to record these behaviors without looking away from the mother/infant dyad.

3) These three two-digit codes were recorded for each four-second interval until five minutes had elapsed, at which time the examiner heard the word "Stop." The recorder was then deactivated.

These procedures were repeated for each of the remaining two settings.

Reliability. Interobserver reliability was computed and recorded for each setting within each weekly session in which a second observer was present. The examiner and reliability observer were positioned near the infant and mother and as close to one another as possible so each could view the infant's and mother's faces from approximately the same angle. Upon completion of a session, reliability was determined for each observational setting. Each two-digit code within the five minute observation was compared for agreement between examiners. Reliability was computed according to the following formula:

$$\text{Reliability} = \frac{\#\ \text{agreements}}{\#\ \text{agreements} + \#\ \text{disagreements}} \times 100$$

Results

Reliability

Measures of interobserver reliability were collected on 75% of the total measurements taken for all four subjects. Reliability results were collected on 90%, 68%, 71%, and 72% of the possible measurements for Subjects 1, 2, 3, and 4, respectively.

The individual interobserver reliability scores for measures of frequency and duration of visual fixations in the Assessment condition are presented in Table 1. The range of reliability scores for frequency of fixation across all four subjects was 94% to 100% with a mean of 99.3%. The range of reliability scores for duration of fixation across all four subjects was 89% to 100% with a mean of 95.6%.

The individual interobserver reliability scores for measures within each setting in the Interaction condition are presented in Table 2. The range of reliability scores for the Lap setting across all four subjects was 80% to 98% with a mean of 91.4%. The range of reliability scores for the Crib/Floor setting across all four subjects was 82% to 97% with a mean of 91.6%. The range of reliability scores for the Infant Seat setting across all four subjects was 83% to 98% with a mean of 91.4%.

Assessment Condition

Performance data in the Assessment condition were analyzed to determine if the assessment procedures detected acquisition of visual fixation skills and were sensitive to emergence of visual fixation behavior in the first four months of the infant's life.

TABLE 1

Interobserver Reliability Scores in
Assessment Condition Over Time by Subject

Subject		Week 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total $\overline{X}$ Reliability
1	Frequency	100	-	100	98	-	100	-	100	100	-	x	100	-	-	100	100	-	100	97	99.5
	Duration	91	-	96	92	-	95	-	95	89	-	x	98	-	-	98	95	-	98	96	94.8
2	Frequency	100	100	100	100	-	x	x	100	-	x	100	100	-	94	100	-	x	98	x	99.2
	Duration	99	98	99	97	-	x	x	95	-	x	95	95	-	94	92	-	x	93	x	95.7
3	Frequency	100	-	x	97	100	100	x	-	-	x	97	100	100	-	97	x	97	-	100	98.8
	Duration	100	-	x	93	93	97	x	-	-	x	90	97	96	-	95	x	95	-	95	95.1
4	Frequency	100	97	100	97	x	x	x	100	100	100	100	x	100	100	100	-	-	-	100	99.5
	Duration	98	97	98	95	x	x	x	96	97	93	97	x	96	97	98	-	-	-	98	96.7

\- No observation for week

x No reliability data for week

TABLE 2

Interobserver Reliability Scores in
Interaction Condition Over Time by Subject

Subject		Week 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total $\bar{X}$ Reliability
	Lap	84	-	84	84	-	90	-	86	89	-	x	89	-	-	89	93	-	93	89	88.2
1	Crib/Floor	82	-	88	82	-	84	-	88	83	-	x	87	-	-	87	88	-	90	93	86.5
	Infant Seat	x	-	84	83	-	85	-	86	84	-	x	87	-	-	92	90	-	91	94	87.6
	Lap	-	88	84	87	-	x	x	98	-	x	95	92	-	93	92	-	88	95	x	91.2
2	Crib/Floor	-	-	89	91	-	x	x	96	-	x	92	95	-	92	-	-	-	92	x	92.4
	Infant Seat	-	-	91	93	-	x	x	96	-	x	-	89	-	91	94	-	94	93	x	92.6
	Lap	80	-	x	92	94	90	x	-	-	x	95	95	94	-	96	x	92	-	94	92.2
3	Crib/Floor	-	-	x	96	92	88	x	-	-	x	95	93	89	-	91	x	89	-	93	91.8
	Infant Seat	89	-	x	93	95	-	x	-	-	x	89	94	96	-	93	x	94	-	95	93.1
	Lap	93	-	-	89	x	x	x	x	96	93	96	97	94	93	94	-	-	-	95	94.0
4	Crib/Floor	-	-	-	90	x	x	x	x	96	97	97	97	96	x	95	-	-	-	96	95.5
	Infant Seat	90	83	86	87	x	x	x	x	95	96	98	94	97	95	94	-	-	-	94	92.4

\- No observation for week

x No reliability data for week

Acquisition of visual fixation. Each subject's total session scores across all gird sections for frequency, duration, and mean duration were graphed over the 20 weeks of observation. Slopes (m) were computed and trend lines were fit to the data by ordinary least-squares to describe each subject's rate of change in performance in the Assessment condition.

The overall frequency of infant visual fixations for all four subjects is displayed in Figure 4. Frequency scores were graphed as number of fixations per minute. For Subject 1, the 12 individual session frequency scores ranged from 1.3 to 5.6 per minute with a slope of .20. For Subject 2, the 15 individual session frequency scores ranged from .2 to 6.4 per minute with a slope of .32. For Subject 3, the 14 individual session frequency scores ranged from .2 to 7.8 per minute with a slope of .30. For Subject 4, the 16 individual session frequency scores ranged from .4 to 7.3 per minute with a slope of .30.

The overall duration of infant visual fixations for all four subjects is displayed in Figure 5. Duration scores were graphed as percentages of the total possible duration of trials. For Subject 1, the 12 individual session duration scores ranged from 3.6% to 83.2% with a slope of 4.26. For Subject 2, the 15 individual session duration scores ranged from 3.0% to 68.1% with a slope of 2.45. For Subject 3, the 14 individual session duration scores ranged from .6% to 60.8% with a slope of 2.66. For Subject 4, the 16 individual session duration scores ranged from 4.8% to 79.6% with a slope of 3.29.

The overall mean duration (duration divided by frequency) of infant visual fixations for all four subjects is displayed in Figure 6. Mean duration scores were graphed in seconds up to 15 seconds since this was

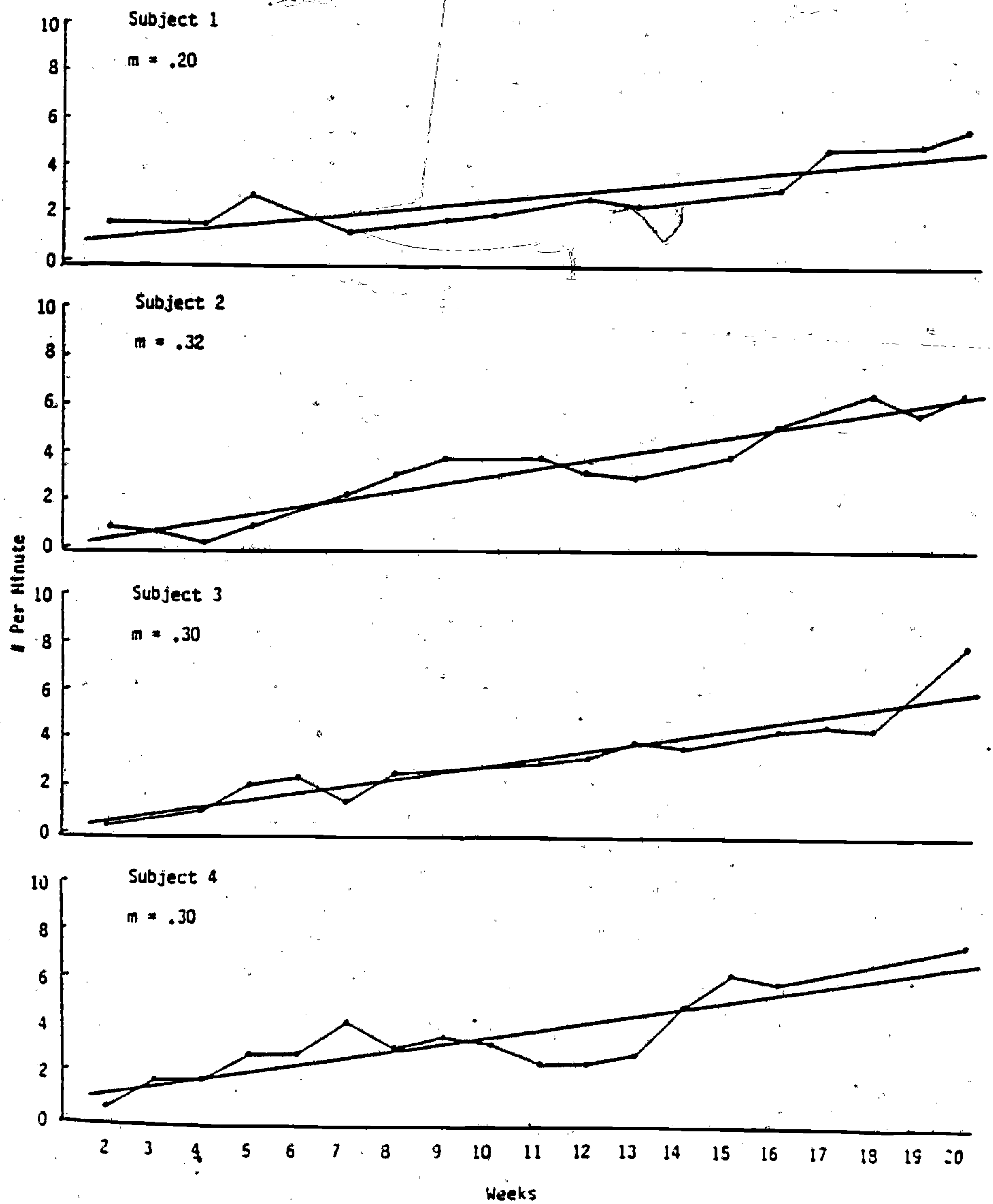

Figure 4: Frequency of infant visual fixation in assessment condition for all subjects.

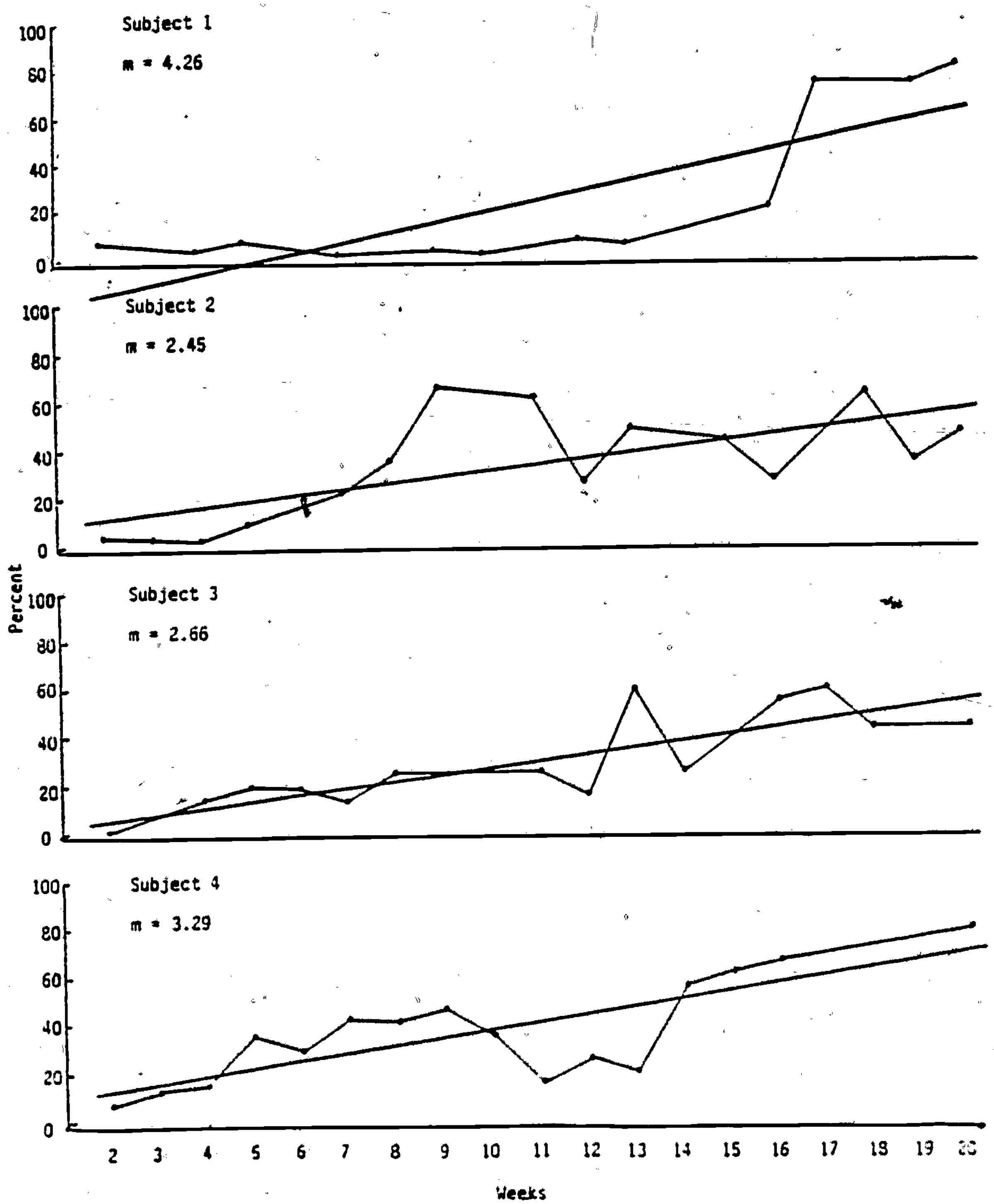

Figure 5: Duration of infant visual fixation in assessment condition for all subjects.

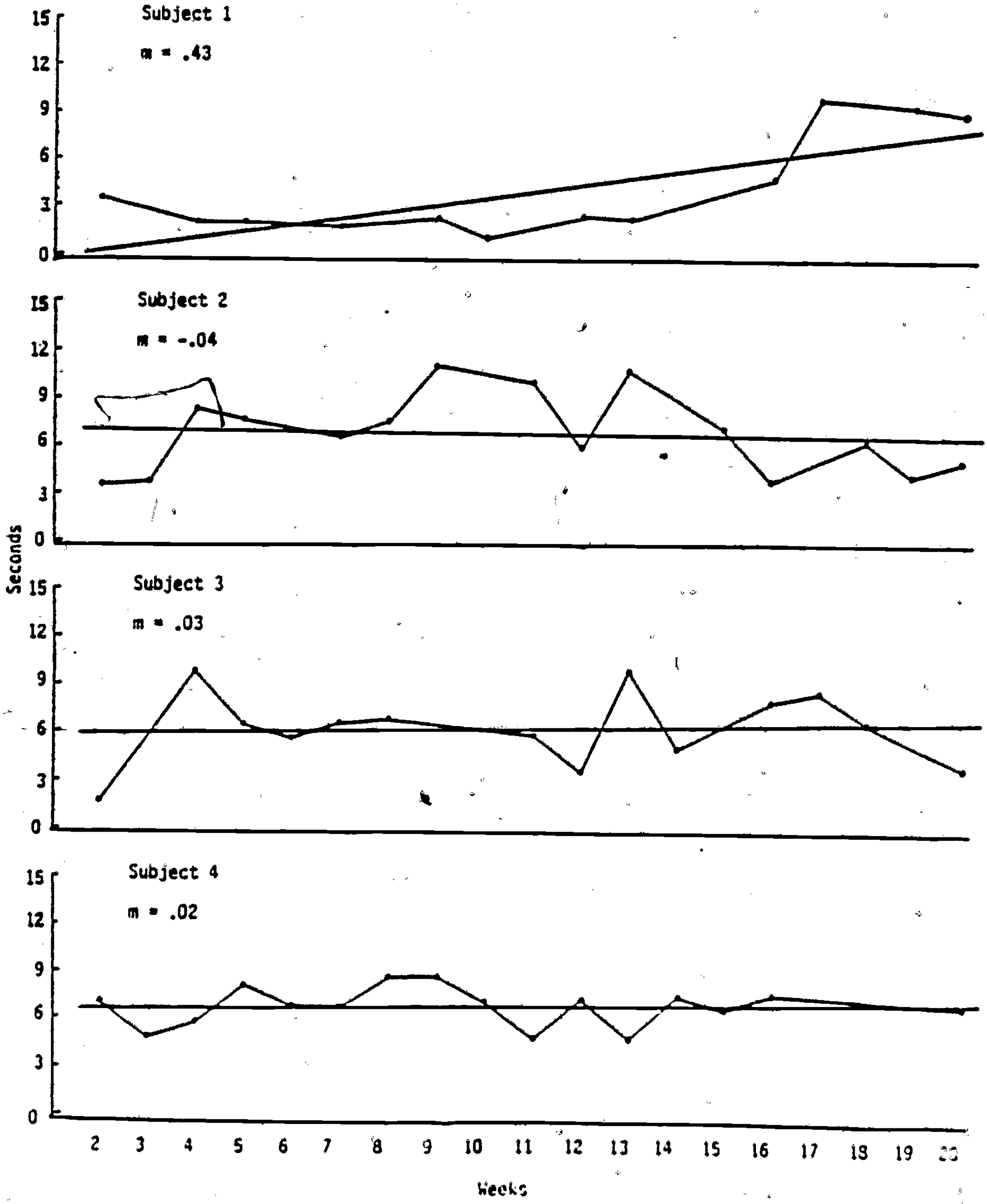

Figure 6: Mean duration of infant visual fixation in assessment condition for all subjects.

the maximum mean duration possible on the Assesssment. For Subject 1, the 12 individual session mean duration scores ranged from 1.08 to 9.81 seconds, with a slope of .43. For Subject 2, the 15 individual session mean duration scores ranged from 3.13 to 10.82 seconds, with a slope of -.04. For Subject 3, the 14 individual session mean duration scores ranged from 1.50 to 9.75 seconds with a slope of .03. For Subject 4, the 16 individual session mean duration scores ranged from 4.23 to 8.33 seconds with a slope of .02.

Emergence of visual fixation. For each subject the individual session scores for the nine sections of the grid were combined into scores for the top three sections (ABC), the middle three sections (DEF), and the lower three sections (GHI). Each subject's individual session scores for the top, middle, and lower sections of the grid, along with the overall combined scores across all nine sections for frequency, duration, and mean duration were graphed over the 20 weeks of observation. Median scores of this performance over time were determined for each of the three levels of grid sections and superimposed on the graphs to describe each subject's average performance within the levels of the grid. As an example, the graphs of performance by levels of grid sections for frequency, duration, and mean duration are presented for Subject 3 in Figures 7, 8, and 9.

Each subject's median performance scores across the three levels of the grid for frequency, duration, and mean duration of visual fixation are presented in Table 3. For frequency of visual fixation, the median scores for all subjects were higher on the middle level (DEF) than on the top level of the grid (ABC). The median scores for Subjects 1, 3, and 4 were higher on the lower level (GHI) than on the middle level of

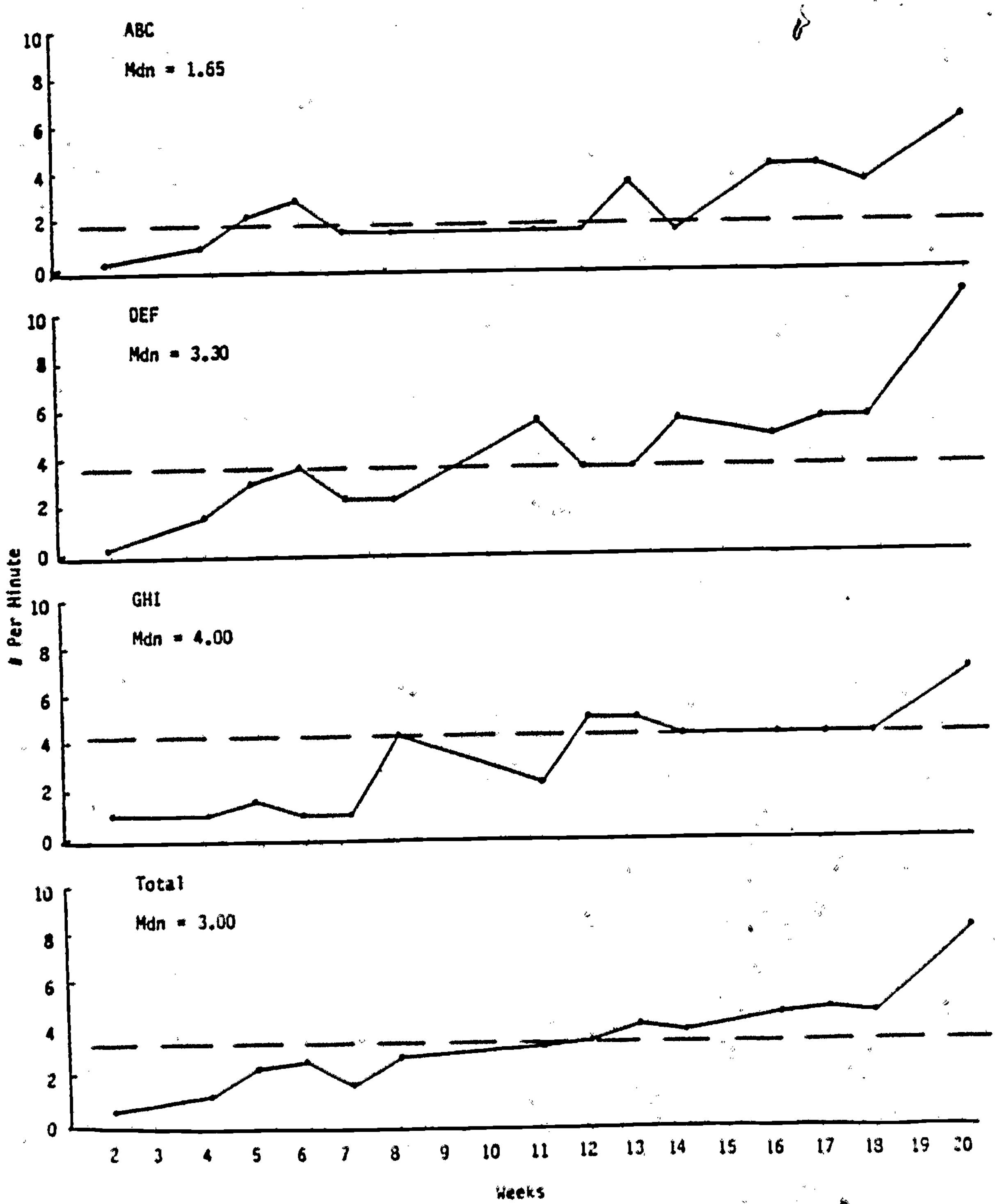

Figure 7: Frequency of infant visual fixation by levels of grid sections in assessment condition for Subject 3.

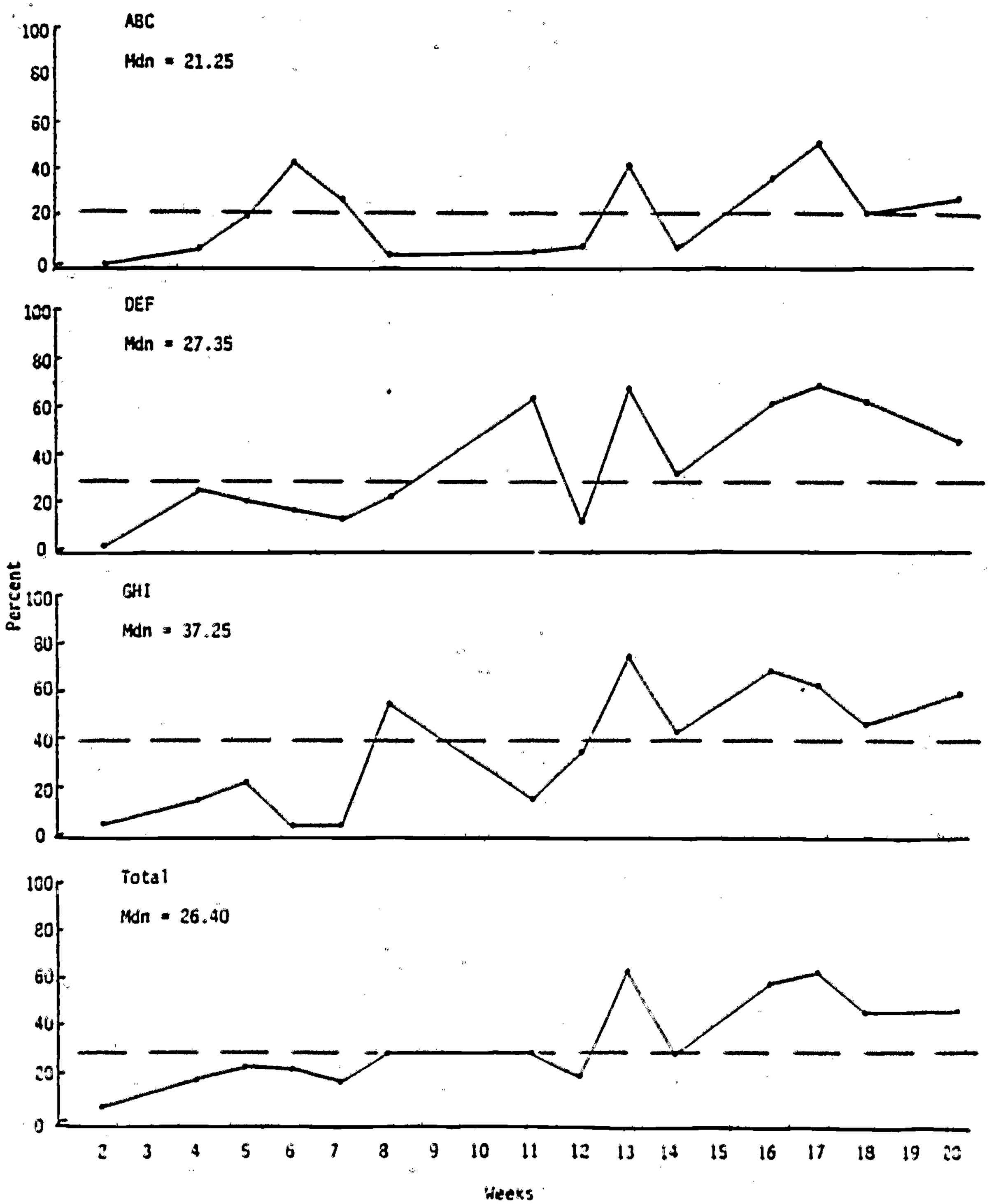

Figure 8: Duration of infant visual fixation by levels of grid sections in assessment condition for Subject 3.

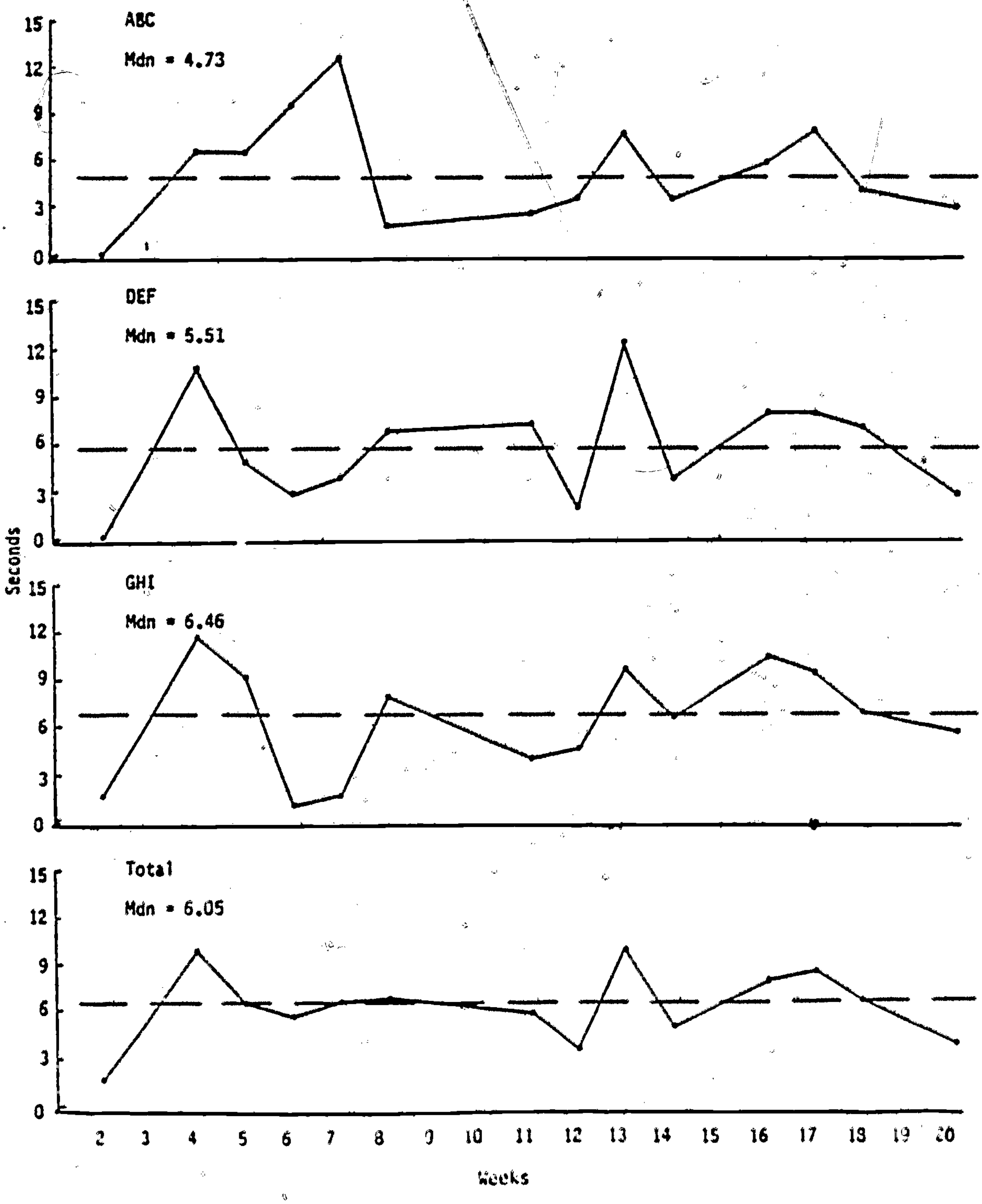

Figure 9: Mean duration of infant visual fixation by levels of grid sections in assessment condition for Subject 3.

TABLE 3

Median Assessment Performance
Scores Across Levels of Grid Sections for
Frequency, Duration, and $\overline{X}$ Duration of Visual Fixation by Subject

Subject	ABC	DEF	GHI	Total
		Frequency Per Minute		
1	2.00	2.70	3.30	2.55
2	2.70	3.30	3.30	3.10
3	1.65	3.30	4.00	3.00
4	.70	4.00	4.70	2.80
		Percent Duration		
1	4.70	10.95	15.30	9.35
2	17.50	36.10	33.30	28.50
3	21.25	27.35	37.25	26.40
4	3.45	42.75	46.40	34.20
		$\overline{X}$ Duration in Seconds		
1	1.92	2.47	2.84	2.20
2	4.94	5.42	5.59	5.97
3	4.73	5.51	6.46	6.05
4	2.84	6.54	6.55	6.51

the grid. The median scores for all subjects were higher on the lower level than on the top level of the grid.

For duration of visual fixation, the median scores for all subjects were higher on the middle level than on the top level of the grid. The median scores for Subjects 1, 3, and 4 were higher on the lower level than on the middle level of the grid. The median scores for all subjects were higher on the lower level than on the top level of the grid.

For mean duration of visual fixation, the median scores for all subjects were higher on the middle level than on the top level of the grid and the median scores for all subjects were higher on the lower level than on the middle level or the top level of the grid.

Assessment and Interaction Comparison

The Assessment and Interaction performance data were compared between conditions and within conditions to determine if the assessment procedures reflected the infants' actual visual fixation skill level in the first four months of life.

Comparison between conditions. Each subject's total session scores in both conditions for frequency, duration, and mean duration of directed looking were graphed over the 20 weeks of observation. Directed looking in the Assessment condition was simply the subject's total session score across all nine grid sections. Directed looking in the Interaction condition included the subject's total session score across all three settings for "look at mother" plus the subject's total session score across all three settings for "look at objects." Spearman's rho correlations were calculated between measures in the Assessment and Interaction conditions to describe the nature and degree of relationship between conditions.

The frequency of infant directed looking in the Assessment and Interaction conditions for all four subjects is displayed Figure 10. Frequency scores were graphed as number of fixations per minute. Individual session score ranges for the Assessment condition were described previously. For Subject 1, the 12 individual session frequency scores for directed looking in the Interaction condition ranged from 1.0 to 3.4 per minute. The rho correlation for frequency of directed looking between conditions was -.11. For Subject 2, the 14 individual session frequency scores for directed looking in the Interaction condition ranged from .5 to 2.9 per minute. The rho correlation for frequency of directed looking between conditions was .28. For Subject 3, the 14 individual session frequency scores for directed looking in the Interaction condition ranged from 1.1 to 3.2 per minute. The rho correlation for frequency of directed looking between conditions was .46. For Subject 4, the 16 individual session frequency scores for directed looking in the Interaction condition ranged from .6 to 2.8 per minute. The rho correlation for frequency of directed looking between conditions was .08.

Frequency of directed looking in the Interaction condition consisted of combining frequency scores for "look at mother" and "look at objects." Figure 11 displays the frequency of infant visual fixation separately for mother and objects for all four subjects. For Subject 1, the individual session frequency scores for "look at mother" ranged from .8 to 2.7 per minute and from .2 to 1.1 per minute for "look at objects." For Subject 2, the individual session frequency scores for "look at mother" ranged from .5 to 2.6 per minute and from 0 to .6 per minute for "look at objects." For Subject 3, the individual session frequency

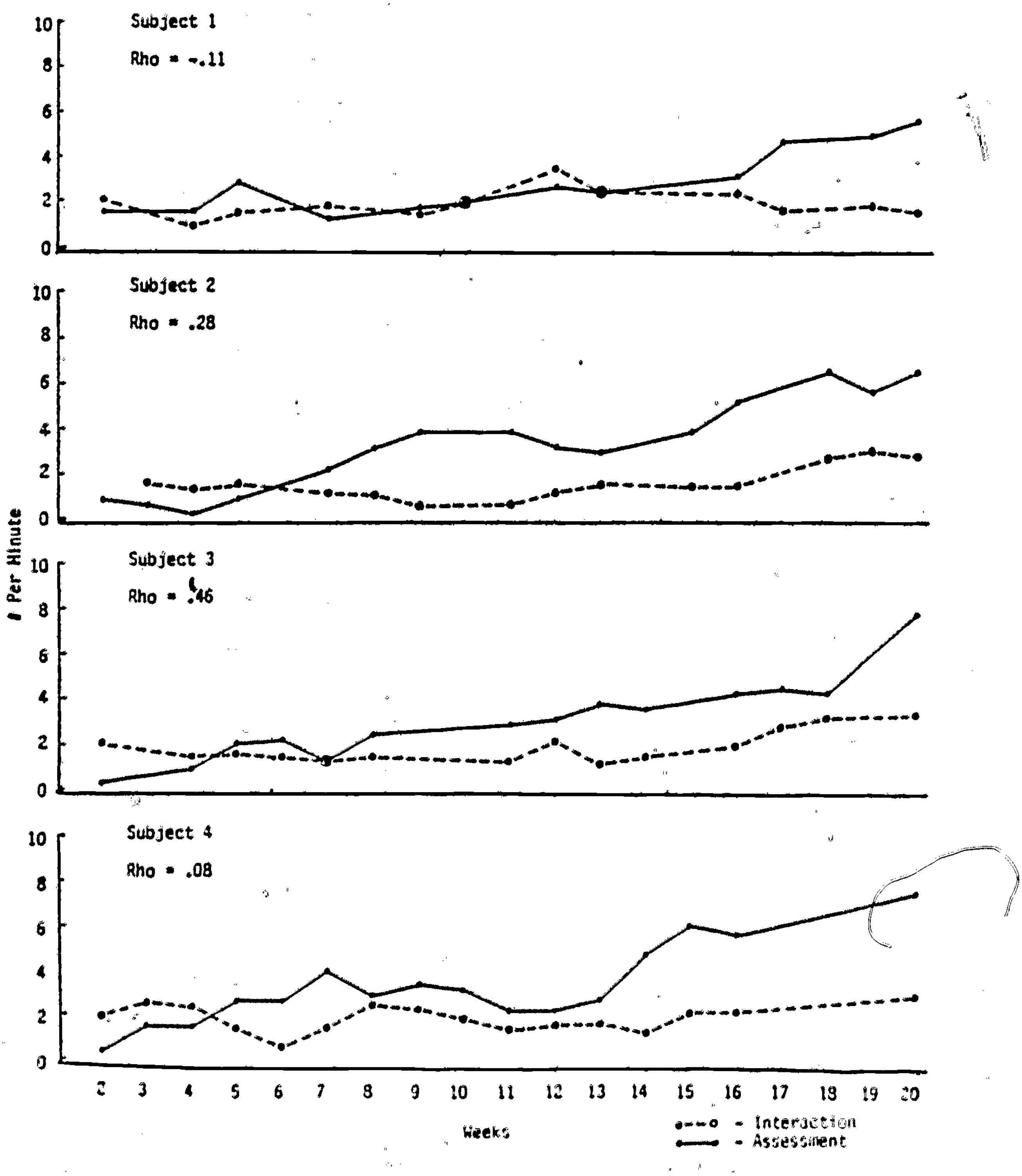

Figure 10: Frequency of infant directed looking in assessment and interaction conditions for all subjects.

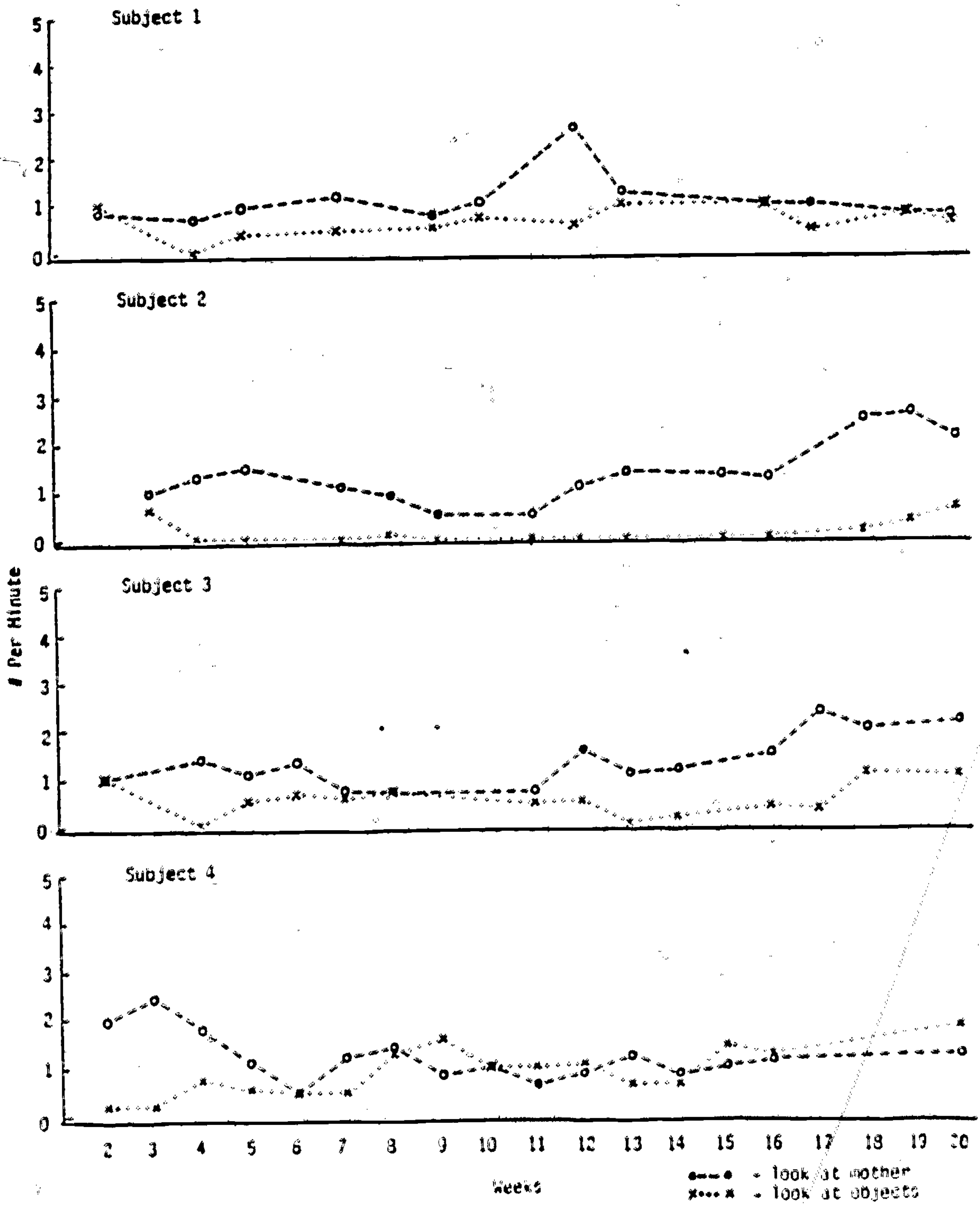

Figure 11: Frequency of infant looking in interaction condition for all subjects.

scores for "look at mother" ranged from .7 to 2.4 per minute and from 0 to 1.1 per minute for "look at objects." For Subject 4, the individual session frequency scores for "look at mother" ranged from .3 to 2.4 per minute and from .2 to 1.7 per minute for "look at objects."

The duration of infant directed looking in the Assessment and Interaction conditions for all four subjects is displayed in Figure 12. Duration scores were graphed as percentages of the total possible duration of a session. Individual session score ranges for the Assessment condition were described previously. For Subject 1, the 12 individual session duration scores for directed looking in the Interaction condition ranged from 25.3% to 84.9%. The rho correlation for duration of directed looking between conditions was .75. For Subject 2, the 14 individual session duration scores for directed looking in the Interaction condition ranged from 34.0% to 97.3%. The rho correlation for duration of directed looking between conditions was .30. For Subject 3, the 14 individual session duration scores for directed looking in the Interaction condition ranged from 22.7% to 90.7%. The rho correlation for duration of directed looking between conditions was -.08. For Subject 4, the 16 individual session duration scores for directed looking in the Interaction condition ranged from 46.7% to 95.6%. The rho correlation for duration of directed looking between conditions was .36.

Duration of directed looking in the Interaction condition consisted of combining duration scores for "look at mother" and "look at objects." Figure 13 displays the duration of infant visual fixation separately for mother and objects for all four subjects. For Subject 1, the individual session duration scores for "look at mother" ranged from 15.5% to 41.3% and from 6.2% to 52.9% for "look at objects." For Subject 2 the individual session duration scores for "look at mother" ranged from 30.7% to 97.3%

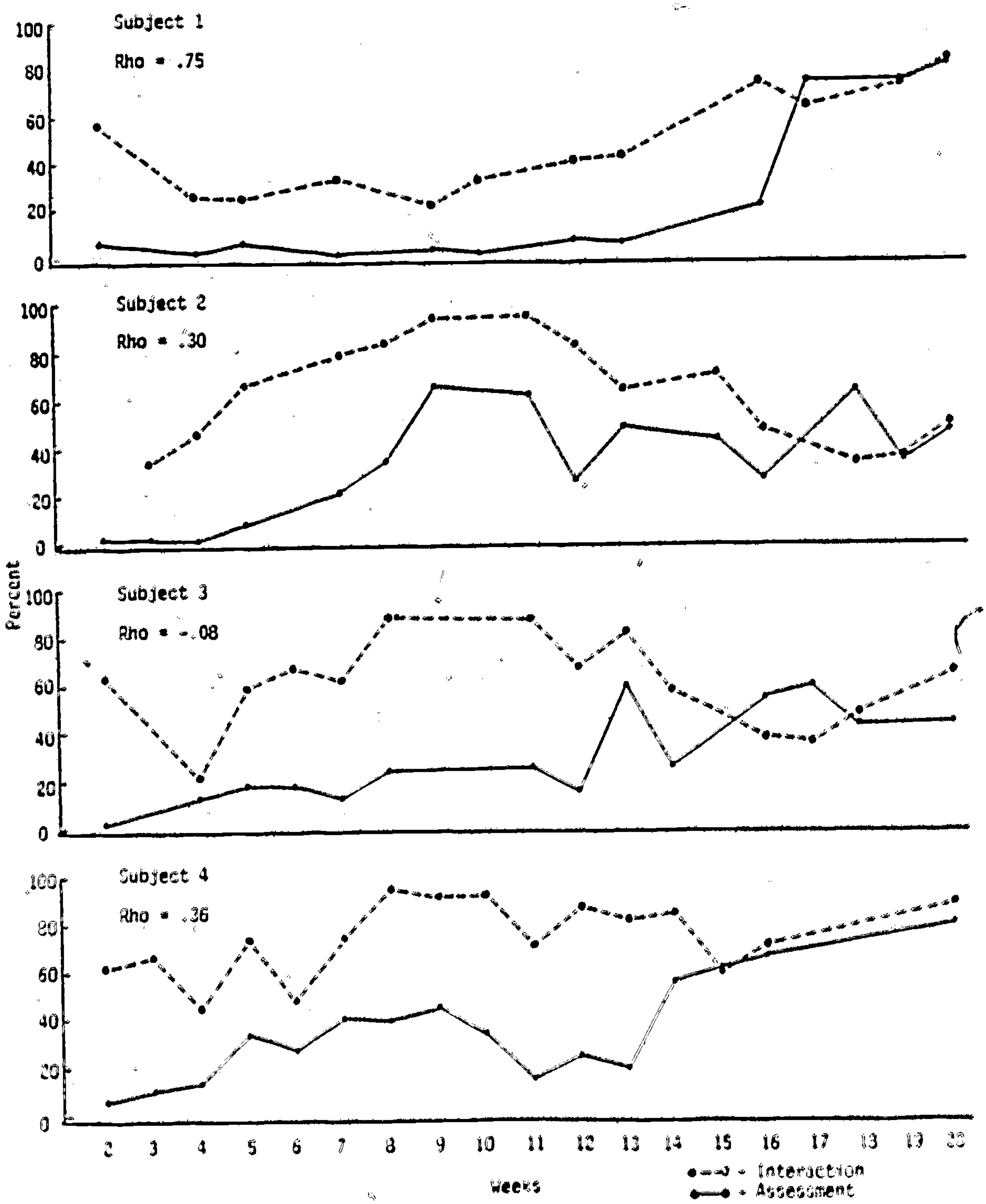

Figure 12: Duration of infant directed looking in assessment and interaction conditions for all subjects .

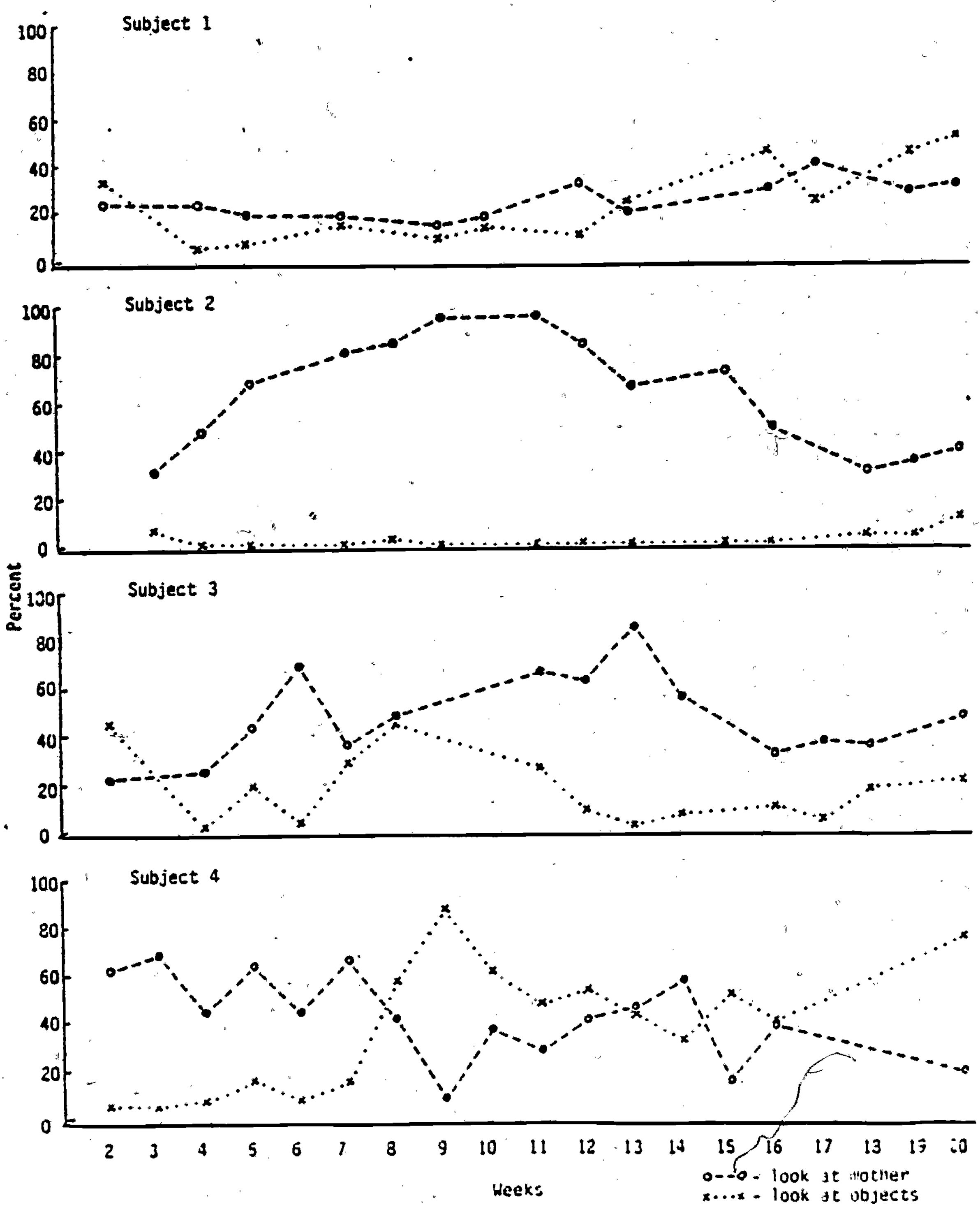

Figure 13: Duration of infant looking in interaction condition for all subjects .

and from 0% to 11.1% for "look at objects." For Subject 3, the individual session duration scores for "look at mother" ranged from 21.3% to 83.1% and from 0% to 45.3% for "look at objects." For Subject 4, the individual session duration scores for "look at mother" ranged from 5.8% to 66.7% and from 1.3% to 85.8% for "look at objects."

The mean duration of infant directed looking in the Assessment and Interaction conditions for all four subjects is displayed in Figure 14. Mean duration scores were graphed in seconds. The dotted line at 15 seconds denotes the maximum mean duration possible in the Assessment condition. The maximum mean duration possible in the Interaction condition was 300 seconds, however most of the subjects' session scores fell below 50 seconds. Individual session score ranges for the Assessment condition were described previously. For Subject 1, the 12 individual session mean duration scores for directed looking in the Interaction condition ranged from 7.7 to 33.2 seconds. The rho correlation for mean duration of directed looking between conditions was .62. For Subject 2, the 14 individual session mean duration scores for directed looking in the Interaction condition ranged from 7.8 to 124.6 seconds. The rho correlation for mean duration of directed looking between conditions was .60. For Subject 3, the 14 individual session mean duration scores for directed looking in the Interaction condition ranged from 8.3 to 46.8 seconds. The rho correlation for mean duration of directed looking between conditions was -.12. For Subject 4, the 16 individual session mean duration scores for directed looking in the Interaction condition ranged from 12.0 to 43.6 seconds. The rho correlation for mean duration of directed looking between conditions was .20.

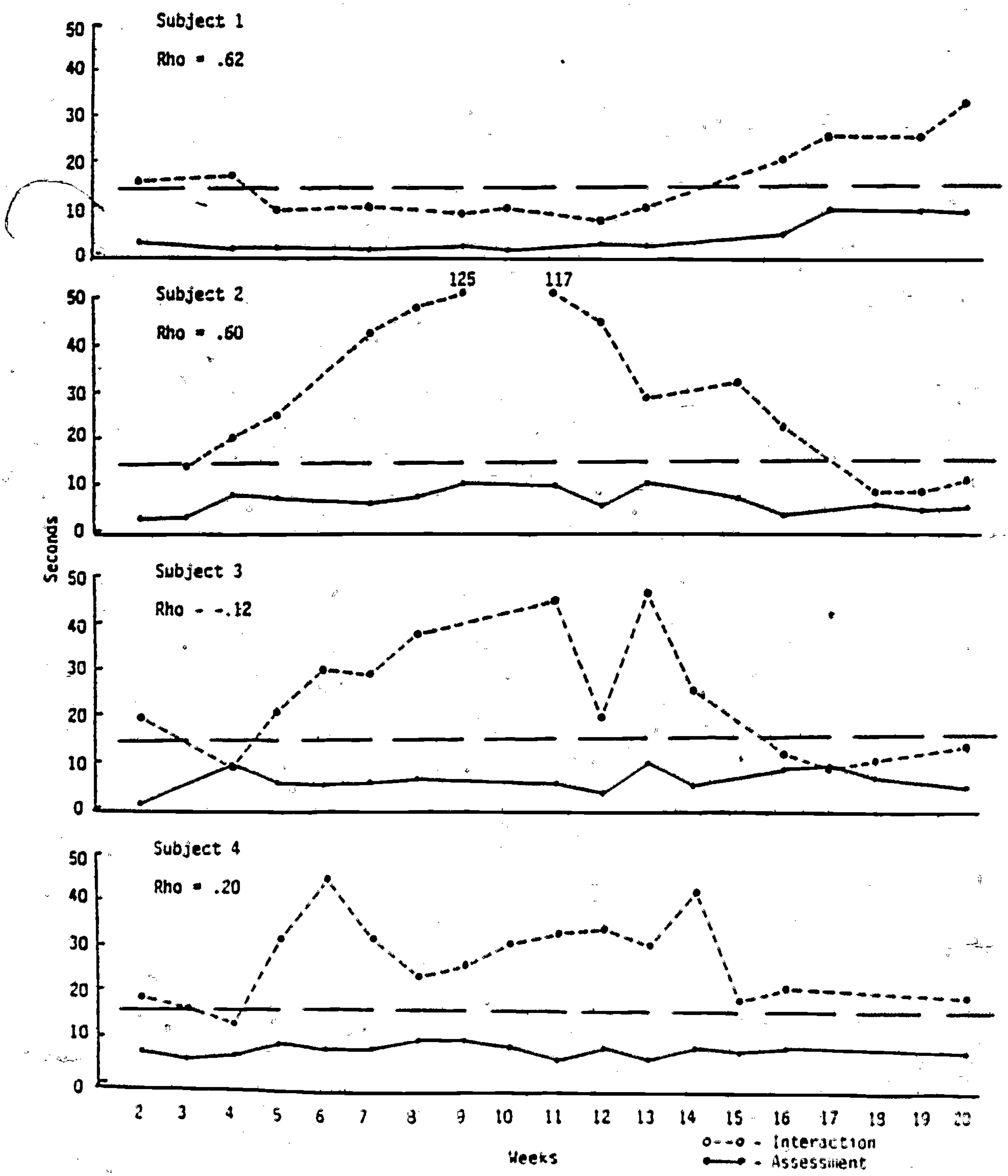

Figure 14: Mean duration of infant directed looking in assessment and interaction Conditions for all subjects.

Mean duration of directed looking in the Interaction condition consisted of combining mean duration scores for "look at mother" and "look at objects." Figure 15 displays the mean duration of infant visual fixation separately for mother and objects for all four subjects. For Subject 1, the individual session mean duration scores for "look at mother" ranged from 7.2 to 24.0 seconds and from 8.8 to 43.3 seconds for "look at objects." For Subject 2, the individual session mean duration scores for "look at mother" ranged from 7.4 to 124.6 seconds and from 0 to 20.0 seconds for "look at objects." For Subject 3, the individual session mean duration scores for "look at mother" ranged from 8.8 to 58.4 seconds and from 0 to 35.6 seconds for "look at objects." For Subject 4, the individual session mean duration scores for "look at mother" ranged from 4.7 to 76.8 seconds and from 4.0 to 45.0 seconds for "look at objects."

To determine if any of the correlations between measures in the Assessment and Interaction conditions were significant, the following hypotheses were tested for each comparison at the .05 level:

Null: rho is less than or equal to zero.

Alternate: rho is greater than zero.

Table 4 presents the correlation value for each comparison tested and denotes (*) those comparisons for which the null hypothesis was rejected in favor of a significant positive correlation. For frequency of visual fixation, significant correlations were found between the Assessment condition and directed looking (combined "look at mother" and "look at objects") in the Interaction condition for Subject 3, between the Assessment condition and "look at mother" in the Interaction condition for Subject 3, and between the Assessment condition and directed looking in the

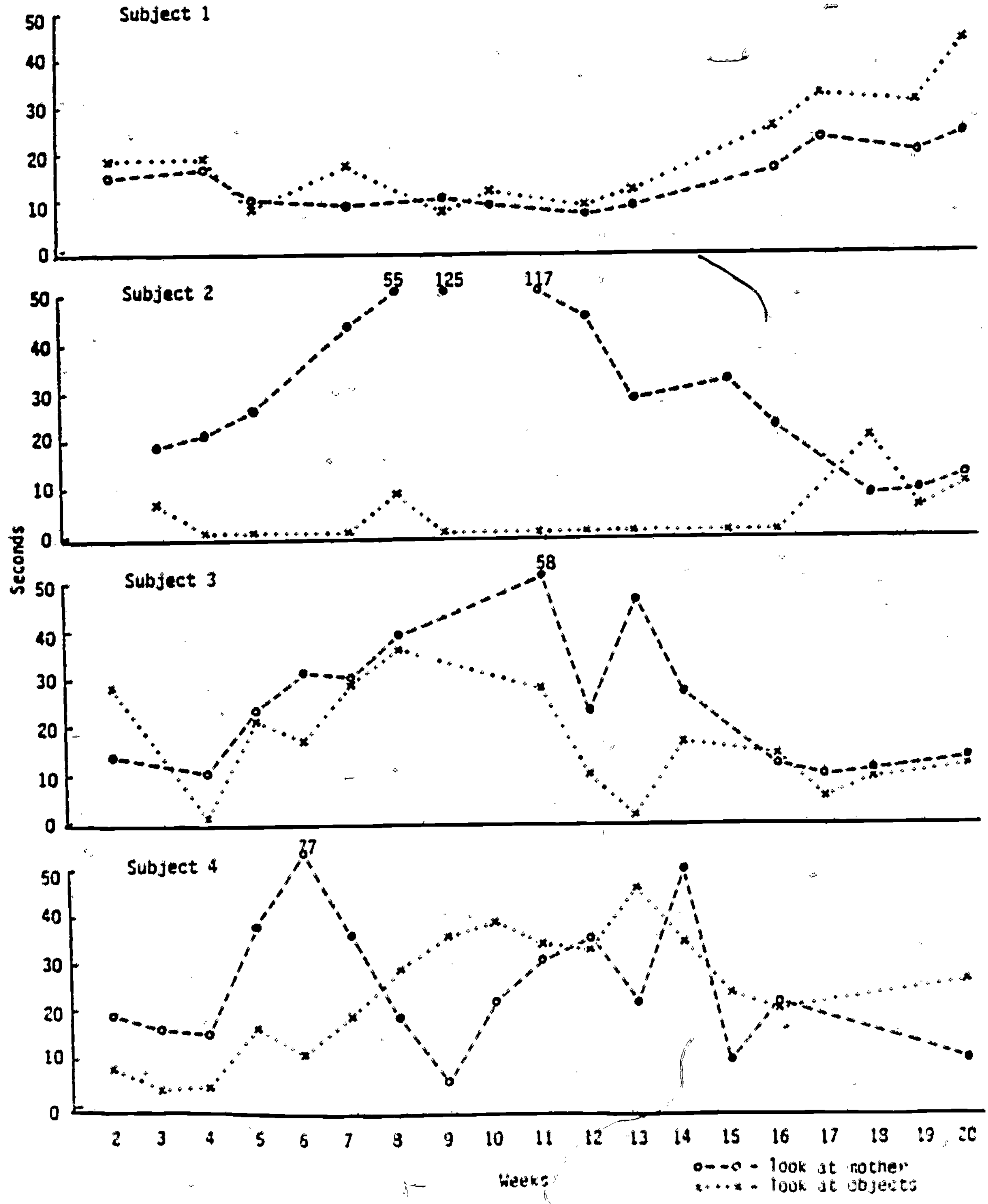

Figure 15: Mean duration of infant looking in interaction condition for all subjects.

TABLE 4

Spearman's Rho Correlations Between
Infant Visual Behavior in Assessment and Interaction for
Frequency, Duration, and $\overline{X}$ Duration of Visual Fixation by Subject

Subjects	Assessment/ Combined look at Mother & Objects	Assessment/ Look at Mother	Assessment/ Look at Objects
		Frequency Per Minute	
1	-.11	-.16	.12
2	.28	.37	.42
3	.46*	.67*	.07
4	.08	-.27	.62*
		Percent Duration	
1	.75*	.87*	.64*
2	.30	.27	.20
3	-.08	.31	-.35
4	.36	-.49	.58*
		$\overline{X}$ Duration in Seconds	
1	.62*	.69*	.64*
2	.60*	.60*	-.33
3	-.12	-.19	-.30
4	.20	.004	.18

* - $p < .05$

Interaction condition for Subject 4. For duration of visual fixation, significant correlations were found between the Assessmnt condition and directed looking in the Interaction condition for Subject 1, between the Assessment condition and "look at mother" in the Interaction condition for Subject 1, and between the Assessment condition and "look at objects" in the Interaction condition for Subjects 1 and 4. For mean duration of visual fixation, significant correlations were found between the Assessment condition and directed looking in the Interaction condition for Subjects 1 and 2, between the Assessment condition and "look at mother" in the Interaction condition for Subjects 1 and 2, and between the Assessment condition and "look at objects" in the Interaction condition for Subject 1.

<u>Comparison within conditions</u>. Each subject's total session scores for frequency and duration of visual fixation were graphed over the 20 weeks of observation and compared within each condition. Within the Interaction condition, frequency and duration of visual fixation were compared for directed looking (combined "look at mother" and "look at objects"), "look at mother," and "look at objects."

Spearman's rho correlations were calculated between frequency and duration scores within each condition to describe the nature and degree of relationship between the two measures. To determine if any of the correlations were significant the following hypotheses were tested for each comparison at the .05 level:

Null: rho is less than or equal to zero.

Alternate: rho is greater than zero.

Table 5 presents the correlation value for each comparison tested and denotes (*) those comparisons for which the null hypothesis was rejected

TABLE 5

Spearman's Rho Correlations Between
Frequency and % Duration Measures of Infant Visual Behavior
Within Each Condition by Subject

Subjects	Assessment	Interaction		
		Combined look at Mother & Objects	Look at Mother	Look at Objects
1	.88*	.19	-.09	.60*
2	.75*	-.84	-.70	.99*
3	.88*	-.41	-.16	.87*
4	.98*	.11	.45*	.88*

* - $p < .05$

in favor of a significant positive correlation. For the Assessment condition, significant correlations were found between frequency and duration scores for all four subjects. Figure 16 displays a graphic presentation of these relationships. For directed looking in the Interaction condition, no significant correlations were found between frequency and duration scores. For "look at mother" in the Interaction condition, a significant correlation was found between frequency and duration scores for Subject 4. For "look at objects" in the Interaction condition, significant correlations were found between frequency and duration scores for all four subjects. Figure 17 displays a grahic representation of the relationships for "look at objects."

Interaction Condition Pilot Data

The Interaction pilot data were analyzed for relationships between the infants' visual and vocal behavior in the first four months of life and their mothers' behavior.

Mother behavior. Each mother's total session percentage scores across the three settings for each of the coded mother behaviors over the 20 weeks of observation are displayed in Figure 18. Looking at the infant included the two coded behaviors of "look at infant only" and "look at and talk to infant." Talking to the infant included the two coded behaviors of "talk to infant only" and "look at and talk to infant."

For Mother 1, the 12 individual session percent scores for looking at her infant ranged from 90.7% to 100% with a median of 98.5% and for talking to her infant the range was from 61.7% to 86.7% with a median of 72.5%. For Mother 2, the 14 individual session percent scores for looking at her infant ranged from 88.4% to 100% with a median of 97.8% and for talking to her infant the range was from 41.4% to 98.7% with a

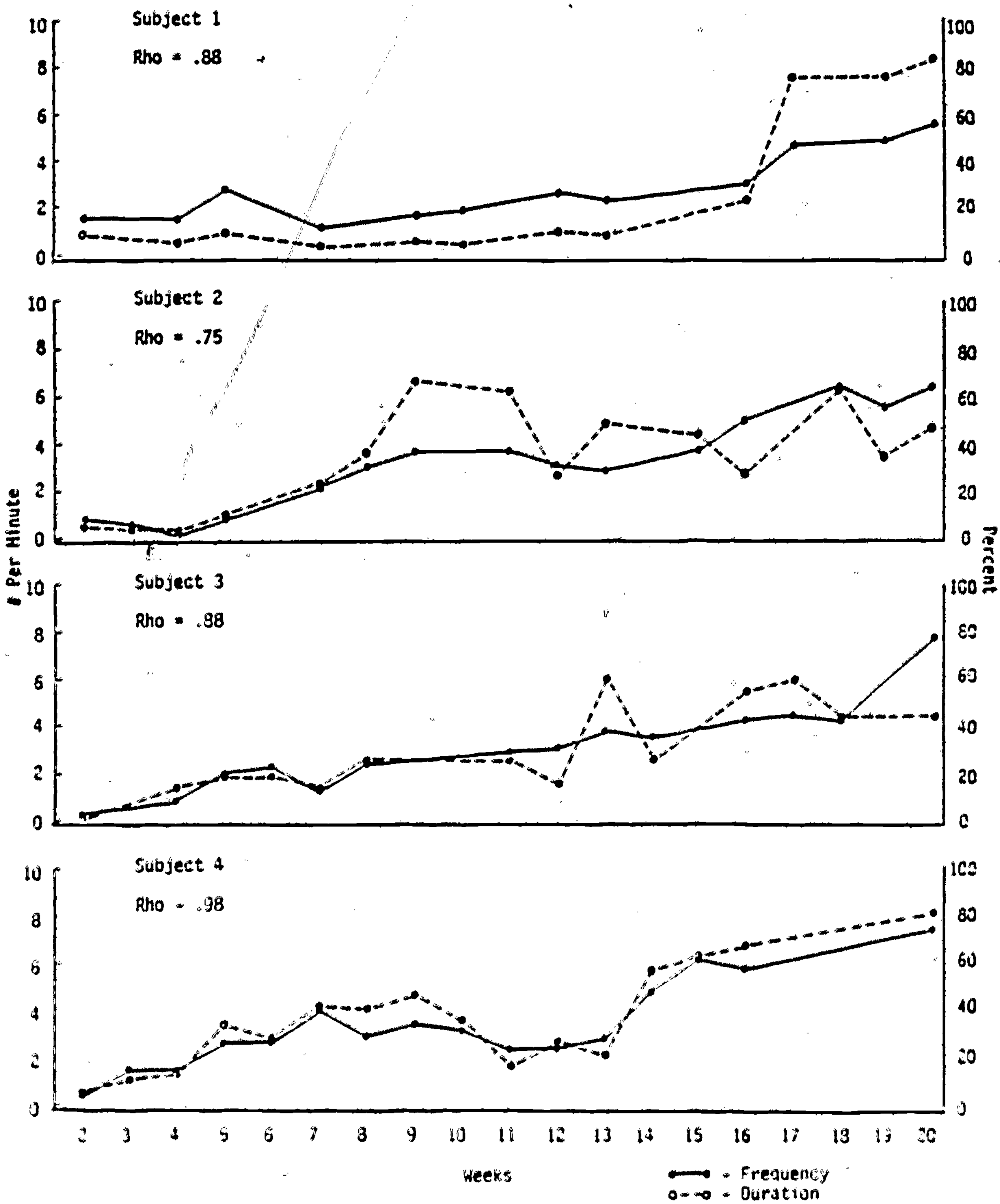

Figure 16: Frequency and duration of infant looking in assessment condition for all subjects .

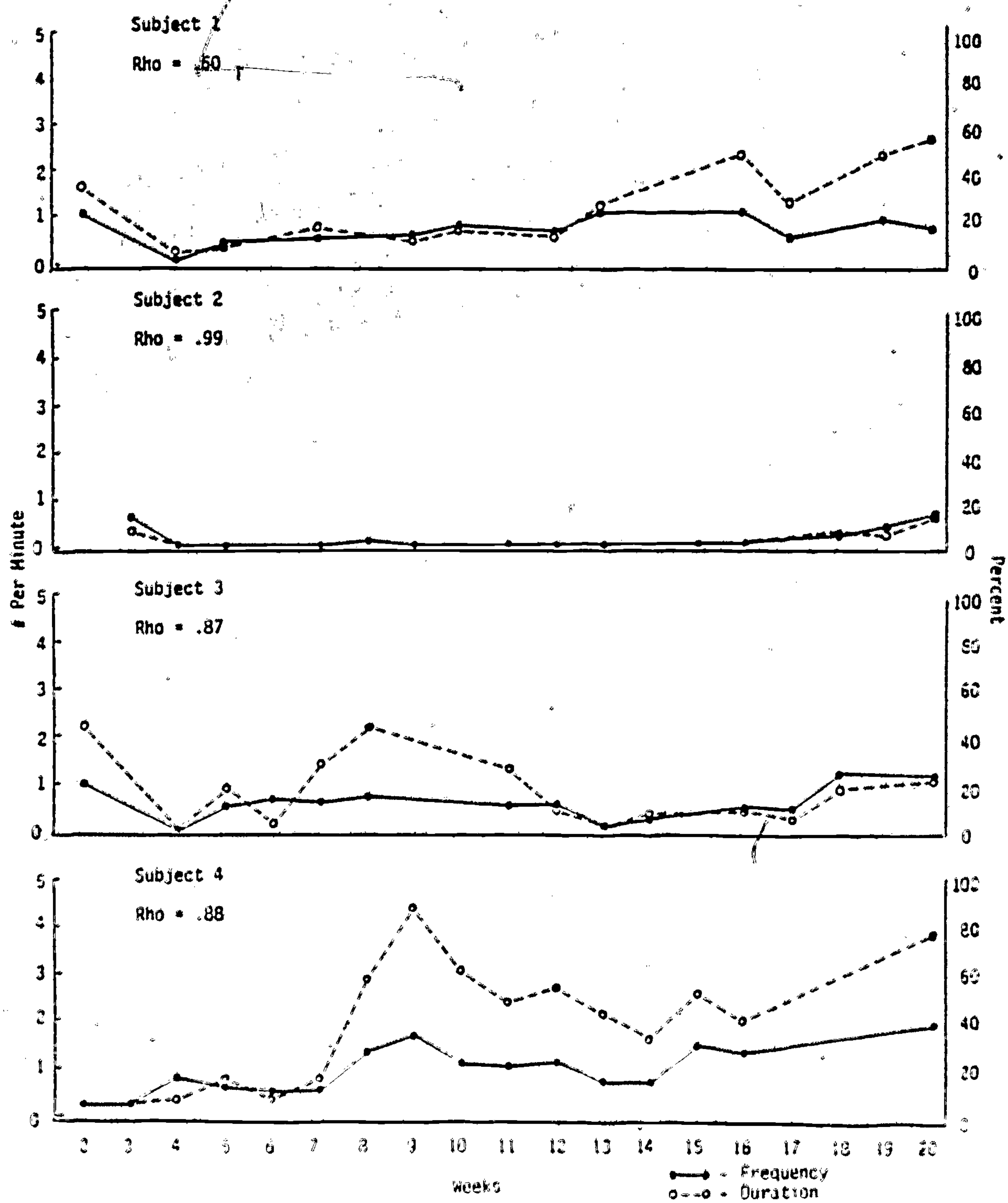

Figure 17: Frequency and duration of infant looking at objects in interaction condition for all Subjects.

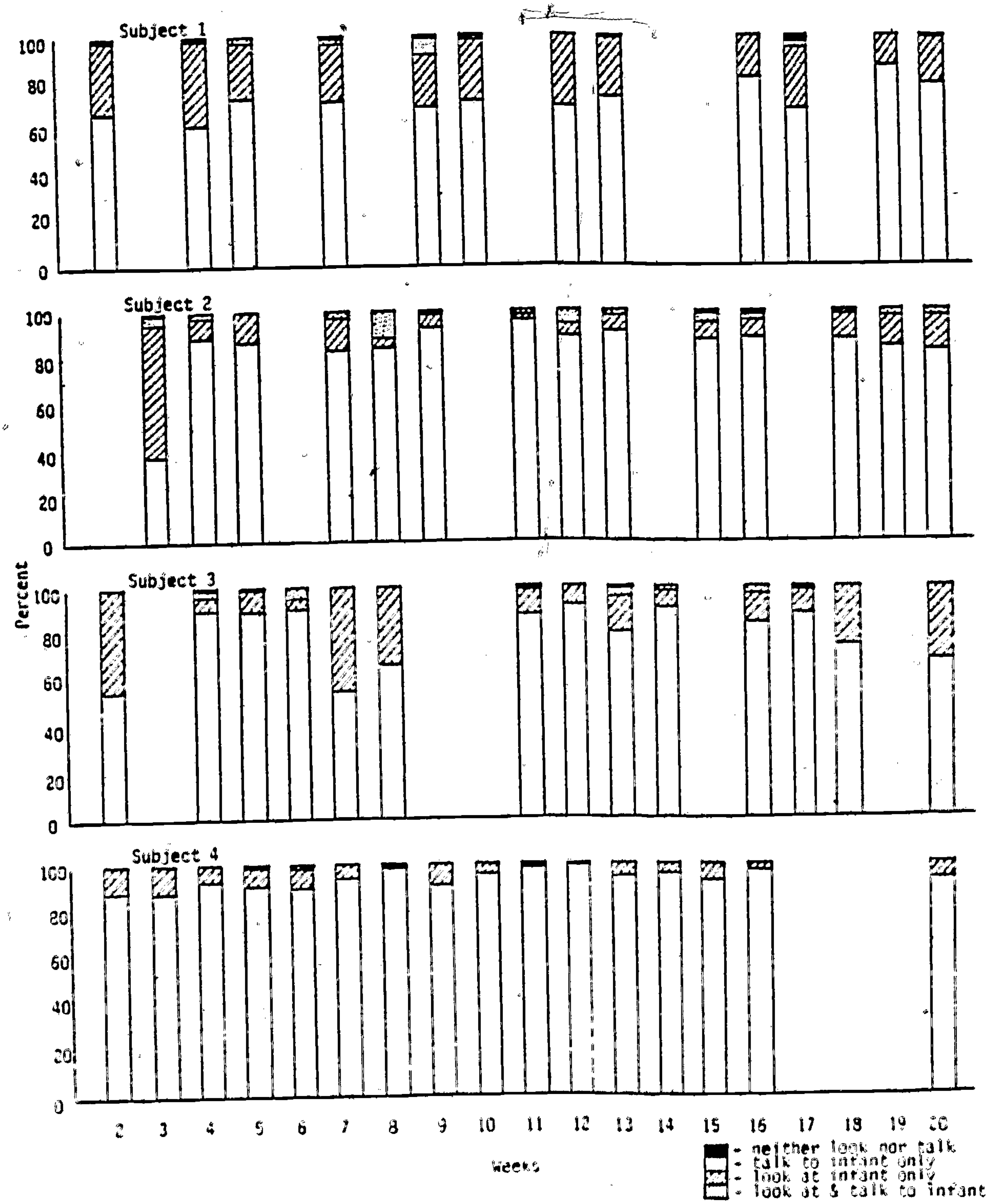

Figure 18: Mother Behavior in Interaction Condition for all Subjects.

median of 91.1%. For Mother 3, the 14 individual session percent scores for looking at her infant ranged from 94.7% to 100% with a median of 99.2% and for talking to her infant the range was from 54.7% to 95.5% with a median of 88.3%. For Mother 4, the 16 individual session percent scores for looking at her infant ranged from 99.1% to 100% with a median of 100% and for talking to her infant the range was from 89.3% to 99.6% with a median of 94.0%.

Infant behavior. Each subject's total session scores across the three settings for frequency, duration, and mean duration of looking at mother and at objects are displayed in Figure 11, 13, and 15 and have been described in previous sections. Each subject's total session percentage scores across the three settings for positive and distress vocalizations over the 20 weeks of observation are displayed in Figure 19. For Subject 1, the 12 individual session percent scores for positive vocalization ranged from 0% to 26.2% and from 0% to 9.8% for distress vocalization. For Subject 2, the 14 individual session percent scores for positive vocalization ranged from 1.3% to 53.3% and from 0% to 6.2% for distress vocalization. For Subject 3, the 14 individual session percent scores for positive vocalization ranged from 0% to 29.8% and from 0% to 12.9% for distress vocalization. For Subject 4, the 16 individual session percent scores for positive vocalization ranged from 0% to 22.2% and from 0% to 48.9% for distress vocalization.

Interaction. Conditional probabilities were computed for specific behaviors and compared to the corresponding unconditional probabilities for each session over the 20 weeks of observation. Conditional probabilities were calculated by determing the number of four-second in-intervals in which two behaviors co-occurred, then dividing by the total

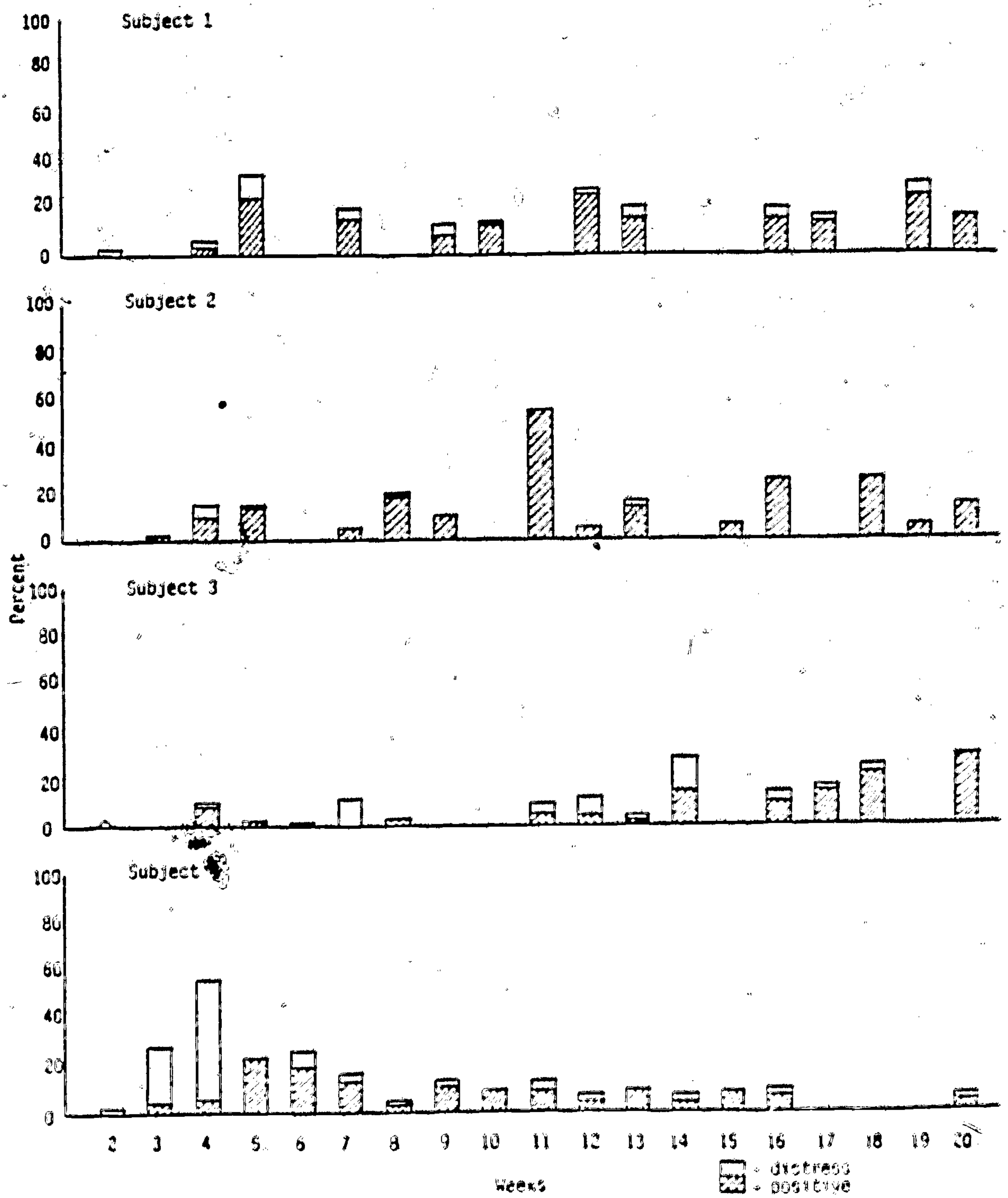

Figure 19: Infant vocal behavior in interaction condition for all subjects.

number of intervals in which only one of the behaviors occurred. For example, the number of intervals in which the infant looked at the mother and the mother talked to the infant was divided by the total number of intervals in which the infant looked at the mother to obtain the conditional probability of mother talking, given infant looks at mother. Unconditional probabilities were calculated by determining the number of four-second intervals in which a behavior occurred, then dividing by the total number of intervals in the session. For example, the number of intervals in which the mother talked to the infant was divided by the total number of intervals in the session to obtain the unconditional probability of mother talking to the infant.

For each subject, four conditional probabilities and one unconditional probability were calculated for mother talks to the infant for each session across the 20 weeks of observation. The probabilities that mother talks to infant, given infant looks at mother ranged from .73 to .99 for Subject 1, from .61 to .99 for Subject 2, from .80 to 1.00 for Subject 3, and from .91 to 1.00 for Subject 4. The probabilities that mother talks to infant, given infant looks at objects ranged from .36 to .92 for Subject 1, from .40 to 1.00 for Subject 2, from .28 to 1.00 for Subject 3, and from .00 to 1.00 for Subject 4. The probabilities that mother talks to infant, given infant looks at neither mother nor objects ranged from .57 to .94 for Subject 1, from .32 to 1.00 for Subject 2, from .61 to .94 for Subject 3, and from .80 to 1.00 for Subject 4. The probabilities that mother talks to infant, given infant vocalizes ranged from .54 to .89 for Subject 1, from .44 to 1.00 for Subject 2, from .33 to 1.00 for Subject 3, and from .82 to 1.00 for Subject 4. The unconditional probabilities that mother talks to infant ranged from .62 to .87

for Subject 1, from .41 to .99 for Subject 2, from .55 to .96 for Subject 3, and from .89 to .99 for Subject 4.

Non-parametric sign tests were used to determine if significant differences existed between the conditional and unconditional probabilities of mother talking to the infant for any mother/infant pair. The following hypotheses were tested for each pair at the .05 level:

Null 1: the conditional probability of mother talks to infant, given infant looks at mother is less than or equal to the unconditional probability of mother talks to infant.

Alternate 1: the conditional probability of mother talks to infant, given infant looks at mother is greater than the unconditional probability of mother talks to infant.

Null 2: the conditional probability of mother talks to infant, given infant looks at objects is less than or equal to the unconditional probability of mother talks to infant.

Alternate 2: the conditional probability of mother talks to infant, given infant looks at objects is greater than the unconditional probability of mother talks to infant.

Null 3: the conditional probability of mother talks to infant, given infant looks at neither mother nor objects is less than or equal to the unconditional probability of mother talks to infant.

Alternate 3: the conditional probability of mother talks to infant, given infant looks at neither mother nor objects is greater than the unconditional probability of mother talks to infant.

Null 4: the conditional probability of mother talks to infant, given infant vocalizes is less than or equal to the unconditional probability of mother talks to infant.

Alternate 4: the conditional probability of mother talks to infant, given infant vocalizes is greater than the unconditional probability of mother talks to infant.

Null hypothesis 1 was rejected in favor of the alternate for all four subjects. Figure 20 is a graphic representation for each subject of the session differences between the conditional probabilities of mother talks to infant, given infant looks at mother and the uncondi-

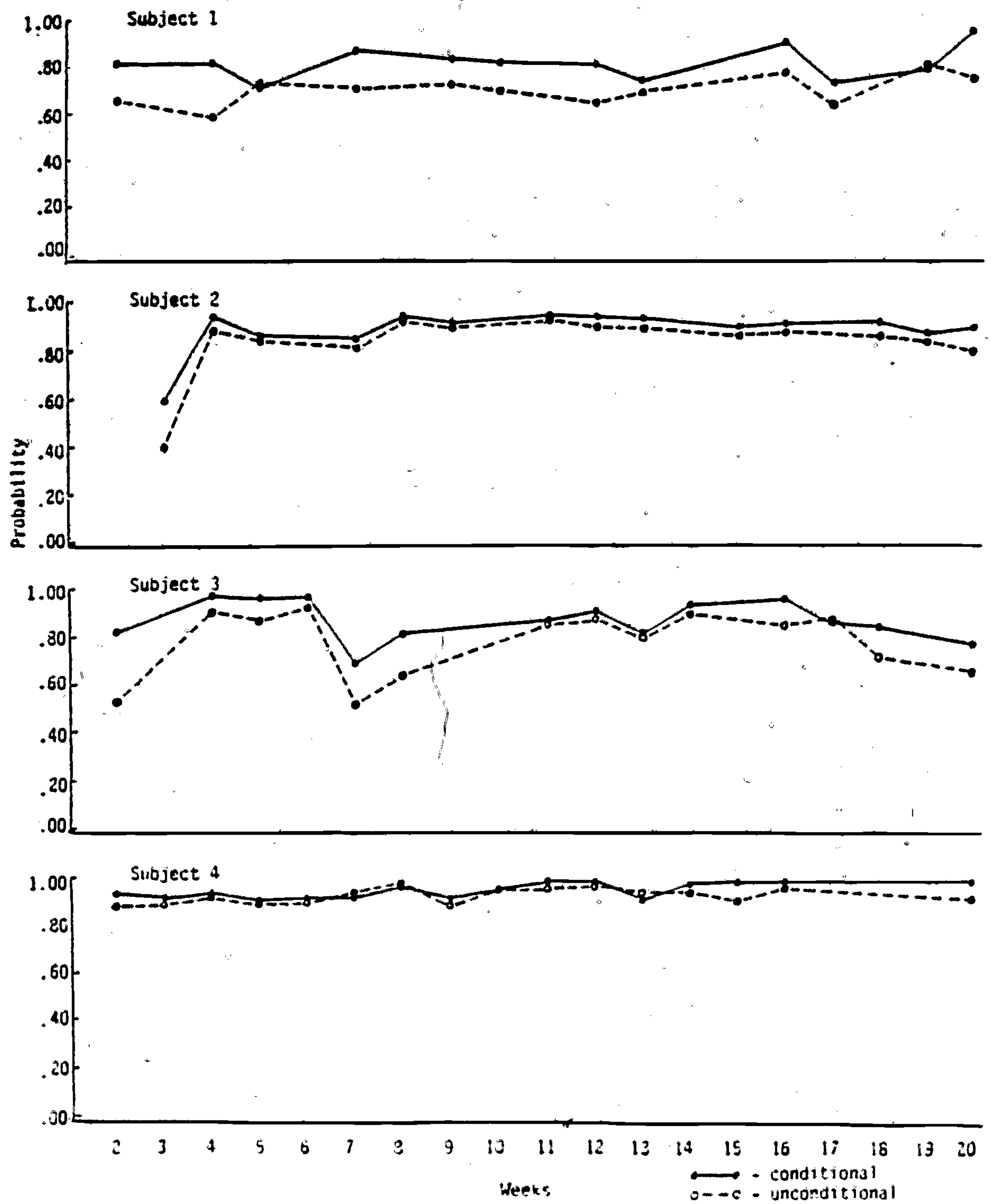

Figure 20: Conditional probabilities of mother talks to infant, given infant looks at mother and unconditional probabilities of mother talks to infant in interaction condition for all subjects.

tional probabilities of mother talks to infant. Null hypothesis 2 was accepted for all four subjects. Null hypothesis 3 was accepted for all four subjects. Null hypothesis 4 was rejected in favor of the alternate for Subject 2 only. Figure 21 is a graphic representation for each subject of the session differences between the conditional probabilities of mother talks to infant, given infant vocalizes and the unconditional probabilities of mother talks to infant.

Discussion

This chapter presents a discussion of the interobserver reliability results, the performance data which provide validation of the quantitative fixation skill assessment, and the results of the pilot study of mother/infant interaction. Implications of the results of this study are presented in terms of the practical application of the assessment procedures for classroom use and the possibilities for further research with respect to intervention for handicapped infants and children.

Assessment Condition Reliability

The interobserver data collected on the four nonhandicapped infants indicated that the procedure for measuring frequency and duration of visual fixations in the first four months of life was clearly reliable. The overall mean reliability scores across subjects and grid sections for frequency and duration of visual fixations were 99% and 96% respectively. These scores were higher than the mean reliability scores of 97% for frequency and 91% for duration of visual fixations reported in the original study (Eye and Janssen, Note 1) and comparable to mean reliability scores of 99% for frequency and 98% for duration of visual fixations reported in the replication study (Janssen, Note 3) both involving handicapped and nonhandicapped infants and children.

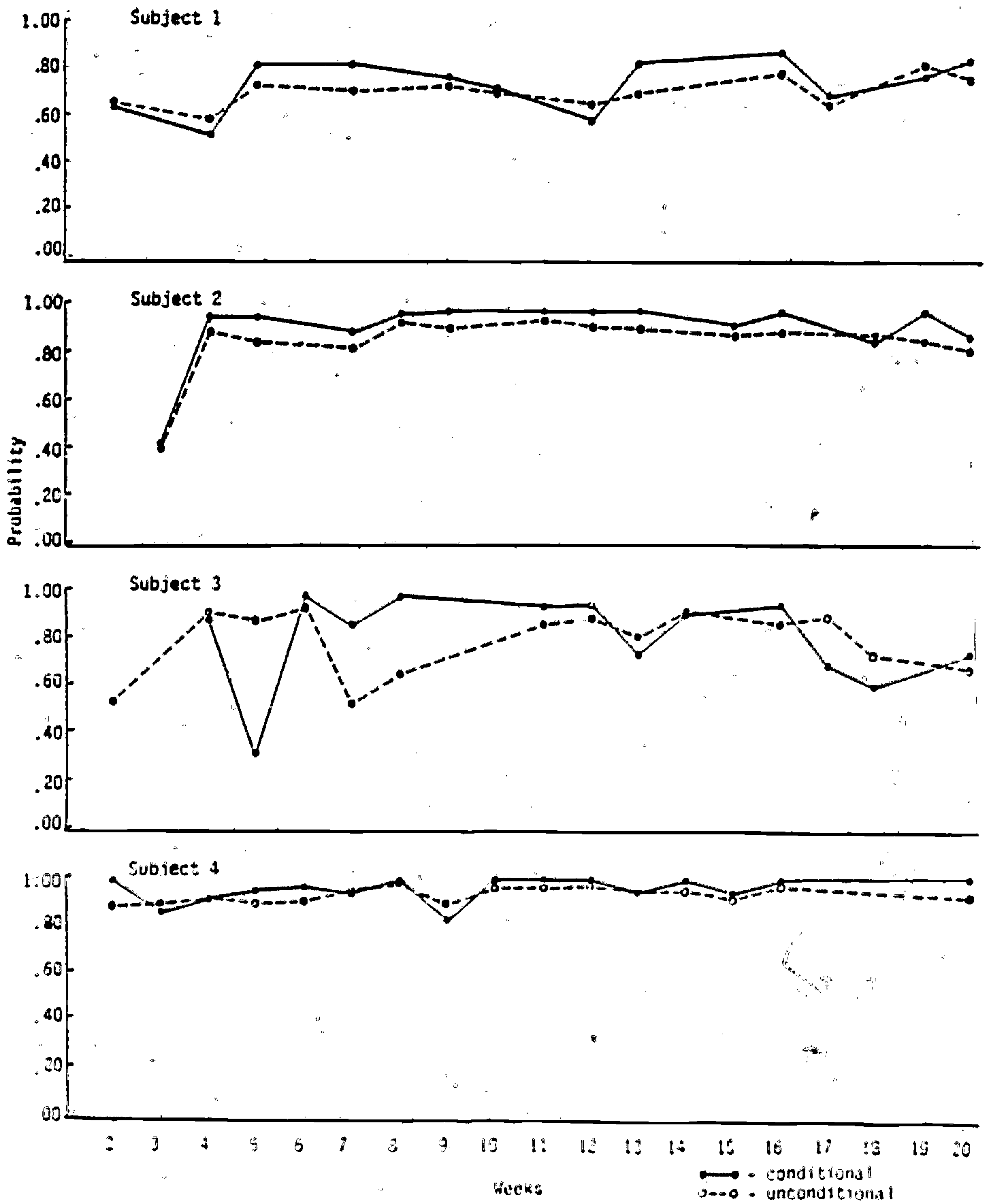

Figure 21: Conditional probabilities of mother talks to infant, given infant vocalizes and unconditional probabilities of mother talks to infant in interaction condition for all subjects.

Interaction Condition

The interobserver reliability data on infant visual, infant vocal, and mother behaviors within each setting in the Interaction condition indicated that the code and measurement procedures provided a reliable method of collecting interaction data on mother/infant pairs in the natural environment of the home. Comparable reliability scores across subjects were found for each of the three settings: 91.4% for Lap, 91.6% for Crib/Floor, and 91.4% for the Infant Seat setting. For all subjects, the lowest reliability scores occurred in the initial sessions, with higher scores obtained in later weeks. This could be due to one of two reasons: 1) the observers became more adept in using the code over time, and/or 2) the visual and vocal behavior of the infants became more pronounced as they were developing.

Not only were the code and procedures a reliable method for collecting mother/infant interaction data, the amount of observer training time prior to data collection was minimal. Three different reliability observers in addition to the experimenter were trained. The code was given to each observer to memorize prior to data collection practice sessions. Two one-hour practice sessions were needed for two of the observers and only one practice session was necessary for the other observer to reach the minimum acceptable reliability score of 80% between observer and experimenter.

Support for Detecting Acquisition of Visual Fixation

The slopes describing each subject's rate of change in performance in the Assessment condition over the 20 weeks of observation (Figures 4-6) indicated that the procedures detected acquisition of visual fixation skills in the first four months of life. For frequency of visual fixation an increasing trend was noted in each subject with positive slopes of .20, .32, .30, and .30 respectively. For duration of visual fixation an increasing trend was also observed in each subject with positive slopes of 4.26, 2.45, 2.66, and 3.29 respectively. These larger values can be accounted for due to the difference in scales of the y-axis. For mean duration of visual fixations an incrasing trend with a slope of .43 was noted in only one subject with the remaining subjects displaying relatively no trend with slopes of -.04, .03, and .02. Since both frequency and duration measures displayed increases over the 20 weeks of observation, mean duration measures reflected this by remaining relatively stable. As a result of these findings, it is felt that mean duration could be eliminated as one of the quantitative measurements in the visual fixation skills assessment.

Support for Sensitivity to Emergence of Visual Fixation

For each subject the individual session scores for the nine sections of the grid were combined into scores for the top three sections(ABC) which involved looking up, the middle three sections (DEF) which involved looking straight ahead, and the lower three sections (GHI) which involved looking down. The median scores of this performance for each of the three levels of grid sections (Table 3) indicated that the assessment was sensitive to emergence of visual fixation behavior in the first four months of life. For all three measures of visual fixation (frequency, duration, and mean duration), subjects' average performance was lowest in the top grid sections and highest in the lower grid sections. There was one exception to this in that Subject 2 had an average percent duration score which was higher for the middle grid sections than for the lower grid sections, however the duration score for the lower sections was still greater than the score for the top grid sections. These results suggest that as fixation skills are developing over the first four months of life, actual fixation behavior as measured by this assessment emerges according to the following general hierarchy: fixation first on objects which are below eye level, then fixation on objects at eye level, followed by fixation on objects above eye level.

Support for Reflecting Actual Visual Fixation Skill Level

To determine if the quantitative fixation assessment procedures reflected actual visual fixation skill level in the first four months of life, measures of frequency, duration, and mean duration were compared between the Assessment and Interaction conditions (Table 4). Hypothesis testing for significant correlations of measures between directed looking in the Assessment and Interaction conditions, between directed looking in the Assessment condition and looking at mother in the Interaction condition, and between directed looking in the Assessment condition and looking at objects in the Interaction condition did not indicate that the assessment reflected the infants' actual visual fixation skills since very few significant correlations were found.

It is felt that there are at least two reasons why only a few significant correlations were found, both of which involve the fact that the conditions, and therefore the comparisons between conditions, were not equal. The first reason involves "who" was in charge of directing the infant in looking at stimuli. For the Assessment condition the examiner gave the instructions to look, while during the Interaction condition the mother was responsible for directing the infant's looking behavior. The second reason why the comparisons were unequal involved "what" was being looked at. In the Assessment condition the infant was directed to look at objects only, while during the Interaction condition the infant looked at both her mother and the objects used in the Assessment condition. Ideally, the comparison between the Assessment condition and looking at objects in the Interaction condition should have resulted in significant correlations, however this was not the case due to a limitation in the Interaction procedures. Additional instructions should have been given to the mothers to provide at least one opportunity per object per setting for the infant to look at the two stimulus objects. As it was, the infants were oftentimes not given the chance to look at the stimulus objects, therefore, their performance scores for looking at objects in the Interaction condition did not reflect the infants' actual fixation skill level for inanimate objects.

Comparisons within conditions do, however, lend some support to the hypothesis that the procedures reflect actual visual fixation skill level. Frequency and duration measures within each condition were compared to determine the relationship between these measures. Hypothesis testing for significant correlations between these measures in each condition resulted in significant positive correlations for all subjects in both the Assessment condition and the looking at objects in the Interaction condition. These findings suggest that a similar relationship between frequency and duration measures exists for looking at objects in the assessment and when given the opportunity to look at objects by the mother. This relationship between frequency and duration of fixation does not exist for looking at the mother nor for combined looking at the mother and objects.

Interpretation of Interaction Pilot Study Results

The intent of the analysis of mother/infant interaction data was to determine the nature of relationships existing between the infants' behavior and both the mothers' visual and vocal behavior. However, the mother data from this study revealed that when under observation, mothers looked at their infants almost constantly (medians for looking at their infants for the four mothers ranged from 97.8% to 100% of the observation time). It was, therefore, not necessary to determine the probabilities of specific infant behaviors occurring, given that the mother looked at her infant, since these would all have been at or close to the perfect probability of 1.00.

These results are not surprising and have been described in other studies of mother/infant interaction: mothers spend the majority of observation time looking at their infants (Jones, 1977) and mothers gaze at their infants for extraordinarily long periods of time compared to average adult gaze exchanges (Stern, 1974). However, it is difficult to define the reason for the high percentage scores for mothers looking at their infants reported in this study. It is not felt that the tendency for mothers to spend large amounts of time looking at their infants is a comprehensive explanation. The presence of observers in the home also had an effect on the behavior of the mothers which must be taken into account. Since the observers started the tape recorder at the beginning of a five-minute observation period and stopped the recorder at the end of the period, the mothers were extremely aware of exactly when the observation periods began and ended. In turn, they were especially attentive to their infants during those periods. In order to obtain measurements in future studies of mother visual behavior which are more natural and which can be utilized in the interaction analysis, it might be advantageous to start the tape recorded intervals of an observation period and begin collecting data for an unspecified length of time before collecting the data for the actual observation period under study.

The mother vocal behavior also occurred at relatively high levels (medians for talking to their infants for the four mothers ranged from 72.5% to 94.0% of the observation time), however, the mother vocal behavior scores were considerably less than the mother visual behavior scores and were low enough to be amenable to conditional probability analysis. The results of this analysis indicated that all four mothers talked to their infants contingent upon the response of the infant looking at her mother. This relationship was not found in any of the four mother/infant pairs when the infant was looking at objects or when looking at something other than her mother or the objects. In addition, it was found that one mother (Subject 2) talked to her infant contingent on her infant's vocalizations.

These results are consistent with those found in other studies of mother/infant interaction. Vietze et al. (1978) found that mothers exhibited contingent vocalization in response to infants' vocal and visual behavior directed to their mothers. In discussing the results of several interaction studies, Yarrow et al. (1977) noted that infants who look at and vocalize to their mothers are likely to elicit more auditory and visual stimulation from their mothers. Bates, Camaioni, and Volterra (1975) contend that these early infant visual and vocal behaviors do not provide evidence of intentional communication in the first four months, but rather because of their signal value to the adult, usually result in prolonged interactions.

The fact is that all four mothers in this study displayed contingent vocalization to their infants when the infants looked at their mothers, yet only one mother provided this vocalization for vocal behavior in her infant. This result might be explained by suggesting that the mothers intuitively interpreted looking as communicative and therefore responded by talking to their infants, whereas the infant vocalizations were seen as random events, not intended for communication. The lack of contingent talking found in response to infant vocalization might also be attributed to a limitation of the analysis. For purposes of this analysis, conditional probabilities were calculated based upon behaviors which occurred within the same interval. A more appropriate analysis to detect the relationship of mother vocalization to infant vocalization might be to figure conditional probabilities based on an interval lag in which the occurrence of one behavior is analyzed in reference to the behavior(s) occurring in the following one, two, etc. intervals.

Further Analysis of Interaction Data

To accurately reflect the nature of the relationships between specific infant and mother behaviors, analyses behond that of within interval conditional probabilities will need to be conducted. The data collected as a result of the interaction procedures reported in this study are suitable for several other types of analysis. Lag interval conditional probabilities provide the probability of any behavior occurring one interval, two intervals, or any number of intervals after another behavior. Transitional analysis involves constructing matrixes of conditional probabilities from frequencies with which individual or groups of behaviors move into other intervals.

Sequential analysis of interaction data offers a method for investigating the flow of interaction in that one looks at the length of, initiator of, terminator of, and the nature of a behavior or chain of behaviors. Rosenfeld and Remmers (1981) have provided a description of techniques for detecting temporal relationships in mother/infant interactions through the use of sequential analysis and are in the process of developing computer programs to conduct this analysis on the type of data collected in this study (Rosenfeld, Note 5).

Problems with Interaction Studies

Several problems were encountered while collecting the mother/infant interaction data for this study which were consistent with those reported by other researchers (cf. Yarrow and Anderson, 1979). The presence of observers in the home which has been noted previously, has an effect which is difficult to define. It seems that in addition to the mere effect of the observer's presence, the way the study and its purposes are defined, the mother's personal definition of the observation situation, and her feelings about being observed will influence the mother's behavior with her infant.

The infants appeared to be less affected by the presence of observers, however their behavior was influenced by physiological factors such as hunger or thirst, time of day observations were taken, and weather conditions of the day of the observation. Of course these variables could have influenced the behavior of the mothers as well. The problem, therefore of obtaining a representative sample of behavior is a question of day-to-day or even hour-to-hour consistency in both mother and infant behavior.

Conclusions

The interobserver data collected on the four nonhandicapped infants indicated that the assessment procedures were reliable for measuring visual fixation behavior in the first four months of life. The performance data demonstrated that the procedures were a valid and therefore effective method of measuring visual fixation in that they detected acquisition of visual fixation, were sensitive to emergence of visual fixation, and reflected the infants' actual visual fixation skill level in the first four months of life.

The interobserver data collected on the four nonhandicapped infants and their mothers indicated that the interaction procedures were a reliable and efficient method for measuring mother/infant interaction behavior in the first four months of life. The initial analysis of the performance data demonstrated that the procedures were an effective method of measuring mother/infant interaction behavior in that the results were consistent with those of other mother/infant interaction studies. The data are suitable for further analysis which is necessary to accurately reflect the nature of mother/infant interactions. The methodology for collecting interaction data reported in this study should provide a useful tool for obtaining similar data on handicapped or at-risk infants and their mothers.

Implications for Practical Application of Assessment Procedures

The implications of this assessment procedure for practical application in a severely/multiply handicapped classroom are several. Performance results could be used to pinpoint weaknesses in visual fixation skills for individual students, therefore providing training objectives for those deficient skills. The results of periodic assessments could be used to measure progress in programs for individual students, thereby alleviating the need for daily data recording of fixation skill training. The results of this assessment could also be used to determine optimal placement of stimuli for other training programs such as those in the preacademic and prevocational curriculum domains.

Based on the assessment performance data of the four nonhandicapped infants in this study and the two infants from previous studies (Eye and Janssen, Note 1 and Janssen, Note 3), a minimum acceptable level of fixation performance could be determined. This information would allow teachers to set an appropriate frequency and duration criterion level for handicapped students to reach for fixation skill mastery.

Implications for Further Research

Further study is necessary in the use of the procedures to assess visual fixation. This should include determining how to integrate these procedures into a more comprehensive total assessment package. Research should also concentrate on the use of the visual fixation assessment as a tool for measuring progress as a result of intervention efforts with handicapped students.

A major emphasis of research in the future should be on how the acquisition of visual behavior in handicapped infants relates to the development of other behaviors. It is also important to discover how best to enhance that visual development in order to provide appropriate early intervention services to handicapped infants and young children. Extensive study needs to be conducted with mothers and their handicapped or at-risk infants to try to determine what factors influence early visual skill development in handicapped infants, how visual skills relate to other infants and mother behaviors when the infant has a handicap, and what strategies are effective in enhancing visual skill development in these infants.

Summary

The data collected on the four nonhandicapped infants indicated that the assessment procedures were a reliable and valid method of measuring visual fixation behavior. The assessment procedures successfully detected acquisition of visual fixation skills, were sensitive to emergence of visual fixation behavior, and reflected the infants' actual visual fixation skill level in the first four months of life. Furthermore, the data on the four infants and their mothers indicated that the interaction procedures were a reliable, efficient, and effective method of measuring mother/infant interaction behavior. The assessment procedures have implications for both practical application in the classroom and for future research efforts. The methodology for collecting interaction data should provide a useful tool to researchers for obtaining much needed data on handicapped or at-risk infants and their mothers.

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71

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AN APPLICATION STUDY:

Evaluating Neurodevelopmental Training and Theory with Cerebral Palsied, Severely Handicapped Students[1]

by

Mary Jo Noonan

[1] The procedures and data reported in this study were taken from a Doctoral disseration by Mary Jo Noonan that was submitted to the Department of Special Education, University of Kansas, in June, 1982.

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?
2. Do improvements in postural reactions correspond to a decrease 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.

Methods

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. Additionally, 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.

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.

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 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. 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.

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, rather than measured each session, to reduce the possibility of reactive effects from repeated measurement (see Table 2).

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 1). 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.

Table 2

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)	

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 1. Training schedule followed by each trainer. The date was recorded in the left column, and the information in each column across from 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.

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:

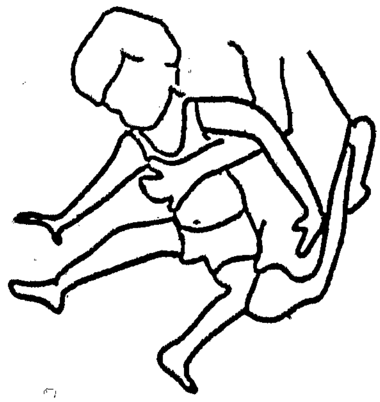
a) equilibrium reaction - The student is seated cross-legged, in ring-sitting, or long-legged, on the floor facing a mirror, and supported by the trainer at the upper trunk. When gently tipped to one side (about 45°) the subject's arm (of the side to which the subject was tipped) will extend and the trunk will tilt towards the opposite side within five seconds (see Figure 2a).

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 2b).

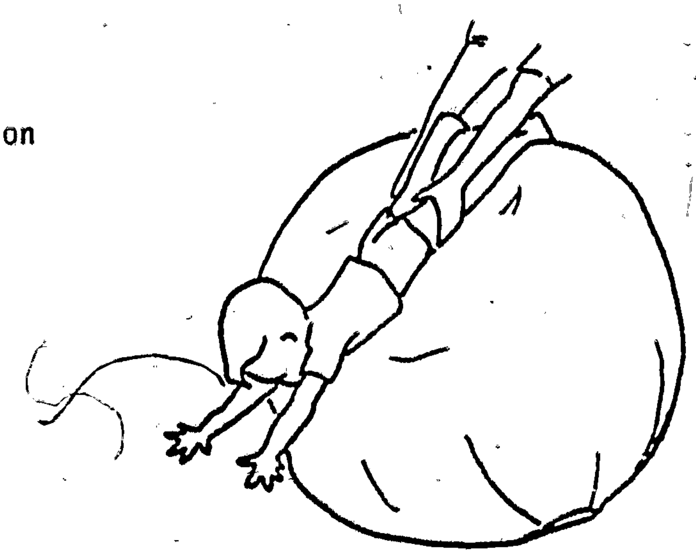
c) righting reaction (head righting) - The trainer is seated on a chair and the student is supported under the arms and seated on the trainer's lap. Both are facing the mirror. When the student is gently tipped to one side (about 45°), the student will maintain or regain a midline head position within five seconds (see Figure 2c).

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 3). The scoring indicated the "level of assistance" needed by the subject to respond as each reaction was defined. Table 3 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



a. Equilbrium Reaction



b. Parachute Reaction

c. Righting Reaction

Figure 2. Stimulus positions for training the three postural reactions.

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													

Figure 3. 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.

Table 3

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.

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).

Tonic reflex. 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 Primitive Reflex Profile (Capute et al., 1978).

An ATNR 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)

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 4).

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 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

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

1, Sam; Subject 3, Charlie; and Subject 4, Loretta) were probed with the degrees of trunk rotation measure from the rolling assessment procedures. Head erect and rolling data sheets are presented in Figures 5 and 6, respectively.

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 3). Levels of assistance training 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.

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 5. 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 longest 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.

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

Name ____________________ Evaluator ________________

Date ____________________ Observer ________________

Descriptors

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

Figure 6. 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.

Experimental Design

A multiple baseline design (Baer, Wolf, & Risley, 1968; Hersen & Barlow, 1976; Sidman, 1960) across two subjects was replicated three times (see Figure 7). 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 previously specified. Verbal and social praise were given noncontingently and for cooperation during the baseline condition.

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 (à 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 following the four levels of assistance training procedure was conducted each session; training was directed at improving equilibrium, righting, and parachute reactions.

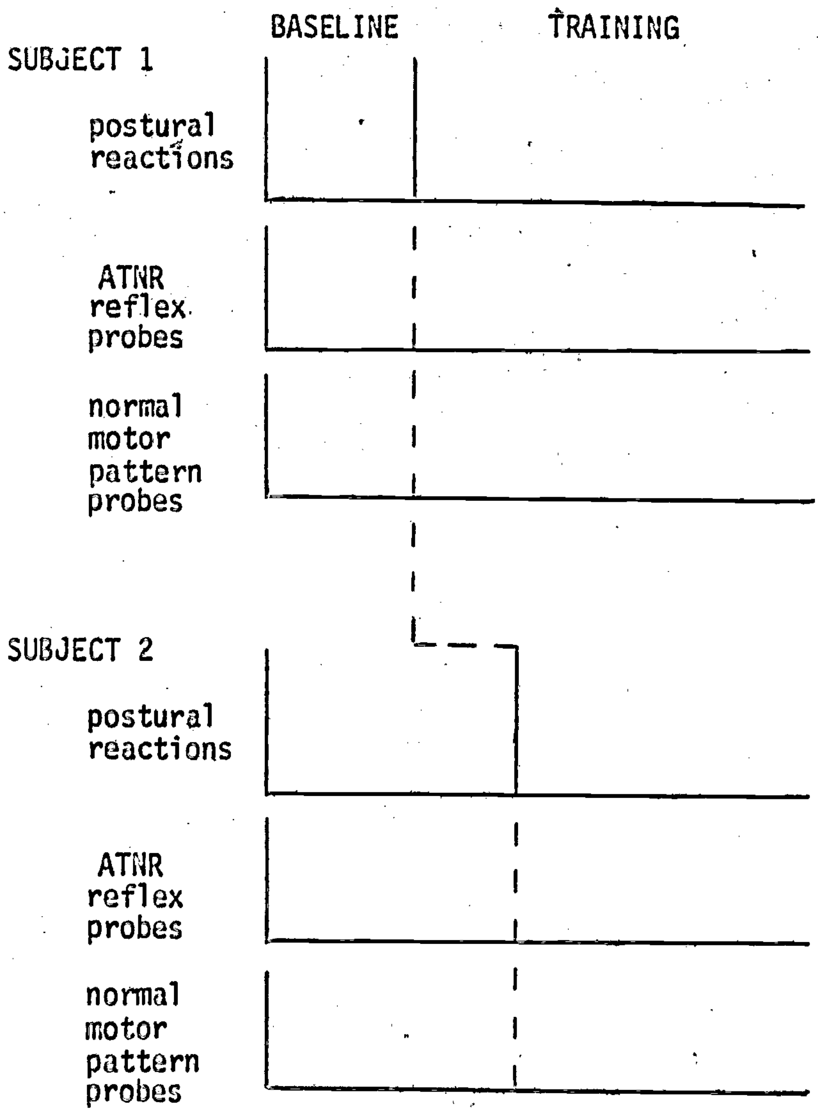


Figure 7. Multiple baseline across two subjects; postural reactions were trained for each subject, and the ATNR and a motor pattern were monitored with probes. (The design was replicated twice.)

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.

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 7). Least squares regression lines calculated with the TI 55 Texas Instrument hand calculator were fitted

102

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 <u>baseline</u> 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 $\underline{b}$ is the slope of the baseline regression line, and $\underline{a}$ 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.

Results

Reliability

Mean interobserver reliability scores across sessions for each child are listed in Table 4. 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%.

Within-Subject Data Analyses

A visual analysis of the data is presented first for each subject (see Figures 8 through 18). 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 19).

Table 4

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

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 corresponding 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.

Subject 1 (Sam) and Subject 2 (Janet). Figure 8 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 9 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 8). 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)

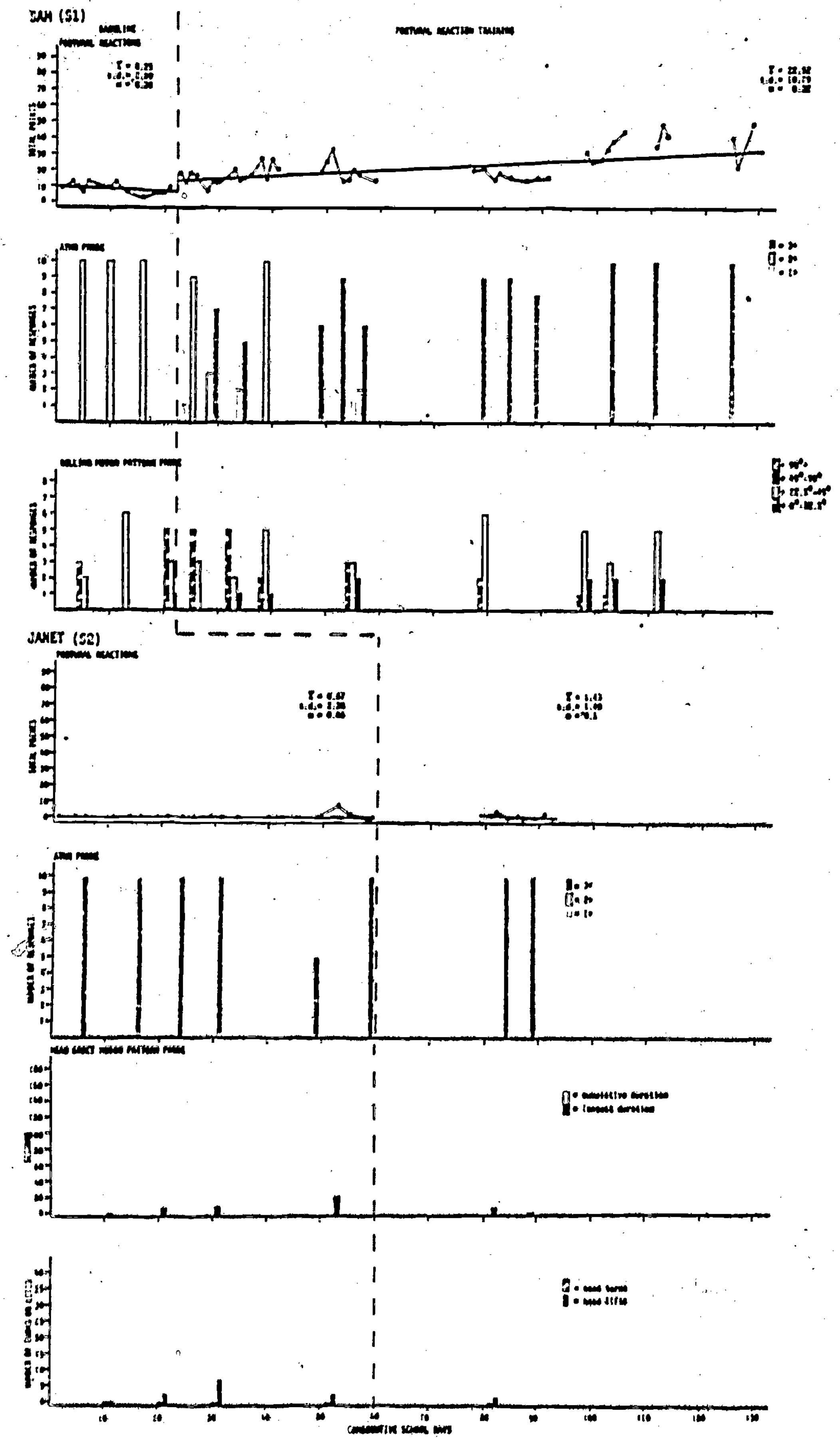


Figure 8. Postural reaction, ATNR probe, and motor pattern probe data for Sam (Subject 1) and Janet (Subject 2) across sessions.

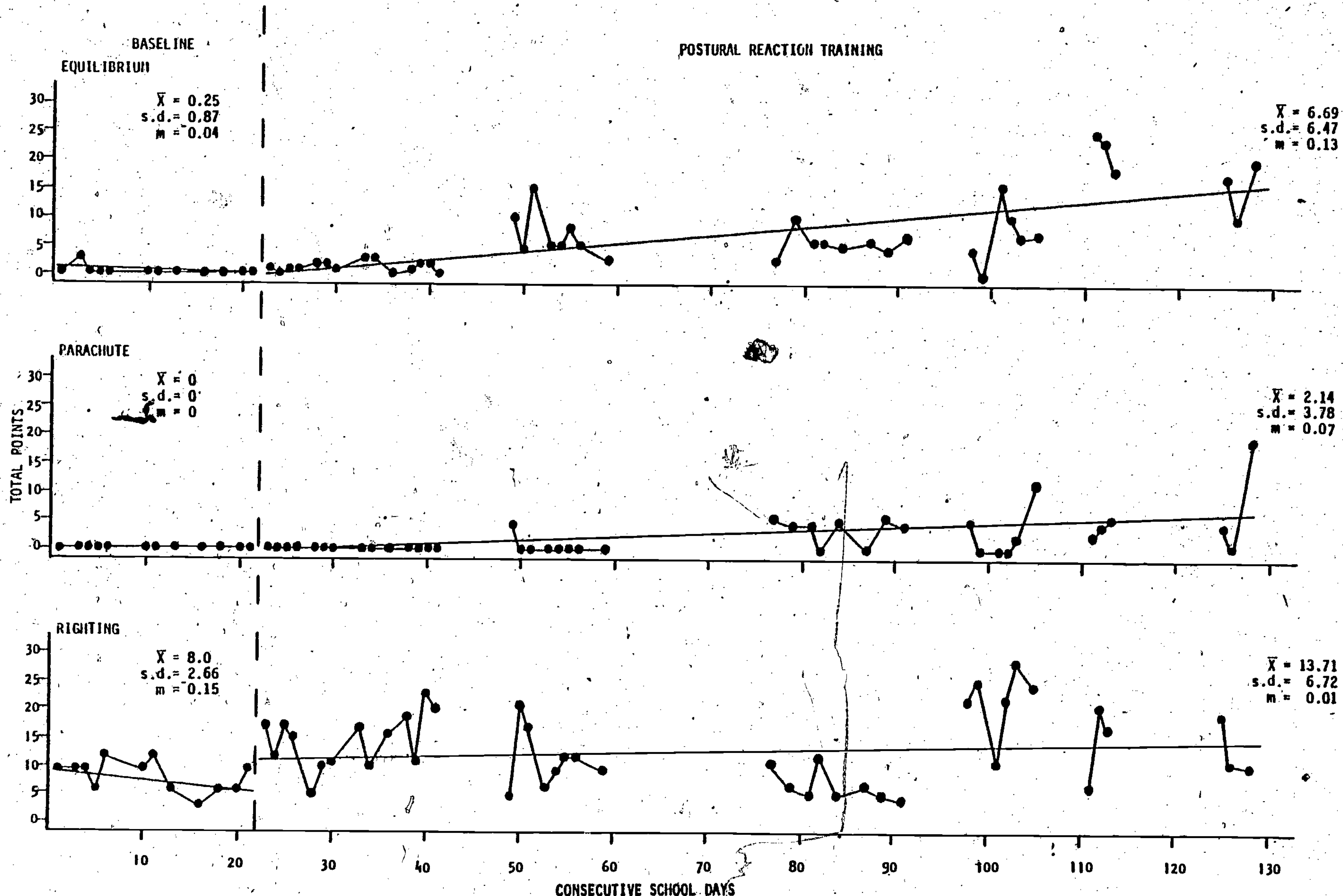


Figure 9. Individual postural reaction data for equilibrium, parachute, and righting responses across sessions for Sam (Subject 1).

were noted with increasing frequency. The improvement in postural reactions were accompanied by an increase in the level of ATNR responses.

Degrees of trunk rotation measured in the rolling motor pattern probe increased slightly throughout training (see Figure 8). 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 5) produced a z-score of -5.10, significant at the .05 level using a two-tailed test. Kendall's Tau (see Table 6) 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 8). 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 10. Baseline and training conditions had consistently lower scores for the equilibrium response; however, all responding greater

Table 5

Mann-Whitney Analysis of Variance

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 6

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	-.73					.39	.67
7. (Matt)								.60	.22

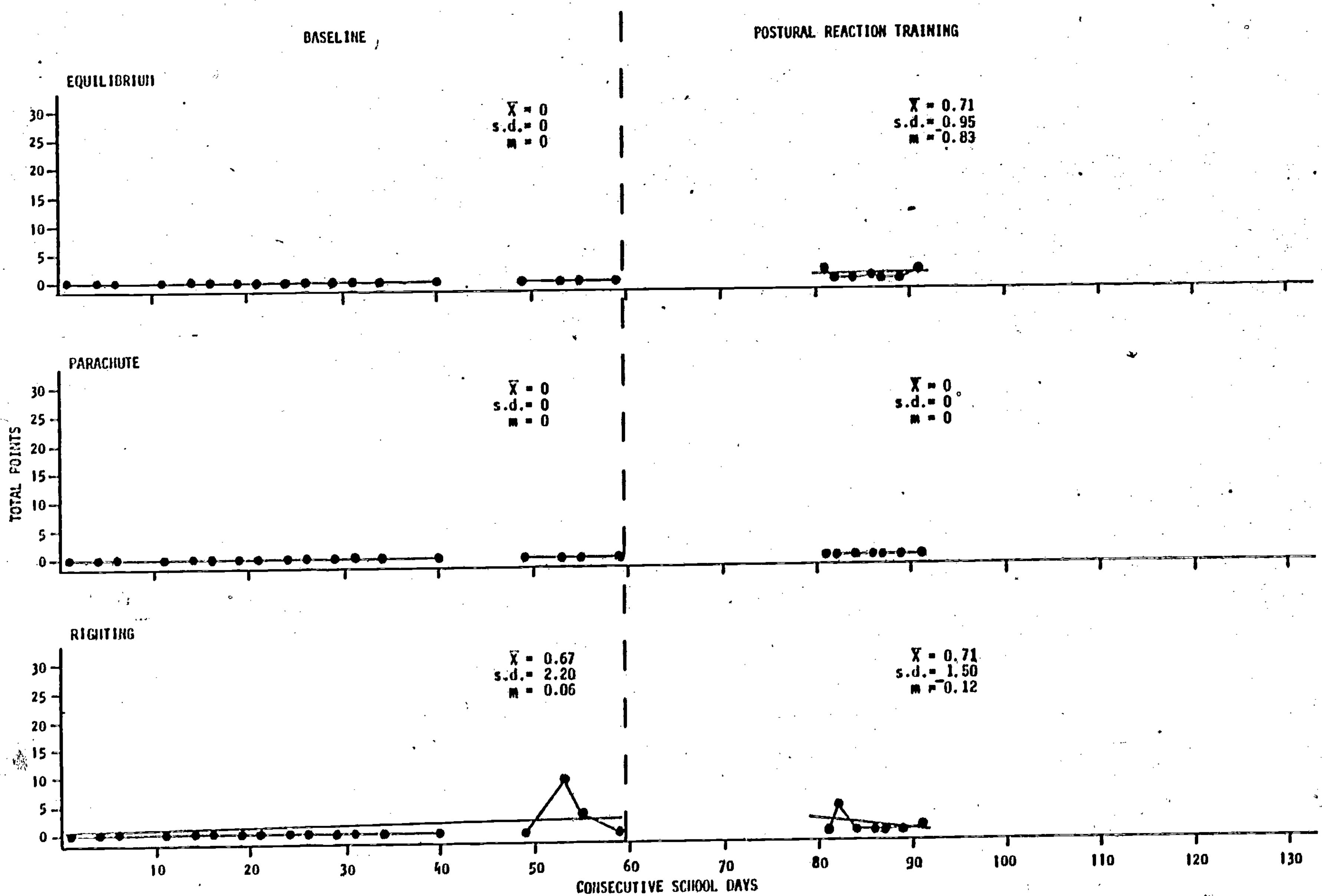


Figure 10. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Janet (Subject 2).

than a score of zero occurred during training. There was no change in 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 8). 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 8 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 5. 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 11, 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 12 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 11 was found in the righting reaction data displayed in Figure 12.

Probe data for the ATNR were variable and no trend in the data was evident for Charlie (see Figure 11). 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 11). 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.

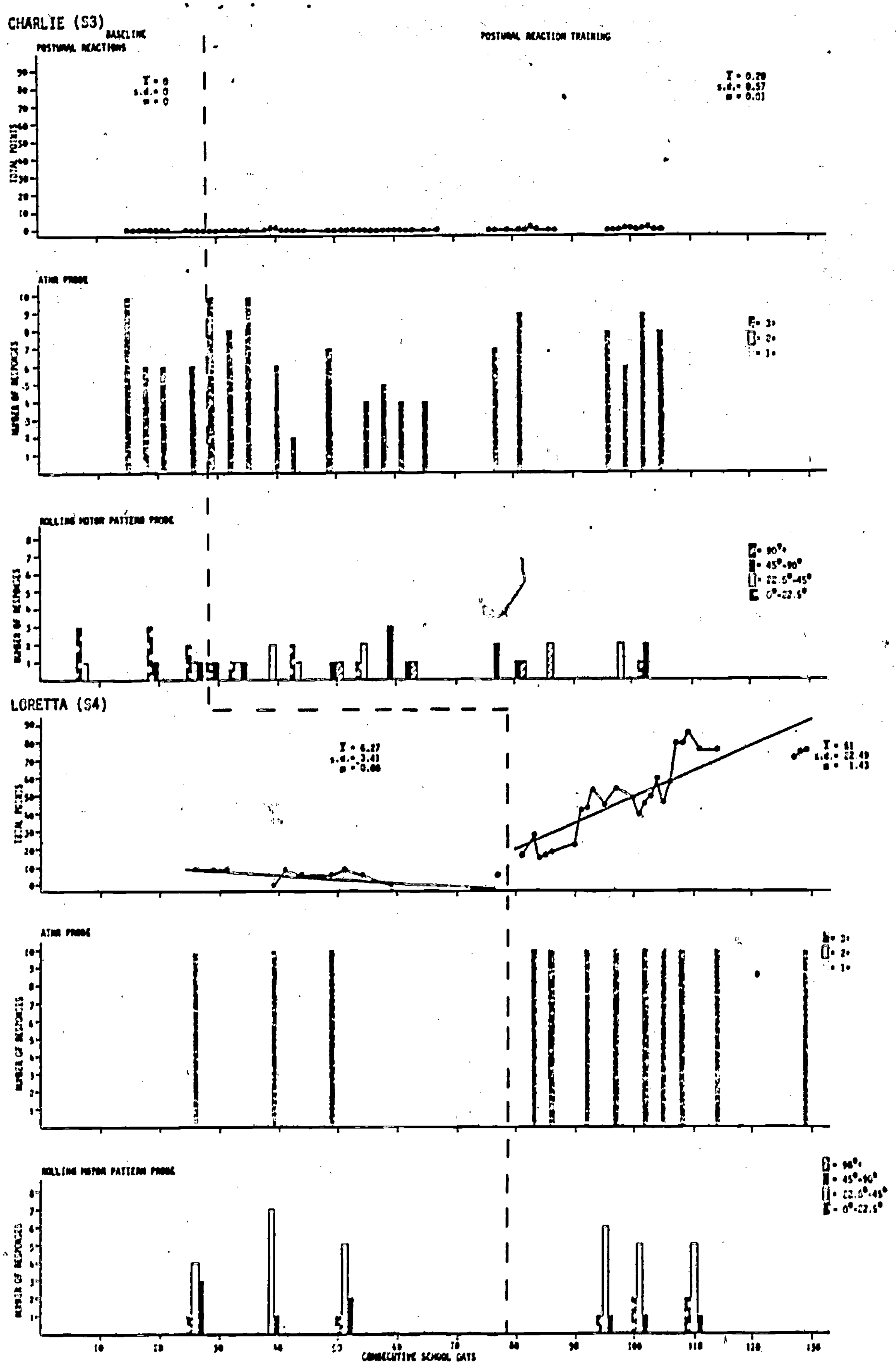


Figure 11. Postural reaction, ATNR probe, and motor pattern probe data for Charlie (Subject 3) and Loretta (Subject 4) across sessions.

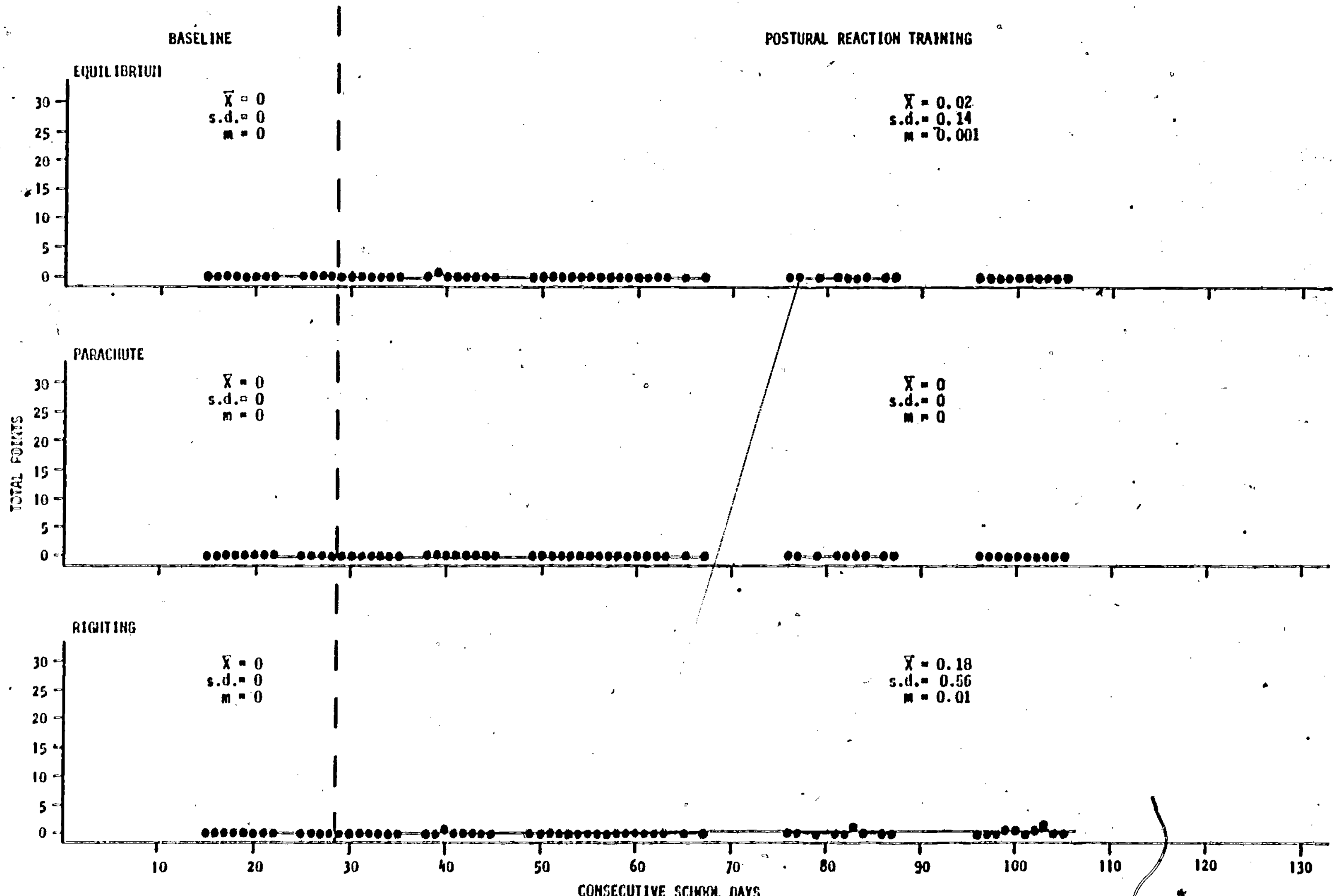


Figure 12. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Charlie (Subject 3).

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 5 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 6).

A gradually decreasing baseline (m = -.08) with a mean of 6.27 characterized the postural reaction data for Loretta (Subject 4) (see Figure 11). 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 86 (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 13 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

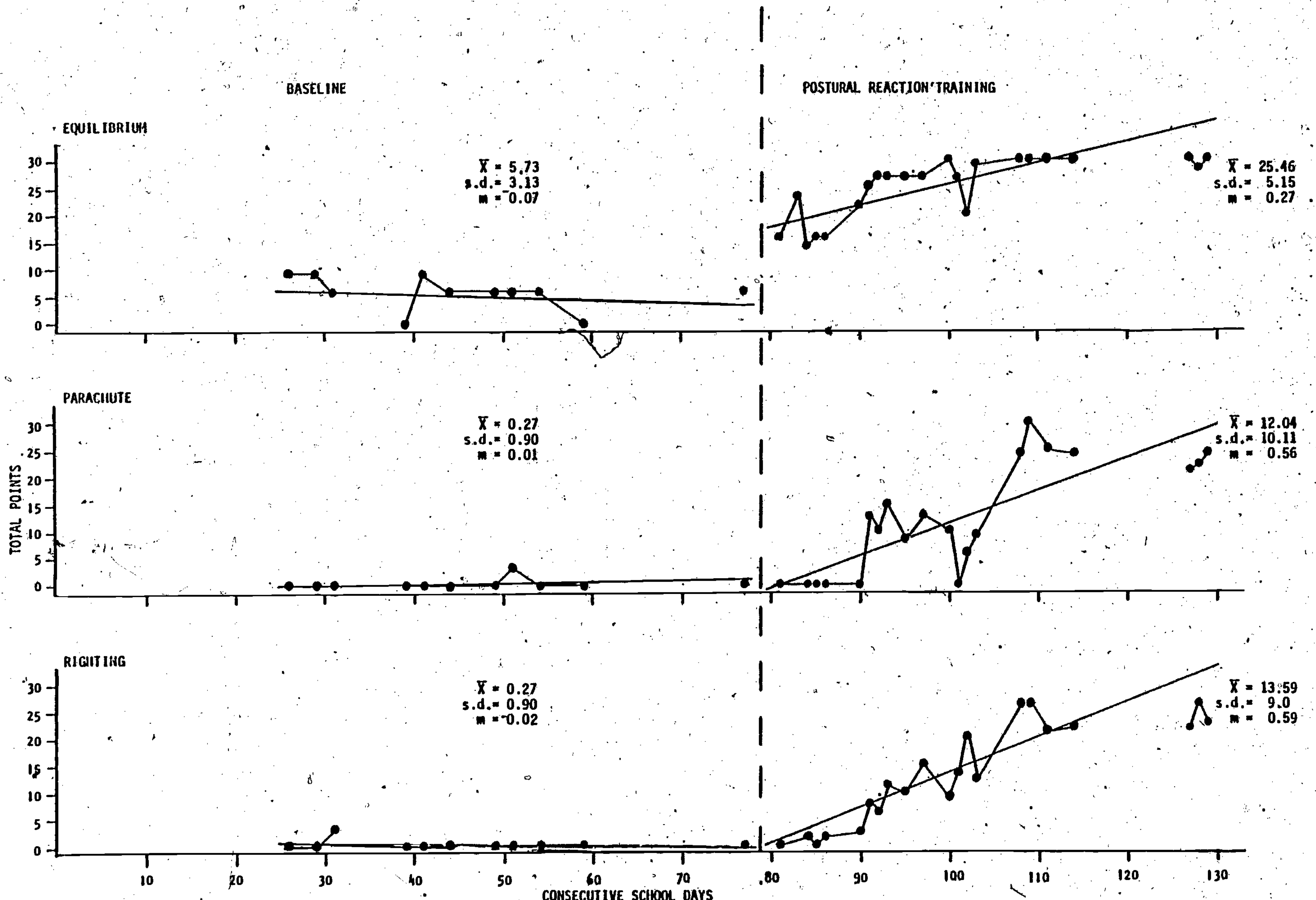


Figure 13. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Loretta (Subject 4).

more gradually than the equilibrium reaction. All three postural reactions, 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 11). 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 11). 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 5, 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 6).

<u>Subject 5 (Kathy) and Subject 6 (Marilyn)</u>. In Figure 14, 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

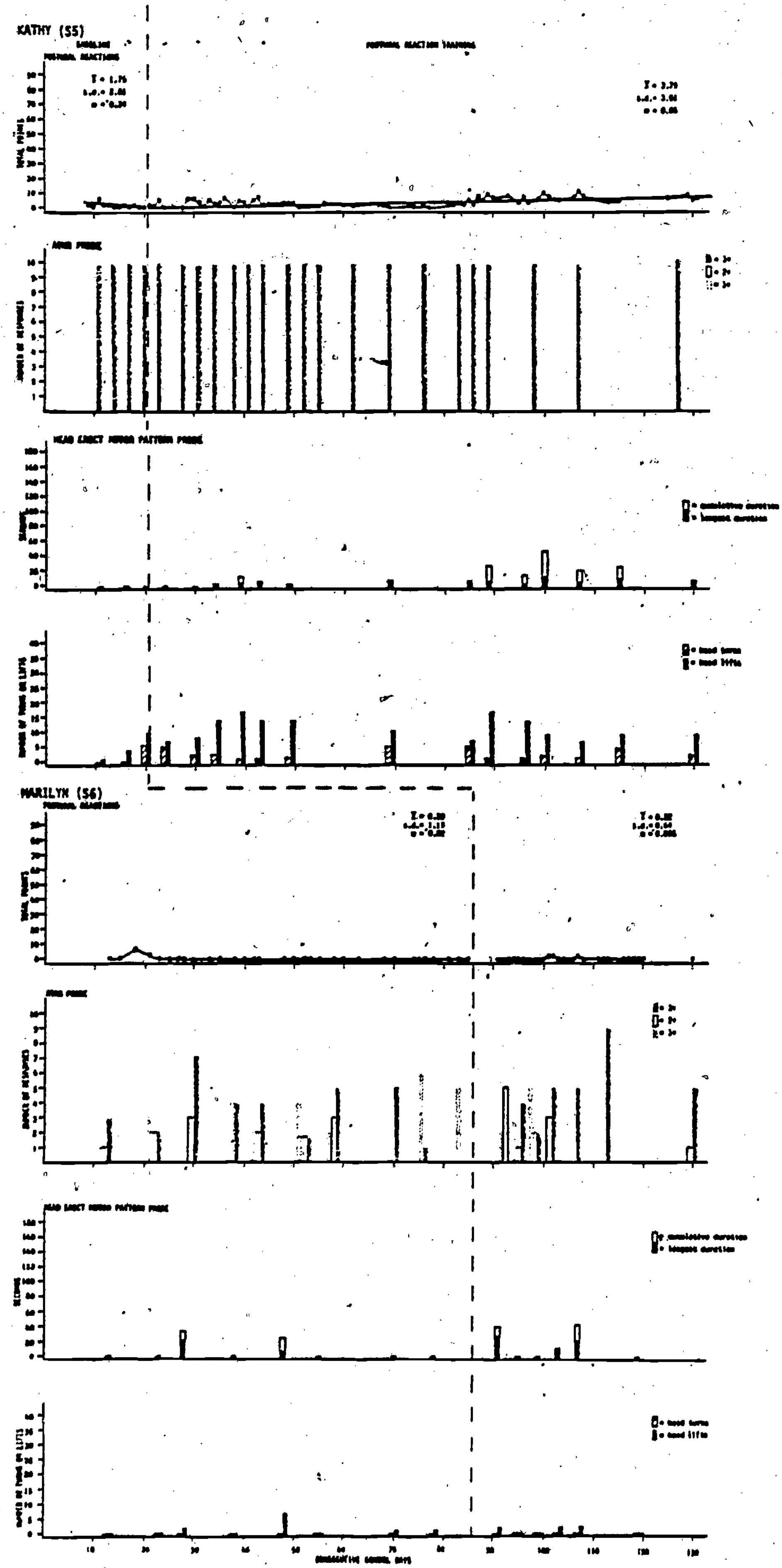


Figure 14. Postural reaction, ATNR probe, and motor pattern probe data for Kathy (Subject 5) and Marilyn (Subject 6) across sessions.

deviation (3.01) of the postural reaction training condition were both 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 15. 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 14). 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 14, 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.

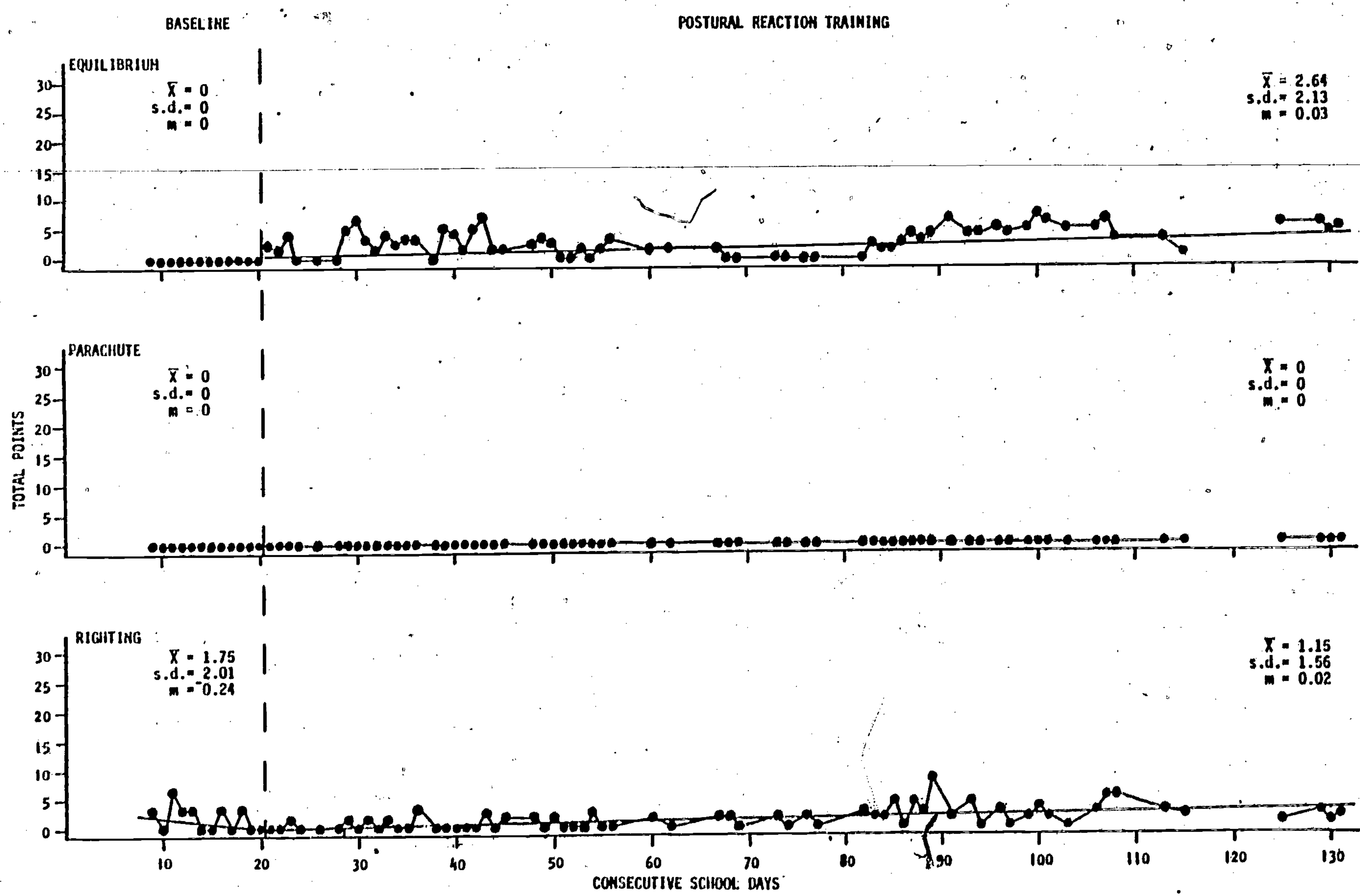


Figure 15. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Kathy (Subject 5).

A Mann-Whitney z-score of -5.10 was obtained for Kathy (see Table 5). Kathy's training condition was significantly different than baseline 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 14). 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 16 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 14). 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 14). 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

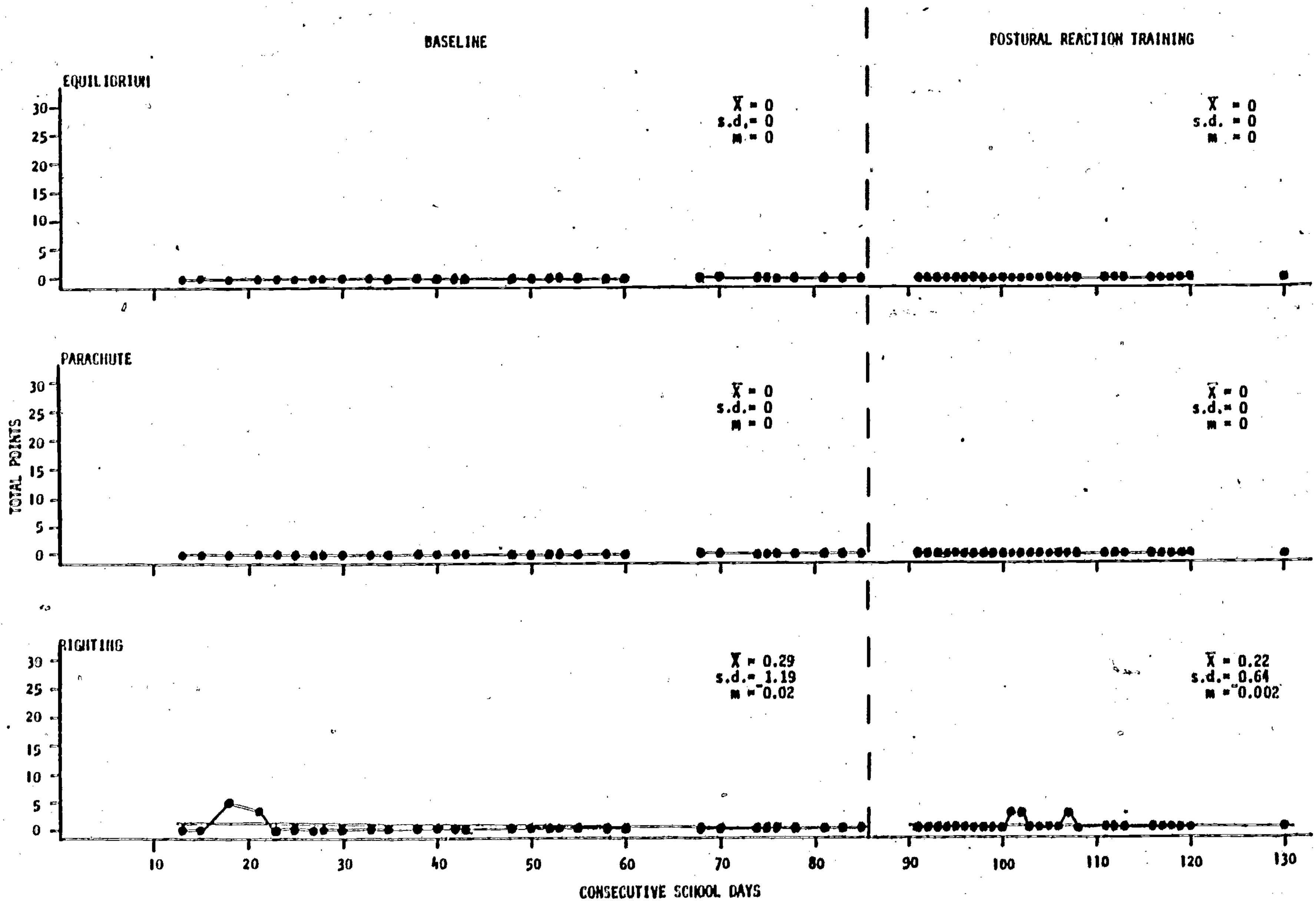


Figure 16. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Marilyn (Subject 6).

seconds (session 107), and 7 was the largest number of head lifts recorded during a 180-second probe (session 48).

Marilyn's z-score from the Mann-Whitney Test was 5.68, significant at the .05 level for a two-tailed test (see Table 5). For Kendall's Rank-Order Correlation Coefficient (see Table 6), 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 17). 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 18 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 17). 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 17). Cumulative duration reached 180 seconds

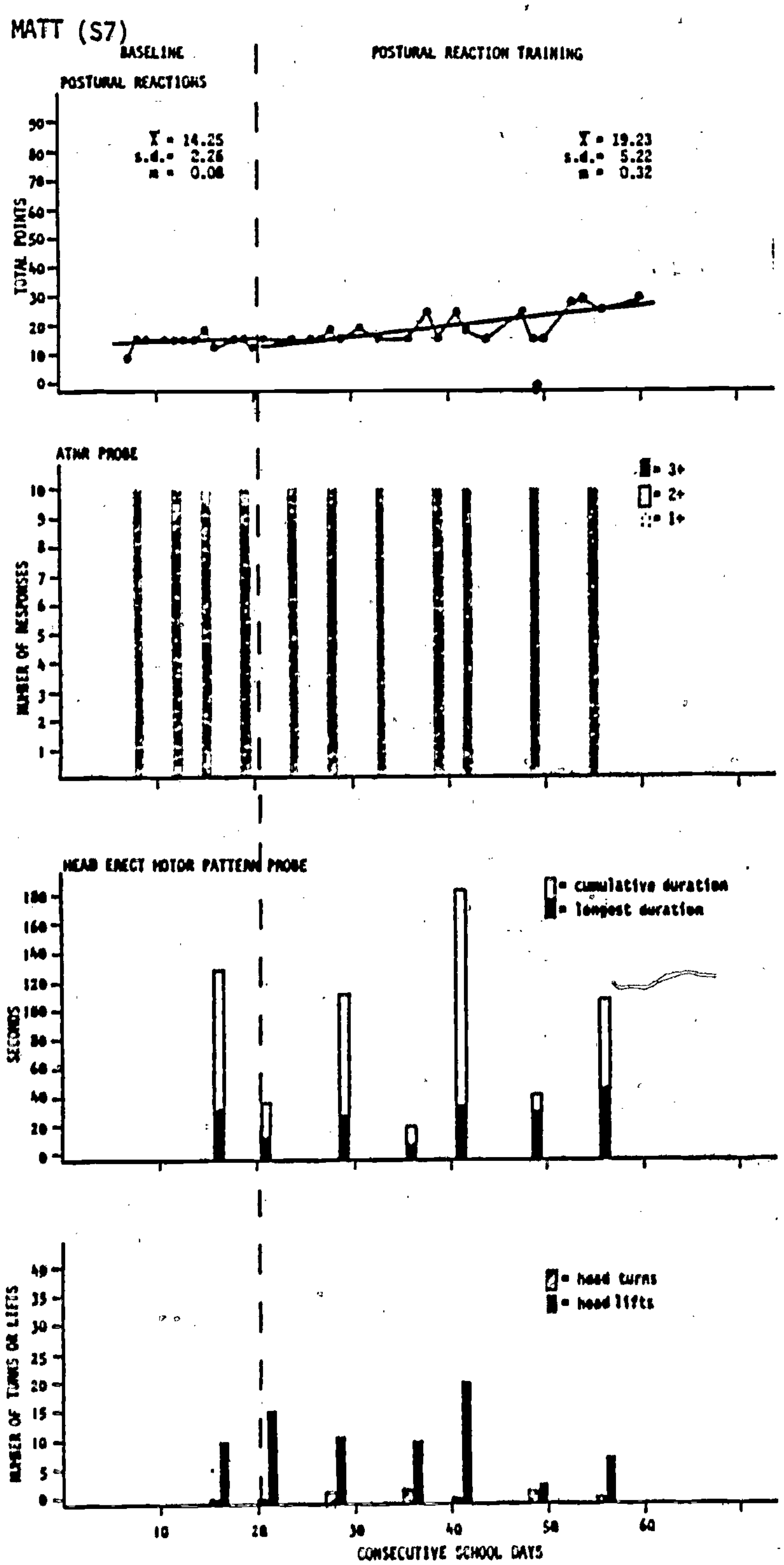


Figure 17. Postural reaction, ATNR probe, and motor pattern probe data for Matt (Subject 7) across sessions.

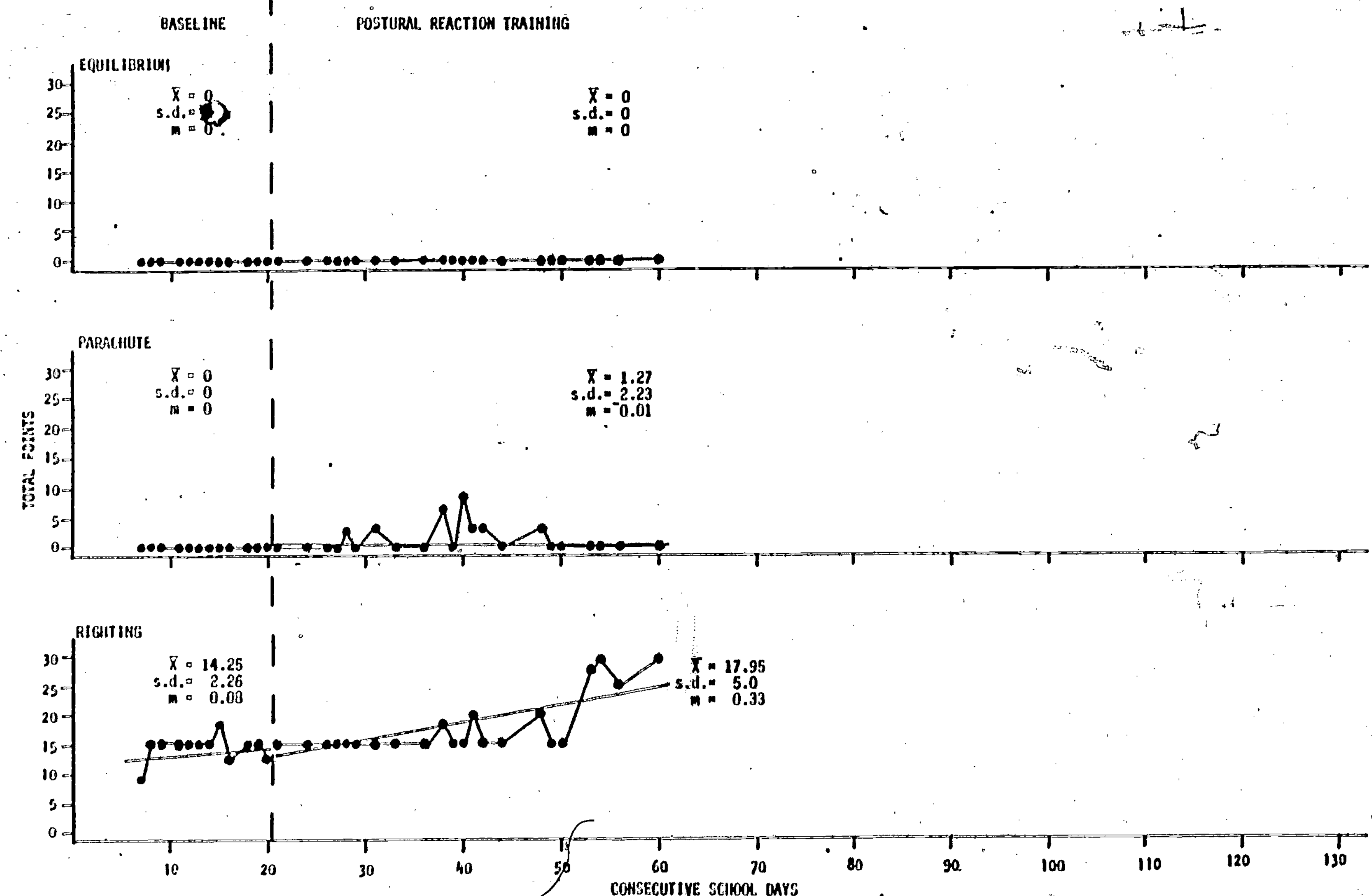


Figure 18. Individual postural reaction data for the equilibrium, parachute, and righting responses across sessions for Matt (Subject 7).

(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).

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 5). 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 6).

<u>Overall postural reaction results</u>. Figure 19 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).

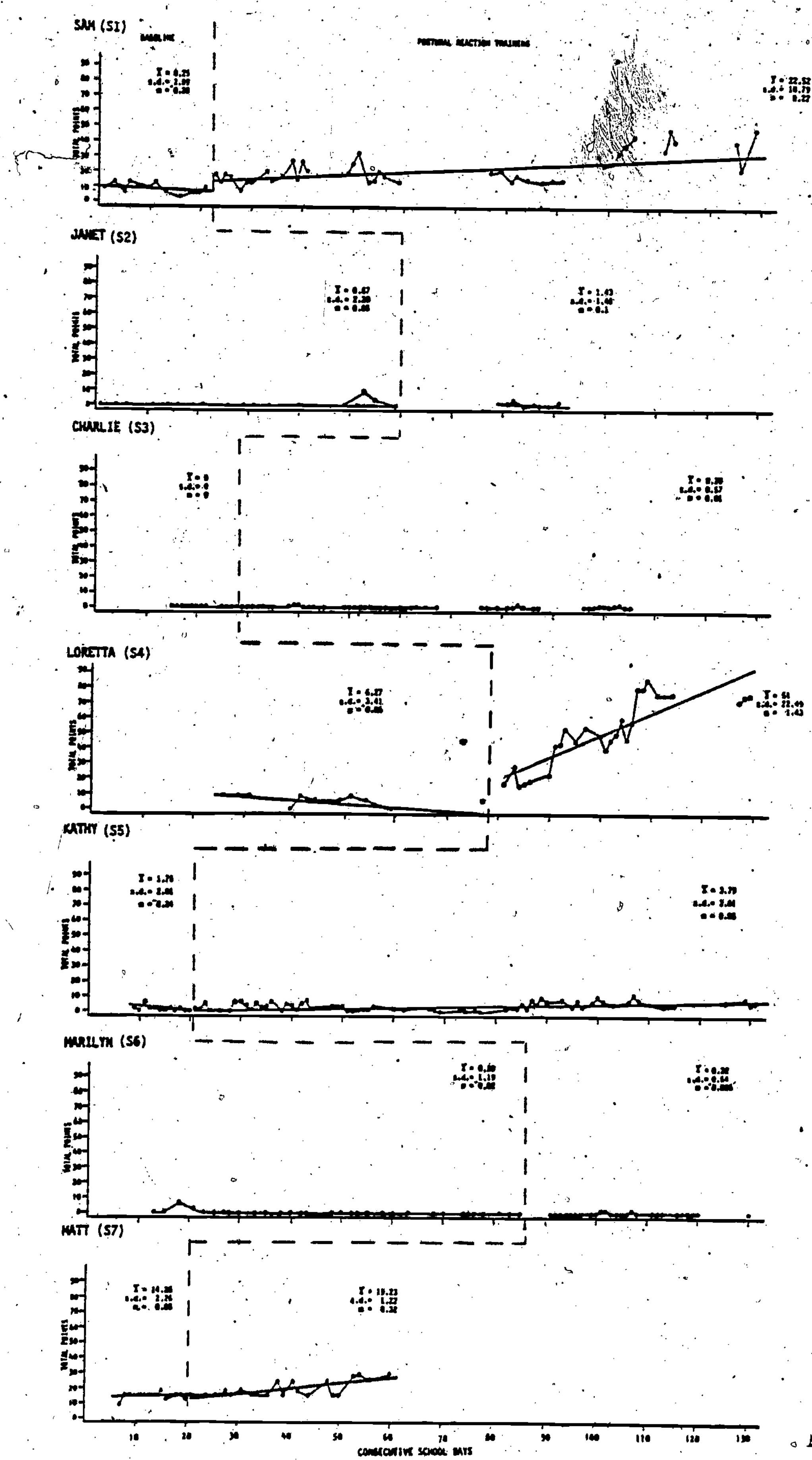


Figure 19. Postural reaction data across sessions for all seven children.

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 discription 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)

Application of single subject research design. 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 reveiwing 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.

Reference Notes

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AN APPLICATION STUDY: The Effects of Vestibular Stimulation and Social Reinforcement on Speech and Motor Behaviors in Multiply Handicapped Preschoolers[1]

by

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

Introduction

The role of the vestibular system in the acquisition of motor, and more recently, speech behavior has been the subject of a number of current investigations. Literature on the influence this system exerts on the developing organism is summarized in order to provide a basis for understanding the pervasive implications of vestibular dysfunction on development. Research on intervention is reviewed to develop a rationale for the application and selection of vestibular stimulating activities as a therapeutic technique to be employed with severely/multiply handicapped children with speech and motor delays.

The purpose of this investigation was to study the effect of vestibular stimulation and social reinforcement as an intervention for decreased head erect behaviors and rates of vocalizations in multiply handicapped preschoolers. The intent was to quantify the effects of this intervention across behaviors and students.

Method

Subjects

Three multiply handicapped preschool aged children participated in the study for a period of fifteen weeks. The children attended the Multiply Handicapped Classroom in the Children's Rehabilitation Unit/ University Affiliated Facility at the University of Kansas Medical Center. Each of the children were involved in motor and speech programs in the classroom with varying degrees of success. They were selected for participation in the study based on their delays in motor development (particularly head control), and low rates of vocalizations.

An authorization and release form were signed by each subject's parent prior to the study.

Subject 1. Randy was a 3½ year old boy with spastic cerebral palsied quadriplegia. Tone fluctuated from moderate to severe hypertonicity. He rolled with assistance and required trunk support in the sitting position. Randy characteristically demonstrated decreased head control in prone, supported sitting, and supported standing positions. The rate of vocalizations were low, and were typically elicited from periods of excitement, contentment or frustration. Vocalizations were not considered to be under stimulus control.

Subject 2. Justin was a 4 year old boy with spastic quadriplegia and microcephaly. Tone fluctuated from mild to moderate hypertonicity. He rolled with assistance and required trunk support in the sitting position. Head control was diminished in prone, supported sitting, and supported standing positions. Justin's rate of vocalizations were highest when he was fussing and in situations where maximum auditory, visual, and tactile stimulation were given on a one-to-one basis. Vocalizations were not considered to be under stimulus control.

Subject 3. Heather was a 5 year old girl with athetoid cerebral palsied quadriplegia. Tone fluctuated from hypotonicity to moderate hypertonicity. She rolled independently and sat unsupported using extended arm props for short periods. Minimal to moderate assistance was required when moving from a lying to sitting position. Head control was inconsistent in the prone, independent sitting and supported standing positions. The rate of vocalizations varied with Heather's mood. Vocalizations for a "yes" response were under stimulus control.

Setting

All three children were observed in a large, well lit, carpeted room located across the hall from the classroom the children attended. Observation windows were available.

Materials and Equipment

Two data sheets were required. One data sheet was used to record head erect behavior, and the other was used to record the coded vocalizations. Three stopwatches were required. Two watches recorded cumulative duration of head erect for each of the two observers, and the other watch was used to record the total duration of the measurement period. A tape recorder was used to record vocalizations made by the children.

The two apparatuses employed to provide the vestibular stimulation included a 24-inch gymnastic ball and a net hammock suspended from the ceiling. A plastic, pre-molded Tumbleforms seat, manufactured by the Preston Company, held the child in a comfortable sitting position while in the hammock. The chair was equipped with a safety belt, which provided additional security for the child while in the chair.

A pair of sandbags or an assitant were typically used to stabilize the subject in the prone position to prevent rolling.

Selected toys and the observers' verbal and facial expressions were used to encourage head erect behavior during the measurement period.

Experimental Procedure

A reversal design across subjects was employed to compare the effects of social reinforcement to vestibular stimulation and social reinforcement. The following behaviors were measured across all conditions: cumulative duration of head erect, frequency of head lifts, and frequency of vocalizations.

Intervention

Social reinforcement. Social reinforcement in the form of verbal and gestural encouragement was present across all conditions, with the exception of the two conditions where the social reinforcement was withdrawn. Across baseline conditions, the children were placed in the same situations and positions employed in the intervention phases but vestibular stimulation was not provided. The duration for each activity was held constant across conditions. They were placed on the ball and in the swing, handled, and given verbal and physical interaction, but no movement was provided.

Vestibular stimulation and social reinforcement. This intervention procedure consisted of a sequence of rocking and spinning movements that was performed on the ball and in the hammock while the subject was in a sitting and sidelying position.

The upright and sidelying positions were chosen in the design of the intervention procedure to promote maximum facilitation of the vestibular mechanism. The upright and sidelying position of the head enabled more efficient stimulation of the horizontal, posterior and anterior semicircular canals. Approximately 100 seconds of vestibular stimulation were given during this procedure. Following the vestibular stimulating activities the child was positioned comfortably on the floor for a 3 minute rest period. Social reinforcement was provided throughout each session for any vocalizations made by the child. After the rest period, the child was placed in the prone position and head erect behavior was measured. Social reinforcement was again given but directed at head lifts rather than vocalizations.

Response Definitions

Head erect behaviors. The following aspects of head erect in the prone position were the target behaviors of data collection: frequency of head lifts and cumulative duration of head erect. These behaviors were observed following the intervention sequence while the subject was maintained in the prone position.

Head lift. The head was considered to be in the erect position when no part of the head or neck (chin to clavicle) was touching or resting on the floor or the childrens' arms.

Each session consisted of one trial, 3 minutes in length. This trial was conducted at the end of each session across all conditions. During the 3 minute session, the frequency of head lifts and cumulative duration of head erect were simultaneously recorded on the data sheet. Specifications of the position of the subject and observers and the sequence for observation for head erect are described in Volume I: Assessment Procedures for Developmental Milestones and Volume III: Replication of the Procedures.

Vocalization behaviors. The target behaviors were any vocalizations made by the child during the data collection period. The data collection of speech behaviors were made by tape recording during the time allotted for the intervention sequence and a three minute rest period that followed.

The code developed by Mavilya (Note 1) was utilized in the determination of speech and non-speech sounds. Nonspeech sounds were listed as a chuckle, laugh, cry, outcry, grunt, struggle grunt, whimper, sputter, sneeze, snort, smack, suck, yawn, sigh, cough, coo, hum, hiccough or throaty sounds. All other utterances were regarded as speech.

Vocalizations were recorded on cassette tapes and marked for date and name of child. The tapes were later played by the observer. A data sheet was used to record and total speech and nonspeech sounds for each child in each session. Hash marks (/) were used to record frequency of vocalizations.

Measurement

Past investigators developed (Foshage, Note 2) and replicated (Collier, Note 3) a procedure for measuring head erect behavior in multiply handicapped children. This procedure was later revised (Rues, Note 4) for use on a nonhandicapped population.

A procedure for measuring infants' vocalizations was developed by Mavilya (Note 1) and was then utilized for longitudinal observations of individual infants' vocalizations by Maskarinec, Cairnes, Butterfield and Weamer (Note 5). This study utilized Mavilya's code for differentiating between speech and nonspeech sounds.

Measures of Reliability

Observers were trained to a minimum criterion of 80% agreement with the experimenter prior to conducting reliability checks for the speech and motor behaviors. A physical therapist, occupational therapist, and secretary were utilized for reliability measures with the motor behaviors. A physical therapist and secretary conducted reliability checks on the speech behaviors.

Reliability was computed by using the following formula:

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

The reliability totals for each child and each session were added, then divided by the total number of sessions to yield the average reliability figure. Reliability measures were taken from tape recordings of each child's vocalizations and direct observation of head erect behaviors. Reliability measures were computed on 81% of the sessions across subjects for head erect behaviors, and 28% of the sessions for vocalization behaviors.

Experimental Design

In order to more clearly compare the effects of the vestibular stimulation and social reinforcement upon motor and speech behaviors, a reversal design across subjects was utilized. The reversal design allowed contrasting analysis across the various conditions.

Sequence of Conditions

The following sequence of conditions was followed: baseline with social reinforcement, vestibular stimulation and social reinforcement, social reinforcement, with continued alternation for a total of 6 conditions. The social reinforcement was then withdrawn from both conditions. The procedure for the social reinforcement and the vestibular stimulation with social reinforcement was re-instituted. Each condition lasted approximately one week, with the exception of the initial baseline social reinforcement condition, which lasted approximately 4 weeks. The sequence of conditions were arranged in an ABABACC manner.

Follow-Up

One month after the completion of the study the subjects were involved in a one week follow-up, during which social reinforcement was used. The follow-up observations were conducted to assess maintenance over time.

Results

Measures of Interobserver Reliability

Tables 1 and 2 present interobserver reliability data for the behavior descriptors for head erect in the prone position and vocalizations for individual subjects and across subjects.

Interobserver reliability for head erect descriptors in the prone position across all behavior descriptors and all subjects ranged from 50%-100%. Row mean reliability for head erect behavior descriptors ranged from 90%-95%, and the grand mean reliability was 92% (see Table 1). Interobserver reliability for vocalizations across all subjects ranged from 82%-100%. The mean reliability of vocalizations for all sessions across all subjects ranged from 94% to 96%, and the grand mean reliability was 93% (see Table 2).

Performance Measures

The subjects were considered individually for presentation of performance data in Figures 1-6. Figures 1-3 present performance data on the frequency of head lifts and cumulative duration of head erect. Figures 4-6 present performance data on the frequency of vocalizations.

Subject 1 (Randy)

Frequency and cumulative duration of head erect. Figure 1 presents performance data on the frequency of head lifts and cumulative duration of head erect behaviors across conditions for Subject 1. Best fit lines computed for the initial baseline condition indicated a descending trend in frequency of head lifts and a slight ascending trend (i.e., from 22 to 26), in cumulative duration of head erect. Variability in successive data points during baseline was evidenced as head lifts ranged between 3 and 26 and cumulative duration ranged between 60 and 170 seconds.

Table 1

Interobserver Reliability Across Behavior Descriptors for Head Erect in the Prone Position for Individual Subjects and Across Subjects

Behavior Descriptors	Reliability for all sessions per subject: Randy	Justin	Heather	Row Mean Reliability
Head lifts	89	92	90	90
Cumulative duration	97	96	93	95
Column mean reliability	93	94	91	Grand mean reliability 92

16

Table 2

Interobserver Reliability for Vocalizations

for Individual Subjects and Across Subjects

	Reliability for all sessions per subject			
	Randy	Justin	Heather	Grand Mean Reliability
Vocalizations	96	91	94	93

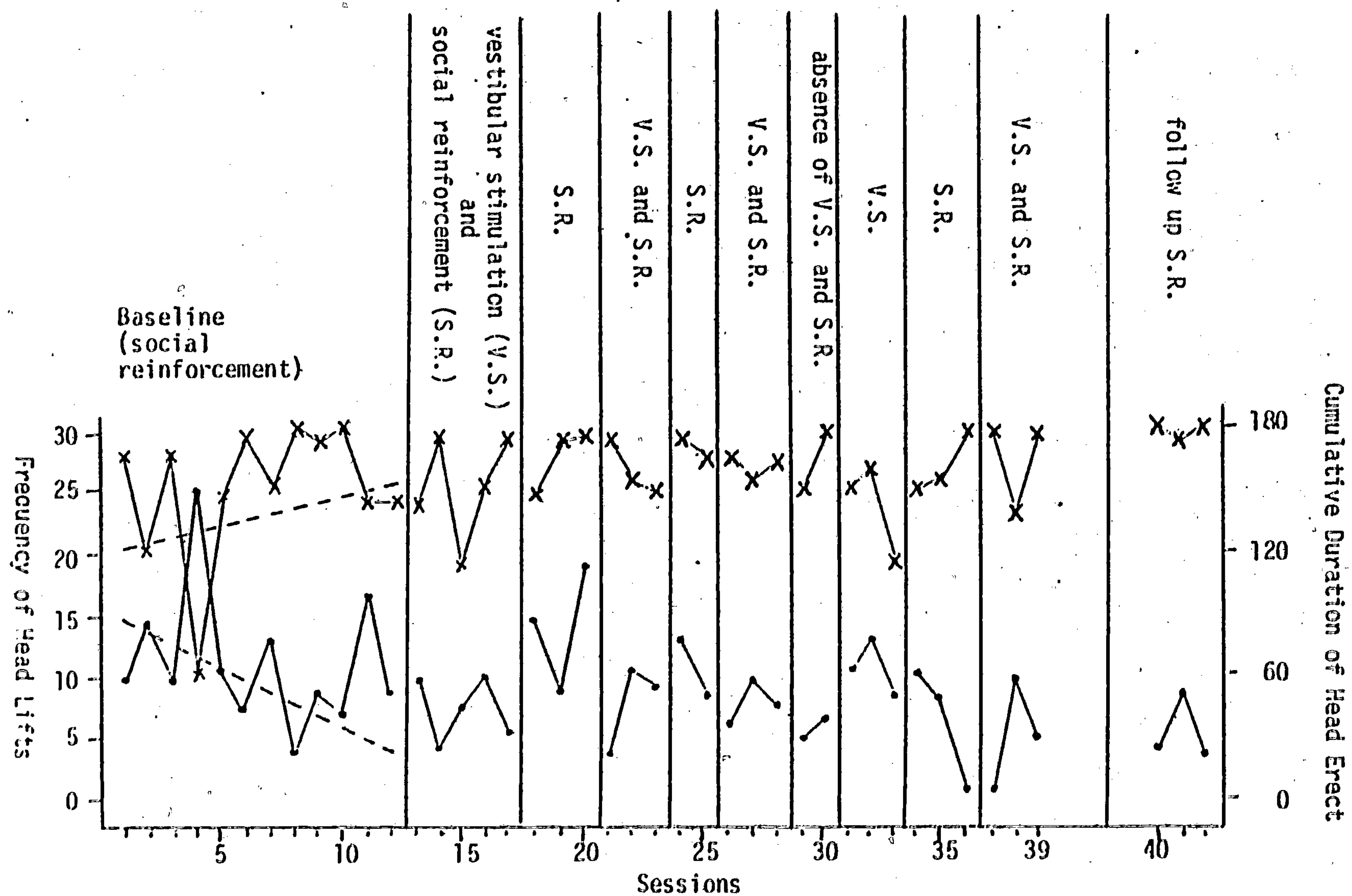

Figure 1. Frequency of Head Lifts/Cumulative Duration of Head Erect for Subject 1 (Randy).

•——• X——X

Generally this variability also reflected an inverse relationship between frequency and cumulative duration, i.e., if frequency was high, cumulative duration of head erect was low.

An analysis of the data across the next five conditions in which vestibular stimulation and social reinforcement were alternated with social reinforcement (or baseline conditions) demonstrated a decrease in the variability of frequency of head lifts. Although there was a decrease across all conditions, the range was smaller during intervention than baseline conditions. After the intial intervention condition, cumulative duration of head erect remained uniformly high.

The withdrawal of social reinforcement represented a new condition in the study. Social reinforcement was withdrawn first from the baseline condition with no appreciable effect on either frequency or cumulative duration of head erect observed. During the following week vestibular stimulation was re-introduced and an increase in frequency of head lifts and decrease in cumulative duration occurred. A return to baseline resulted in a reversal of this trend, i.e., frequency decreased as cumulative duration increased. This trend was maintained during the subsequent intervention condition.

One month after the completion of the study, a follow up observation was conducted employing baseline conditions. Results from the follow up demonstrated that frequency of head lifts remained low and stable and cumulative duration of head erect remained high and stable.

<u>Frequency of vocalizations</u>. Figure 2 presents performance data on the frequency of vocalizations across conditions. Best fit lines computed for the initial baseline condition indicated a decreasing trend in the frequency of vocalizations. The variability of data points during baseline was evidenced as vocalizations ranged from 8 to 35.

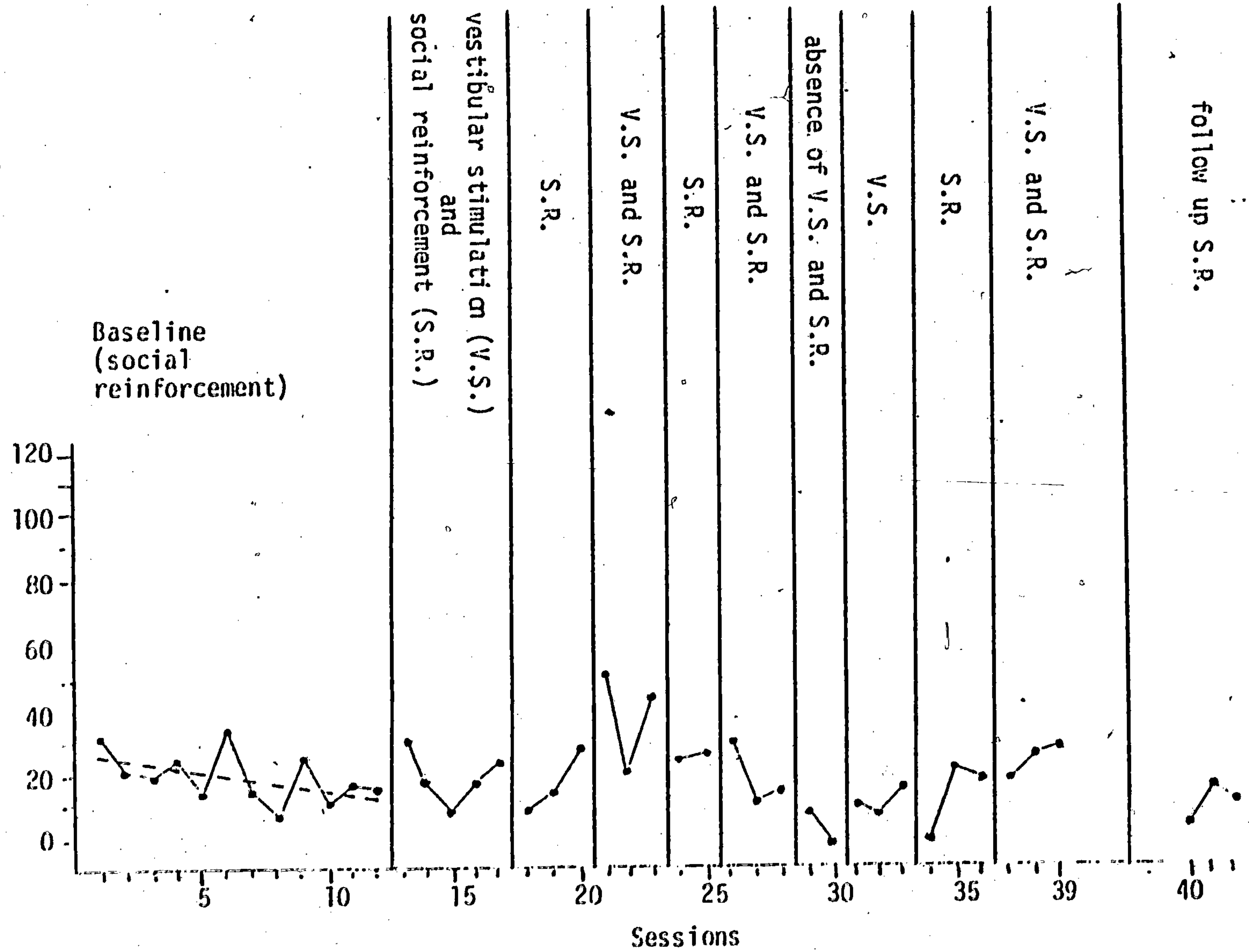

Figure 2. Frequency of Vocalizations for Subject 1 (Randy).

Data analysis across the next five conditions in which vestibular stimulation and social reinforcement were alternated with social reinforcement (or baseline conditions) demonstrated a continued variability in frequency of vocalizations. The range was greater during intervention than baseline conditions.

The withdrawal of social reinforcement from the baseline condition demonstrated a significant decrease in the frequency of vocalizations, with little variability in the data range. Reintroduction of the vestibular stimulation the following week yielded a slight increase in vocalizations, although the range was generally lower. A return to baseline condition resulted in wide variability in the frequency of vocalizations, with a general increased trend. This increasing trend was maintained in the subsequent intervention condition, with less variability and increased frequency in vocalizations.

The baseline probe conducted one month following the completion of the study demonstrated a similar trend evidenced in the previous return to baseline condition, i.e., variability in vocalization frequencies, with a general increased trend.

Subject 2 (Justin)

Frequency and cumulative duration of head erect. Figure 3 presents performance data on the frequency of head lifts and cumulative duration of head erect behavior across conditions for Subject 2. Best fit lines computed for the initial baseline condition indicated slight ascending trends in the frequency of head lifts and cumulative duration of head erect. Variability in successive data points during baseline was evidenced as head lifts ranged from 3 to 26 and cumulative duration ranged between 38 and 167 seconds. Generally this variability also reflected an inverse

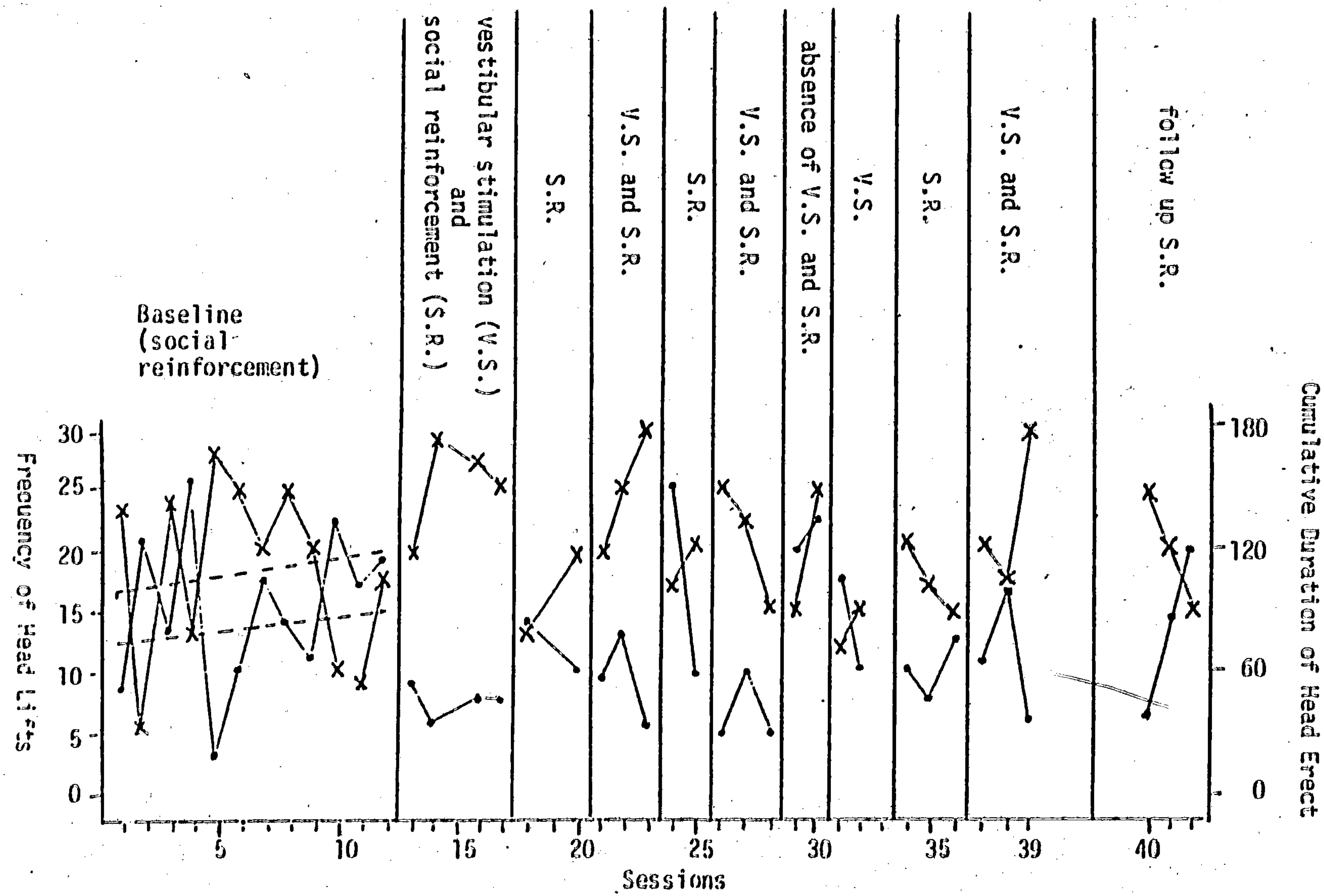

Figure 3. Frequency of Head Lifts/Cumulative Duration of Head Erect for Subject 2 (Justin).

•——• X——X

relationship between frequency and cumulative duration, i.e., if cumulative duration of head erect was low, frequency of head erect was high.

Data analysis across the next five conditions demonstrated a decrease in variability and frequency of head lifts during all three intervention conditions (i.e., range 5 to 10). This was associated with an increasing trend in cumulative duration of head erect during the first two intervention conditions and a decreasing trend in the third intervention condition. Alternately, a return to baseline condition resulted in an initial increase in frequency of head lifts and a marked decrease in cumulative duration. Although this trend was reversed on subsequent data points within each condition, cumulative duration during baseline conditions was lower than intervention conditions.

The withdrawal of social reinforcement from the baseline condition yielded a marked increase in frequency of head lifts which was associated with an increased trend in cumulative duration. During the following week when vestibular stimulation was re-introduced, both the cumulative duration of head erect and the frequency of head lifts decreased. A return to baseline resulted in an initial increase in cumulative duration followed by a decreasing trend; this was associated with a relatively low stable level of frequency of head erect. In the subsequent intervention condition, an inverse relationship was evidenced as cumulative duration of head erect increased and frequency of head lifts decreased.

The follow up observation employing baseline conditions one month after the completion of the study demonstrated again an inverse relationship between head erect and cumulative duration. The frequency of head lifts increased, while cumulative duration of head erect decreased.

Frequency of vocalizations. Figure 4 presents performance data on the frequency of vocalizations across conditions. Best fit lines computed for the initial baseline condition indicated a slight decreasing trend in the frequency of vocalizations. Wide variability was evidenced during baseline as vocalizations ranged from 32 to 111.

Data analysis across the next five conditions demonstrated continued variability. Data collected from the initial intervention condition reflected similar variability in range as was evident in the previous baseline condition. A marked decrease in vocalizations followed in the subsequent baseline condition. An initial increase in the next intervention condition was noted, followed by a reduction which was maintained. A continued decline was evident in the subsequent return to baseline condition. The following intervention condition reflected a marked increase in frequency, which later fell and stablized. Data comparison across all conditions illustrated that frequency of vocalizations were typically higher during intervention conditions than during baseline conditions.

The withdrawal of social reinforcement from the baseline condition produced an initially sharp decrease in frequency of vocalizations, with subsequent increase. Re-introduction of the vestibular stimulation condition the following week demonstrated a decreasing trend. A return to baseline condition demonstrated variability with a range of 14-58 vocalizations. A sharp increase characterized the next intervention condition, which later fell with the same frequency as it had increased.

The follow up observation conducted one month following the completion of the study demonstrated an initial decrease in frequency, followed by an increased trend.

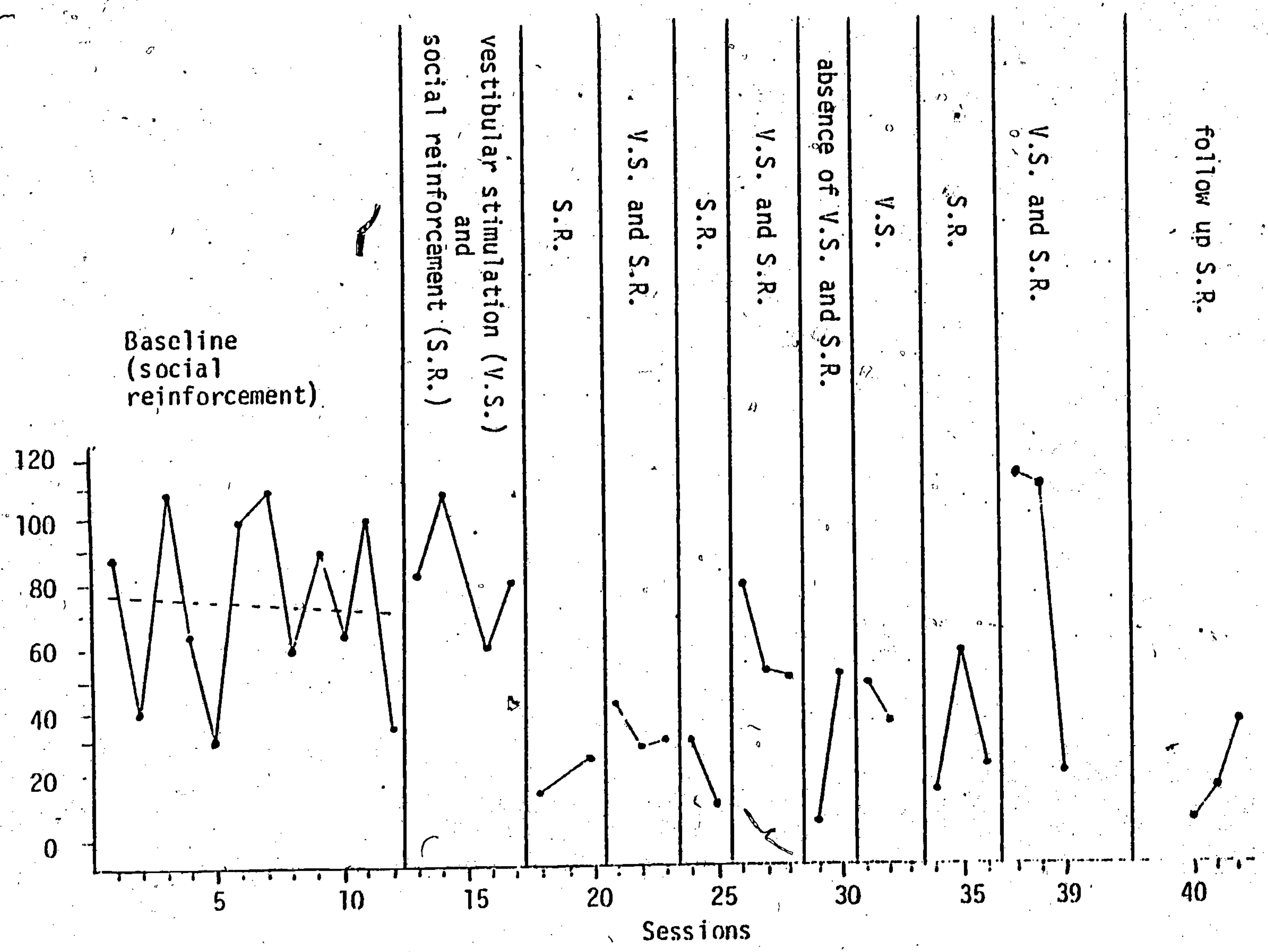

Figure 4. Frequency of Vocalizations for Subject 2 (Justin).

Subject 3 (Heather)

Frequency and cumulative duration of head erect. Figure 5 presents performance data on the frequency of head lifts and cumulative duration of head erect behavior across conditions for Heather. Best fit lines computed for the initial baseline condition indicated a descending trend for frequency of head lifts and an increasing trend for cumulative duration of head erect. Variability of successive data points for both measures decreased over time.

Data analysis across the next five conditions demonstrated a general increase in the cumulative duration of head erect. Variability in cumulative duration and frequency of head lifts was observed more consistently in the interventions, rather than the baseline conditions.

The withdrawal of social reinforcement represented an increase in the frequency of head lifts and a marked decrease in cumulative duration of head erect. During the following week, re-introduction of vestibular stimulation yielded decreased stable levels of cumulative duration of head erect, and variability in the frequency of head lifts (i.e., a slight increase trend followed by a marked decrease in frequency). A return to baseline resulted in a marked increased trend in cumulative duration with a moderate stable level of frequency of head lifts. An inverse relationship with increased cumulative duration and decreased frequency of head lifts was evident in the subsequent intervention condition.

The follow up observation conducted one month following the study resulted in an initial decrease in cumulative duration, followed by an increasing trend. Frequency of head lifts were maintained at moderate levels with little variability in range.

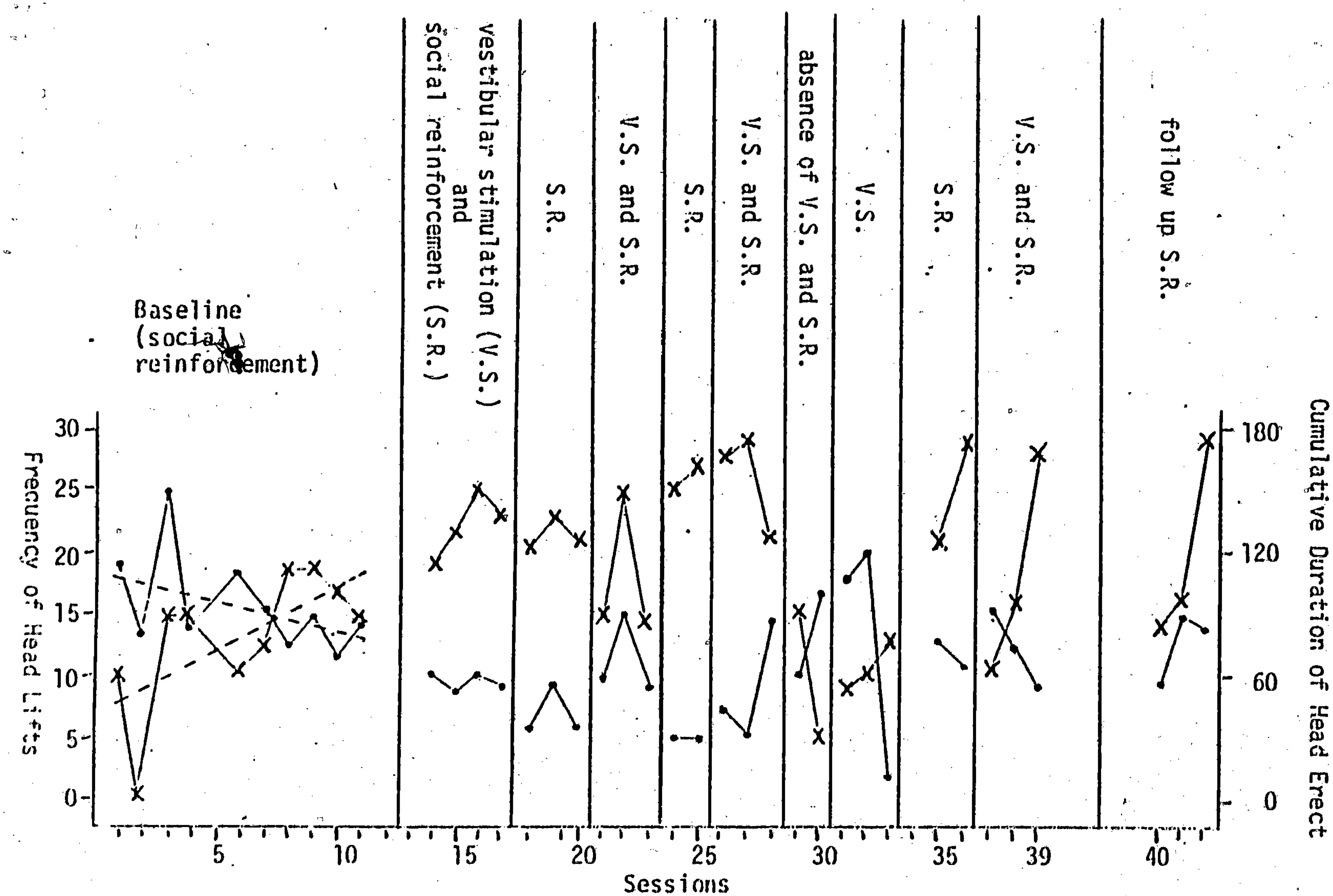

Figure 5. Frequency of Head Lifts/Cumulative Duration of Head Erect for Subject 3 (Heather).

•——• X——X

Frequency of vocalizations. Figure 6 presents performance data on the frequency of vocalizations across conditions. Best fit lines computed for the initial baseline condition indicated a slight increased trend in the frequency of vocalizations. Moderate variability of data points during baseline was evidenced as vocalizations ranged from 11 to 40.

Data analysis across the next five conditions demonstrated a similar range and variability as was observed in the initial baseline condition.

The withdrawal of social reinforcement from the baseline condition demonstrated an initial sharp decrease in the frequency of vocalizations. Re-introduction of the vestibular stimulation yielded a variable trend with a range of 25 to 42. A return to baseline condition resulted in an initial increase, followed by a decrease in frequency of vocalizations. The subsequent intervention condition demonstrated an increasing trend.

The follow up observation conducted one month after the study resulted in low levels of vocalizations. Range was decreased in contrast to the previous conditions.

Discussion

This research studied the effects of vestibular stimulation and social reinforcement upon head erect and vocalization behaviors in preschool aged multiply handicapped children. Initially, a multiple baseline design was employed, but was subsequently changed due to variable baseline conditions, and data which reflected acquisition of the behavior during the baseline (social reinforcement) condition. An alternating treatment design replaced the initial multiple baseline design. This design was selected to allow for the comparison of the effects of the alternating conditions and allowed the study to proceed without a

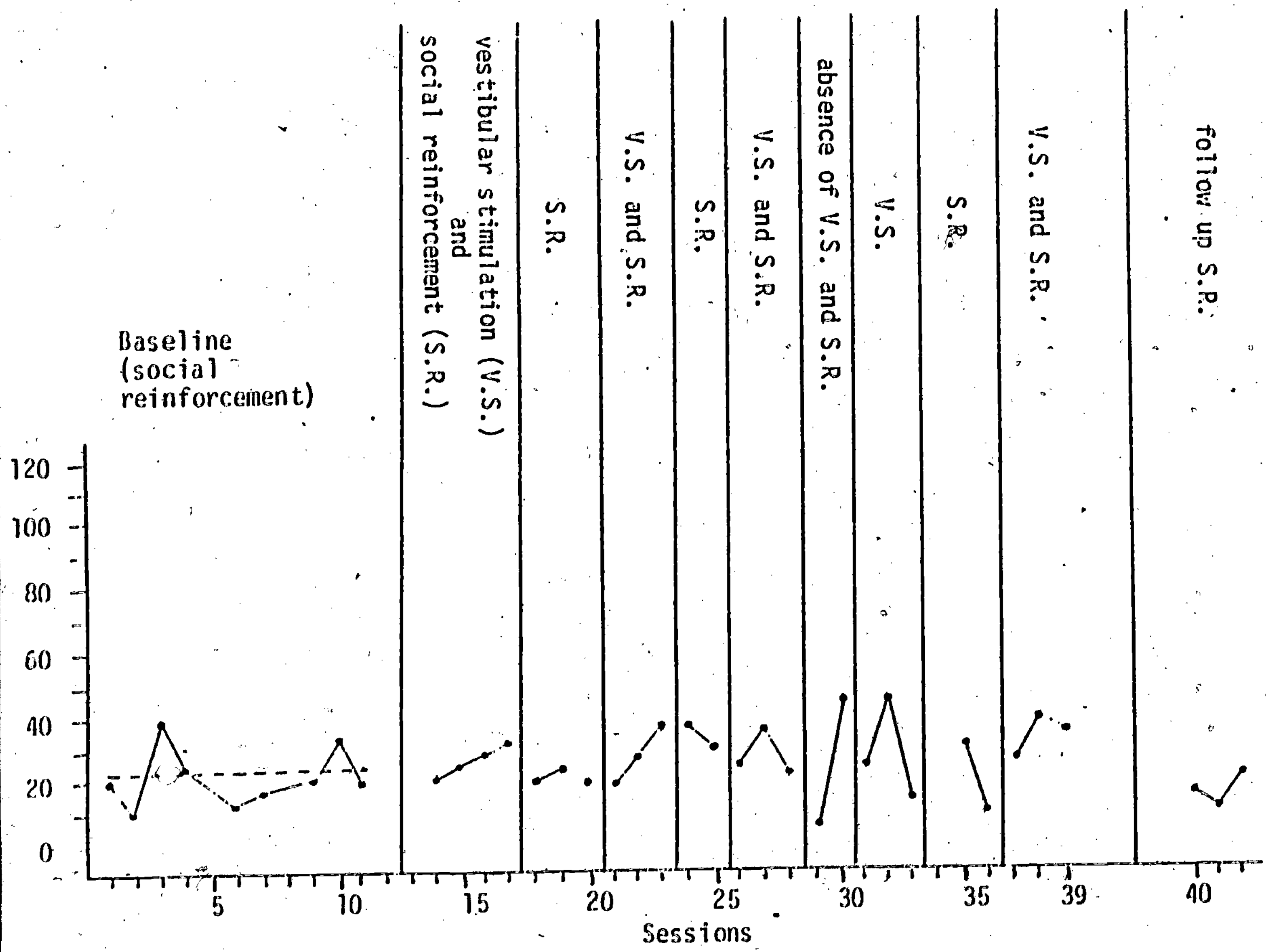

Figure 6. Frequency of Vocalizations for Subject 3 (Heather).

stable baseline. The overall performance of the subjects across behaviors and conditions dictated the final study arrangement, which was a reversal design. The reversal design more accurately compared the effects of social reinforcement of vestibular stimulation and social reinforcement than did the previously described designs.

Performance Data

The performance data are discussed across behaviors and conditions for all subjects. The effects of the various conditions on the interaction between frequency of head lifts and cumulative duration of head erect are considered as are the effects on vocalizations.

Frequency of head lifts and cumulative duration of head erect. Performance data for cumulative duration of head erect increased across subjects during the initial baseline (or social reinforcement) condition. Heather and Randy demonstrated a decrease in the frequency of head lifts, while Justin's frequency slightly increased during that time.

The subsequent conditions, in which vestibular stimulation and social reinforcement were alternated with social reinforcement (or baseline conditions), yielded differential effects across subjects. Randy demonstrated uniformly high levels of cumulative duration across conditions with lower levels of head lifts during conditions of vestibular stimulation and social reinforcement. Analysis of Justin's data indicated increased cumulative duration and decreased frequency of head lifts in conditions where vestibular stimulation and social reinforcement were combined. Heather displayed increased levels of cumulative duration across conditions, with lower more stable levels of head lifts evident in conditions of social reinforcement.

The following conditions in which social reinforcement and vestibular stimulation were withdrawn demonstrated a decrease in Randy's cumulative duration of head erect and slight increase in frequency of head lifts during the second week of the condition. Data points began to taper off for both behaviors at the end of the withdrawal condition, suggesting a possible cumulative effect from the absence of the social reinforcement for two weeks. Justin's marked increase in frequency of head lifts and cumulative duration of head erect during the first week of the condition where social reinforcement and vestibular stimulation were withdrawn, were followed by a paralleled, decreased trend the second week. The absence of both paired and singular stimuli yielded the decrease in frequency of head lifts and cumulative duration of head erect. Vestibular stimulation alone was not sufficient to maintain previous levels of head erect for two weeks without social reinforcement. Heather appeared most affected by the removal of social reinforcement, which was demonstrated by a decrease in cumulative duration and an increase in frequency of head lifts over both weeks.

A return to baseline (or social reinforcement) condition resulted in generally decreased levels of head lifts and general increasing levels of cumulative duration of head erect across subjects. Inverse and maintained trends were observed in the subsequent condition of vestibular stimulation and social reinforcement for all three subjects. These trends were characterized by an increase in cumulative duration of head erect and a decrease in frequency of head lifts.

The follow up observation conducted one month after the completion of the study demonstrated variable responses across subjects. Maintained levels of cumulative duration and frequency of head lifts was evident in

Randy's data. An inverse relationship, i.e., decreased cumulative duration and increased head lifts, was observed in Justin's data points. This trend was typically evident when social reinforcement and vestibular stimulation were not paired. The presence of social reinforcement appeared sufficient to maintain levels of increased cumulative duration and low levels of head lifts for Heather.

Frequency of vocalizations. Performance data for frequency of vocalizations across subjects for the initial baseline (or social reinforcement) condition demonstrated decreasing trends for Randy and Justin and a slight increasing trend for Heather. Fluctuation between successive data points was particularly evident in Justin's data.

Comparison of performance data across the following conditions in which social reinforcement was alternated with vestibular stimulation and social reinforcement demonstrated a trend similar to baseline conditions for Heather. Conditions which paired social reinforcement and vestibular stimulation yielded higher levels of vocalizations for Justin, than in those conditions where only social reinforcement was present. Generally Randy's frequency of vocalizations were higher during the conditions in which vestibular stimulation and social reinforcement were paired; the combined stimuli appeared to be a more powerful intervention for increasing frequency of vocalizations.

The following conditions in which social reinforcement and vestibular stimulation were withdrawn produced a decrease in Randy's vocalizations. Justin and Heather's data demonstrated a similar response to the withdrawal of vestibular stimulation and social reinforcement, i.e., a marked decrease followed by an increase in frequency. The withdrawal of social reinforcement and the vestibular stimulation exerted influence across all three subjects, with Randy demonstrating the least ability to recover in terms of increasing his level of vocalizations. The following week when vestibular stimulation was presented and the social reinforcement omitted, Randy demonstrated low levels of vocalizations with little variability. Vestibular stimulation alone was not sufficient to increase Randy's level of vocalizations. A similar trend was evident in Justin's and Heather's data. Both demonstrated decreased trends of vocalizations.

In the subsequent condition, i.e., social reinforcement, Heather's vocalization rate was initially increased over the previous condition, yet that increase was not maintained. The following week when vestibular stimulation and social reinforcement were paired, Heather's rate increased. Generally, the pairing of vestibular stimulation and social reinforcement appeared to be a more effective intervention in increasing Heather's rate of vocalizations. The presence of social reinforcement alone was not sufficient to produce and maintain an increase in Justin's level of vocalizations. The presentation of vestibular stimulation and social reinforcement the following week resulted in a marked increase in Justin's level of vocalizations, for 2 of the 3 sessions. Randy responded to the presentation of social reinforcement with an initial decrease, then maintained an increase in levels of vocalizations. Presentations of vestibular stimulation and social reinforcement the following week resulted in a continued increase in levels of vocalizations.

The follow-up observation conducted one month after the completion of the study where social reinforcement was present showed a general increased trend of vocalizations across all three subjects. The level of vocalizations in this condition was compatible to previous levels obtained during baseline or social reinforcement across subjects.

Generally increased levels of vocalizations were evident across subjects in conditions that paired vestibular stimulation and social reinforcement.

Arm Positions

Data on the frequency and topography of arm positions was collected across subjects and conditions during this study in an attempt to study potential covariations in head erect behavior and upper extremity weight bearing. These data were not included in the text due to difficulties encountered in interpreting the findings. Distinct trends in arm positions were noted across subjects, which appeared to be correlated with the subject's tone and movement disorder. Rues (Note 4) hypothesized that the arm position code may provide an early quantitative differentiation between different types of handicapping conditions. Heather, who presented with fluctuating tone and athetoid movements, typically demonstrated increased frequency and topography of arm positions. Randy's and Justin's, both spastic quadriparetics, topography and frequency were less variable.

Summary

The differential effects of the various conditions across subjects and behaviors were summarized. Randy's initial data indicated that the frequency of head lifts was lower during social reinforcement and vestibular stimulation. Cumulative duration was uniformly high across conditions. The withdrawal of social reinforcement had the least effect on this subject. For this youngster the presence of the examiner appeared to be highly reinforcing; thus physical proximity may have counterbalanced the withdrawal of verbal and gestural reinforcement. Randy's frequency of vocalizations were generally positively influenced by those conditions where vestibular stimulation and social reinforcement were paired. The absence of both the conditions significantly depressed his levels of vocalization. Justin's cumulative duration and frequency of head lifts were most favorably influenced by those conditions where vestibular stimulation and social reinforcement were paired. His frequency of vocalizations were also increased during these same conditions. The absence of both conditions resulted in a decrease in vocalizations. Heather's performance data for cumulative duration of head erect and frequency of head lifts were most favorably influenced by social reinforcement. Marked decrease in both behaviors were observed when social reinforcement was withdrawn. Social reinforcement did not exert the same influence over her vocalizations, as frequency of vocalizations were generally higher during conditions which paired vestibular stimulation and social reinforcement.

Limitations of the Study

Limitations are discussed as they relate to the various codes employed in the measurement of head erect, arm positions, and vocalizations. The code used for head erect behavior defined the occurrence of head erect with differentiating qualitative aspects of the response. Employing the existing code allowed for crediting occurrences of head erect that resulted in hyperextension of the neck prohibiting visual interaction with the environment. Modifications in the code would enable the examiner to discriminate between these qualitiative or functional aspects of head erect in future studies. The imposed ceiling on cumulative duration of head erect (i.e., 180 seconds) posed a problem for one subject. In the instance where a subject acquires and maintains high levels of cumulative duration of head erect, the duration measure should be shifted to allow for measurement of the duration of arm positions.

Although frequency and topography were recorded, cumulative duration of arm positions was not simultaneously measured. Without the duration measure it was impossible to accurately analyze and interpret the final data. Frequency and topography proved insufficient as an index of change or progress. Although the subject may have demonstrated forearm props across conditions the duration measure would have provided valuable information on the effects within and/or across conditions, e.g., subject's ability to maintain position for increasing periods of time.

The code used for differentiating speech and nonspeech vocalizations did not adequately reflect those nonspeech vocalizations which perhaps had the potential to be shaped into a communicative response. For example, such nonspeech sounds as cries and yawns were included in the total frequency, yet may not be desirable to shape into a communicative pattern. Another aspect of the vocalization recording which posed a problem with data analysis was the period of time during which the vocalizations were recorded. The various positions and areas that the child was placed in during the sequence where vestibular stimulation was provided, were not held to a constant time (i.e., the period on the ball was not the same length of time as the time spent in the hammock). Thus comparison across settings where vestibular stimulation was provided was not applicable. The absence of a duration recording for the coded vocalizations also made data analysis difficult. For example, Heather's vocalizations were typically of a longer, sustained quality than were Justin's. These qualitative factors were unable to be expressed in a frequency measurement.

Implications for Future Research

The original intent in the design of this study was to produce a "package" intervention program that utilized vestibular stimulation activities. Social reinforcement was paired with the vestibular stimulation to increase the power of the stimulus. This "package" has implications for use in a classroom or clinic program as a nontraditional method of facilitating higher rates of vocalizations and improved duration of head control. These activities could be an adjunct to other motor and vocal communication programming that currently exist.

The single subject design allowed an analysis of each subject's response to the various conditions and a comparison across subjects with different movement disorders. The data analysis demonstrated the variations in each subject's response to vestibular stimulation and social reinforcement and reinforces the concept of individualized programming for this population.

The overall results of this study did not uniformly support Magrum, Ottenbacher, McCue and Keifer's (1981) study. These researchers reported results which were reversed when vestibular stimulation was introduced and withdrawn. The finding that vestibular stimulation may be an effective stimulation technique for facilitating spontaneous verbal responses (Magrum, et al., 1981) was supported in this research. However, the pairing of social reinforcement with vestibular stimulation may prove to be a more powerful stimulus than the vestibular stimulation alone. The research of Kanter, Kanter and Clark (1982) has implications for this study. These researchers reported that passive vestibular stimulation failed to confirm or deny a definite link in language acquisition. They suggest that vestibular stimulation in combination with other multisensory approaches may be useful.

Future research in this area is needed to address a number of questions regarding the use of vestibular stimulation and social reinforcement with multiply handicapped children and youth. These include studies which will address the effects of frequency and/or duration of vestibular stimulation on motor and speech behaviors. Important also is a determination of whether the effects are immediate or cumulative and to what extent generalization occurs across motor programs.

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195

A Replication Study: Quantitative Assessment of Rolling Behavior in Handicapped and Nonhandicapped Infants and Children[1]

by

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and

Mary Jo Noonan

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

Overview of Measurement Procedures

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.

MEASUREMENTS 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° 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

Several problems were encountered in the use of stopwatches to 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 of rotation occurring during each trial were recorded. However, it was 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

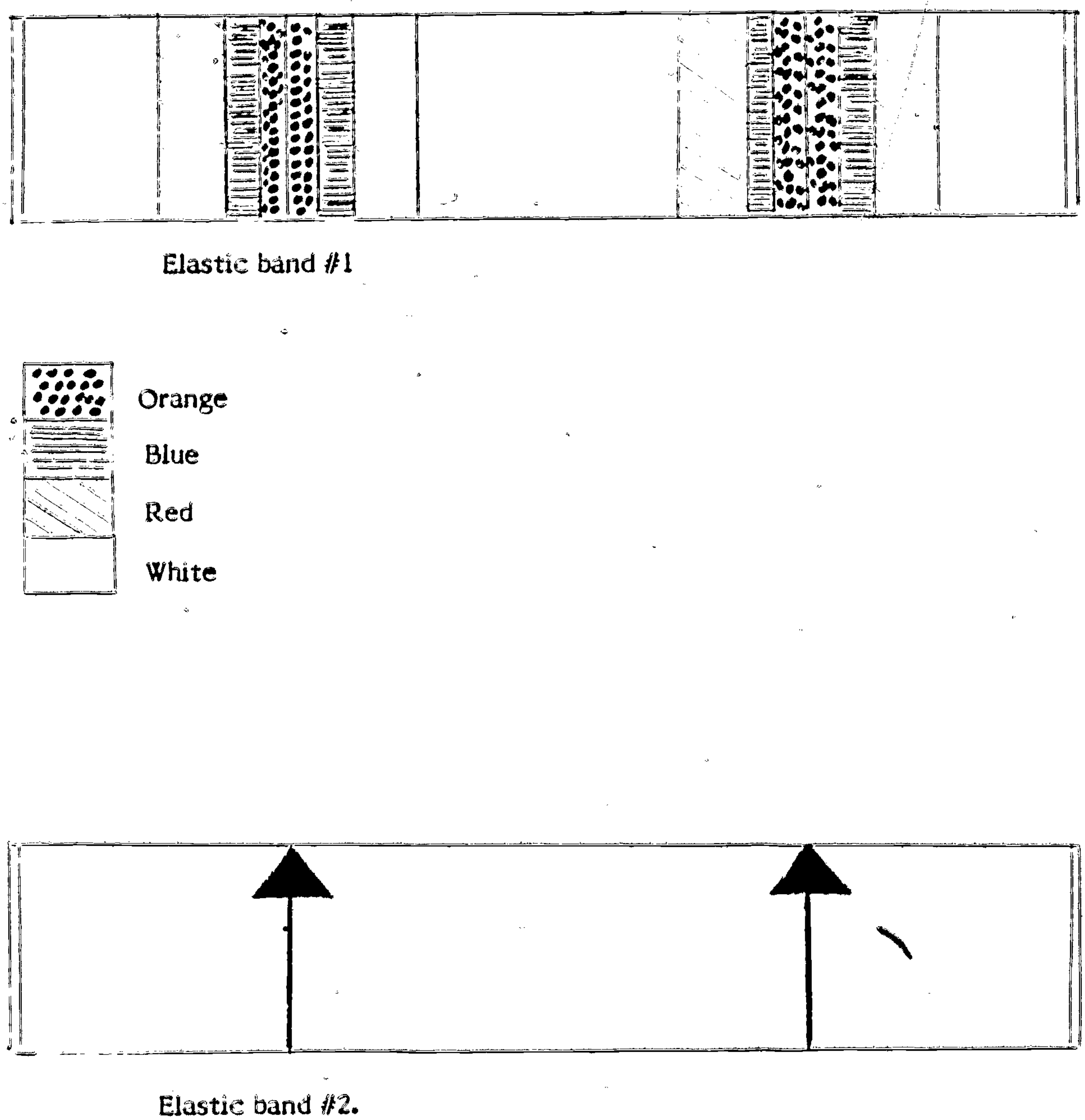


Figure 2. Elastic bands for rolling.

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.

Subjects

This study included three handicapped children and one nonhandicapped infant. The criterion for selection was the ability to roll independently in at least one direction from the prone or the supine position.

Subject 1. Laura was a normally-developing infant who was observed from three to six months of age. At the start of the study, she was not rolling as a means of mobility, but she acquired the skill during the study.

Subject 2. Cary was a three-year-old female with microcephaly and a heart deformity secondary to Smith Syndrome. According to Callier-Azusa scales (Stillman, et al. 1977), Cary's postural control was at the one-month level, and her locomotor skills were at the three-month level. Cognitive and perceptual abilities were assessed to be at the one- and two-month levels respectively.

Subject 3. Beth was a four-year-old spastic quadraplegic with a more-affected left side. According to Callier-Azusa scales, Beth's postural control and locomotor skills were at the two-month level. Cognitive and perceptual abilities were assessed to be at the one- and two-month levels respectively.

Subject 4. Keri was a six-year-old with spastic right hemiplegia. According to Callier-Azusa scales, Keri's postural control and locomotor skills were at the three-month level. Cognitive and perceptual abilities were assessed to be at the two- and three-month levels respectively.

The following subjects were observed in a second replication study:

Subject 5. Keri participated in the first replication study and has been described.

Subject 6. Danny was a four-year-old with spastic quadriplegia. According to Callier-Azusa scales, Danny's postural control and locomotor skills were at the three-month level. Cognitive and perceptual abilities were assessed to be at the three- and four-month levels respectively.

Subject 7. Ryan was a normally developing infant who was observed from five to six months of age. At the start of the study, Ryan was not rolling as a means of mobility, but he began to acquire this skill during the study. By the end of the observation period, Ryan was pivoting in prone and was reluctant to roll out of this position.

The methods used to measure rolling behavior from prone, supine, and sidelying were identical to those previously described, with one exception. An additional person was present during each session to encourage the child to roll. This facilitator was positioned at a point from which he/she could encourage rolling in the desired direction.

This position may be in the path of the desired roll (some children tend to roll toward the facilitator regardless of the placement of other stimuli), or on the opposite side of the direction of the roll (when observing children who tend to roll away from the observer). Observers did not participate in facilitating rolling behavior but observed and recorded data only. They were positioned at a point from which they could clearly observe but not interfere with the child's response.

<u>Specifications for Taking Reliability</u>

Reliability measurements for degrees of body rotation, body part leading the roll, and rolling mobility for each session were calculated separately, using the following formula:

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

An agreement occurred when both observers marked the same initial (for degrees of trunk rotation), abbreviation (for body part leading the roll), or number (for rolling mobility) on the data sheet. For each descriptor, the number of agreements per session was divided by the number of agreements plus disagreements and this quotient was multiplied by 100 in order to be stated as a reliability percentage. Mistrials and those trials during which the child made no observable response were not considered in the calculation of reliability percentages.

The following reliability data are presented in Tables 1 through 5: separate reliability scores for degrees of trunk rotation, body part leading the roll, and rolling mobility per session for each child; a reliability score for each of these descriptors across sessions for each subject; and a reliability score for each dscriptor across sessions and subjects. In addition, mean reliability scores per trial for each sessions and across sessions are presented for each subject. Finally, a

Table 1

Subject 1 (Laura)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Séssion	1	100	100	100	100
	2	100	100	100	100
	3	100	66	66	77
	4	20	100	100	72
	5	100	100	100	100
	6	20	100	100	72
	7	42	42	85	61
	8	100	100	100	100
	9	71	85	100	90
Overall Reliability Across Sessions		58	82	94	82

Table 2

Subject 2 (Cary)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	100	100	100	100
	2	80	80	100	86
	3	50	100	100	83
	4	100	66	100	88
	5	40	20	100	53
	6	83	100	83	88
	7	60	100	80	79
Overall Reliability Across Sessions		74	80	93	82

Table 3

Subject 3 (Beth)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	80	80	80	79
	2	100	100	60	100
	3	100	100	100	100
	4	60	100	80	79
	5	80	100	100	93
	6	80	100	100	100
	7	100	100	100	100
	8	42	100	100	80
	9	33	100	83	71
Overall Reliability Across Sessions		71	97	89	89

mean reliability score per trial across subjects and sessions is presented.

Reliability Data

Subject 1 (Laura). Reliability scores for degrees of trunk rotation ranged from 20 percent to 100 percent per session, with a mean of 58 percent; for the body part leading the roll ranged from 42 percent to 100 percent per session, with a mean of 82 percent; and for rolling mobility ranged from 66 percent to 100 percent per session, with a mean of 94 percent. The mean reliability score per trial across sessions was 82 percent (see Table 1).

Subject 2 (Cary). Reliability scores for degrees of trunk rotation ranged from 50 percent to 100 percent per session, with a mean of 74 percent; for the body part leading the roll ranged from 20 percent to 100 percent per session, with a mean of 80 percent; and for rolling mobility ranged from 80 percent to 100 percent per session, with a mean of 93 percent. The mean reliability score per trial across sessions was 82 percent (see Table 2).

Subject 3 (Beth). Reliability scores for degrees of trunk rotation ranged from 33 percent to 100 percent per session, with a mean of 71 percent; for the body part leading the roll ranged from 80 percent to 100 percent per session, with a mean of 97 percent; and for rolling mobility ranged from 60 percent to 100 percent per session, with a mean of 89 percent. The mean reliability score per trial across sessions was 89 percent (see Table 3).

Subject 4 (Keri). Reliability scores for degrees of trunk rotation ranged from 60 percent to 100 percent per session, with a mean of 74 percent; for the body part leading the roll ranged from 83 percent to 100 percent per session, with a mean of 94 percent; and for rolling mobility ranged from 80 percent to 100 percent per session, with a mean of 93 percent. The mean reliability score per trial across sessions was 87 percent (see Table 4).

Reliability results across subjects. The reliability scores for degrees of trunk rotation across sessions and subjects was 70 percent, for the body part leading the roll across sessions and subjects was 90 percent, and for rolling mobility across sessions and subjects was 92 percent. The mean reliability score per trial across sessions and subjects was 84 percent (see Table 5).

Results from the Second Replication Study

Results from the second replication study were obtained over a one-month period during which weekly observations of each child were scheduled.

Subject 5 (Keri). Reliability scores for degrees of trunk rotation ranged from 66 percent to 100 percent, with a mean of 80 percent; for the body part leading the roll across sessions was 100 percent; and for rolling mobility ranged from 83 percent to 100 percent per session, with a mean of 92 percent. The mean reliability score per trial across sessions was 91 percent (see Table 6).

Subject 6 (Danny). Reliability scores for degrees of trunk rotation ranged from 50 percent to 83 percent per session, with a mean of 68 percent; for the body part leading the roll across sessions was 100 percent; and for rolling mobility across sessions was 100 percent. The mean reliability score per trial across sessions was 88 percent (see Table 7).

Subject 7 (Ryan). Reliability scores for degrees of trunk rotation ranged from 60 percent to 83 percent per session, with a mean of 76

Table 4

Subject 4 (Keri)

Reliability Percentages for Each Descriptor And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	83	100	100	95
	2	60	60	80	66
	3	66	83	100	83
	4	62	100	87	83
	5	71	100	85	85
	6	66	100	100	88
	7	60	100	100	86
	8	83	100	100	94
	9	100	100	80	83
	10	100	100	100	100
Overall Reliability Across Sessions		74	94	93	87

Table 5

Overall Reliability Percentages for Each Subject, Reliability Percentages for Each Descriptor Across Sessions and Subjects, And Mean Reliability Percentages Per Trial Across Sessions and Subjects

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Subject	1	58	82	94	82
	2	74	80	93	82
	3	71	97	89	89
	4	74	94	93	87
Reliability Across Sessions and Subjects			70	90	92

Table 6

Subject 5 (Keri)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	66	100	83	83
	2	100	100	100	100
	3	85	100	85	90
	4	75	100	100	91
Overall Reliability Across Sessions		81	100	92	91

Table 7

Subject 6 (Danny)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	83	100	100	94
	2	75	100	100	91
	3	71	100	100	90
	4	50	100	100	83
Overall Reliability Across Sessions		69	100	100	89

percent; for the body part leading the roll across sessions was 100 percent; and for rolling mobility ranged from 60 percent to 100 percent per session; with a mean of 92 percent. The mean reliability score per trial across sessions was 85 percent (see Table 8).

Reliability results across subjects. The reliability score for degrees of trunk rotation across sessions and subjects was 75 percent; for the body part leading the roll across sessions and subjects was 100 percent; and for rolling mobility across sessions and subjects was 95 percent (see Table 9).

Performance Data

Each child's performance is described in the following order: frequency of trials rolled, degrees of trunk rotation, body part leading the roll, and rolling mobility across sessions; frequency of each descriptor per session; frequency of each descriptor during trials initiated from prone; and frequency of each descriptor during trials initiated from supine. Performance results for Subjects 5 (Keri), 6 (Danny), and 7 (Ryan) are not reported because the purpose of the second replication study was solely to improve upon the reliability results of the first replication study.

Subject 1 (Laura). Laura was given 93 opportunities to roll. She rolled 36 percent of the time, making 34 measurable responses. As indicated in Figure 3, Laura most frequently demonstrated between 11.25° and 22.5° of trunk rotation, led rolls with her shoulder, and made one-quarter or one-half of a roll per trial. Figures 4 through 7 illustrate that these responses were most frequent during each session.

Laura rolled during 6 percent of prone over right trials and during 7 percent of prone over left trials, between the third and ninth sessions

Table 8

Subject 7 (Ryan)

Reliability Percentages for Each Descriptor
And Mean Reliability Percentages Per Trial

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Session	1	83	100	83	88
	2	83	100	100	94
	3	60	100	60	73
	4	75	100	100	87
Overall Reliability Across Sessions		76	100	92	85

Table 9

Overall Reliability Percentages for Each Subject,
Reliability Percentages for Each Descriptor Across Subjects and Sessions
And Mean Reliability Percentages Across Subjects and Sessions

		Degrees of Trunk Rotation	Body Part Leading Roll	Mobility	Mean Reliability Per Trial
Subject	1	80	100	92	91
	2	68	100	100	88
	3	76	100	92	85
Overall Reliability Across Sessions		75	100	95	88

196

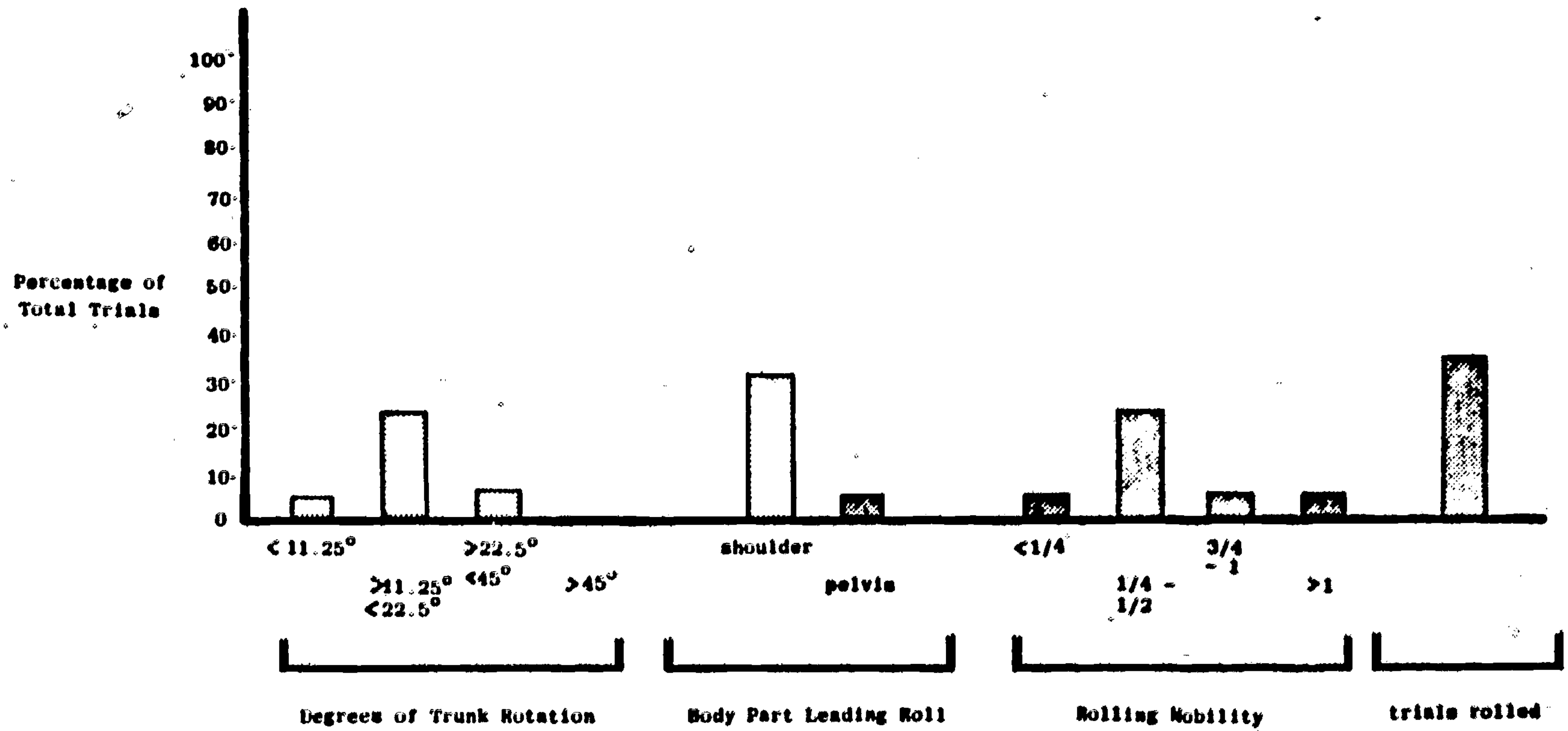


Figure 3. Frequency of trunk rotation, body part leading the roll, rolling mobility and trials rolled across sessions.

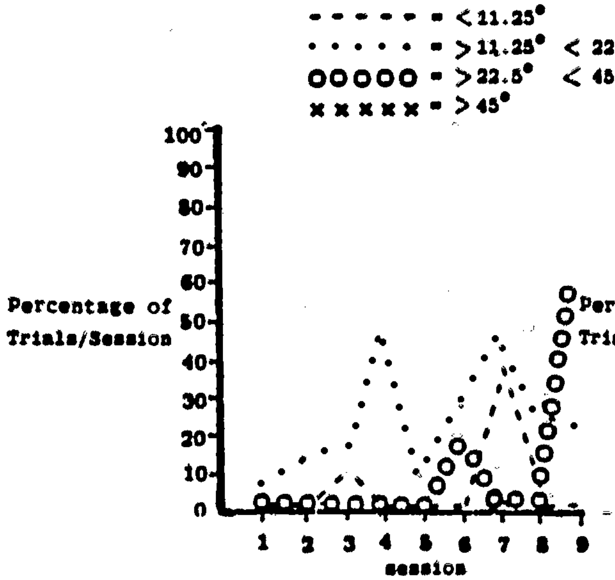


Fig. 4. Frequency of trunk rotation per session.

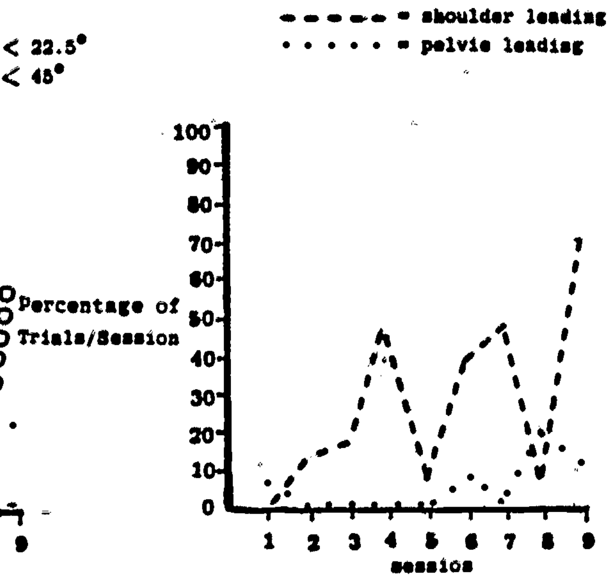


Fig. 5. Frequency of body part leading the roll per session.

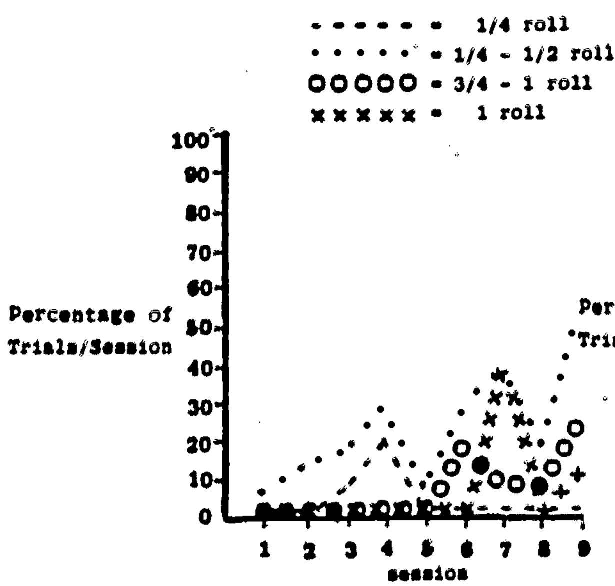


Fig. 6. Frequency of rolling mobility per session.

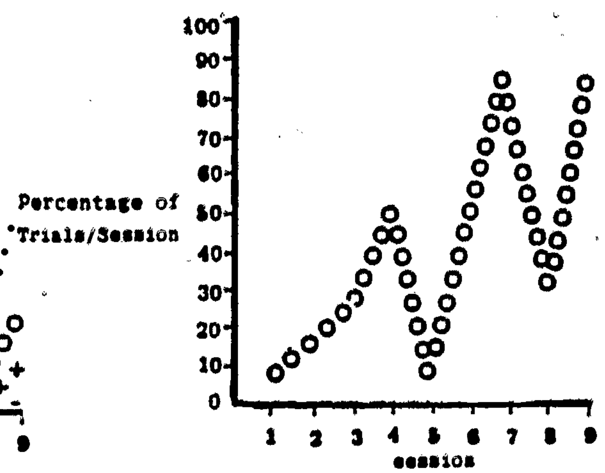


Fig. 7. Frequency of trials rolled per session.

(see Figures 8 and 22). She rolled during 6 percent of supine over right trials, between the fourth and ninth sessions and during 8 percent of supine over left trials, between the sixth and ninth sessions (see Figures 9 and 22).

As indicated in Figure 10, Laura demonstrated between 11.25° and 22.5° of trunk rotation during rolls over the right side from prone with one exception. During the sixth session, she exhibited between 22.5° and 45° of trunk rotation during rolls over the right and left sides from prone. Figure 12 and 13 indicated that Laura also demonstrated between 11.25° and 22.5° of rotation during initial rolls in either direction from supine.

Laura led all but three of her rolls with her shoulder, as seen in Figures 14 through 17. Figures 18 through 22 show an increase over time in rolling mobility during rolls in both directions from prone and supine.

<u>Subject 2 (Cary)</u>. Cary rolled 45 percent of the time, making 34 measurable responses. As indicated in Figure 23, Cary most frequently demonstrated between 11.25° of trunk rotation, led rolls with her shoulder, and made one-quarter or one-half of a roll per trial. As indicated in Figure 24, the degrees of trunk rotation ranged from 0° to 45°. The shoulder consistently led the roll during all but the first and ninth sessions (see Figure 25). Figure 26 illustrates that Cary most frequently made one-quarter to one-half of a roll during all seven sessions. A generally increasing trend in rolling responses over time appears to be indicated in Figure 27.

Cary rolled during 92 percent of prone over right trials and during 50 percent of prone over left trials, between the first and seventh

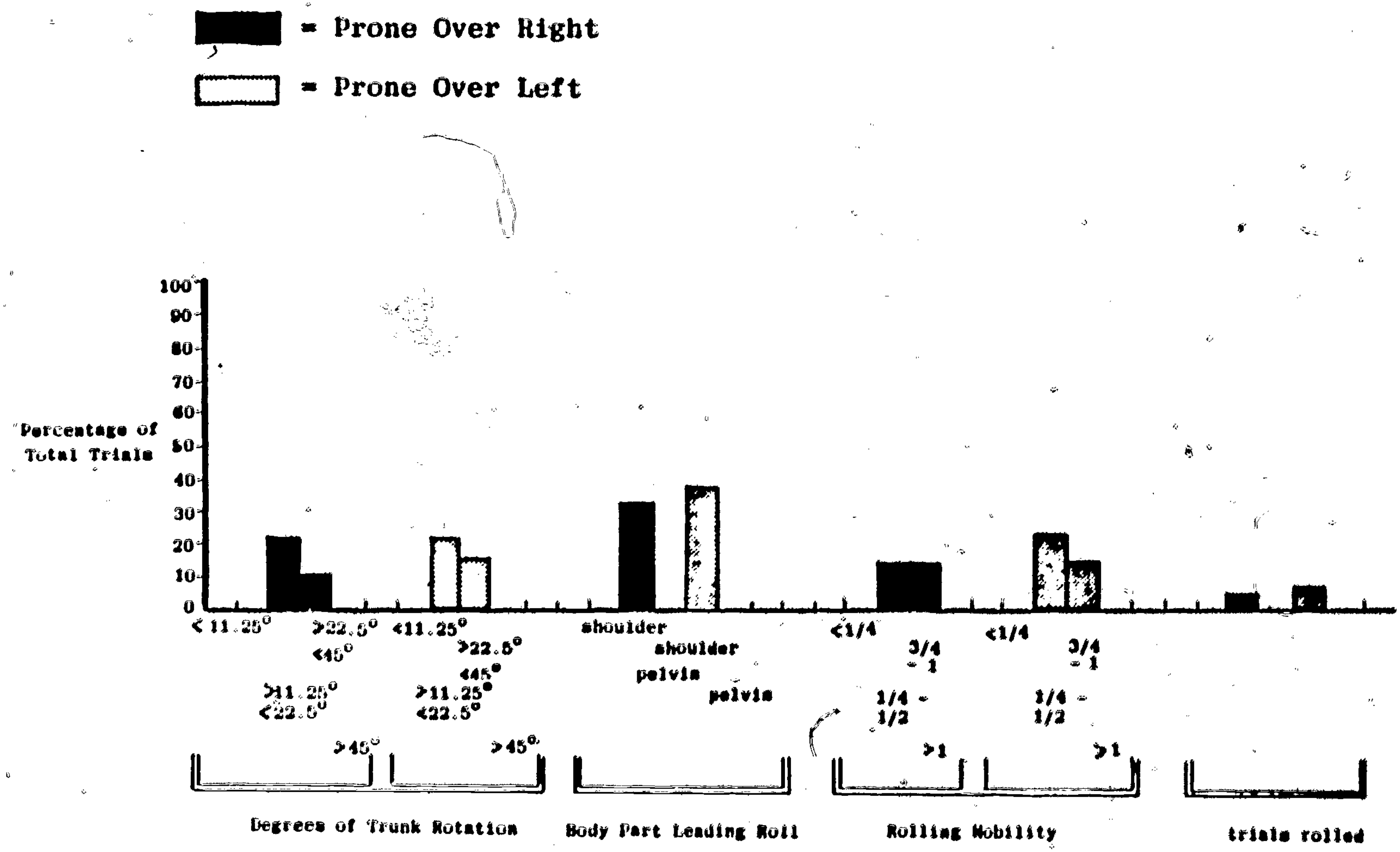


Figure 8. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Prone

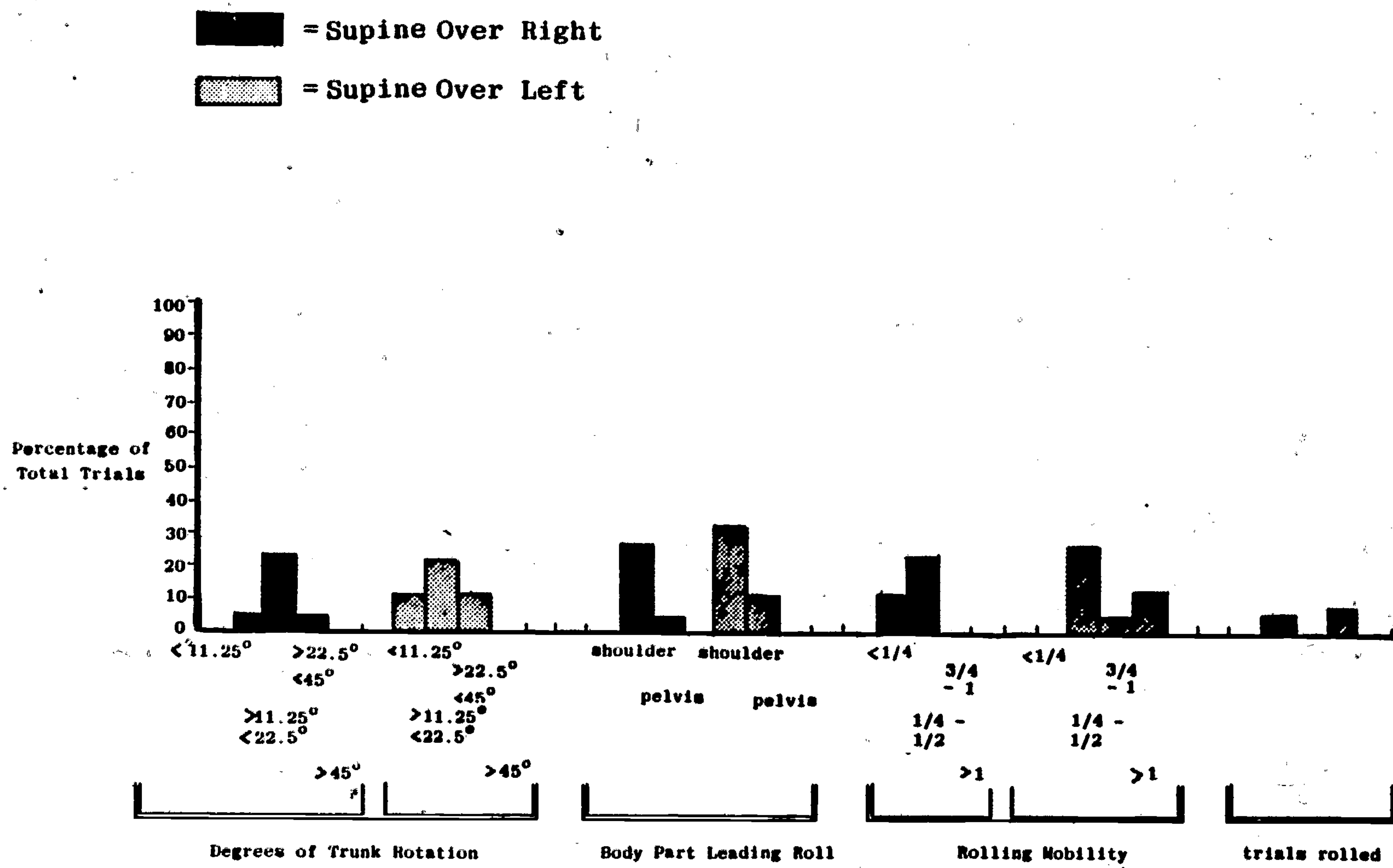


Figure 9 Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Supine

Rolling from Prone | Rolling from Supine

Right

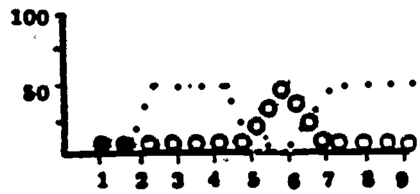


Fig. 10

Right

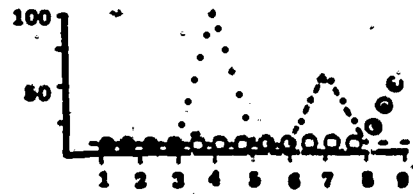


Fig. 12

Left

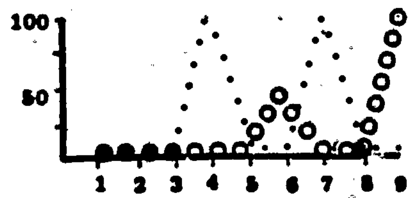


Fig. 11

Left

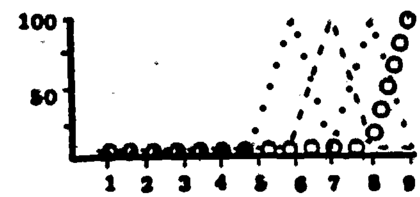


Fig. 13

- - - - - - = $< 11.25^\circ$
· · · · · · = $> 11.25^\circ$ $< 22.5^\circ$
ooooo = $> 22.5^\circ$ $< 45^\circ$
x x x x x = $> 45^\circ$

Figures 10 - 13 Frequency of trunk rotation from prone and supine per session.

Right

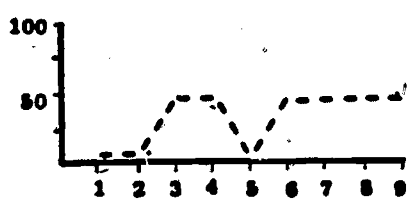


Fig. 14

Right

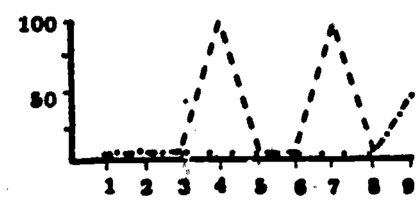


Fig. 16

Left

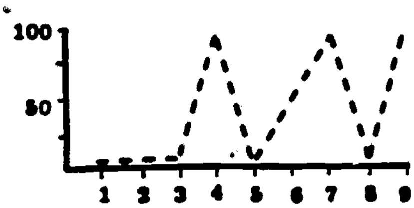


Fig. 15

Left

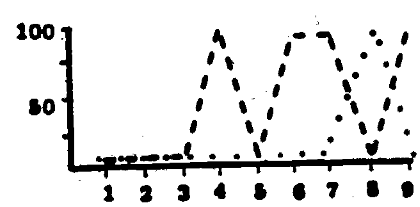


Fig. 17

- - - - - = shoulder leading
· · · · · · = pelvis leading

Figures 14 - 17 Frequency of body part leading the roll from prone and supine per session.

Rolling from Prone

Rolling from Supine

Right

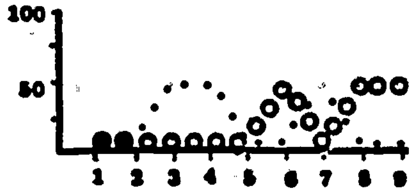


Fig. 18

Right

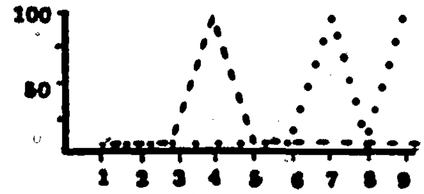


Fig. 20

Left

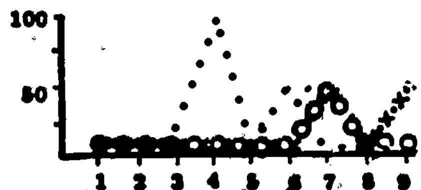


Fig. 19

Left

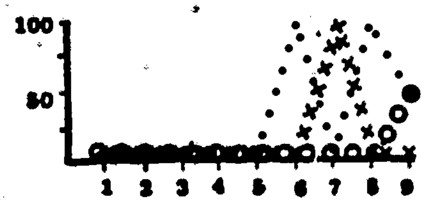


Fig. 21

- - - - - - = 1/4 roll
• • • • • • = 1/4 - 1/2 roll
OOOOO = 3/4 - 1 roll
x x x x x = 1 roll

Figures 18 - 21. Frequency of rolling mobility from prone and supine per session.

Fig. 22

- - - - - - = Prone Over Right
• • • • • • = Prone Over Left
OOOOO = Supine Over Right
x x x x x = Supine Over Left

Figure 22. Frequency of trials rolled from prone and supine per session.

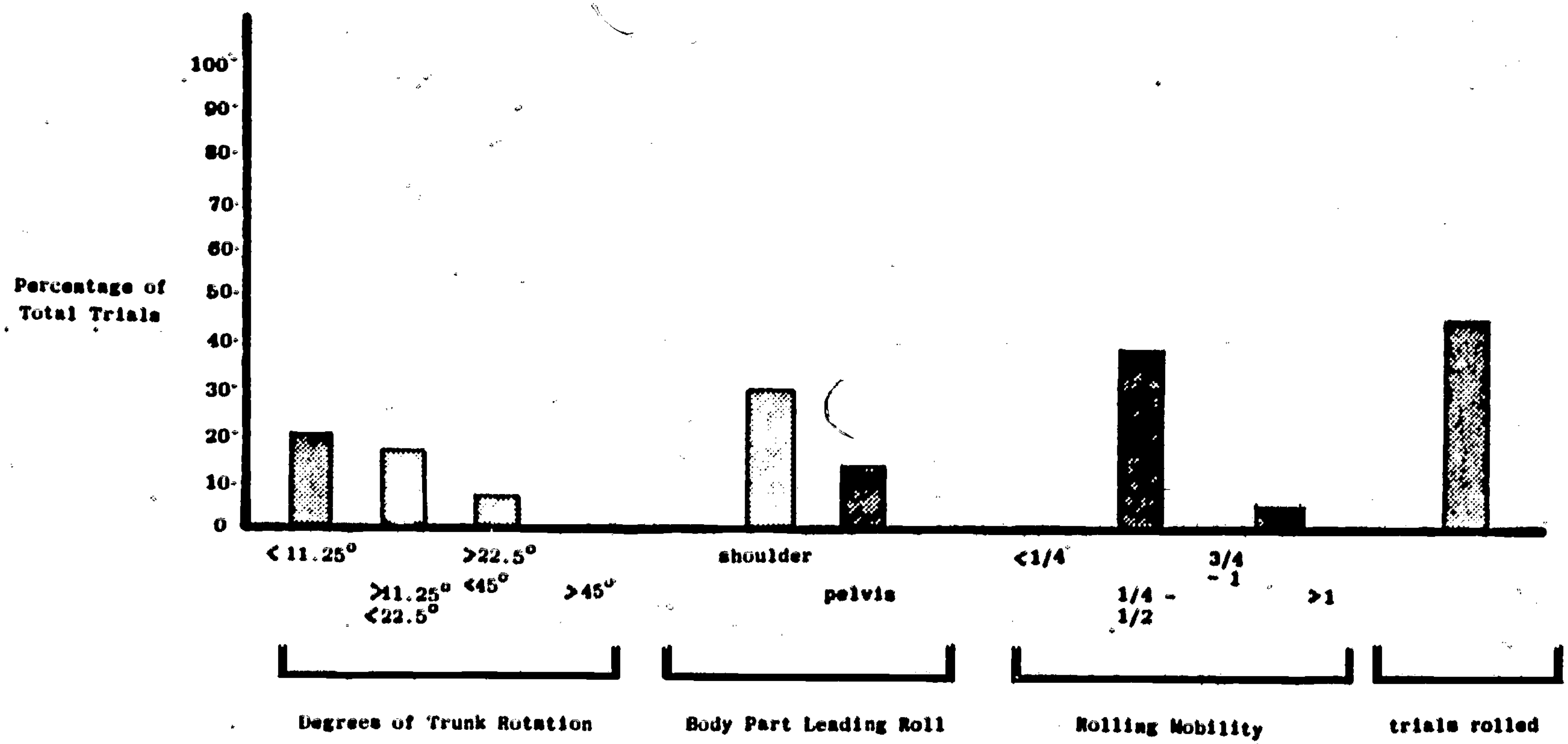


Figure 23. Frequency of trunk rotation, body part leading the roll, rolling mobility and trials rolled across sessions.

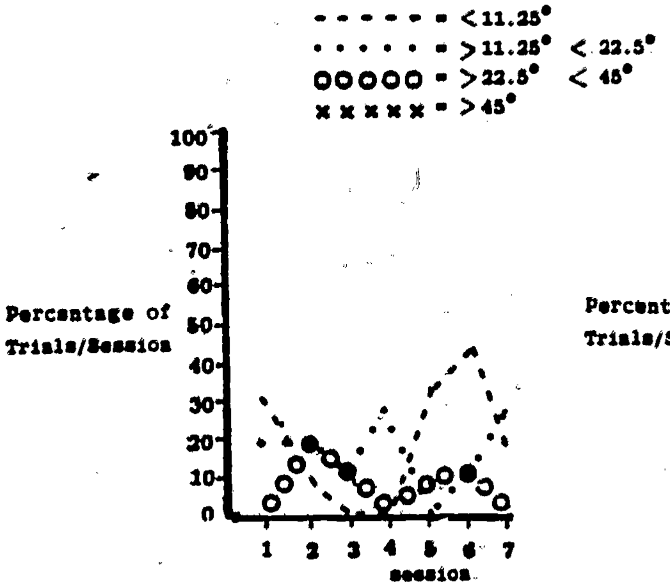


Fig. 24. Frequency of trunk rotation per session.

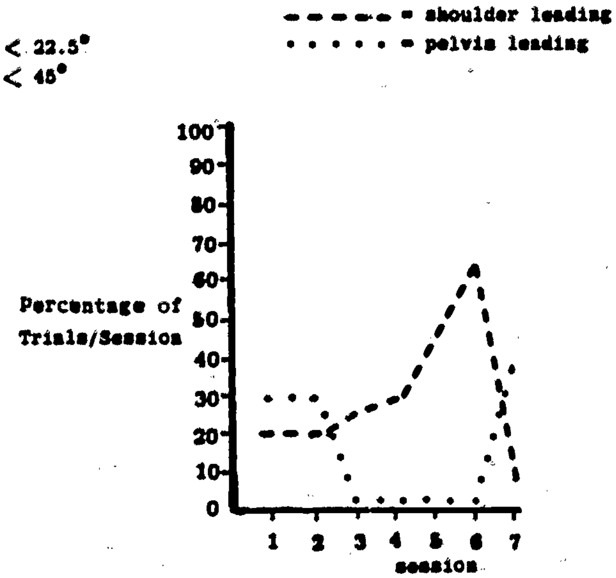


Fig. 25. Frequency of body part leading the roll per session.

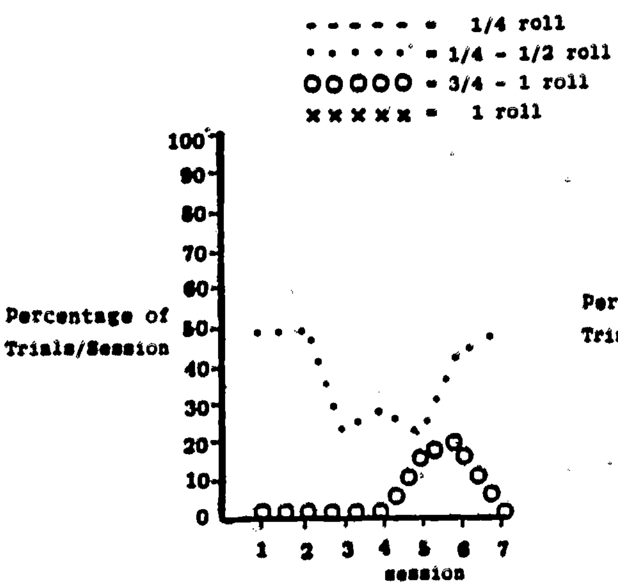


Fig. 26. Frequency of rolling mobility per session.

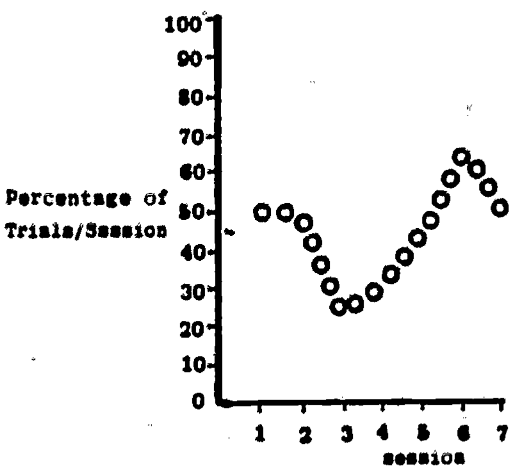


Fig. 27. Frequency of trials rolled per session.

23?

sessions (see Figures 28 and 42). Cary did not roll at all from supine over the right side. She rolled during 28 percent of supine over left trials between the sixth and seventh sessions (see Figures 29 and 38).

The degrees of trunk rotation demonstrated during prone over right and left trials ranged from 0° to 45° (see Figures 30 and 31). When rolling over the left side from supine, Cary demonstrated between 0° and 22.5° of trunk rotation (see Figure 33).

As Figures 34 and 37 illustrate, Cary led rolls with her pelvis as often as with her shoulder while rolling from prone over the right side and supine over the left side. It was only when rolling from prone over the left side that she led rolls with her shoulder the majority of times, as seen in Figure 35. Figures 38 through 41 illustrate that Cary made one-quarter to one-half of a roll during all but two measurable responses from prone and supine.

Subject 3 (Beth). Beth rolled 52 percent of the time, making 47 measurable responses. As indicated in Figure 43, Beth most frequently demonstrated between 11.25° and 22.5° of trunk rotation and made one-quarter of one-half of a roll per trial. The body part leading the roll was always the shoulder. Figure 44 illustrates the relative stability in the number of trials during which Beth demonstrated less than 11.25° or more than 45° of trunk rotation. As indicated in Figure 46, the frequency of each rolling mobility score per session, as well as the relative frequencies of each rolling mobility score per session, as well as the relative frequencies between scores, remained fairly stable throughout the study. Figure 45, depicting the frequency with which the shoulder led the roll per session, is identical to the number of trials rolled per session (see Figure 47). Both indicated a generally increasing trend over time.

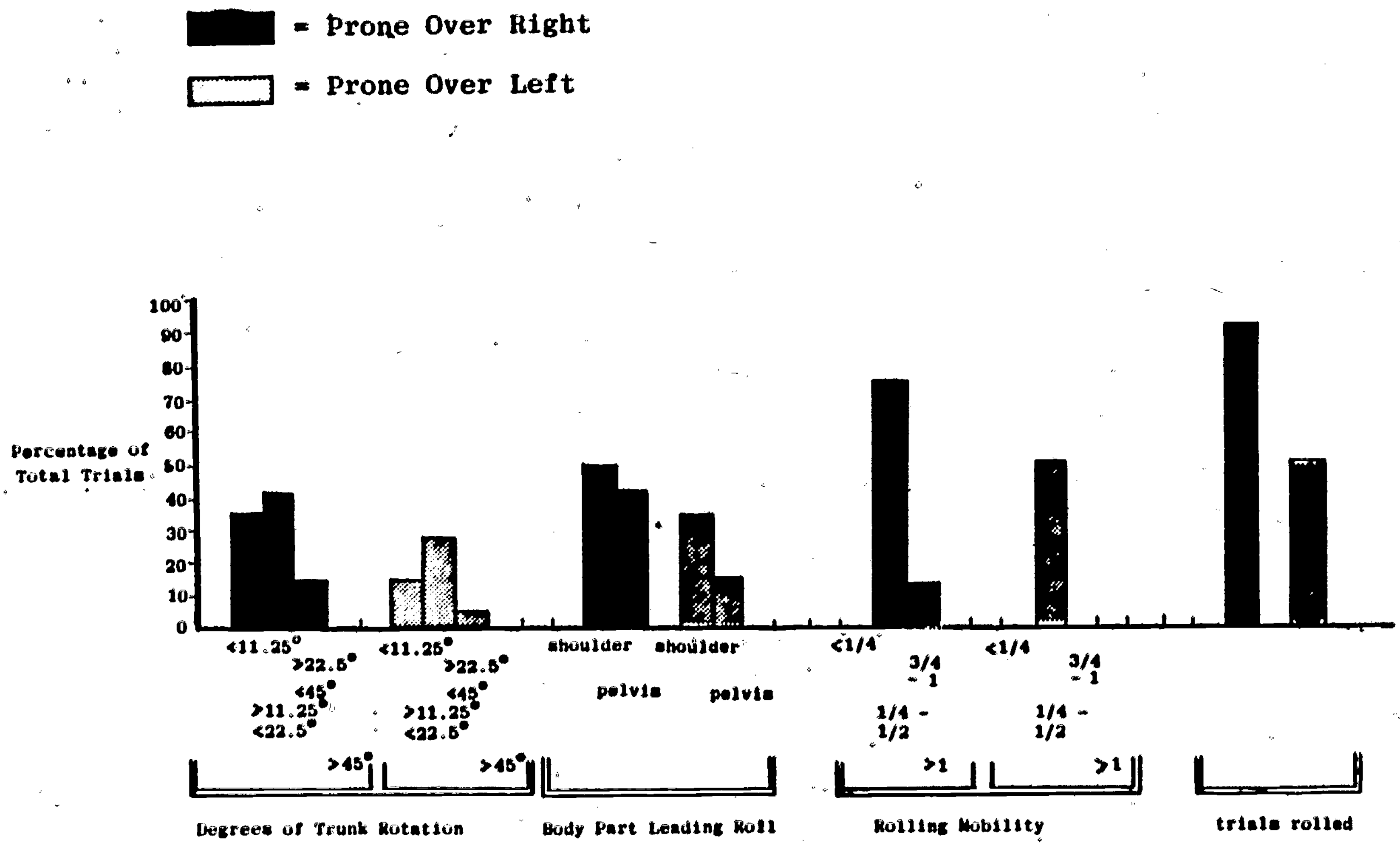


Figure 28. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Prone

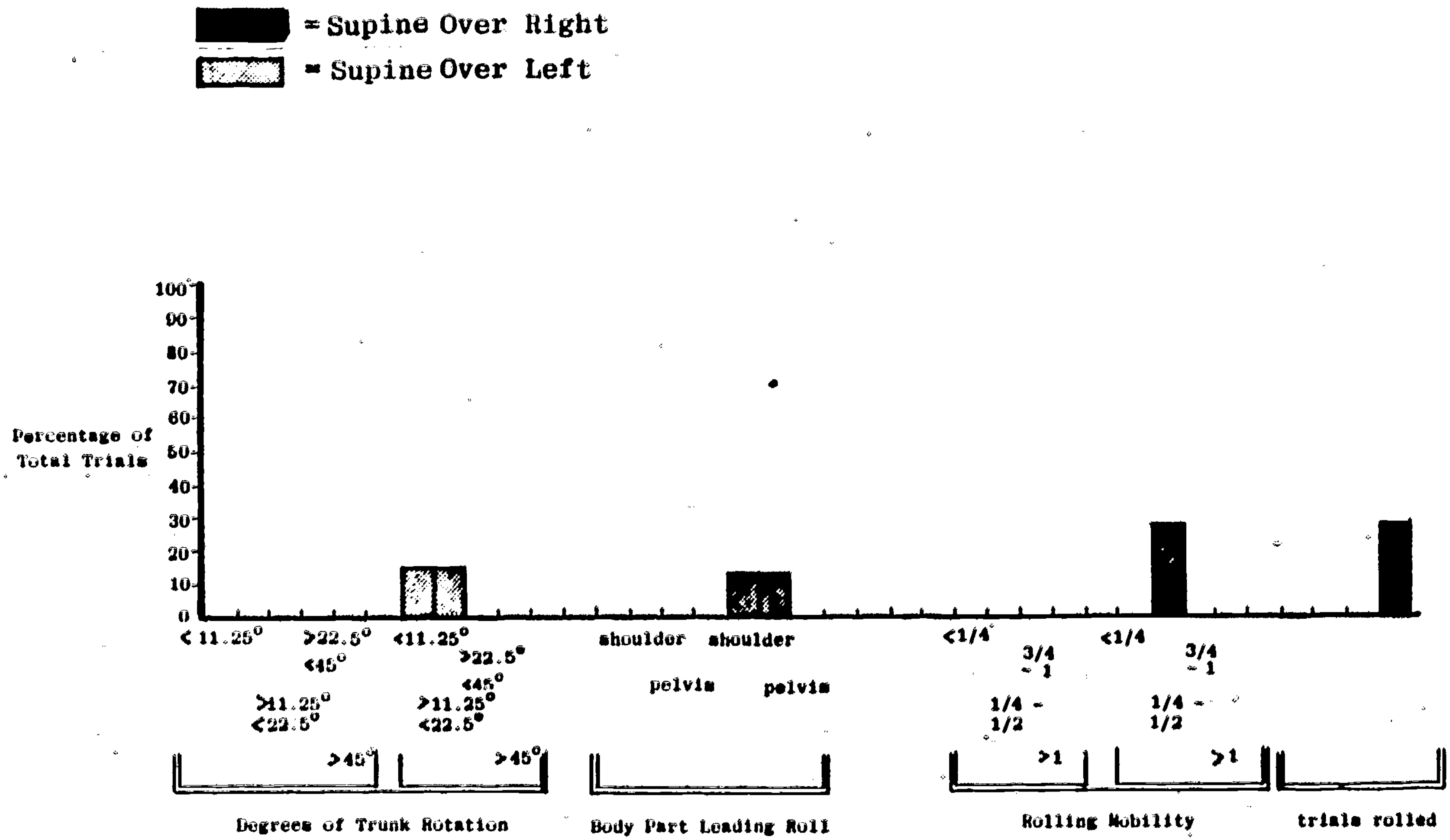


Figure 29. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Supine

207

Rolling from Prone | Rolling from Supine

Right

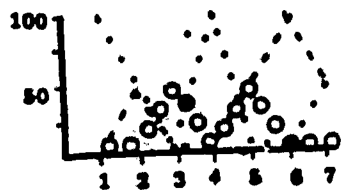


Fig. 30

Right

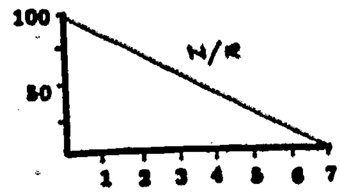


Fig. 32

Left

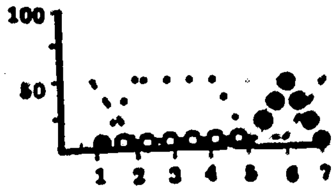


Fig. 31

Left

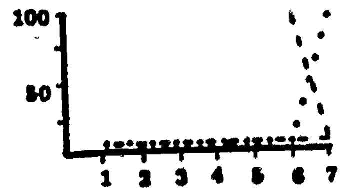


Fig. 33

- - - - - - = $< 11.25°$
. . . . . . = $> 11.25°$ $< 22.5°$
ooooo = $> 22.5°$ $< 45°$
x x x x x = $> 45°$

Figures 30 - 33 Frequency of trunk rotation from prone and supine per session.

Right

Fig. 34

Right

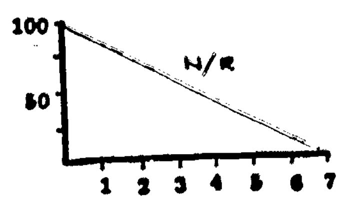


Fig. 36

Left

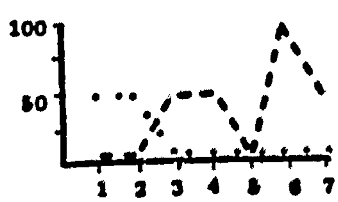


Fig. 35

Left

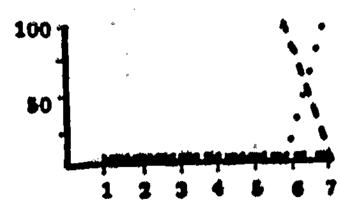


Fig. 37

- - - - - = shoulder leading
. . . . . . = pelvis leading

Figures 34 - 37 Frequency of body part leading the roll from prone and supine per session.

Rolling from Prone

Rolling from Supine

Right

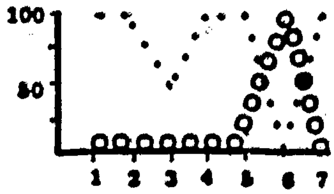


Fig. 38

Right

Fig. 40

Left

Fig. 39

Left

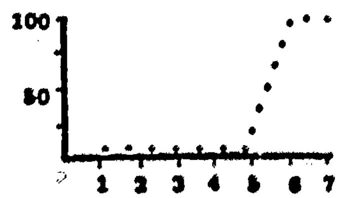


Fig. 41

- - - - - - = 1/4 roll
• • • • • • = 1/4 - 1/2 roll
OOOOO = 3/4 - 1 roll
x x x x x = 1 roll

Figures 38 - 41 Frequency of rolling mobility from prone and supine per session.

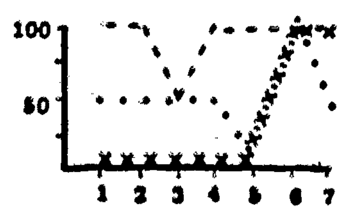


Fig. 42

- - - - - - = Prone Over Right
• • • • • • = Prone Over Left
OOOOO = Supine Over Right
x x x x x = Supine Over Left

Figure 42 Frequency of trials rolled from prone and supine per session.

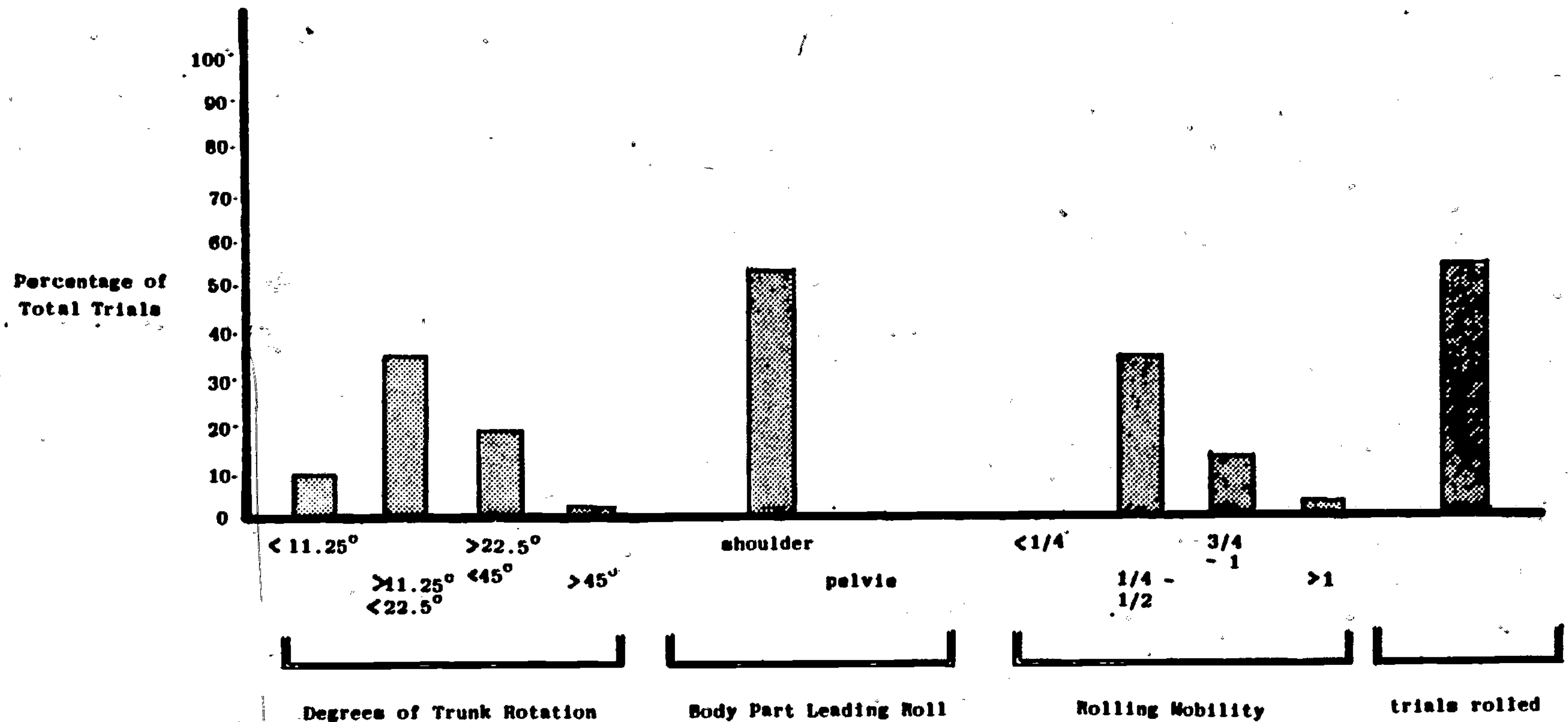


Figure 43 Frequency of trunk rotation, body part leading the roll, rolling mobility and trials rolled across sessions.

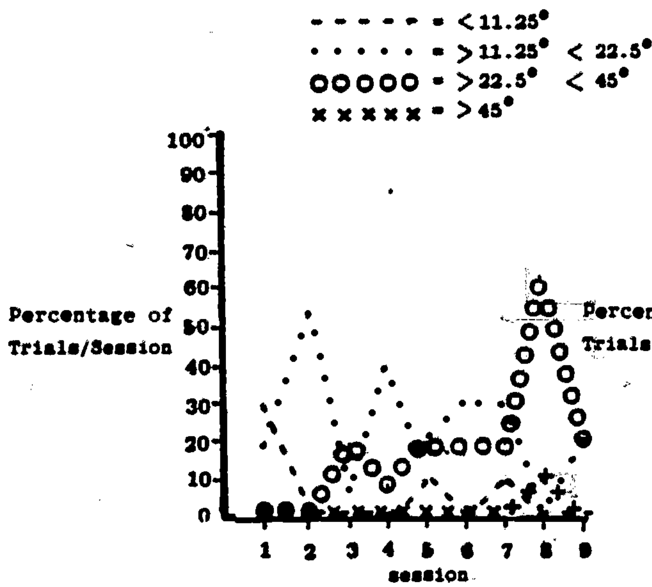


Fig. 44. Frequency of trunk rotation per session.

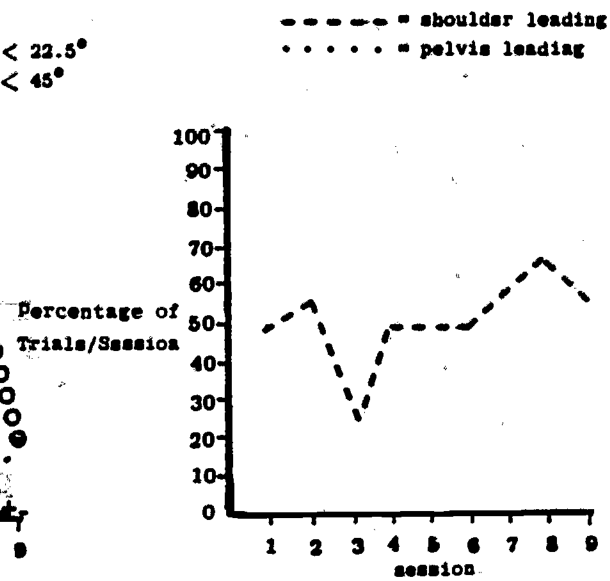


Fig. 45. Frequency of body part leading the roll per session.

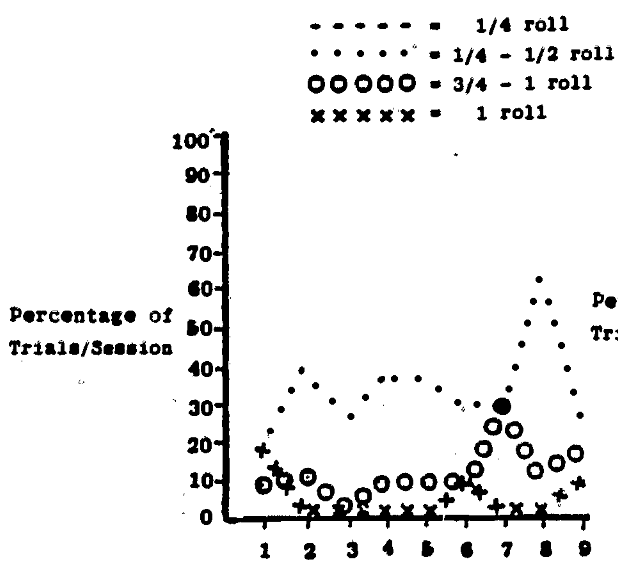


Fig. 46. Frequency of rolling mobility per session.

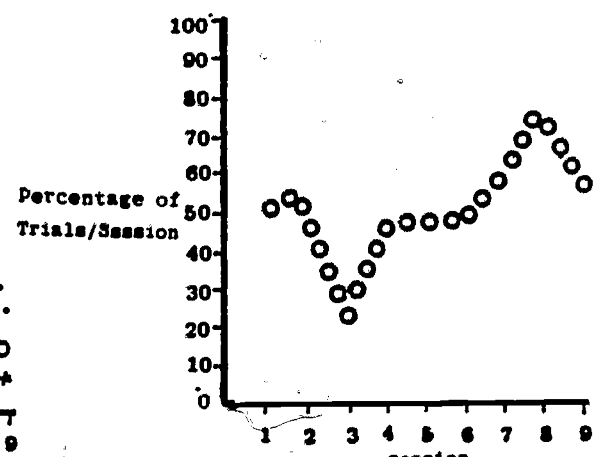
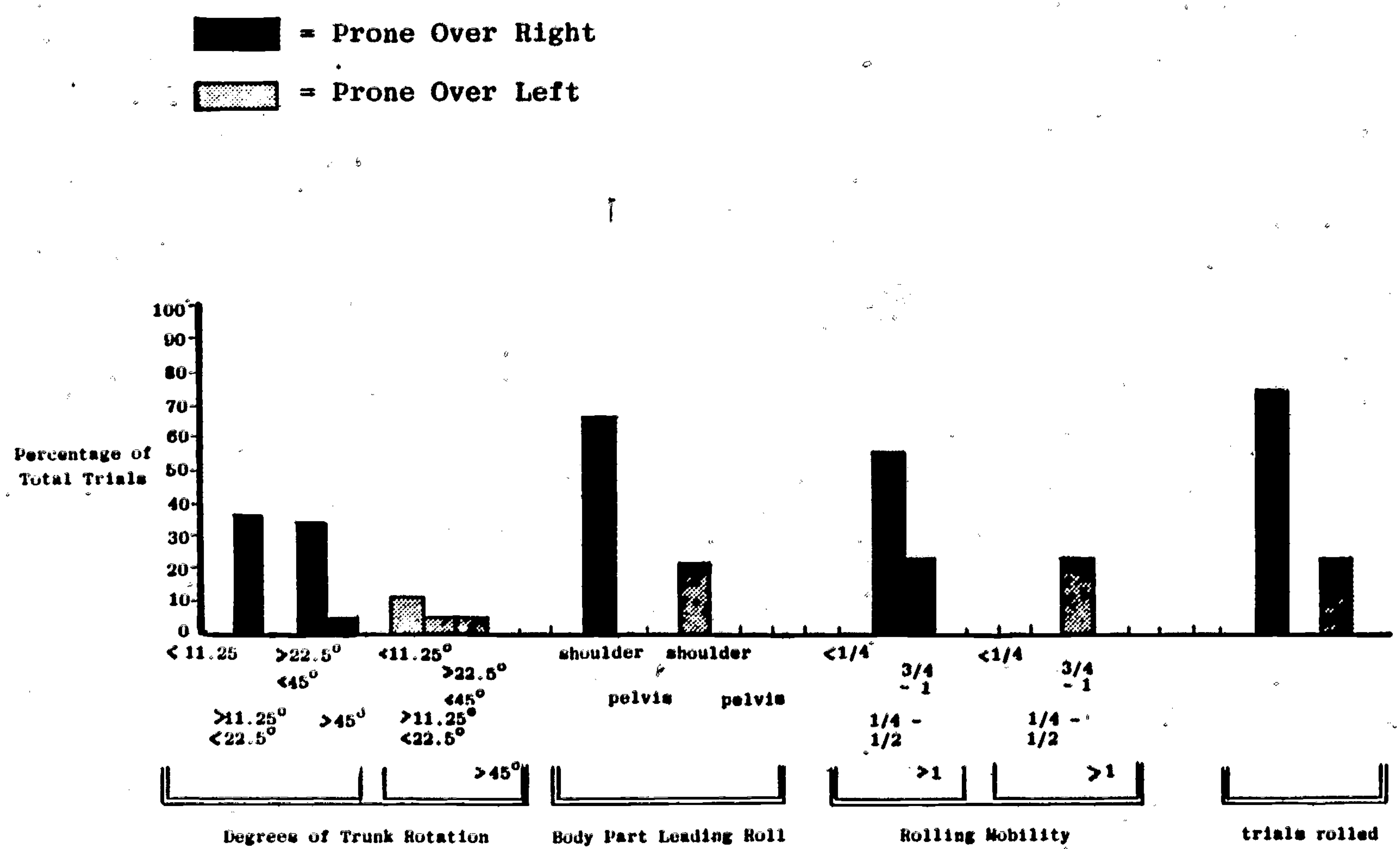


Fig. 47. Frequency of trials rolled per session.

As indicated in Figures 48 and 62, Beth rolled during 77 percent of prone over right trials, between the second and ninth sessions, and during 22 percent of prone over left trials, between the first and eighth sessions. She rolled during 94 percent of supine over right trials, between the first and ninth sessions, and during 27 percent of supine over left trials, between the seventh and ninth sessions (see Figures 49 and 62).

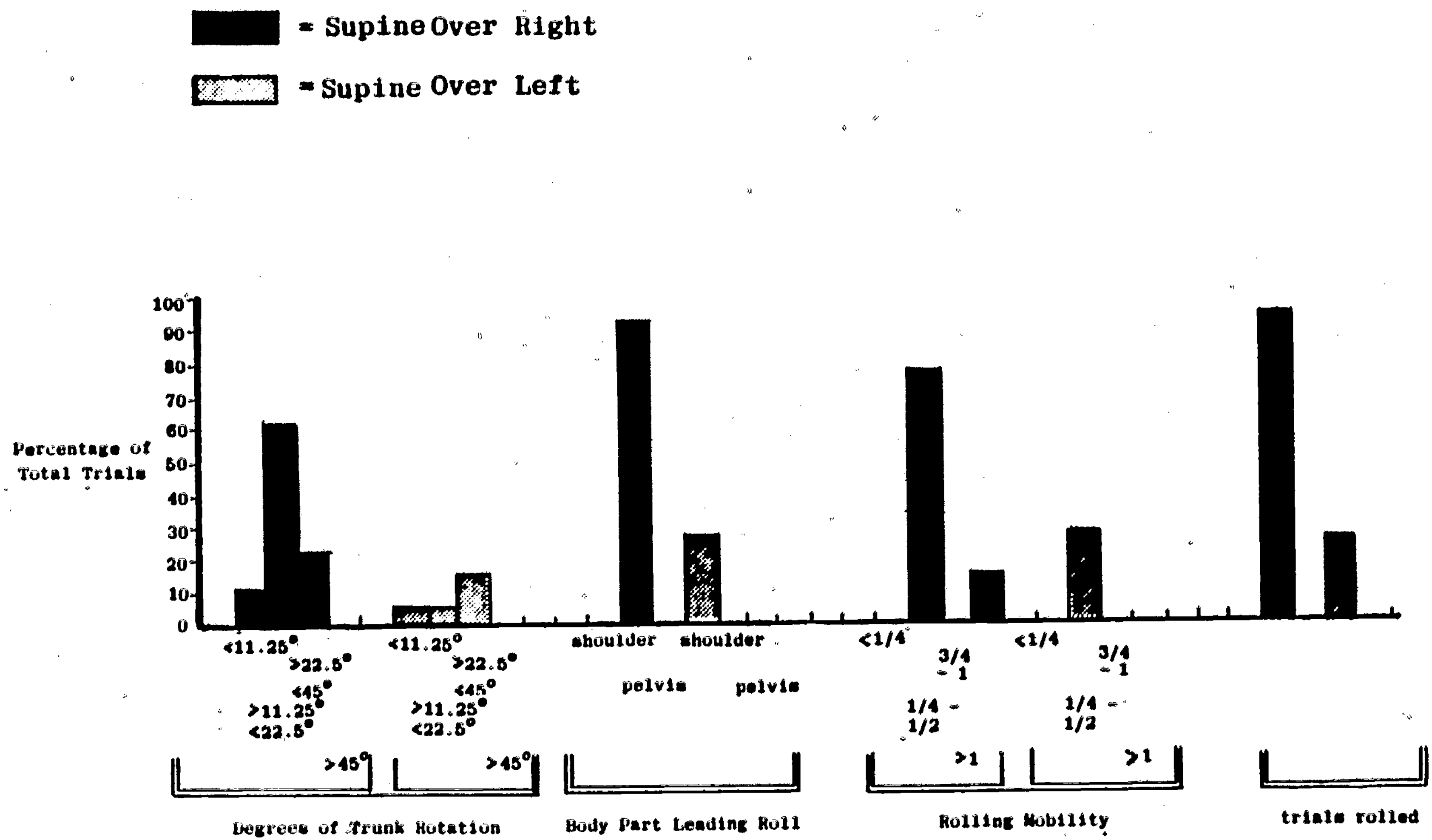
Degrees of trunk rotation exhibited during rolls from prone over the right side most frequently ranged between 11.25° and 45° (see Figure 50). Degrees of trunk rotation exhibited during rolls from prone over the left side ranged from 0° to 45° (see Figure 51). Beth most frequently demonstrated between 11.25° and 22.5° of trunk rotation when rolling from supine over the right side, although she repeatedly showed between 22.5° and 45° of rotation following its emergence during the sixth session, as seen in Figure 52. The degrees of trunk rotation exhibited during rolls from supine over the left side were highly variable, ranging from 0° to 45° (see Figure 53).

The body part leading the roll, identical to the number of trials rolled per session, is illustrated in Figures 54 through 57. Beth consistently made one-quarter to one-half of a roll over the right side from prone until the seventh session when three-quarters of a roll to one-roll responses emerged (see Figure 58). When rolling over the left side from prone, she always made three-quarters of a roll to one roll (see Figure 59). Beth made one-quarter to one-half of a roll over the right side from supine the great majority of times (see Figure 60). When rolling over the left side from supine, she always made less than a quarter of a roll (see Figure 61).



213

Figure 48. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Prone



252

253

Figure 43. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Supine

Rolling from Prone　　　　Rolling from Supine

Right

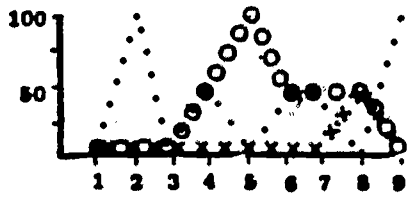


Fig. 50

Right

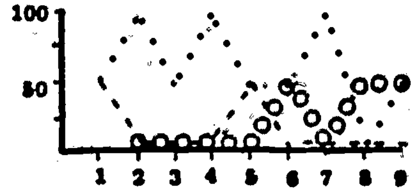


Fig. 52

Left

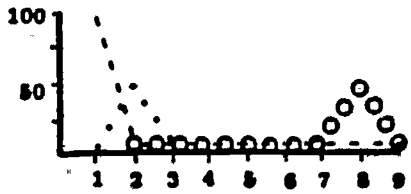


Fig. 51

Left

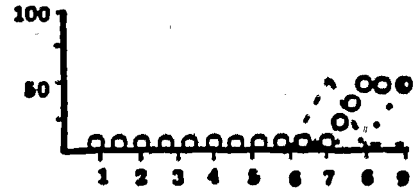


Fig. 53

- - - - - = < 11.25°
. . . . . = > 11.25° < 22.5°
OOOOO = > 22.5° < 45°
x x x x x = > 45°

Figures 50 - 53. Frequency of trunk rotation from prone and supine per session.

Right

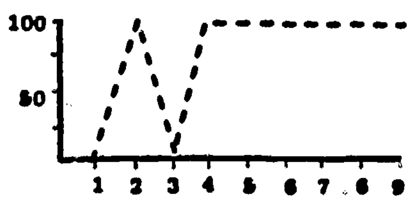


Fig. 54

Right

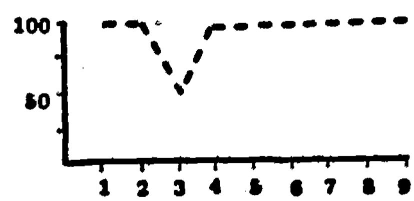


Fig. 56

Left

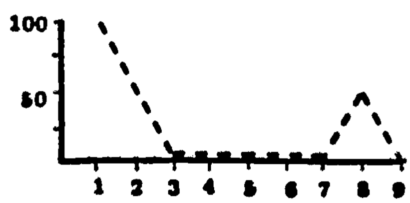


Fig. 55

Left

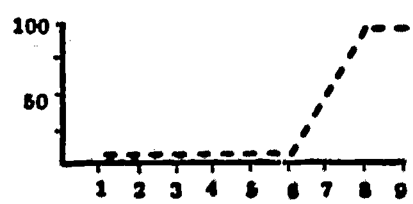


Fig. 57

- - - - - = shoulder leading
. . . . . = pelvis leading

Figures 54 - 57 Frequency of body part leading the roll from prone and supine per session.

Rolling from Prone | Rolling from Supine

Right

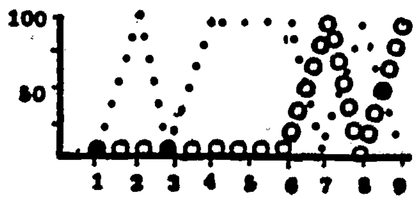


Fig. 58

Right

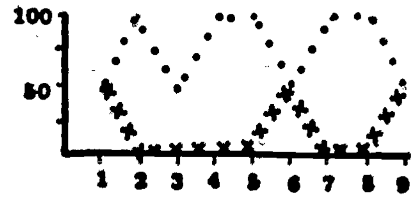


Fig. 60

Left

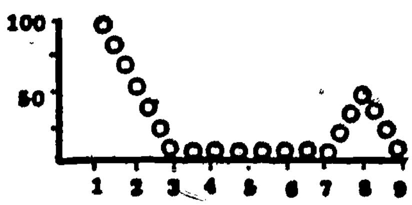


Fig. 59

Left

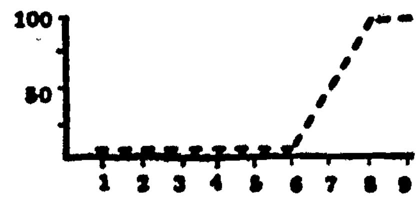


Fig. 61

- - - - - - = 1/4 roll
• • • • • • = 1/4 - 1/2 roll
OOOOO = 3/4 - 1 roll
x x x x x = 1 roll

Figures 58 - 61 Frequency of rolling mobility from prone and supine per session.

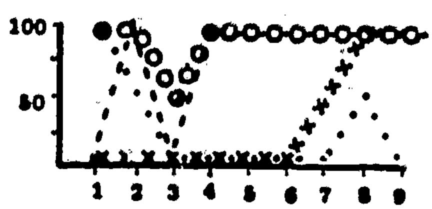


Fig. 62

- - - - - - = Prone Over Right
• • • • • • = Prone Over Left
OOOOO = Supine Over Right
x x x x x = Supine Over Left

Figure 62. Frequency of trials rolled from prone and supine per session.

Subject 4 (Keri). Keri rolled 60 percent of the time, making 58 measurable responses. As indicated in Figure 63, Keri most frequently demonstrated between 22.5° and 45° of trunk rotation, led rolls with her shoulder, and made one-quarter to one-half of a roll per trial. Degrees of trunk rotation demonstrated a fairly high degree of variability within a range of 0° to 45° (see Figure 64). The body part leading the roll was almost always the shoulder. As illustrated in Figure 65, the pelvis was not observed to lead any roll after the first session. Rolling mobility scores ranged from less than one-quarter of a roll to more than one roll (see Figure 66).

Keri rolled during 20 percent of prone over right trials, between the fourth and fifth sessions, and during 100 percent of prone over left trials (see Figures 68 and 82). She rolled during 7 percent of supine over right trials, between the second and ninth sessions, and during 100 percent of supine over left trials (see Figures 69 and 82).

When rolling from prone over the right side, Keri demonstrated between 0° and 22.5° of trunk rotation (see Figure 70). When rolling from prone over the left side, the degrees of trunk rotation were highly variable, ranging from 0° to 45° (see Figure 71). Keri most frequently demonstrated between 11.25° and 22.5° of trunk rotation while rolling from supine over the right or left side. In either case, however, this was highly variable as scores ranged from 0° to 45° (see Figures 72 and 73).

The body part leading the roll per session from prone and supine is illustrated in Figures 74 through 77. When rolling from prone over the right side, Keri consistently made less than one-quarter of a roll (see Figure 78). When rolling from prone over the left side, rolling mobility

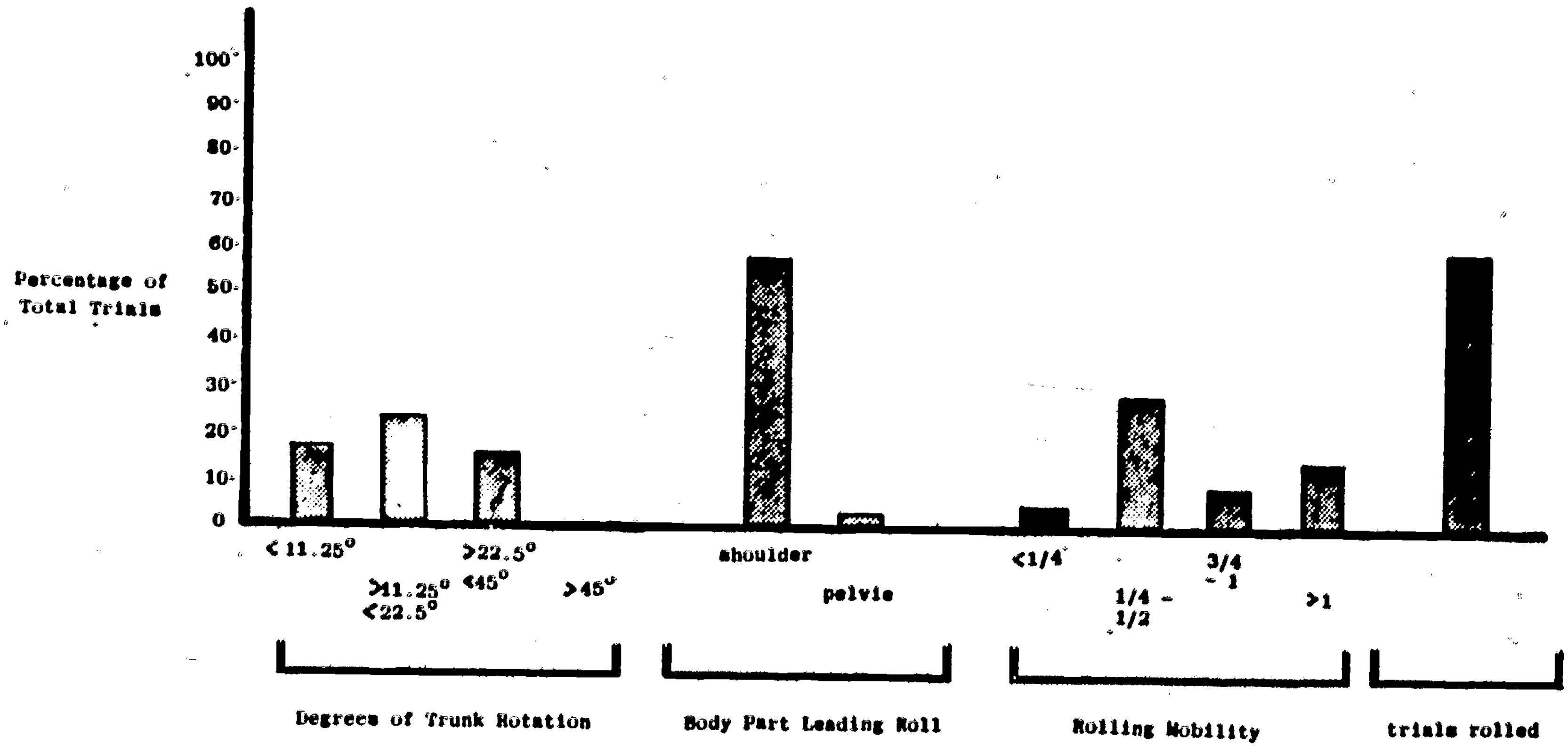


Figure 63. Frequency of trunk rotation, body part leading the roll, rolling mobility and trials rolled across sessions.

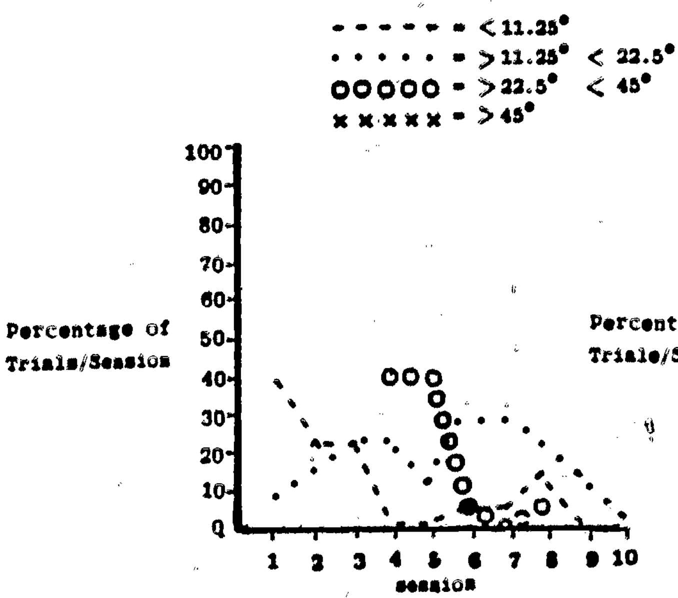


Fig. 64. Frequency of trunk rotation per session.

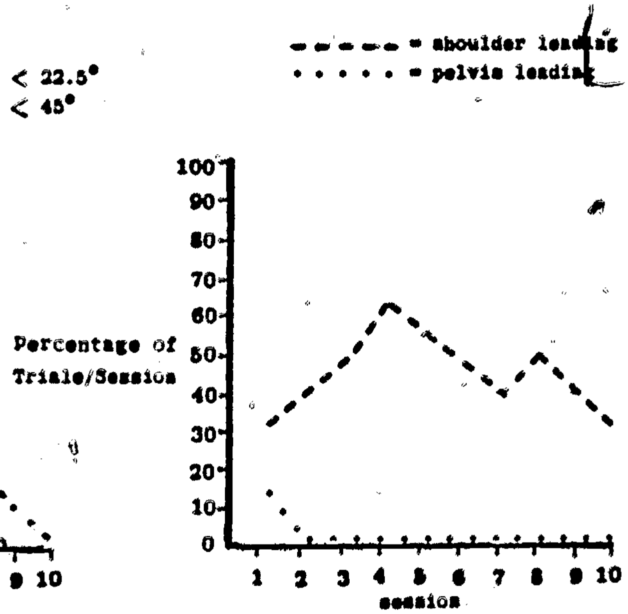


Fig. 65. Frequency of body part leading the roll per session.

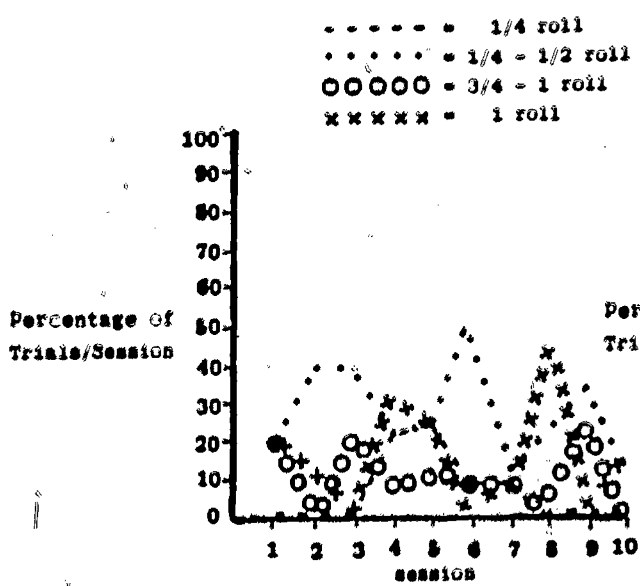


Fig. 66. Frequency of rolling mobility per session.

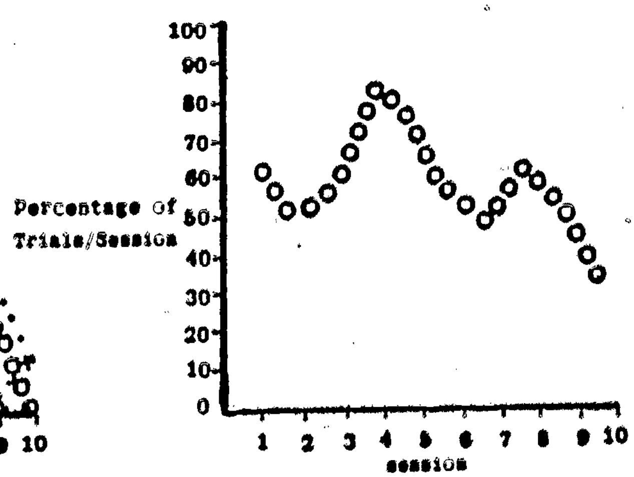
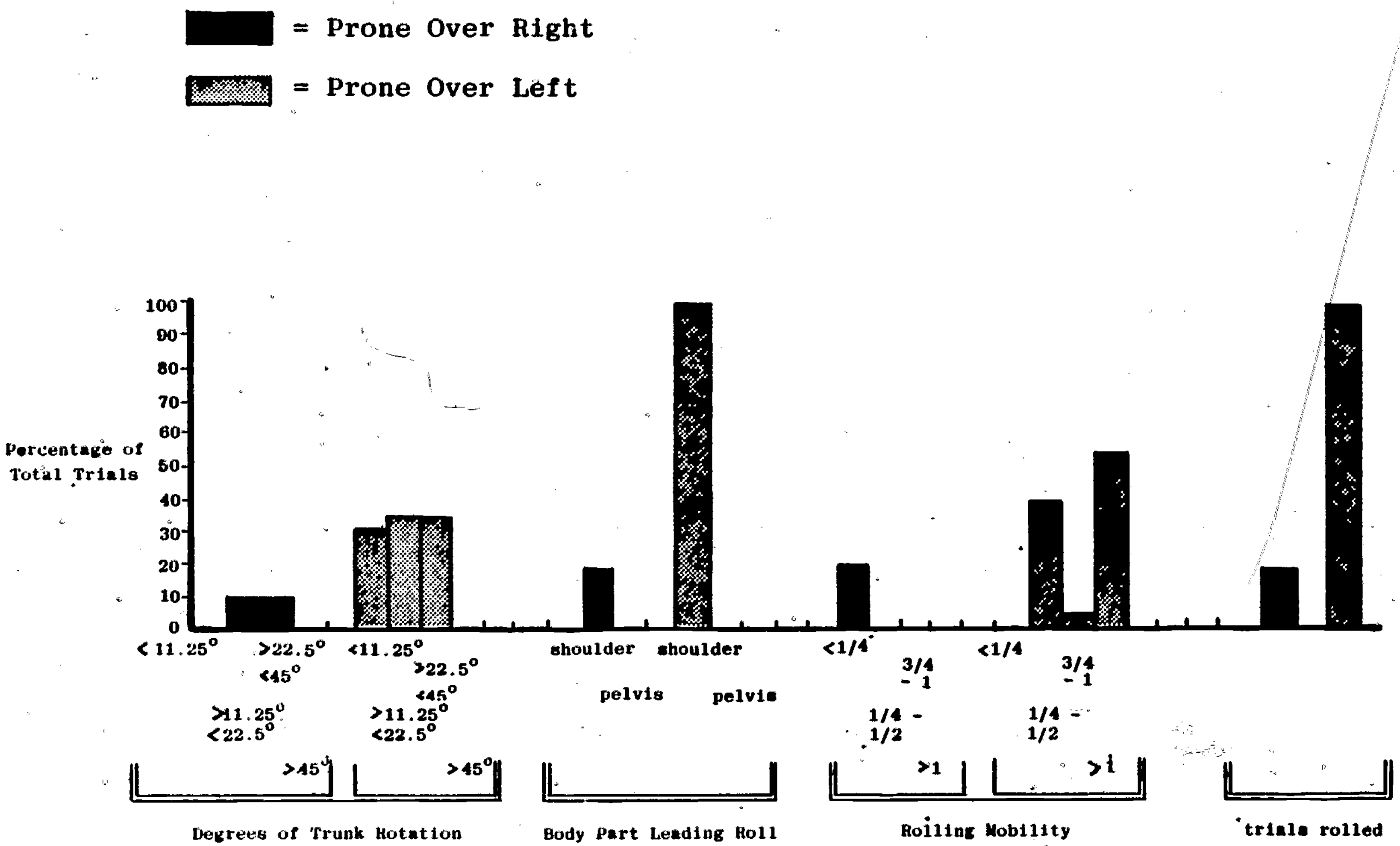


Fig. 67. Frequency of trials rolled per session.



220

Figure 68. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Prone

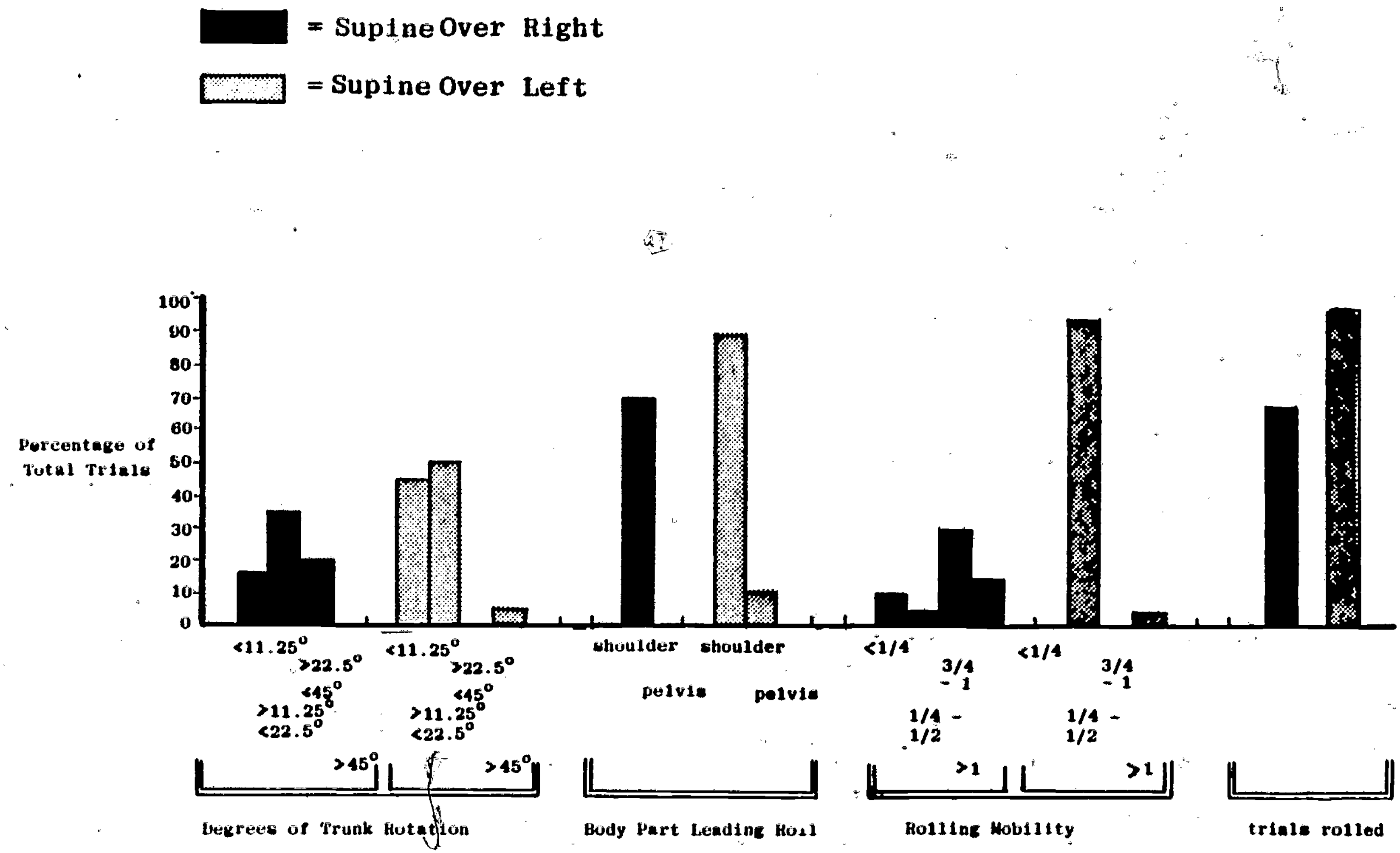


Figure 69. Frequency of trials rolled, Degrees of Trunk Rotation, Body Part Leading Roll and Rolling Mobility across sessions from Supine

Rolling from Prone | Rolling from Supine

Right

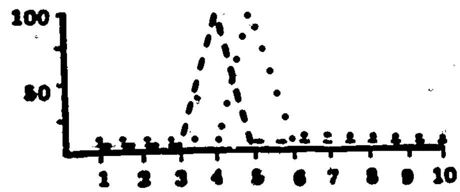


Fig. 70

Right

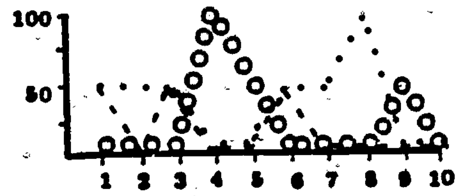


Fig. 72

Left

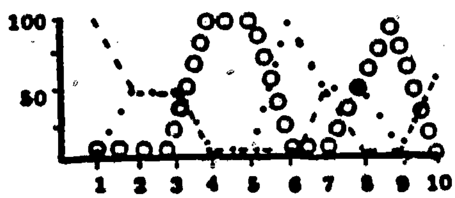


Fig. 71

Left

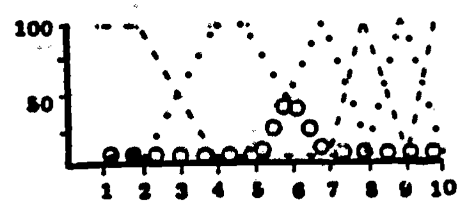


Fig. 73

- - - - - - = $< 11.25^\circ$
. . . . . . = $> 11.25^\circ$ $< 22.5^\circ$
OOOOO = $> 22.5^\circ$ $< 45^\circ$
x x x x x = $> 45^\circ$

Figures 70 - 73 Frequency of trunk rotation from prone and supine per session.

Right

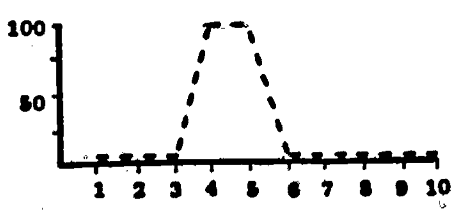


Fig. 74

Right

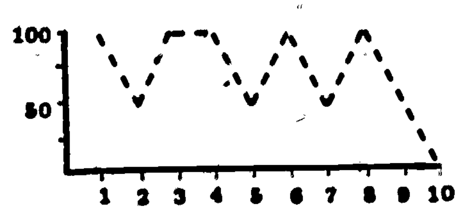


Fig. 76

Left

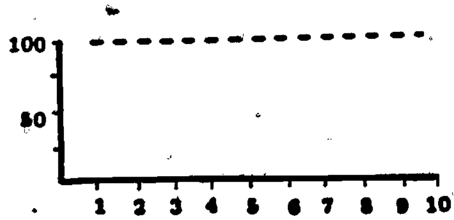


Fig. 75

Left

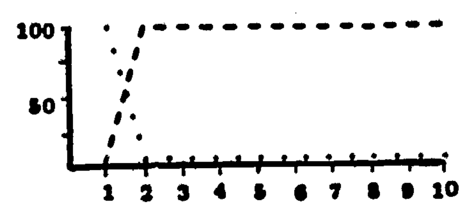


Fig. 77

- - - - - = shoulder leading
. . . . . . = pelvis leading

Figures 74 - 77. Frequency of body part leading the roll from prone and supine per session.

Rolling from Prone | Rolling from Supine

Right

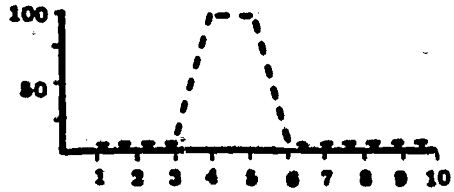


Fig. 78

Right

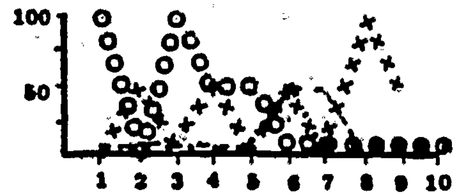


Fig. 80

Left

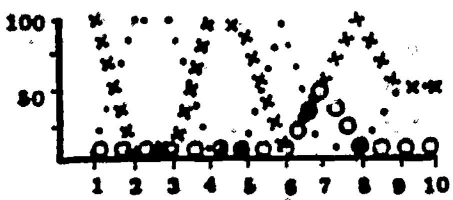


Fig. 79

Left

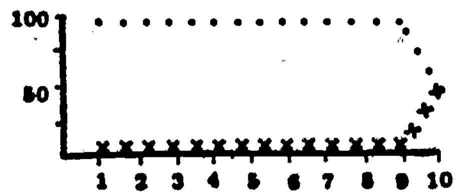


Fig. 81

- - - - - - = 1/4 roll
• • • • • • = 1/4 - 1/2 roll
OOOOO = 3/4 - 1 roll
✖✖✖✖✖ = 1 roll

Figures 78 - 81 Frequency of rolling mobility from prone and supine per session.

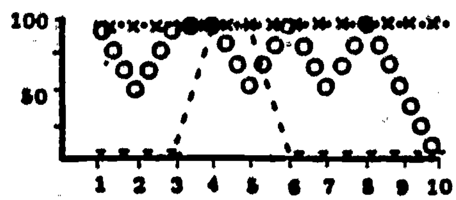


Fig. 82

- - - - - - = Prone Over Right
• • • • • • = Prone Over Left
OOOOO = Supine Over Right
✖✖✖✖✖ = Supine Over Left

Figure 82. Frequency of trials rolled from prone and supine per session.

scores most often fluctuated between one-quarter to one-half of a roll and more than one roll (see Figure 79). Keri most frequently made three-quarters to one roll from supine over the right side although scores were highly variable within a range of less than a quarter of a roll to more than one roll (see Figure 80). As seen in Figure 81, she made one-quarter to one-half of a roll during all but one response while rolling from supine over the left side.

Performance results across subjects. As indicated in Figure 83, the amount of trunk rotation most frequently exhibited across sessions and subjects was between 11.25° and 22.5°. Rolls were led by the shoulder during the great majority of trials, and the most frequent rolling mobility score was one-quarter to one-half of a roll per trial. The number of trials rolled across sessions and subjects was equal to 49 percent of total trials administered.

Discussion

Reliability Results

The reliability measures for trunk rotation were low for all subjects. The lower reliability obtained for this measure (70 percent across sessions and subjects) may have been due to four factors. First, elastic band #1 was often obscured by the child's arm as he or she rolled. This was a particular problem with the handicapped children who, because of spasticity, often held their arms in flexed, adducted, and internally rotated positions as they rolled. Second, the rolling response was often initiated so quickly that it was difficult to make an accurate measurement. Third, it was often difficult to obtain a reliable measure when the attention of the observers was divided between facilitation of

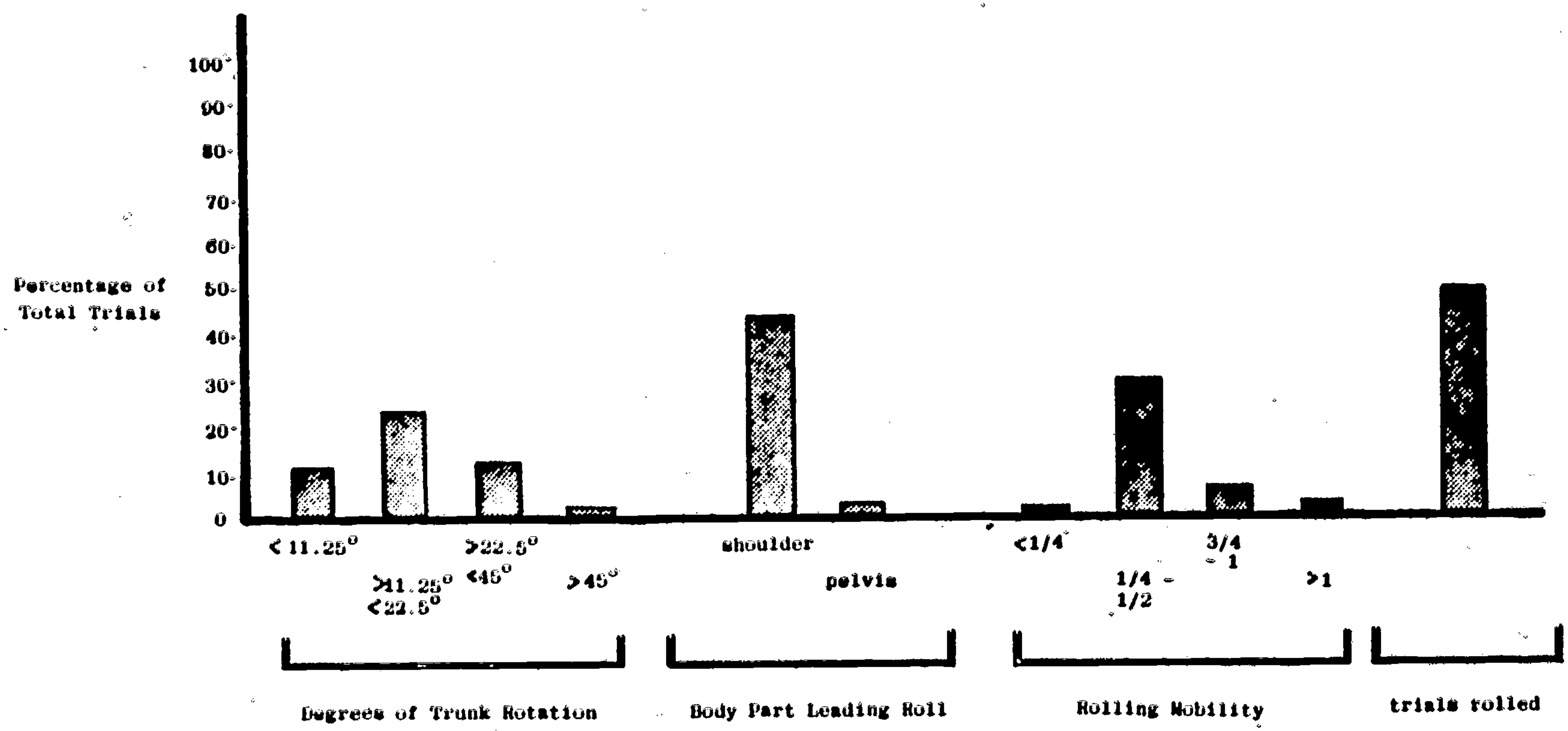


Figure 83. Frequency of trunk rotation, body part leading the roll, rolling mobility and trials rolled across subjects and sessions.

a rolling response and measurement of that same behavior. Fourth, the lower number of trials administered per session during the replication study may have contributed to the lower reliability measure.

Despite these problems, reliability measures of 80 percent or more were obtained during 54 percent of all sessions. This suggests that the procedures used for measuring trunk rotation can be used reliably.

The procedures used to determine the body part leading the roll and rolling mobility yielded highly reliable observations across sessions and subjects. This is probably because the choices for these descriptors were more distinguishable from each other. For example, it is easier to distinguish the shoulder leading the roll from the pelvis leading the roll than it is to distinguish degrees of trunk rotation.

Reliability Results from the Second Replication

While it was still below 80 percent, the reliability measure for trunk rotation was 5 percent higher across sessions and subjects than that obtained during the first replication. It is possible that the improved measure was due in part to the addition of a person to facilitate the rolling response, thus allowing the two observers to focus their complete attention on that response.

Performance Results Across Subjects

The procedures used during this replication study proved to be sensitive to changes in the quantity of the rolling response and quality with respect to degrees of trunk rotation, body part leading the roll, and rolling mobility exhibited. In addition, right-left asymmetries, as well as differences in performance between trials, initiated from prone and from supine presented themselves during the use of these procedures.

Recommendations for Future Research

Increased reliability measures obtained during the second replication study suggest the advantage of a person to facilitate the rolling response. Further research is recommended in order to clearly assess the value of such a facilitator.

With or without the facilitator, reliable measures of all three descriptors (degrees of trunk rotation, body part leading the roll, and rolling mobility) were obtained. Therefore, the procedures outlined in the first or second replication are recommended in order to establish norms and clarify developmental trends in rolling behavior of handicapped and nonhandicapped children. It is possible that such data would be of value in the differential diagnosis of various handicapping conditions.

These procedures are also recommended in order to establish relationships between descriptors and the relationship between an individual descriptor and other areas of development. An example of the former would be to determine if and how the quantity of trunk rotation is related to the quantity of rolling mobility that a child demonstrates. An example of the latter would be to determine if and how the quantity of trunk rotation is related to the presence or absence of protective extension responses in ring sitting. It is possible that these data would be valuable in treatment planning and in the assessment of treatment techniques used with various handicapping conditions.