EFFECTS OF VESTIBULAR STIMULATION ON

SITTING AND VOCAL BEHAVIORS

AMONG PRESCHOOLERS WITH

SEVERE AND MULTIPLE HANDICAPS

by

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ABSTRACT

A multiple baseline design across subjects was used to assess The effect of vestibular stimulation on the acquisition of erect and symmetrical sitting and vocal behaviors of preschoolers with severe and multiple handicaps. The subjects were three children aged three to five with various handicapping conditions. Measurements of erect and symmetrical sitting were taken in separate 3-minute time samples following vestibular stimulation. Frequency of vocalizations was recorded throughout the spinning sequence and the two 3-minute measurement periods that followed. All three subjects made gains in both erect and symmetrical sitting as well as in speech vocalizations during the intervention phase. The two subjects with athetosis appeared to maintain these gains across a 4-month follow-up period while the subject with hypertonicity did not.

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CHAPTER I

INTRODUCTION

The role the vestibular system plays in the developing organism is impressive. The vestibular system begins an influential role in utero by responding to the force of gravity and the gentle movements of the environment (Neal, 1977). Infants receive passive vestibular stimulation through movement in space in virtually every act of mothering (Raver, 1980). Maturation of the infant's muscles, reflexes, and vestibular system soon stimulate the infant to lift its head against gravity. According to Thelen (1980), the infant becomes able to independently stimulate its own vestibular system and may at times become completely absorbed in the act of moving (e.g., rocking). The vestibular system continues to respond to gravity and movement, and the body continues to be influenced by the vestibular system throughout life.

Research on the influence of the vestibular system on normal development, as well as implications for vestibular dysfunction are reviewed. Literature on vestibular stimulation as a therapeutic technique is reviewed, including applications to persons with severe and multiple handicaps.

The Vestibular System

The vestibular system consists of the vestibular apparatuses and a network of central nervous system connections. There are two vestibular apparatuses, one on either side of the head, located in the inner ear. Each apparatus is composed of three structures: a) the semicircular canals; b) the utricle; and c) the saccule.

The three semicircular canals are set at right angles to one another so that each canal lies on a different plane in space: a horizontal or lateral plane, a superior or anterior plane, and a posterior or sagittal plane (Figure 1). The semicircular canals respond to angular acceleration such as that received through spinning or rotating. The utricle and saccule respond to linear acceleration such as bouncing and the gravitational pull. These three structures share a common fluid called the endolymph, that shifts in response to motion. The flow of the endolymph across hair cells within these three structures triggers nerve endings to send impulses through the vestibular nuclei to the brain (Parker, 1977). The three semicircular canals, in combination with the utricle, the saccule, and vision, inform the brain as to any movement that may occur, and to the exact position of the head in three dimensional space (Ayres, 1972; Kelly, 1981). The brain is then able to send messages to various parts of the body to make adjustments (e.g., realignment of the trunk to midline) inaccordance with the newly integrated information from the vestibular system (Grollman, 1978; Guyton, 1976; Kelly, 1981; Parker, 1977; Shuer, Clark, & Azen, 1980; Wilson, 1975).

<u>The Vestibular System and Motor and Language Acquisition</u>

Both motor and language development in normal infants have universally been found to progress in orderly sequences. Motor development begins with gross motor movements in which the whole body moves as a single unit, and proceeds onward through the developmental "milestones" to coordinated, purposeful gross and fine motor acts (Gesell, 1948; 1952). Language development moves from

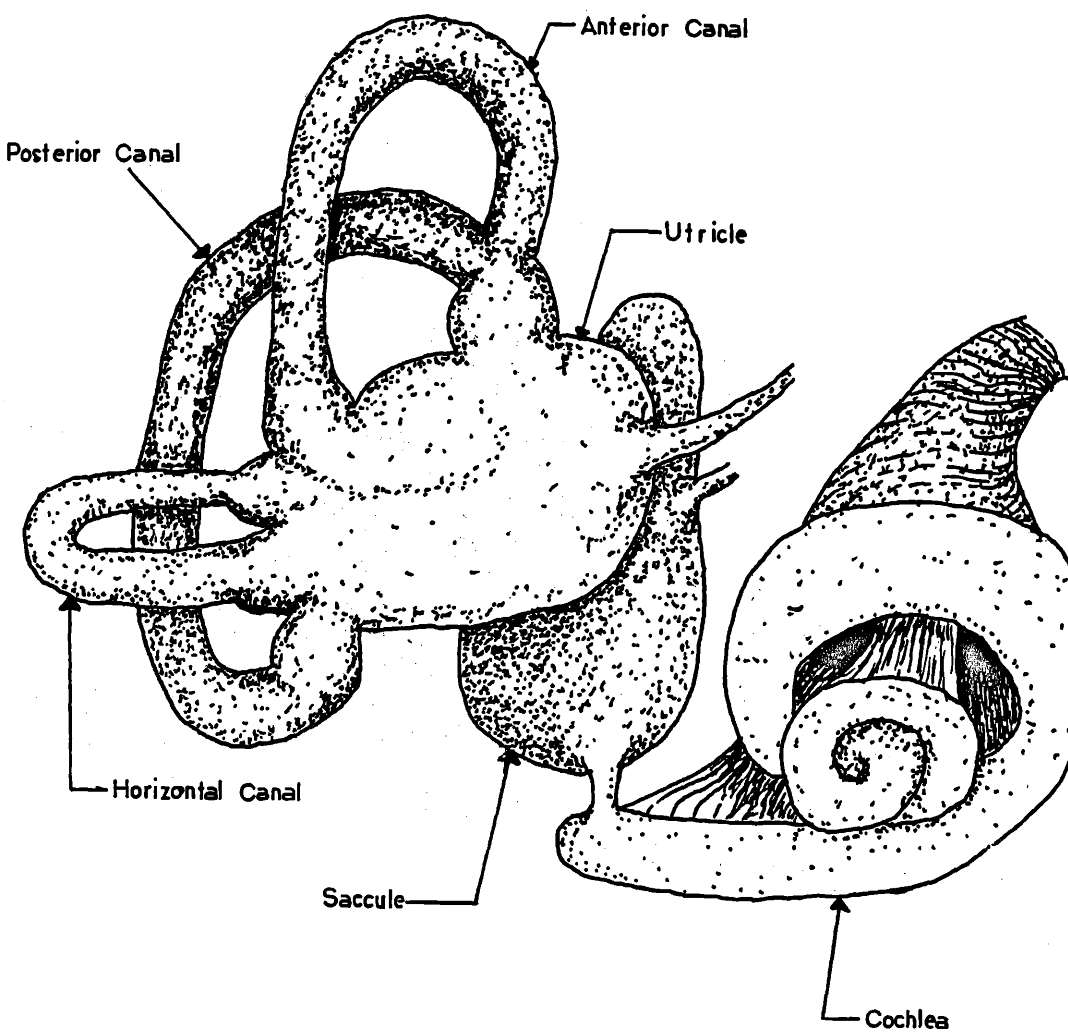

Figure 1. The vestibular system.

reflexive vocalizations through babbling, holophrases, and telegraphic speech to spontaneous, functional, appropriate, and effective verbal communication (Bates, 1976; Bloom, 1973; 1976; Bruner, 1975; Ingram, 1976). The vestibular system has been implicated as the basic mechanism promoting these motor and language behaviors to emerge, by mediation of the neurological interplay between the proprioceptive, visual, and motor systems (Eviatar, Eviatar, & Naray, 1974). The vestibular system accomplishes this mediation through anatomical association with the vestibular nuclei, spinal cord, brain stem, cerebellum, reticular formation, cerebral cortex, and extraocular eye muscles (Wilson, 1975). The maturation of the vestibular system and reflexive system allows for the development of righting and equilibrium reactions (Ayres, 1975; DeGangi, Berk, & Larsen, 1980). Such righting reactions function to maintain the head and body in an upright position in relation to gravity (Guyton, 1976; Weeks, 1979). The development of righting and equilibrium reactions are necessary components to allow movement while in the sitting position, which is the basis of functional independent sitting. The vestibular system also plays a role in the sequential development of body posture (Matzke & Flotz, 1972), muscle tone, ocular motor control, and reflex integration (Ayres, 1975), and speech, language and hearing development (Ayres, 1975; de Quiros & Schrager, 1978; Sperry & Gazzaniga, 1967). De Quiros (1976) proposed that interaction of the information from the proprioceptive and vestibular receptors may be a fundamental requirement for learning, in association with human communication.

Vestibular Dysfunction

Erway (1975) has noted that any genetic or environmental factors which alter the normal development or maintenance of this elaborate inertial-guidance system may affect the development of early locomotor functions. Disorders in the function of the vestibular system can have far-reaching effects. Dysfunction, as noted by deviations in the duration or the excursion of postrotary nystagmus (Ayres, 1975), has been observed in various groups of individuals who are developmentally delayed. Those groups include: 1) persons with motor delays (Rapin, 1974; Torok & Perlstein, 1962); 2) individuals with mental retardation (Kantner, Clark, Allen, & Chase, 1976; Kantner, Kantner, & Clark, 1982; Shuer, et al., 1980); 3) persons with emotional disturbances (Erway, 1975); 4) individuals with autism (Ayres & Tickle, 1980; Ritvo, Ornitz, & Eviatar, 1969); and 5) individuals with learning disabilities (Ayres, 1975; de Quiros, 1976).

The Vestibular System and the Severely-Multiply Handicapped

Two areas of major importance to the severely handicapped population are motor and language development. This population has been characterized by severe delays and/or impairments in both of these areas (Guess & Horner, 1978). Individualized education programs for the severely and multiply handicapped population are often devoted primarily to remediation of, or compensation for, these motor and language deficits. It has been hypothesized by Ayres (1975), Bobath (1967), and Rood (1956) that improvements in motor output can be achieved by presenting sensory input through the vestibular system.

Ayres (1975) further hypothesized improvements in language output as a result of vestibular stimulation. Sensory input to the vestibular system is achieved by techniques that have included rocking, bouncing, spinning, and riding on a scooter board (Weeks, 1979).

Effects of Vestibular Stimulation

A growing body of research has reported findings of developmental improvements resulting from vestibular stimulation. These improvements have been observed in motoric abilities, language skills, as well as in numerous other behaviors such as social skills (Morrison & Pothier, 1972), affect, perception, and cognitive schemes (Ayres & Tickle, 1980; Norton, 1975), environmental awareness and purposeful activities (Ayres & Tickle, 1980; Webb, 1969), auditory memory (Ayres, 1975), academic achievement (Ayres, 1978), and eye contact, visual attentiveness, and visual tracking (Gregg, Haffner, & Korner, 1976; Korner & Grobstein, 1966; Neal, 1967; Resman, 1981; White & Castle, 1964). Improvements in gross motor, fine motor, and reflexive abilities have been reported to result from vestibular stimulation in preambulatory normal children (Clark, Kreutzberg, & Chee, 1977; Neal, 1967), persons with mental retardation (Kantner et al., 1976; Montgomery & Richter, 1977; Morrison & Pothier, 1972; Norton, 1975; Ottenbacher, Short, & Watson, 1981), children with cerebral palsy (Chee, Kreutzberg, & Clark, 1978), and children with developmental delays (MacLean & Baumeister, 1982). Vestibular stimulation has also been reported to affect improvements in expressive language among persons with mental retardation (Clark, Miller, Thomas, Kucherway, & Azen, 1978; Kantner et al., 1982; Magrun, Ottenbacher, McCue, &

Keefe, 1981; Morrison & Pothier, 1972; Newman, Roos, McCann, Menolascino, & Head, 1974; Webb, 1969), individuals with autism (Ayres & Tickle, 1980), persons with cerebral palsy (Carlson, 1975), individuals who are learning disabled (Ayres, 1972; 1975), persons who have severe language delays (Magrun et al., 1981), persons with aphasia (Ayres & Mailloux, 1981), and persons with chronic schizophrenia (Bailey, 1978).

Kantner et al. (1976) noted marked improvements in motor behavior and reflexes in children with Down's Syndrome and non-handicapped children as a result of vestibular stimulation. The vestibular stimulation received by the subjects consisted of ten days of stimulation of specific pairs of semicircular canals through rotation. The horizontal semicircular canals were stimulated twice each day (once clockwise (SW), and one counter-clockwise (CCW)), and the pairs of vertical canals received four periods of stimulation each day (two CW, and two CCW), with a 60 second rest period between rotations. Each stimulus consisted of a two-to-five second acceleration, one-minute of constant velocity, and an impulsive stop. This procedure was employed to facilitate maximum stimulation of the semicircular canals. Sudden stops and starts were incorporated into the procedure since the semicircular canals respond only to a change in angular acceleration such as initiation and cessation of motion. The more dramatic this change, the greater the stimulation provided to the canals. A 60-second rest period between rotations also provided maximum stimulation. According to a later study done by MacLean & Baumeister (1982) the 60-second rest period is necessary since the cupula would be returned from maximum deflection if any movement occured after the stop.

An impulsive stop presents the canals with the greatest amount of stimulation, and was employed in a study by Clark et al. (1977). In this study, 26 preambulatory non-handicapped children were assigned as matched pairs to either the treatment or the control group on the basis of motor and reflex abilities. The treatment group was exposed to 16 sessions of semicircular canal stimulation over a four week period through 10 minutes of spinning in a rotating chair. Maximal stimulation to each semicircular canal was achieved by positioning the subjects in upright sitting for two spins (one CW, and one CCW), right sidelying for four spins (alternating two CW, and two CCW), and left sidelying (alternating two CW, and two CCW). Each spin consisted of a rapid (1-3 second angular acceleration), a one-minute period of constant velocity, followed by an impulsive stop in less than one second. These procedures resulted in significant improvements in reflex and gross motor abilities for the treatment group (N =13) as compared with the control group (N =13).

Chee et al. (1978) followed the same procedures followed by Clark et al. (1977) in their study involving 23 preambulatory children with cerebral palsy. The treatment group (N =12) exhibited significantly greater improvements in reflex and motor abilities than did the control group (N =11). Improvements were also noted in fine motor and social/emotional behaviors for the treatment group. Findings suggested that repeated vestibular stimulation facilitates integration of the vestibulo-ocular reflex and results in a more stable retinal image during head movements, thus providing a more stable background for motor performance.

Contra-indications of Vestibular Stimulation

Johnson and Jonijkees (1974) and Shuer et al. (1980) have indicated that vestibular stimulation may affect vascular changes, perspiration, salivation, the gastro-intestinal system, and respiration, due to connections with the autonomic centers of the medulla, midbrain, thalamus, and cerebral cortex. Although such side effects of vestibular stimulation may be possible, literature in this area is conflicting.

Chee et al. (1978) screened their subjects for cardiac problems or recurrent seizures, and selected only those who had no history of either condition. Ayres (1975) suggested monitoring autonomic responses such as flushing, blanching of the face, unusual perspiration and nausea, as well as seizures. Ayres (1975) noted that evidence of a detrimental effect of vestibular stimulation on seizure activity was inconclusive. She made no mention of either screening or monitoring subjects with a history of cardiac problems. Ayres further suggested the importance of proper positioning of subjects during vestibular stimulation. She recommended the flexed position to avoid increasing muscle tone, especially for those subjects who are already exhibiting high muscle tonus.

Many studies have presented vestibular stimulation either in a dimly lit or darkened room (Chee et al., 1978; Clark et al., 1977; Gregg etal., 1976; MacLean & Baumeister, 1982). This step was taken as a precaution against seizures, regardless of the lack of evidence to support the notion that vestibular stimulation may induce seizures. Little effort was made to assess the effects of vestibular stimulation on seizure activity in any of these studies. Kantner, Clark, Atkinson, and Paulson (1982) investigated more closely the effects of vestibular stimulation on seizures. After taking baseline data on electroencephalographic (EEG) disturbances of ten seizure-prone children, the investigators exposed the subjects to caloric stimulation by placing warm and cold water into the ear canals. An electronystagmographic (ENG) record confirmed the effectiveness of the stimulation. Posttest EEG's depicted no accentuation of abnormal brain wave patterns as a result of this type of vestibular stimulation. In fact, a significant reduction in abnormal high voltage activity (paroxysmal activity) was noted for six of the ten subjects.

Summary

A review of the relevant literature reveals some areas where further systematic research is needed, specifically concerning the contra-indication of vestibular stimulation, the optimal frequency and duration of stimulation, the correlation of the postrotary nystagmus response with the effectiveness and tolerance of stimulation, and the specific effects of therapy on children with severe and multiple handicapping conditions.

The purpose of the present investigation is to study the effect of vestibular stimulation on the acquisition of sitting and vocal behaviors in preschoolers with severe and multiple handicaps. The intent is to use quantifiable assessments to measure the effects of this intervention on several behaviors.

CHAPTER II

METHOD

Subjects

Three preschoolers attending day programs for children with severe and multiple handicaps in a midwestern metropolitan area served as subjects. The criterion for subject selection was the inability of the child to maintain a cumulative duration of independent sitting for 60 seconds, but the ability to maintain supported sitting for a cumulative duration of 100 seconds or more, as measured in a 3-minute time sample.

Written consent and a release form were obtained from each of the subject's parents/guardians prior to their participation in the study. Copies of these forms are included in Appendix A.

Subject 1. Stephen was a 4-year 10-month old boy with athetoid cerebral palsy and a severe-profound bilateral hearing loss. Stephen was the second born of twin boys, both of whom exhibited athetoid cerebral palsy. Stephen had no history of seizures and did not have a formal communication mode. Stephen exhibited several behavior problems including: scratching, pinching, dismantelling his hearing aids, and removing his leg splints.

Stephen was most stable in tailor-style sitting in which he was able to maintain 10 seconds of independent sitting and 160 seconds of supported sitting. Stephen used some extended arm propping to maintain the sitting posture. Detailed characteristics are found in Table 1.

Subject 2. Jennifer was a 3-year old girl with spastic

Table 1

Characteristics of the Three Subjects Included in the Study

Characteristics	Subjects		
	Stephen	Jennifer	Thomas
Age	4-years-10-months	3-years-0-months	3-years-4-months
Diagnosis	Athetoid cerebral palsy, severe-profound bilateral hearing loss.	Spastic quadriplegic cerebral palsy, severe bilateral hearing loss.	Athetoid cerebral palsy, severe-profound bilateral hearing loss.
History of Seizures	None	at birth, controlled with phenobarbital	None
Gross Motor Level	10-11 months	6-7 months	17-18 months
Fine Motor Level	18-30 months	4-5 months	25-26 months
Cognitive Level	23-24 months	1-2 months	18-19 months
Modes of Communication	No formal mode	Eye gaze	Sign language Communication book and board.
Adaptive Devices	Bilateral hearing aids, Ployurethane ankle-foot orthoses.	Bilateral hearing aids, corrective glasses.	Unilateral hearing aid.

quadriplegic cerebral palsy and a severe bilateral hearing loss. Jennifer exhibited some seizures at the time of her birth, which was premature at $6\frac{1}{2}$ months. Phenobarbital has controlled the seizures since infancy, valium was also being given to reduce some of her muscle tension. Jennifer was beginning to use an eye gaze for communication at the time of the study.

Jennifer was most stable in ring-style sitting, she was unable to maintain any independent sitting, but could maintain 120 seconds of supported sitting. Jennifer often arched backwards and extended out of the sitting position. Jennifer did not use any arm props to maintain the sitting posture. Detailed characteristics are found in Table 1.

Subject 3. Thomas was a 3-year 4-month old boy with athetoid cerebral palsy and severe-profound bilateral hearing loss. Thomas had no history of seizures. Thomas had a large receptive signing vocabulary and some expressive signs; he also used a communication book and board to express himself.

Thomas was most stable in tailor-style sitting in which he was able to maintain 5 seconds of independent sitting and 155 seconds of supported sitting, during which he frequently used forearm propping. Detailed characteristics are found in Table 1.

Setting

Baseline observations and intervention procedures were conducted in brightly lit rooms adjacent to the subjects' regular classrooms. Subject 1 was observed in a room approximately 4 m by 5.2 m. Subjects 2 and 3 were observed in a room approximately 5.5 m by 7.3 m.

Materials and Equipment

Intervention

The materials and equipment used for the provision of specific vestibular stimulation included a platform swing, a tumbleform chair with shoulder and hip straps (and its supporting base), a nylon safety belt, a timing device, towel roll, and pillow. Specifications for each piece of equipment are listed below:

Platform swing. The platform swing was a 1 m^2 wooden board that was carpeted and suspended by four nylon cords, each 1.9 m in length. The cords were attached on one end to the four corners of the board and, connected to a heavy-duty swivel hook on the other end. The swivel hook was then attached to the ceiling. The platform swing was suspended approximately 30 cm from and parallel to, the floor (Figure 2).

Tumbleform chair. The tumbleform chair was a molded soft plastic chair with contour shape and an integral abductor. The chair was equipped with a hip positioning belt and an H-Belt for shoulder and trunk support. The supporting base for the tumbleform chair was a separate wedge which was used to hold the chair in the upright positions.

Nylon safety belt. The safety belt was made of nylon netting and was approximately .05 m (2 inches) wide and 4.1 m long.

Timing device. A cassette tape recorder and two pre-recorded timing tapes served as the timing devices. The first timing tape marked off 2-second intervals for a period of 1-minute, followed by a 10-second rest interval for the clockwise direction and then again

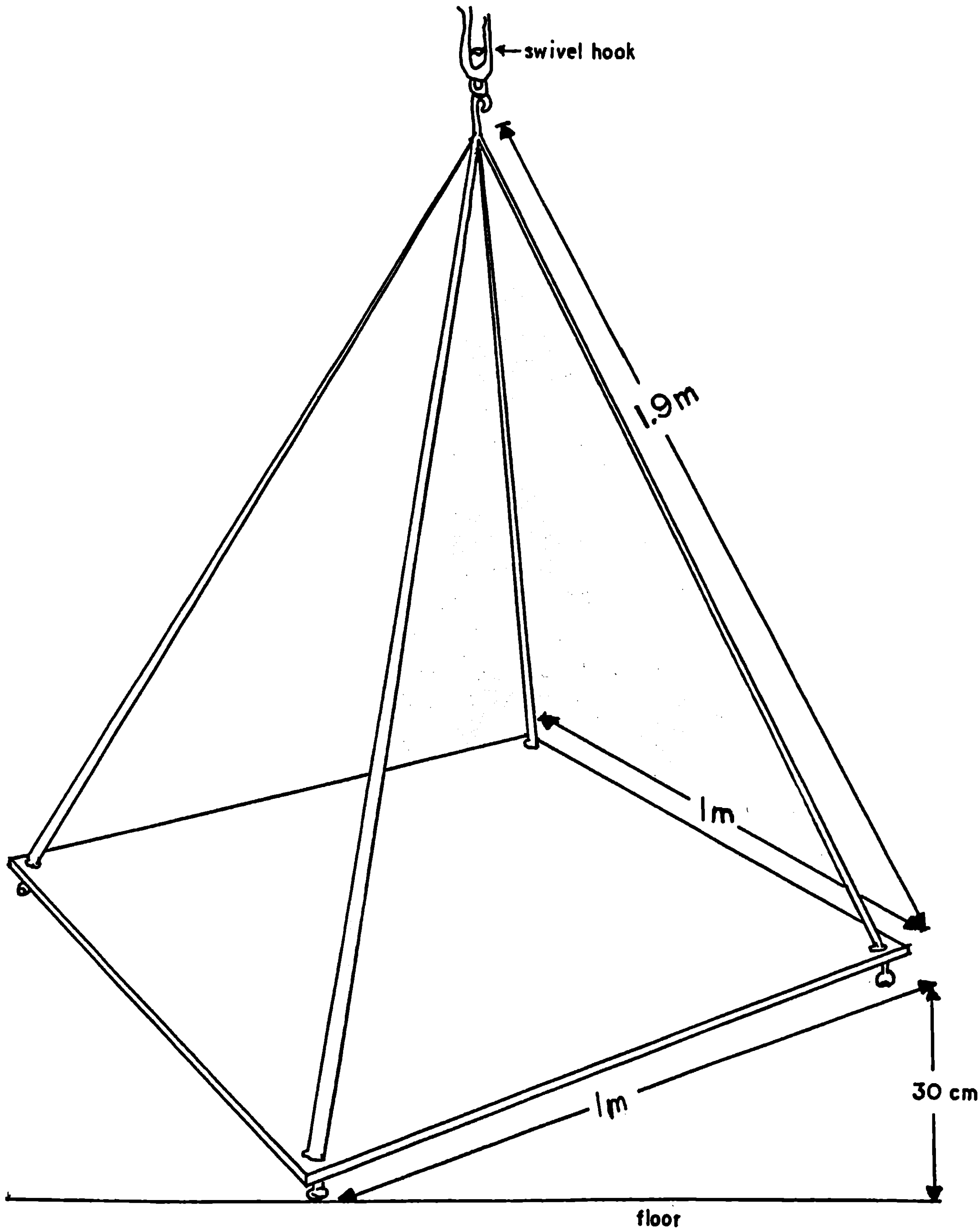

Figure 2. Platform swing used for vestibular stimulation.

for the counter-clockwise direction for each of the three positions (upright sitting, right sidelying, and left sidelying) employed during intervention. This timing tape produced a cumulative duration of vestibular stimulation of 6-minutes and was a total of 7-minutes in length. The second timing tape marked off the same intervals, but included two additional spins in the upright sitting position (one clockwise and one counter-clockwise). This timing tape produced a cumulative duration of 8-minutes of vestibular stimulation and totalled 9-minutes and 20-seconds in length.

Erect sitting measurement

The materials and equipment used for the assessment of erect sitting included a plexiglass section device, a timing device, data sheets, a 14.6 cm high bolster, and adhesive marker, pencils, barrettes, and preferred toys. Specifications for each piece of equipment are listed below:

Plexiglass section device. A 60 cm high and 90 cm wide clear plexiglass sheet was used. The plexiglass sheet was mounted on a wooden frame for support. Alternating strips of red and black adhesive tape divided the plexiglass sheet into six equal section of 15 degrees each. The sections were numbered one through six consecutively with each section encompassing successive 15 degree angles from the vertical plane (Figure 3).

Timing device. A cassette tape recorder and a pre-recorded timing tape served as the timing device. The timing tape marked off 5-second intervals for a period of three minutes, resulting in 36 time checks.

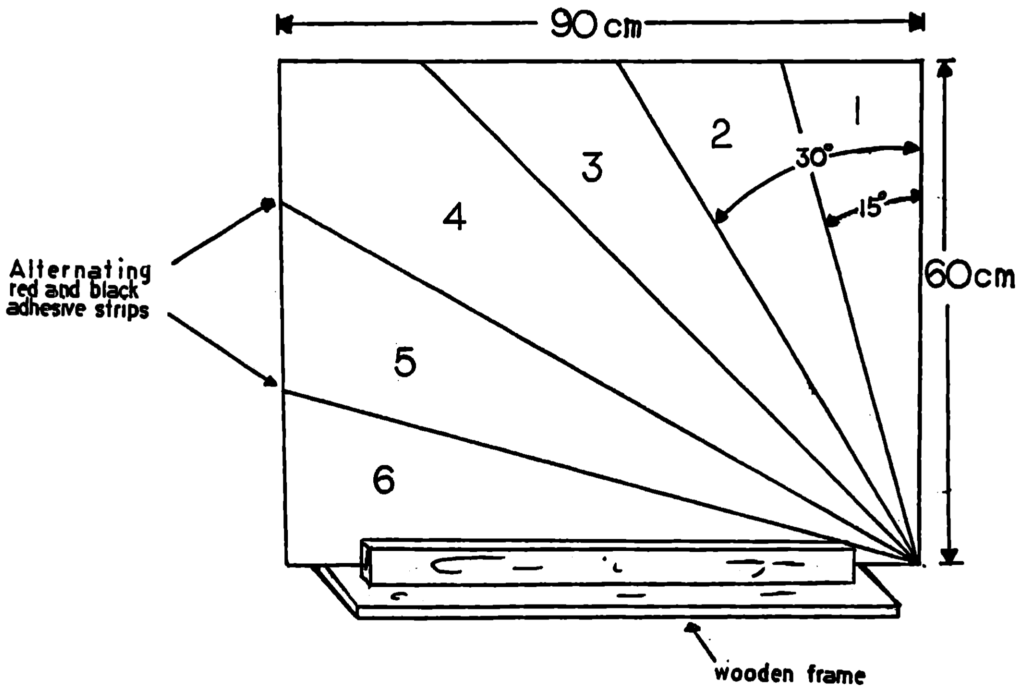

Figure 3. Plexiglass section device for measuring erect sitting.

Data sheets. The data sheet included space for recording data, at 5-second intervals for each of the six grid sections designated on the plexiglass device. A column for position checks (e.g., tailor, propped, etc.), and a column to note if the subject was repositioned, were also included. A sample data sheet is shown in Figure 4.

Adhesive marker. A 12.7 mm adhesive star was placed on the subject's shoulder (below the acromion process and centered over the deltoid muscle) as a reference point.

Symmetry measurement

The materials and equipment used for the assessment of symmetrical sitting included a posture grid, a timing device, data sheets, a 19.7 cm high bolster, two 1.3 cm by 7.6 cm adhesive markers, pencils, barrettes, and preferred toys. Specifications for each piece of equipment are listed below:

Posture grid. The posture grid was a clear plexiglass sheet 58 cm high and 43 cm wide. The posture grid was mounted on a wooden frame for support. Alternating strips of yellow and red adhesive tape were placed horizontally 2 cm apart on the plexiglass from the top to the bottom of the grid. An additional red strip marked the middle of the plexiglass on the vertical axis, separating the right and left sides of the posture grid. Figure 5 illustrates the plexiglass measurement grid used for measuring symmetry of sitting.

Timing device. A cassette tape recorder and a pre-recorded tape served as the timing device. The timing tape was marked at 15-second intervals, for a period of three minutes, resulting in a total of 12 time checks.

STABILITY IN SITTING

SUBJECT: ______________________ EXAMINER: ______________________

DATE & SESSION: ______________________ OBSERVER: ______________________

TO RECORD POSITION, MARK ONE FROM EACH CATEGORY:

(I)		(II)		(III)
L-Long T-Tailor R-Ring	&	S-Supported I-Independent	&	P-Propped N-Not Propped

INDICATE REPOSITIONG by marking a star (*) in the Assist. space.

SYMMETRY: First/Second

Tally higher side or "="

Pos.	Ass.	Time	R	L	=	Rel.
		:15				
		:30				
		:45				
		1:00				
		1:15				
		1:30				
		1:45				
		2:00				
		2:15				
		2:30				
		2:45				
		3:00				
		Total				

RELIABILITY: _____ out of _____ trials

= _____%

ERECT SITTING: First/Second

Tally appropriate sector

Time	1	2	3	4	5	6	Rel.	Pos.	Ass.
:05									
:10									
:15									
:20									
:25									
:30									
:35									
:40									
:45									
:50									
:55									
1:00									
1:05									
1:10									
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2:15									
2:20									
2:25									
2:30									
2:35									
2:40									
2:45									
2:50									
2:55									
3:00									
Total									

RELIABILITY: _____ out of _____ trials = _____%

Figure 4. Data for recording erect and symmetrical sitting.

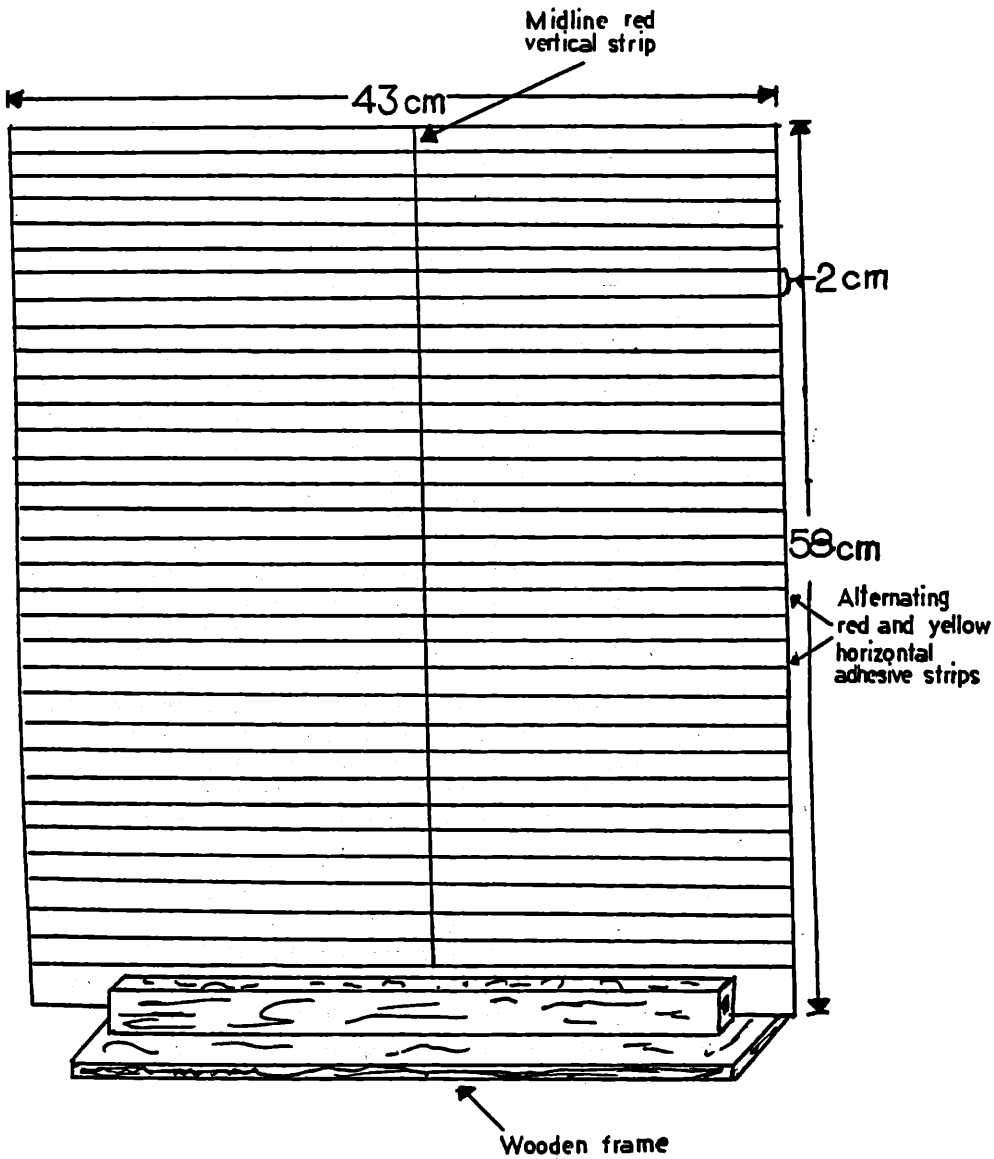


Figure 5. Posture grid for measuring symmetry of sitting.

Data sheets. The data sheet included space for recording data, at 15-second intervals for equal shoulders, right shoulder higher, or left shoulder higher. A column for position checks (e.g., tailor, propped, etc.), and a column to note if the subject was repositioned, were also included. A sample data sheet is shown in Figure 4.

Vocalization measurement

The materials and equipment used for the measurement of vocalizations include a tape recorder, blank tapes, data sheets, and pencils. Specifications of each piece of equipment/materials are listed below:

Tape recorder. A cassette tape recorder with a microphone was used to record all vocalizations during the sessions.

Blank tapes. Blank cassette tapes were used to record the vocalizations of each subject. The tapes were labelled according to the session and subject for each session.

Data sheets. The data sheets included sections for scoring each vocalization as being either speech or non-speech. The data sheets were separated in terms of the three positions employed during intervention and the two three minute periods of observations following intervention (erect sitting, and symmetry). Figure 6 presents a sample of the data sheet used.

Probe measurement of protective extension

The assessment of protective extension required a data sheet, pencil, and an assistant to provide the stimuli.

Data sheet. The data sheet included sections to score both the right and left protective arm responses for 3 quick and 3 slow

CODED VOCALIZATIONS

SUBJECT: ______________________ EXAMINER: ______________________

DATE & SESSION: ________________ OBSERVER: ______________________

	NON-SPEECH	SPEECH
INTERVENTION:		
SITTING		
	TOTAL:	TOTAL:
RIGHT SIDELYING		
	TOTAL:	TOTAL:
LEFT SIDELYING		
	TOTAL:	TOTAL:
TOTAL		
MEASUREMENT:		
ERECT SITTING		
	TOTAL:	TOTAL:
SYMMETRY		
	TOTAL:	TOTAL:
TOTAL		
OVERALL TOTAL:		

Figure 6. Data sheet for recording speech and non-speech vocalizations.

stimuli, both forward and laterally. The data sheet was divided by descriptors for the shoulder, elbow, hand, breaks fall, and no response (Figure 7).

Probe measurement of postural fixation

The assessment of postural fixation required a data sheet, pencil, and an assistant to provide the stimuli.

Data sheet. The data sheet included sections to score both the right and left postural responses for 3 stimuli in the forward, and 3 stimuli in the lateral directions. The data sheet was divided by descriptors for the head, trunk, protective extension, and no response (Figure 7).

Probe measurement of postrotary nystagmus

The assessment of postrotary nystagmus included the platform swing, tumbleform chair and its supporting base, the nylon safety belt, and the towel roll described for the intervention materials. A stopwatch, data sheet, and pencil were also required.

Data sheet. The data sheet for postrotary nystagmus included sections for scoring the cumulative duration of the nystagmus, the subject's affective response, the direction and length of the excursion for a stimuli of 10 spins and a stimuli of 20 spins (Figure 8).

Positioning and Preparation of the Subjects

Intervention

Three positions were employed during the intervention procedures: upright sitting, right sidelying, and left sidelying for each subject as shown in Figure 9. Specifications for positioning the subjects in

REFLEXIVE BASE

SUBJECT: ______________________ EXAMINER: ______________________

DATE & SESSION: ______________________ OBSERVER: ______________________

PROTECTIVE EXTENSION

Stimulus	Descriptors																
	Shoulder				Elbow				Hand								
	N/R opposite		> 45°		< 90°		> 90°		Fist		Partial Fist		Finger Extension		Breaks Fall		Rel.
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	R	L	
Forward Quick 1																	
2																	
3																	
Slow 1																	
2																	
3																	
Lateral Quick 1																	
2																	
3																	
Slow 1																	
2																	
3																	
Reliability																	

POSTURAL FIXATION

Stimulus	Descriptors 1		2		3		4		5		6	
	N/R Falls forward		Head rights to midline		Head upright		Trunk rights not completely		Trunk rights completely		PE	
	R	L	R	L	R	L	R	L	R	L	R	L
Lateral 1												
2												
3												
Forward 1												
2												
3												
Reliability												

Figure 7. Data sheet for measuring protective extension and postural fixation.

NYSTAGMUS DATA SHEET

SUBJECT:____________________ EXAMINER:____________________

DATE & SESSION:________________ OBSERVER:____________________

POSITION: Sitting with head flexed approximately 30 degrees.

<u>TRIAL 1</u>:

METHOD: Spin 10 times, approximately 180° per second.

RESPONSE:	TO RIGHT	TO LEFT
Absence of any nystagmus		
Direction (horizontal, vertical, oblique)		
Length of excursion		
Duration of nystagmus		
Child's response (pleasurable, adversive)		
Comment		

<u>TRIAL 2</u>:

METHOD: Spin 20 times, approximately 180° per second

RESPONSE:	TO RIGHT	TO LEFT
Absence of any nystagmus		
Direction (horizontal, vertical, oblique)		
Length of excursion		
Duration of nystagmus		
Child's response (pleasurable, adversive)		
Comment		

<u>Figure 8</u>. Data sheet for recording postrotary nystagmus.

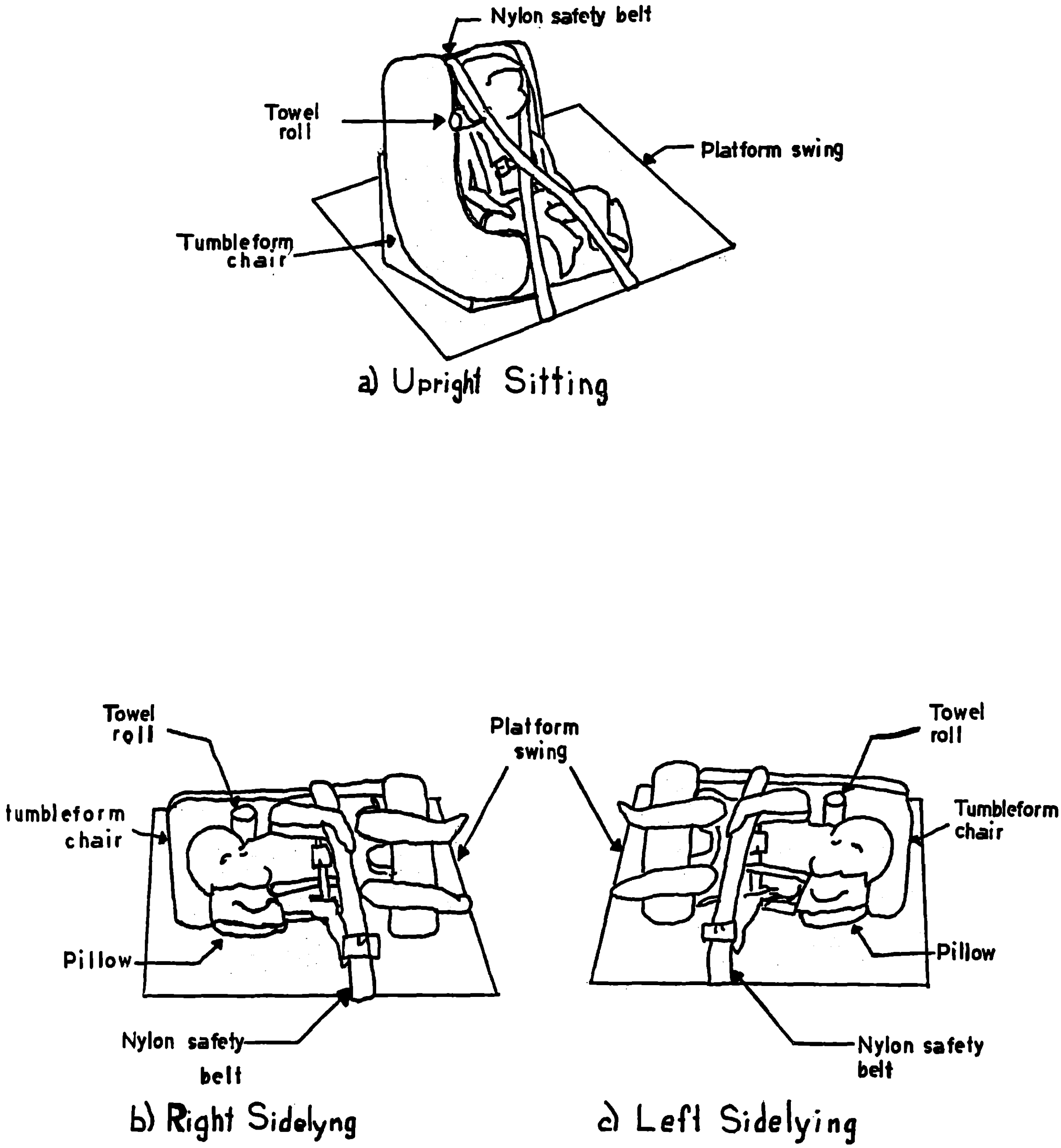


Figure 9. Positioning for vestibular stimulation in the upright, right, and left sidelying positions.

each of the three positions are listed below:

Upright sitting. The tumbleform chair an its supporting base were positioned in the center of the platform swing in an upright position. The subject was then positioned in the chair and strapped in with the shoulder and hip belts. A towel roll was then placed at the base of the subject's head to maintain a flexed position at 30°. The nylon safety belt was then crossed over the subject and the chair and secured below the base of the platform swing, thus securing the chair to the swing.

Right sidelying. The supporting base of the tumbleform chair was removed and the chair was turned on its right side with the subject in it. The towel roll was repositioned and a pillow was placed beneath the subject's head to support it at midline. The nylon safety belt was then wrapped over the chair and subject and fastened below the base of the platform swing, thus securing the chair to the swing.

Left sidelying. The tumbleform chair was turned onto its left side with the subject in it and secured in the same manner as in right sidelying.

Erect sitting measurement

The position selected for each subject was determined by observation of the most stable sitting posture. The potential sitting positions and descriptions are found in Figure 10.

After the subject's upper clothing was removed, a 12.7 mm adhesive star was placed on the subject's shoulder (e.g., 2.54 cm below the acromion process and centered over the deltoid muscle).

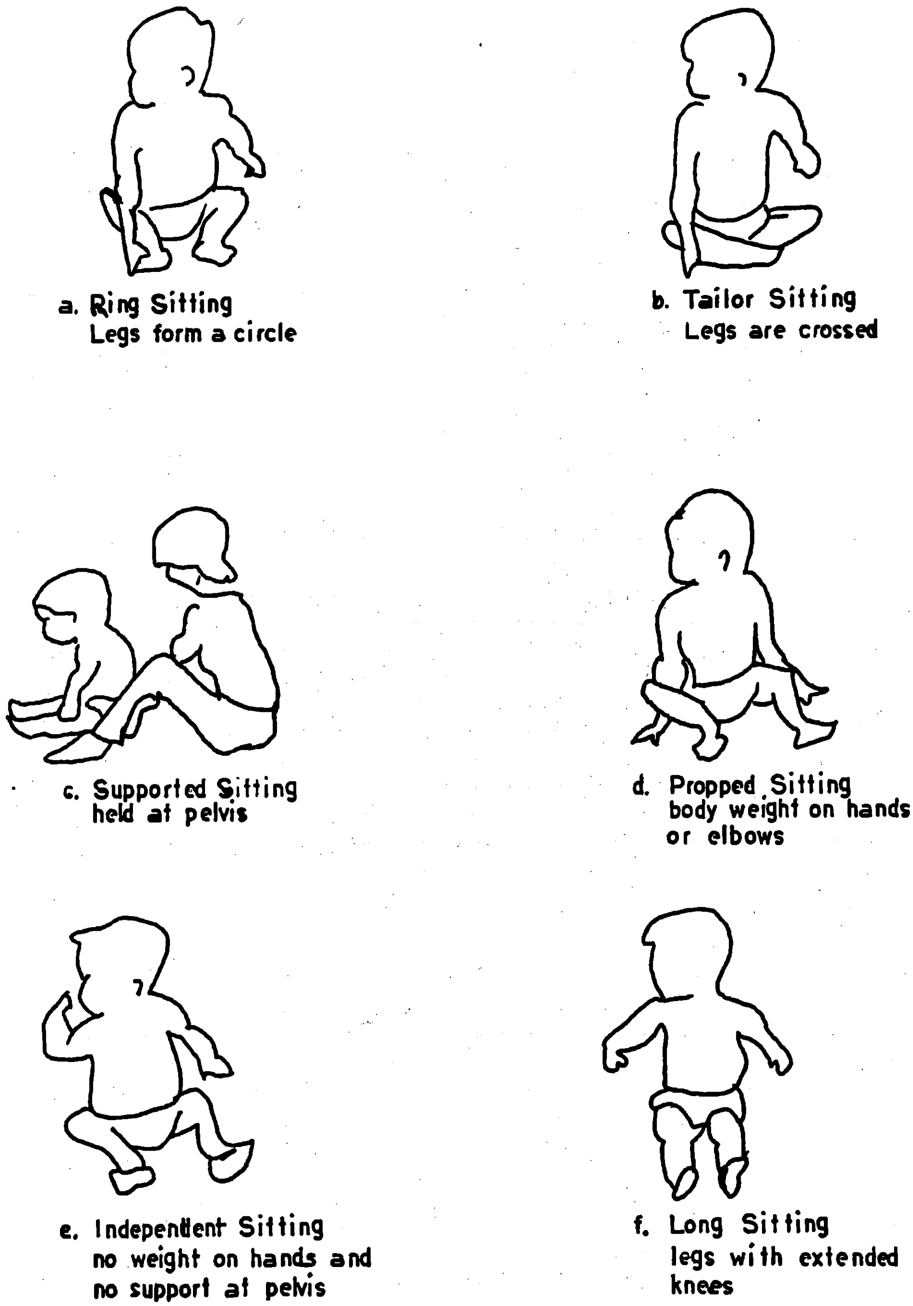


Figure 10. Potential sitting positions.

The subject's hair was pulled back with barrettes if necessary, so as not to obscure observation of the adhesive marker. The subject was then positioned behind the section device so that his/her left side was toward the grid and his/her hip joint was in alignment with the bottom corner of the plexiglass at the common origin of the angles. An assistant was positioned behind the subject to provide posterior pelvic support to the child.

The examiner and observer were positioned prone at a distance of 2.4 m from the plexiglass section device so that they viewed the subject through the device. The examiner was supported under her chest with a 14.6 cm high bolster. The observer rested her chin on the examiner's shoulder thus making the discrepancy in the angles of observation minimal, so the angle of the subject's spine in relation fo the vertical position could be reliably measured with the section device. A tape recorder with the timing tape was positioned within reach of the observers. Preferred toys were placed directly in front of each subject at a height that would encourage an erect posture. The arrangement of the plexiglass section device, the subject and assistant, and the examiner and observer is illustrated in Figure 11.

Symmetry measurement

The most stable sitting position determined for the erect sitting measurement was again used for each subject.

After the subject's upper clothing was removed, a 1.3 cm by 7.6 cm adhesive marker was placed on each of the subject's shoulders over the edge of the acromium. The subject's hair was pulled back with barrettes if necessary, so as not to obscure observation of the

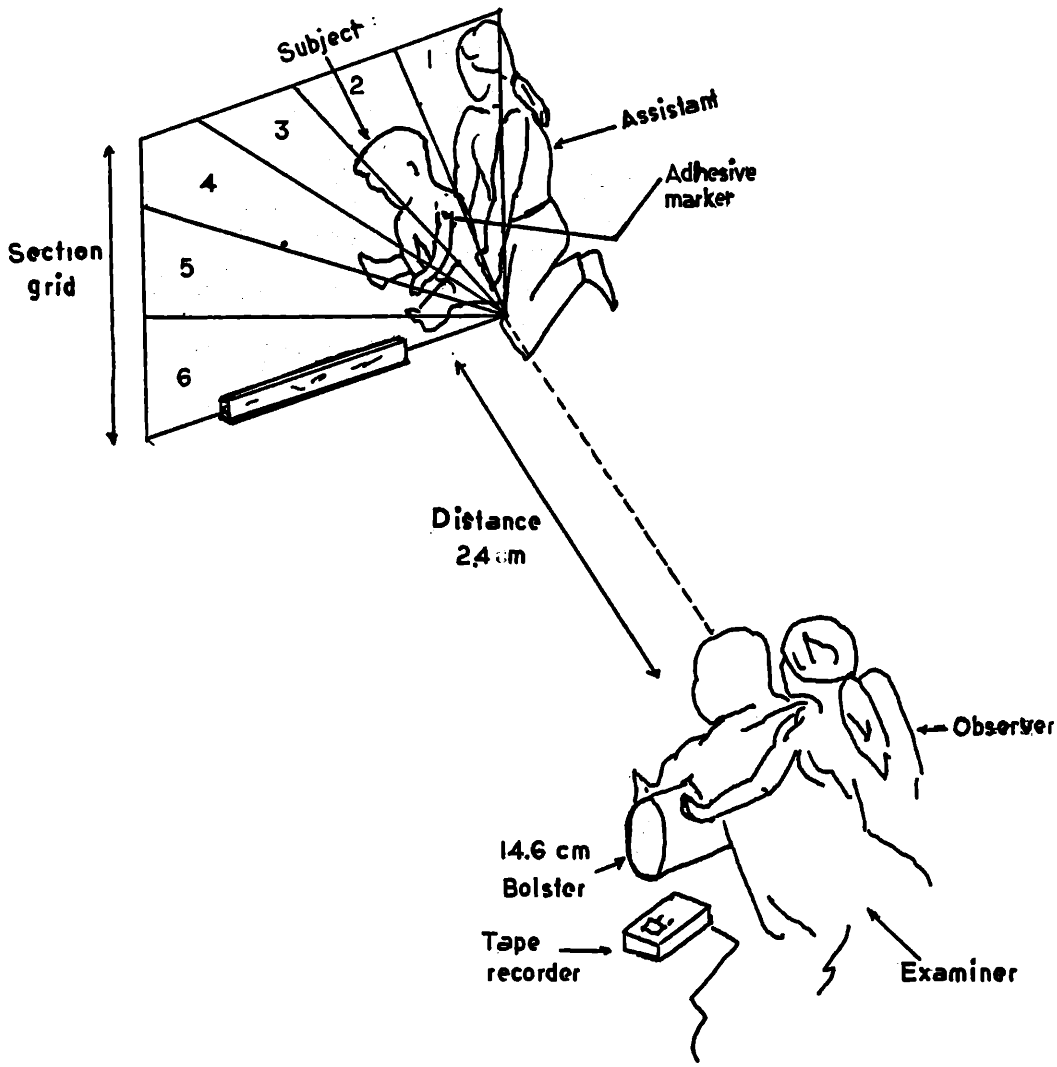


Figure 11. Plexiglass and positioning of examiner and observer for recording erect sitting.

adhesive markers. The subject was then positioned behind the posture grid so that the subject was facing the grid and his/her pubic symphisis was in alignment with the vertical line on the grid, thus separating the subject into right and left halves. An assistant positioned behind the subject so as to provide posterior pelvic support.

The examiner and observer were positioned side-by-side in prone with their chins on a 19.7 cm high bolster at a distance of 2.4 m from the posture grid so that they viewed the subject through the grid. A tape recorder with the timing tape was positioned within reach of the observers. Preferred toys were placed in front of the observers and were held at a height that would encourage erect posture. The arrangement of the posture grid, the subject and assistant, and the examiner and observer is illustrated in Figure 12.

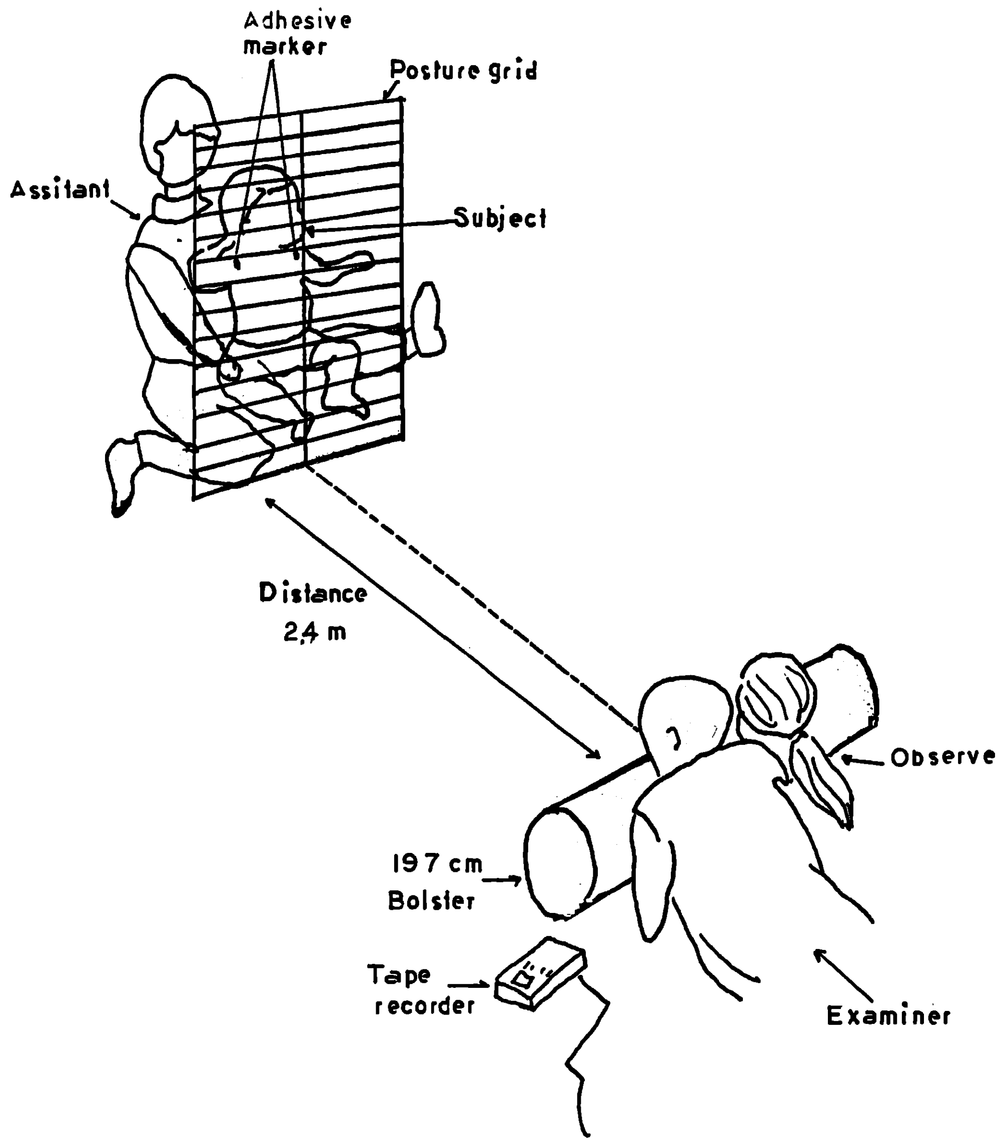
Vocalization measurement

Positioning for the vocalization measurement was the same as for the intervention, erect sitting, and symmetry positioning with the addition of a tape recorder with a microphone and blank tapes being positioned as close to the subject as possible.

Probe measurement of protective extension

The conditions for this procedure required the subject to be alert and compliant. The subject was positioned in his/her most stable sitting with an assistant positioned behind the subject providing posterior pelvic support. The subject's arms were positioned in his/her lap prior to each trial.

The examiner and observer were positioned in the sitting



<u>Figure 12</u>. Posture grid and positioning of examiner and observer for measuring the symmetry of sitting.

position, facing the subject and the assistant. Figure 13 illustrates the positioning of the subject, assistant, examiner, and observer.

Probe measurement of postural fixation

The conditions and positions of the subject, assistant, examiner, and observer were the same as described for protective extension.

Probe measurement of postrotary nystagmus

The position of the subject for postrotary nystagmus are the same as described earlier for the upright position for intervention.

Procedures

Intervention

Two phases of vestibular stimulation were employed in the study. Phase one involved a cumulative duration of 6-minutes of vestibular stimulation, and phase two involved a cumulative duration of 8-minutes of vestibular stimulation. Phase one was implemented for all subjects. Phase two was only implemented for those subjects that did not demonstrate a gain in the target behvior of erect sitting following the 6-minutes of stimulation. The change from phase one to phase two was determined through a daily analysis of the graphed data. The specific procedures used for each spin in both phases promoted maximum stimulation of the horizontal, posterior, and anterior semicircular canals (Chee et al., 1978). Table 2 presents an outline of the intervention procedures for both phases.

Phase one. The subject was initially positioned and secured in the upright sitting position on the platform swing. The examiner began the timing tape and manually spun the swing in a clockwise direction, creating an acceleration period of 1-2 seconds. The

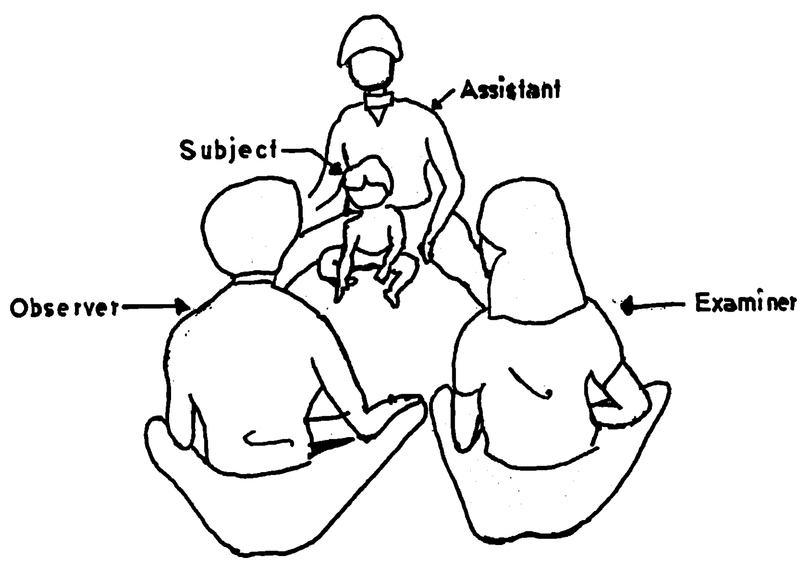


Figure 13. Positioning of the child, assistant, examiner, and observer for the probe measurements of postural fixation and protective extension.

Table 2

Spinning Sequence for Vestibular Stimulation during Phase One and Phase Two of Intervention

Phase	Subject Position	Spin Direction	Duration of Stimulation
One	Upright Sitting	1. Clockwise*	
		2. Counter-Clockwise	
	Right Sidelying	1. Clockwise	
		2. Counter-Clockwise	
	Left Sidelying	1. Clockwise	
		2. Counter-Clockwise	6-Minutes
Two	Upright Sitting	1. Clockwise	
		2. Counter-Clockwise	
		3. Clockwise	
		4. Counter-Clockwise	
	Right Sidelying	1. Clockwise	
		2. Counter-Clockwise	
	Left Sidelying	1. Clockwise	
		2. Counter-Clockwise	8-Minutes

* Each spin consisted of: a) a 1-2 second acceleration, b) a 1-minute period of constant velocity at 180°/second (30 RPM), c) an impulsive stop in less than 1-second, and d) a 10-second period of no movement.

spinning was maintained at a constant velocity (one spin every 2-seconds) of 180°/second (30 RPM), for 1-minute by the examiner who paced the spinning rate according to the 2-second intervals marked off on the timing tape. The 1-minute period of constant velocity was followed by an impulsive stop in less than 1-second, followed by a 10-second period of no movement. The swing, with the subject remaining in the upright sitting position, was then spun in the counter'clockwise direction following the same pattern as delineated for the clockwise direction. After the 10-second rest period in the counter-clockwise direction, the subject was repositioned and secured in right sidelying and spun in both the clockwise and counter-clockwise directions following the procedures described above. The same spinning sequence was then repeated with the subject positioned and secured in left sidelying. This procedure produced a cumulative duration of 6-minutes of vestibular stimulation.

Phase two. The procedures for phase two followed the same sequence of spins as described for phase one, with the exception of the addition of two spins. These two spins were inserted into the spinning sequence immediately following the two initial spins (clockwise and counter-clockwise) in the upright sitting position. The subject remained in the upright sitting position and was spun in the clockwise direction, and then in the counter-clockwise direction following the same procedures as for the initial two spins. The subject was then positioned in right sidelying and then repositioned in left sidelying according to the sequence delineated for phase one. This procedure resulted in a cumulative duration of 8-minutes of vestibular stimulation.

After the final 10-second rest period for each session, measures were taken on the subject's sitting behaviors.

Erect sitting measurement

The subject's back posture in relation to the trunk's deviation from the vertical plane, as viewed from the side, was used to record erect sitting.

Measurement. After the subject and observers were positioned, a 3-minute tape was started that marked off 36 time-checks at 5-second intervals. The numbered (1 through 6) in which the adhesive marker on the subject's shoulder was observed was recorded at each time-check. If the marker was directly on a line, it was judged to be in the section directly above that line. If more of the star was visible below the line, it was judged to be in the section below. If the subject leaned backward so the marker was off the plexiglass (illustrated in Figure 14), a line was drawn through that time-check on the data sheet. If the subject began falling out of the sitting position, the assistant repositioned the subject into erect sitting and a slash was placed in that time-check, as well as recording a star in the repositioned column on the data sheet. The assistant manipulated the preferred toys in front of the subject and provided social praise.

Summarization of the data. For purposes of data analysis, erect sitting was identified as sitting in a position within either section 1 or section 2. The percentage of erect sitting was computed by dividing the total number of occurrences in which the subject was

a) Sitting in section 3

b) Sitting in section 4

c) Sitting in position off the grid.

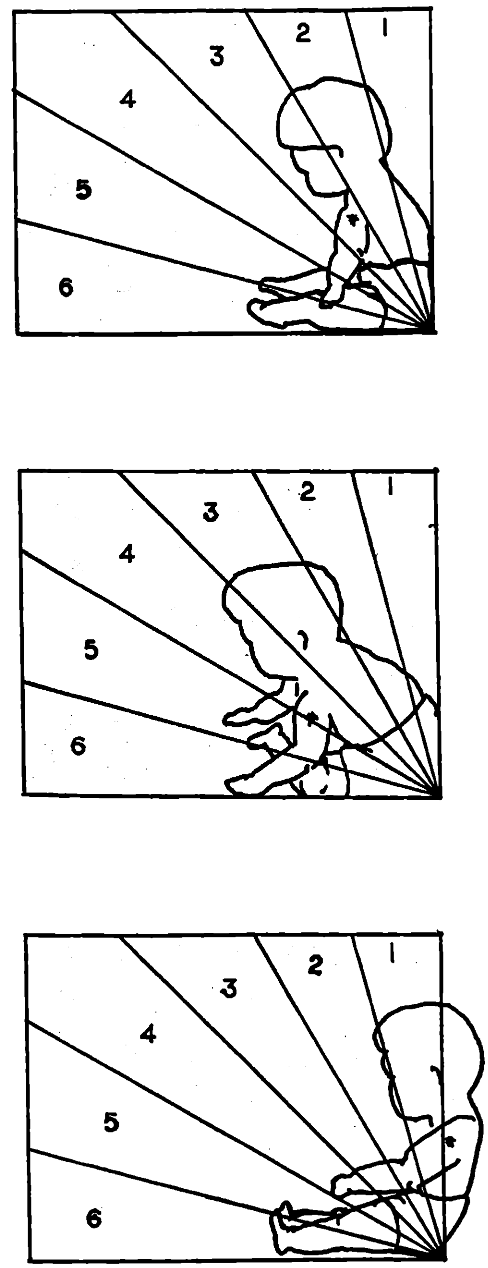


Figure 14. Shoulder marker as viewed through different sections of the plexiglass grid.

observed in sections 1 and 2, by the total number of time checks for which data was recorded. This was converted into the percentage of erect sitting. For example:

	Sections					
	1	2	3	4	5	6
Totals	13	5	13	3	0	0

(in a total of 34 time-checks scored)

Use the following equation:

$$\frac{\text{\# of occurrences of (section 1 + section 2)}}{\text{\# of time checks scored}} \times 100 = \text{percentage of erect sitting}$$

Therefore,

$$\frac{\text{18 (sections 1 \& 2)}}{\text{34 time checks}} \times 100 = 53\% \text{ of erect sitting}$$

Reliability. Reliability for each trial was determined by comparing the results of the observer to those of the examiner. The reliability was calculated as follows:

$$\frac{\text{\# of agreements}}{\text{\# of disagreements + agreements}} \times 100 = \text{R (overall reliability)}$$

Reliability for each trial was computed useing the formula above. Agreement of 80% or better was considered to be acceptable.

Visual alignment of the observers was checked prior to each measurement of erect sitting by verbally comparing each observer's recording of the position of a 12.7 mm star that was slowly moved through the sections behind the plexiglass grid by the assistant.

Observers were trained to a minimum criterion of 80% agreement with the investigator prior to conducting reliability checks for the measure of erect sitting.

Symmetry measurement

Symmetry of the shoulders in the sitting position, as viewed anteriorly, was used as the measure of symmetry of sitting.

Measurement. After the subject and observers were positioned, a 3-minute tape was started that marked off 12 time-checks at 15-second intervals. The position of the shoulders was recorded at each time-check. Asymmetrical posture was indicated by shoulder placement in uneven grids. If an asymmetrical posture was observed, the subject's shoulder that was higher was recorded (i.e., if the subject's right shoulder was observed to be higher, a tally was placed under the "R" column next to the appropriate time-check; if the subject's left shoulder was observed to be higher, a tally was placed under the "L" column next to that time check). If the tops of the shoulders at the acromium (as indicated by adhesive markers) were in the same 2 cm section on the posture grid, the shoulders were considered to be equal, and the sitting posture was considered to be symmetrical (a tally was placed under the "=" column on the data sheet). If the subject turned his/her body, obscuring the view of either one or both shoulders, a slash was placed in the appropriate box to indicate that the data were voided. Illustrations of the potential positions demonstrated are shown in Figure 15. A notation was also made every minute as to the type of sitting demonstrated (i.e., supported, independent, propped, ring, tailor).

Summarization of the data. The measure of symmetry was computed by dividing the total number of occurrences of the "=" descriptor, by the total number of time checks scored. This was converted into the percentage of symmetrical sitting. For example:

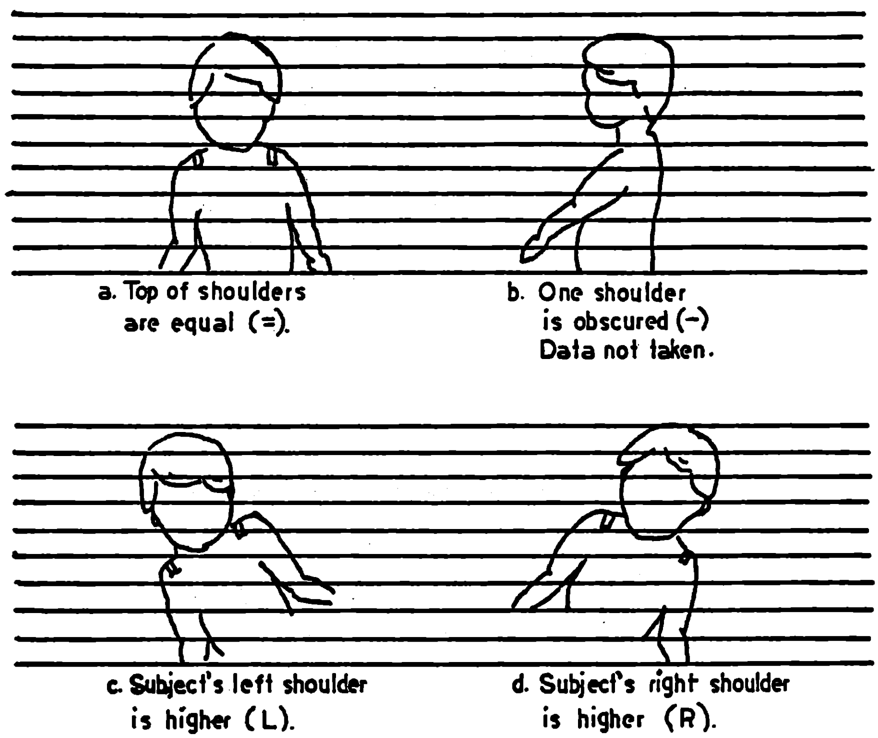


Figure 15. Potential shoulder positions (=, R, L, -) used to measure symmetry of sitting.

4 L's 2 R's and 4 ='s
(in a total of 10 time checks scored)

Use the following equation:

$$\frac{\text{\# of occurrences (='s)}}{\text{\# of time checks scored}} \times 100 = \text{percentage of symmetrical sitting}$$

Therefore,

$$\frac{4\ \text{='s}}{10\ \text{time checks}} \times 100 = 40\%\ \text{of symmetrical sitting}$$

Reliability. Reliability for each trial was computed using the same method as used for reliability in the erect sitting measurement. Agreement of 80% or better was considered to be acceptable.

Visual alignment of the observers was checked verbally prior to the measurement of symmetry by comparing each observer's recording of the symmetry or assymmetry of a .3 m long wooden dowel. The dowel had stripes place at points equivalent to the shoulder width of the subjects. It was held by the assistant in different positions behind the posture grid to simulate the position of the adhesive markers on the child.

Observers were trained to a minimum criterion of 80% agreement with the examiner prior to conducting reliability checks.

Vocalization measurement

The vocalizations of the subject were recorded on a tape recorder that was placed near the subject. Vocalizations were recorded during the baseline, intervention, erect sitting measurement, and symmetry measurement. Vocalizations were later scored as being either speech or non-speech according to the code developed by Mavilya (1969). Specific definitions are lested below:

Non-speech sounds. Vocalizations were scored as being non-speech if they fit any of the following definitions:

Chuckle: A quiet and short laughing sound that is just audible.

Laugh: Sound expressing joy shown by peculiar movement of face, usually the mouth, and by the emission of explosive sounds from the throat.

Cry: Utterance of emotion expressing affliction, "audible lamentation".

Outcry: A vehement or loud cry.

Grunt: A deep gutteral sound, usually a short noise.

Struggle Grunt: A deep gutteral sound, accompanying a physical exertion (like pulling up body).

Whimper: A low whining, broken cry expressive of complaint.

Sputter: Sound of emission of saliva from the mouth in small scattered particles.

Sneeze: A sudden audible expiration of breath chiefly or wholly from the nose.

Snort: Sound made by forcing the air through the nose.

Smack: A quick, sharp noise made by rapidly compressing and opening the lips in gusto.

Smacking: Plying the tongue and lips as if in drawing goodness from something.

Yawn: Act of opening the mouth involuntarily excited by drowsiness, dullness or fatigue and consisting of a deep audible inspiration.

Gasp: Act of catching breath violently or in laborious respiration with wide open mouth.

<u>Sigh</u>: A deep and prolonged audible inspiration and respiration of air, especially when involuntary, and when expression is of some feeling of relief.

<u>Cough</u>: To expel air from the lungs suddenly and in a series of efforts with an explosive noise made by the opening of the glottis.

<u>Coo</u>: A low repeated sound implying affection.

<u>Hum</u>: A sound like, or suggestive of, that of the letter m, prolonged without opening the mouth.

<u>Hiccough</u>: An inspiratory movement, consisting of a sudden contraction of the diaphragm, accompanied with closure of the glottis, the inrush of air against the closed glottis producing a peculiar sound.

<u>Sucking & Humming</u>: Sucking and humming together.

<u>Throaty Sounds</u>: Uttered in the throat; gutteral.

<u>Speech Sounds</u>. Vocalizations were scored as being speech if they did not fit any of the non-speech definitions. The speech sound would then fall into one of the following categories:

<u>Consonant</u>: Speech sound made by occluding or obstructing the breath stream.

<u>Vowel</u>: Vocal sound in which there is no audible friction or stoppage of the breath stream.

<u>CV</u>: A combination of a consonant and a vowel.

<u>VC</u>: A combination of a vowel and a consonant.

<u>CVC</u>: A combination of a consonant, a vowel, and the same or

different consonant.

Words: Spoken English used to communicate meaning.

Measurement. The recorded tapes were later listened to by the examiner and observer. Each vocalization was recorded on the data sheet in the appropriate section. A one second latency between vocalizations determined the start of a separate vocalization. All vocalizations were scored as being either speech or non-speech according to the above definitions.

Summarization of the data. A frequency count was obtained for both the speech and the non-speech vocalizations by totalling the number of vocalizations recorded under each descriptor for each session.

Reliability. Reliability for each trial was computed using the same method as used for reliability in the erect sitting measure. Separate reliabilities were conducted for speech vocalizations and for non-speech vocalizations.

Observers were trained to a minimum criterion of 80% agreement with the examiner prior to conducting reliability checks.

Protective extension measurement

Forward and lateral protective extension was measured in response to both slow and quick displacement of the shoulder in either a lateral or forward direction. The code used was developed by Bessenbacher (1982) and included definitions of a wide range of observable upper extremity responses to both stimuli and directions. The stimulus definitions used for the protective extension measures are presented below. The same definitions were used for all directions of the stimuli (i.e., forward or laterally).

Quick stimulus. The assistant displaced the subject's shoulders (forward or laterally) 30 degrees within 1-second. The assistant did not restrict any movement of the subject's arm or shoulders, but did prevent the subject from hitting the mat with any other body part.

Slow stimulus. The assistant displaced the subject's shoulders (forward or laterally) 60 degrees within 5 seconds. Again, the assistant prevented the subject from hitting the mat if an inadequate protective response was elicited.

A diagram illustrating the range of displacement for both quick and slow stimuli is shown in Figure 16.

Measurement. After the subject, assistant, examiner and observer were positioned, the assistant provided 3 slow and 3 quick stimuli for the right, left, and forward directions. The assistant allowed enough time between each trial to mark the data sheet for the observed response.

Following each stimulus, the examiner and the observer recorded the observed response. Each response included descriptors of the shoulder, elbow, and hand positions along with the subject's ability to break the fall. The response definitions are listed below:

Protective extension responses at the shoulder.

No response/opposite. There was no shoulder movement in the direction to break the fall, or the shoulder pulled in the opposite direction from breaking the fall.

Abducts/flexes ≥ 45. The shoulder moved in the direction

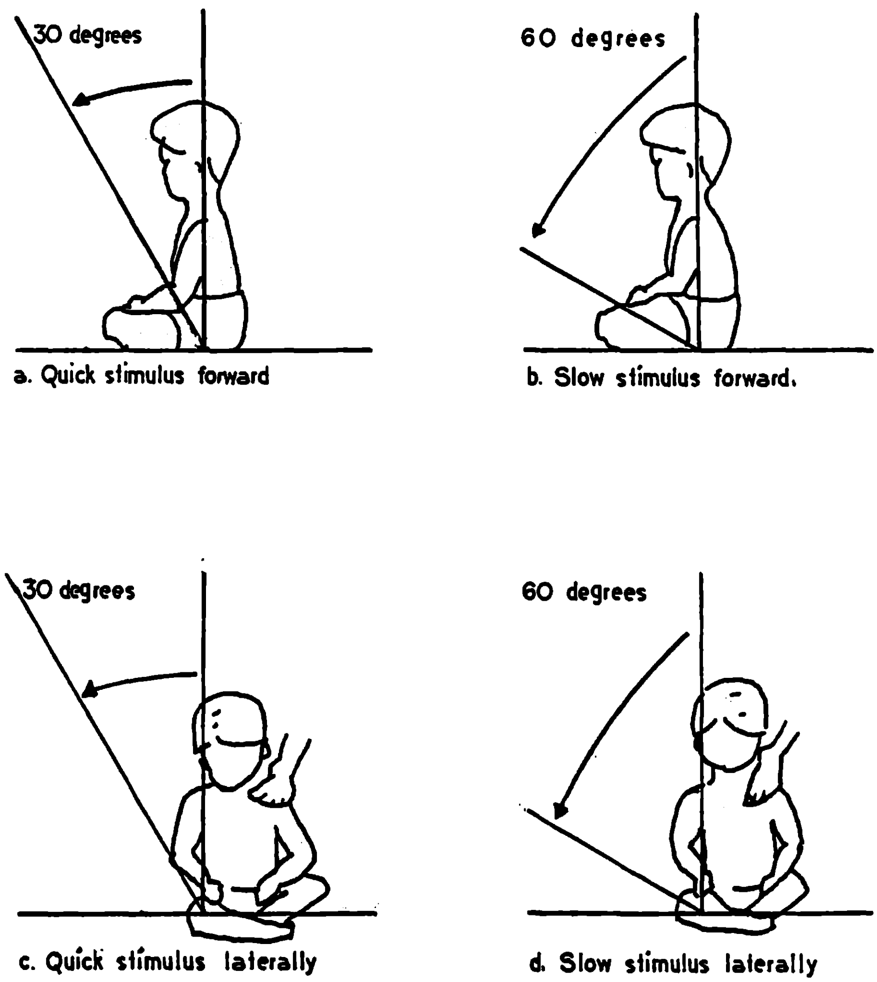


Figure 16. Stimuli for protective extension and postural fixation, quick (30° arc), slow (60° arc).

to break the fall with abduction (when pushed laterally) or flexion (when pushed forward) greater than 45°.

Protective extension responses at the elbow.

Less than (<) 90°. As the subject's arm moved in the direction to break the fall, the angle of the elbow was less than 90 of extension.

Greater than or equal to (≥) 90°. As the subject's arm moved in the direction to break the fall, the elbow was equal to or greater than 90° of extension.

Protective extension responses at the hand.

Fist. The hand contacted the floor with all fingers flexed and the dorsal surface of each finger tip touching the floor (extension of the metacarpal-phalangeal joints was accepted).

Finger extension. Every finger was extended and the palmar tip of each finger touched the floor. (This allowed for slight flexion at the phalangeal joints).

Partial fist. The hand contacted the floor with one or more fingers fisted as in the above definition of Fist and one or more fingers extended as in the above definition of Finger extension.

Breaks the fall.

This response indicated that the part of the body breaking the fall was adequate to support the body weight of the subject for at least 5-seconds after displacement. An illustration of the potential responses during protective extension is found in Figure 17.

The individual response decriptors (i.e., shoulder, elbow, hand, and breaks fall) could be scored independently of each other. For

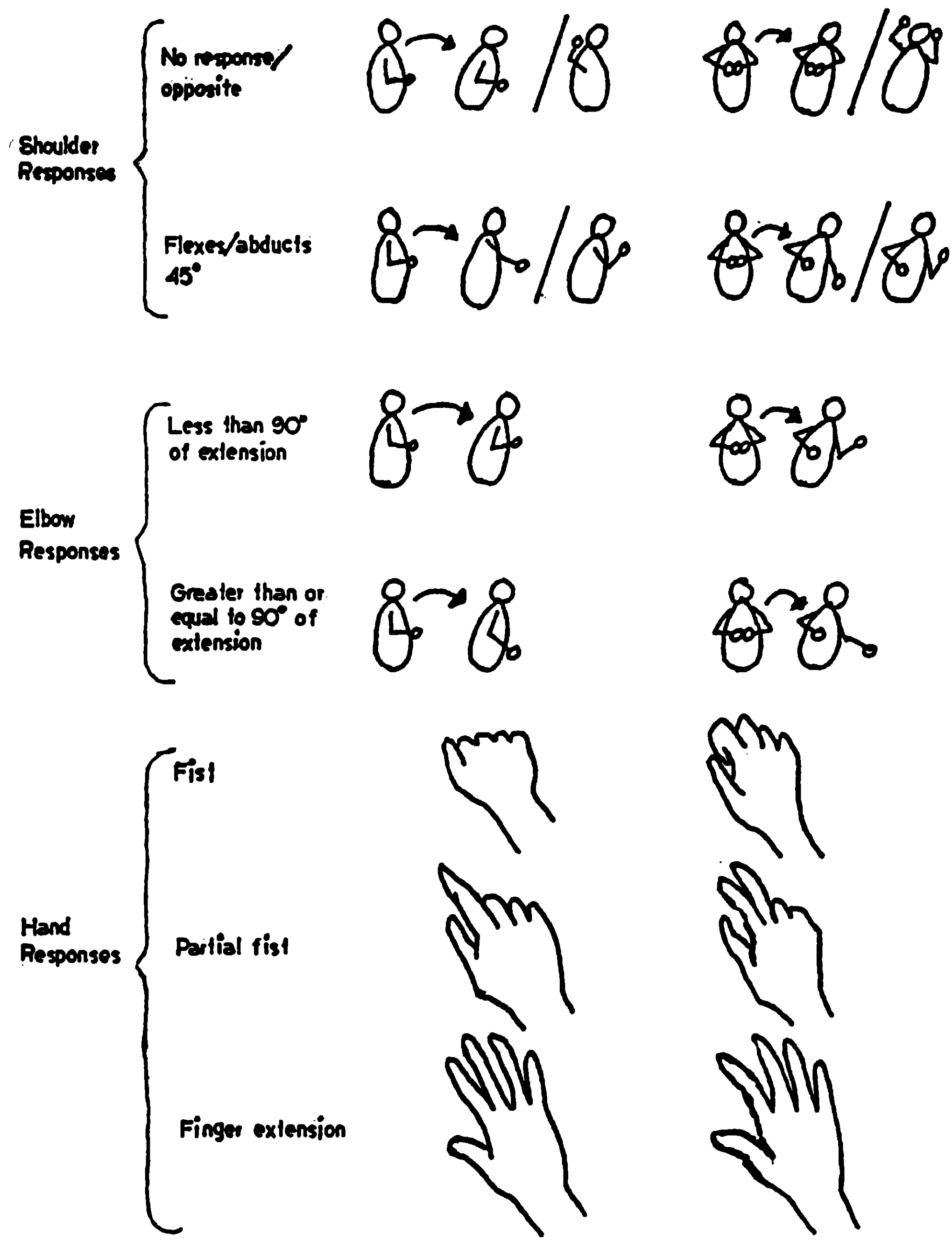


Figure 17. Illustrations of potential responses during measurement of protective extension.

instance, if a shoulder and elbow response were seen but the subject did not contact the floor with his/her hand or break the fall, check marks were recorded only in the columns under the shoulder and elbow response headings.

Summarization of the data. The results from the data sheet offered information on two aspects of the protective response: (1) the shoulder, arm and hand movement elicited, and (2) the subsequent ability to break the fall.

The following formula was used to compute the percentage of responses that broke the fall (BF):

$$\frac{\text{\# of occurrences of "BF"}}{\text{\# of occurrences + non-occurrences}} \times 100 = \text{Percentage of responses that broke the fall}$$

The protective ability was considered poor if it was 0%-50%; fair if it was 50%-85%; good if it was 85% or better.

Reliability. Separate reliability scores were computed for each descriptor (shoulder, elbow, hand, breaks fall) for each subject. Column mean reliability scores for each descriptor for each subject were computed. Reliability for each trial was determined by comparing the results of the observer with those of the examiner. The reliability was calculated as follows:

$$\frac{\text{\# of agreements on occurrence \& non-occurrences}}{\text{\# of disagreements + agreements on occurrences \& non-occurrences}} \times 100 = \text{R (overall reliability)}$$

Reliability for each trial was computed using the formula above. Agreement of at least 80% was considered to be acceptable.

Postural fixation measurement

This procedure measured the subject's ability to partially or fully realign the head and trunk to an erect sitting posture in response to an external stimulus. The stimulus definitions used for the postural fixation measurement are presented below.

Postural fixation forward stimulus. The assistant displaced the subject's shoulder forward 30 degrees within 2-to-5 seconds (as illustrated earlier in Figure 16).

Postural fixation lateral stimulus. The assistant displaced the subject's shoulder to the desired side (right or left) 30 degrees withing 2-to-5 seconds. One of the assistant's hands was used to provide the stimulus while the other hand was positioned to catch the subject if s/he did not maintain sitting or did not exhibit protective extension.

Measurement. After the subject, assistant, examiner and observer were positioned, the assistant provided 3 trials for the right, left, and forward directions. The assistant allowed enough time between each trial to mark the data sheet for the observed response.

Following each stimulus, the examiner and the observer recorded the observed response. Each response included descriptors of the head, trunk, or protective extension. The response definitions are listed below:

Response #1. The subject demonstrated no righting response (i.e., vertical orientation) of the head or trunk toward miline and continued to fall forward or to the side.

Response #2. The subject could right the head toward the midline, but to less than the upright position (the head had to be perpendicular to the ground to be fully upright).

Response #3. The subject could right the head to the upright position (see Response #2), but there was no righting of the trunk to midline or to an upright position.

Response #4. The subject could right the head and trunk toward the midline, but to less than the fully upright position (perpendicular to the ground). This response was also checked when the subject utilized protective extension to right his/her head and trunk.

Response #5. The subject could right the head and the trunk to an erect sitting posture or to an upright position without using protective extension (i.e., the head and the trunk were perpendicular to the ground).

Protective extension (PE). The subject used protective extension in the upper extremities in response to the stimulus for postural fixation.

Illustrations of the potential responses possible during measurement for postural fixation are shown in Figure 18.

Responses occurring within 5 seconds were recorded.

Reliability. Reliability was scored for each descriptor (head, trunk, PE) for each subject. Column mean reliability scores for each descriptor for each subject were computed. Reliability for each trial was determined by comparing the results of the observer with those of the examiner. The reliability was calculated using the same formula used to obtain the reliability for the protective extension measure. Agreement of 80% or better was considered to be acceptable.

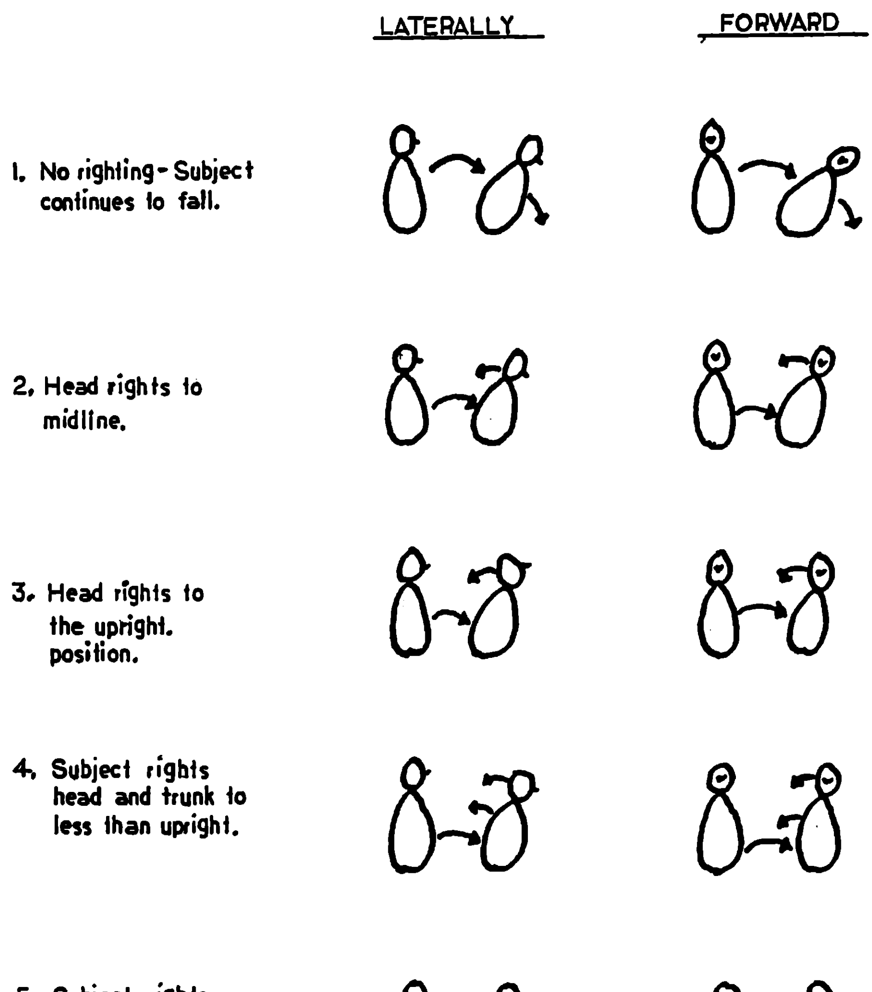


Figure 18. Illustrations and response definitions for the measurement of postural fixation.

Postrotary nystagmus measurement

Postrotary nystagmus is the involuntary movement of the eyes following an angular acceleration, and is used clinically to determine the functional state of the vestibular system.

Measurement. The subject was placed in the upright sitting position on the platform swing and spun clockwise 10 times. After an impulsive stop, the examiner and an observer measured the duration of the nystagmus with a stopwatch and recorded the length of the excursion, the direction (horizontal, vertical, or oblique), and the subject's affective response (pleasurable, distressed). The same procedures were repeated in the counter-clockwise direction. If no postrotary nystagmus was elicitted with the stimulus of 10 spins, the procedures were repeated in each direction with a stimulus of 20 spins. Descriptor definitions are listed below:

Duration of nystagmus. The amount of time that elapsed from the beginning of the nystagmus to the time the eyes stopped the nystagmus movement.

Length of the excursion. The distance covered by the eye during the nystagmus movements, as measured from the perimeter of the iris.

Direction of nystagmus. The path that the eyes predominantly followed during the nystagmus movements (horizontal, vertical, or oblique).

Reliability. Reliability for the duration, length, and direction descriptors was calculated following the same formula that was employed to obtain reliability in the measurement of erect sitting.

Agreement of 80% or better was considered acceptable.

Experimental Design

A multiple baseline design across subjects over time was used (Baer, Wolf, & Risley, 1968). All three subjects entered baseline at the same time. Baseline continued until stability was demonstrated in the erect sitting measure, and the first subject was selected for phase one of intervention on this basis. The baseline for each succeeding subject was stable or descending prior to being moved to phase one intervention. The experimental variable was applied to the remaining subjects after an intervention effect was noted on the prior subject. Phase two of intervention was implemented only for subject 1 since little gain was noted during the first intervention phase.

The covarying behaviors (protective extension, postural fixation, and postrotary nystagmus) were measures as probes once during baseline and once during intervention for each subject.

Follow-up measures of erect sitting and symmetry of sitting were taken three-to-four times during the 4 months following the cessation of intervention. No vestibular stimulation was given at these follow-up sessions.

Social reinforcement and preferred toys were present across all conditions.

Baseline. The baseline condition consisted of positioning the subject on the platform swing in the same positions for the same durations as those used during phase one of intervention, but no movement was provided. Measurements were then taken on the subject's sitting behavior with the erect sitting and symmetry measures being alternated with respect to the order in which they were measured. This was an attempt to control for any fatigue effects that may have entered into the measurements. Measurement of vocalizations were taken during the positions on the platform swing and during both measures of sitting ability. Probe measurements were taken on protective extension, postural fixation, and postrotary nystagmus one time during the baseline condition.

Intervention. The intervention condition consisted of providing specific vestibular stimulation according to the procedures outlined previously. The same measurement procedures used during baseline were used during the intervention phase(s).

Follow-up. The follow-up condition consisted of the measurement of erect sitting and symmetry only. The subjects were not positioned on the platform swing, nor were measurements taken on vocalizations due to the difference in the time samples. The covarying behaviors were not measures at this time.

CHAPTER III

RESULTS

This chapter presents interobserver reliability and performance data collected during the study. Tables and figures provide graphic presentation of the data.

Measures of Interobserver Reliability

The interobserver reliability data for sitting are presented in Tables 3-6. Table 3 presents interobserver reliability data for Symmetrical Sitting and Erect Sitting for all subjects. Tables 4-6 present interobserver reliability data for both measures of sitting for the individual subjects.

The interobserver reliability data for vocalizations are presented in Tables 7-10. Table 7 presents interobserver reliability data for Non-Speech Vocalizations and Speech Vocalization for all subjects. Tables 8-10 present interobserver reliability data for both measures of vocalizations for the individual subjects.

The interobserver reliability data for the covarying behaviors are presented in Tables 11-14. Table 11 presents interobserver reliability data for forward protective extension for each descriptor and stimulus, across subjects. Table 12 presents interobserver reliability data for lateral protective extension for each descriptor and stimulus, across subjects. Table 13 presents interobserver reliability data for forward and lateral postural fixation for each descriptor, across subjects. Table 14 presents interobserver reliability data for postrotary nystagmus across subjects.

Table 3

Mean Interobserver Reliability Across Behaviors for Sitting for Individual Subjects and Across Subjects

	Percent reliability for all sessions per subject			
	Stephen	Jennifer	Thomas	Row Mean
Erect Sitting	90	94	89	91
Symmetry	68	93	74	78

Table 4

Reliability Scores for Sitting for Stephen

	Percent reliability per session	
Session Number	Erect Sitting	Symmetry
1	88	60
3	89	88
5	97	40
7	91	50
8	89	100
9	--	75
10	--	50
11	92	83
13	75	60
17	86	50
21	91	86
22	100	80
23	92	63
Column Mean	90	68

Table 5

Reliability Scores for Sitting for Jennifer

	Percent reliability per session	
Session Number	Erect Sitting	Symmetry
1	77	75
2	94	100
4	94	100
7	94	100
8	97	83
10	97	82
13	97	100
16	100	100
17	97	100
19	92	100
21	89	90
25	97	88
Column Mean	94	93

Table 6

Reliability Scores for Sitting for Thomas

Session Number	Erect Sitting	Symmetry
	Percent reliability per session	
2	81	50
3	92	90
6	97	55
7	72	82
9	94	63
10	86	100
12	89	80
15	89	55
19	94	92
20	89	100
22	94	70
24	83	50
27	100	75
Column Mean	89	74

Subject 1 (Stephen)

The interobserver reliability data for the sitting measures represent data collected in 52% of the sessions across all conditions.

The interobserver reliability data (see Table 4) for erect sitting ranged from 75% to 97% with a mean of 89%. Interobserver reliability for symmetry ranged from 40% to 100% with a mean of 68%.

The interobserver reliability for vocalizations represent data collected in 21% of the sessions across all conditions.

The interobserver reliability data (see Table 8) for non-speech vocalizations ranged from 75% to 97% with a mean of 88%. Interobserver reliability for speech vocalizations ranged from 72% to 100% with a mean of 91%.

Interobserver reliability data (see Table 11) for forward protective extension for all descriptors for the quick stimulus ranged from 67% to 95% with a mean of 81%, and from 67% to 97% with a mean of 83% for the slow stimulus. These reliability scores represent data collected during both of the probe sessions.

Interobserver reliability data (see Table 12) for lateral protective extension for all descriptors for the quick stimulus ranged from 67% to 100% with a mean of 81%, and from 67% to 97% with a mean of 83% for the slow stimulus. These reliability scores represent data collected during both of the probe sessions.

Table 13 presents the interobserver reliability data for postural fixation for all descriptors which ranged from 67% to 83% with a mean of 72% for the forward stimulus, and from 75% to 92% with a mean of 83% for the lateral stimulus across both probe sessions.

Table 7

Mean Interobserver Reliability Across Descriptors for Vocalizations for Individual Subjects and Across Subjects

Percent reliability for all sessions per subject

Descriptors	Subjects			
	Stephen	Jennifer	Thomas	Row Mean
Non-Speech Voc	88	94	95	92
Speech Voc	91	98	80	90
Column Mean	90	96	88	Grand Mean 91

Interobserver reliability data for postrotary nystagmus for all descriptors (see Table 14) was 100% for one of the two probe sessions. It is noted that Stephen exhibited no nystagmus across the two stimuli (10 spins and 20 spins) in either direction.

Subject 2 (Jennifer)

The interobserver reliability data for the sitting measures represent data collected in 50% of the sessions across all conditions.

The interobserver reliability data (see Table 5) for erect sitting ranged from 77% to 100% with a mean of 94%. Interobserver reliability for symmetry ranged from 75% to 100% with a mean of 93%.

The interobserver reliability for vocalizations represent data collected in 27% of the sessions across all conditions.

The interobserver reliability data (see Table 9) for non-speech vocalizations ranged from 86% to 99% with a mean of 94%. Interobserver reliability for sppech vocalizations ranged from 91% to 100% with a mean of 98%.

Interobserver reliability data (see Table 11) for forward protective extension for all descriptors for the quick stimulus was 100%, and 100% for all descriptors for the slow stimulus for both of the probe sessions. It is noted that Jennifer exhibited no response across both stimuli.

Interobserver reliability data (see Table 12) for lateral protective extension for all descriptors for the quick stimulus was 100%, and 100% for all descriptors for the slow stimulus for both of the probe sessions. It is noted, again that Jennifer exhibited no response to either of these stimuli laterally.

Table 8

Reliability Scores for Vocalizations for Stephen

	Percent reliability per session		
Session Number	Non-Speech Voc	Speech Voc	Row Mean
2	97	100	99
3	93	72	83
6	75	100	88
8	88	90	89
Column Mean	88	91	Grand Mean 90

Table 9

Reliability Scores for Vocalizations for Jennifer

	Percent reliability per session		
Session Number	Non-Speech Voc	Speech Voc	Row Mean
1	99	91	95
6	97	100	99
7	86	99	93
9	92	98	95
12	91	100	96
13	98	100	99
Column Mean	94	98	Grand Mean 96

Table 10

Reliability Scores for Vocalizations for Thomas

	Percent reliability per session		
Session Number	Non-Speech Voc	Speech Voc	Row Mean
5	100	70	85
6	91	75	83
7	84	80	82
12	95	85	90
16	100	82	91
23	100	87	94
Column Mean	95	80	Grand Mean 88

Table 13 presents the interobserver reliability data for postural fixation for all descriptors which ranged from 83% to 100% with a mean of 94% for the forward stimulus, and from 88% to 100% with a mean of 96% for the lateral stimulus across both probe sessions.

Interobserver reliability data for postrotary nystagmus for all descriptors (see Table 14) ranged from 88% to 100% with a mean of 96% for one of the two probe sessions.

Subject 3 (Thomas)

The interobserver reliability data for the sitting measures represent data collected in 46% of the sessions across all conditions.

The interobserver reliability data (see Table 6) for erect sitting ranged from 72% to 97% with a mean of 88%. Interobserver reliability for symmetry ranged from 50% to 100% with a mean of 74%.

The interobserver reliability for vocalizations represent data collected in 25% of the sessions across all conditions.

The interobserver reliability data (see Table 10) for non-speech vocalizations ranged from 84% to 100% with a mean of 95%. Interobserver reliability for speech vocalizations ranged from 70% to 87% with a mean of 80%.

Interobserver reliability data (see Table 11) for forward protective extension for all descriptors for the quick stimulus was 100% (Thomas exhibited no response), and ranged from 94% to 100% with a mean of 99% for the slow stimulus for both of the probe sessions.

Interobserver reliability data (see Table 12) for lateral protective extension for all descriptors for the quick stimulus was 100%, and 100% for the slow stimulus for both of the probe

Table 11

Mean Percent Reliability Scores for Each Descriptor and Stimulus Across Subjects for Protective Extension Forward

Response to Quick Stimulus

Subject	Total # of Trials	Descriptors: Shoulder	Elbow	Hand	Breaks Fall	Row Mean
Stephen	6	100	83	94	92	92
Jennifer	6	100	100	100	100	100
Thomas	6	100	100	100	100	100
Column Mean		100	94	98	97	Grand Mean 97

Response to Slow Stimulus

Subject	Total # of Trials	Descriptors: Shoulder	Elbow	Hand	Breaks Fall	Row Mean
Stephen	6	83	96	97	100	94
Jennifer	6	100	100	100	100	100
Thomas	6	100	100	94	100	99
Column Mean		94	99	97	100	Grand Mean 98

Table 12

Mean Percent Reliability Scores for Each Descriptor and Stimulus Across Subjects for Protective Extension Laterally

Response to Quick Stimulus

Subject	Total # of Trials	Descriptors: Shoulder	Elbow	Hand	Breaks Fall	Row Mean
Stephen	12	100	67	81	75	81
Jennifer	12	100	100	100	100	100
Thomas	12	100	100	100	100	100
Column Mean		100	89	94	92	Grand Mean 94

Response to Slow Stimulus

Subject	Total # of Trials	Descriptors: Shoulder	Elbow	Hand	Breaks Fall	Row Mean
Stephen	12	83	83	97	67	83
Jennifer	12	100	100	100	100	100
Thomas	12	100	100	100	100	100
Column Mean		94	94	99	89	Grand Mean 94

Table 13

Mean Percent Reliability Scores for Each Descriptor Across Subjects for Postural Fixation

Forward

Subjects	Total # of Trials	Descriptors: Head	Trunk	Protective Extension	Row Mean
Stephen	6	67	67	83	72
Jennifer	6	83	100	100	94
Thomas	6	100	100	100	100
Column Mean		83	89	94	Grand Mean 89

Laterally

Subjects	Total # of Trials	Descriptors: Head	Trunk	Protective Extension	Row Mean
Stephen	12	83	92	75	83
Jennifer	12	88	100	100	96
Thomas	12	88	100	100	96
Column Mean		86	97	92	Grand Mean 92

Table 14

Mean Interobserver Reliability Across Descriptors for Postrotary Nystagmus for Individual Subjects and Across Subjects

Percent Reliability to the Right

Subject	Descriptors				Row Mean
	Absence	Direction	Excursion	Duration	
Stephen	100	---	---	---	--
Jennifer	---	100	100	88	96
Thomas	---	100	100	100	100
Column Mean	100	100	100	94	Grand Mean 99

Percent Reliability to the Left

Subject	Descriptors				Row Mean
	Absence	Direction	Excursion	Duration	
Stephen	100	---	---	---	--
Jennifer	---	100	100	100	100
Thomas	---	100	100	100	100
Column Mean	100	100	100	100	Grand Mean 100

sessions. It is noted that Thomas exhibited no response to either of these stimuli laterally.

Table 13 presents the interobserver reliability data for postural fixation for all descriptors which was 100% for the forward stimulus, and ranged from 88% to 100% with a mean of 96% for the lateral stimulus across both probe session.

Interobserver reliability data for postrotary nystagmus for all descriptors across stimuli (see Table 14) was 100% for one of the two probe sessions.

Performance Measures

Performance data on erect sitting (sectors 1 and 2 of the plexiglass grid, see Figure 3) for all subjects, across all conditions are presented in Figure 19. Figure 20 represents the symmetry of sitting for all subjects across all conditions, and Figure 21 represents the vocalizations (non-speech and speech) for all subjects, across all conditions.

Subject 1 (Stephen)

Percentage of erect sitting. Performance data on the percentage of erect sitting (sectors 1 and 2) across all conditions for Stephen are presented in the top graph of Figure 19. During the baseline condition, percentage of erect sitting in sectors 1 and 2 ranged from 19% of the time checks scored to 72% with a mean of 46%. There was a slight ascending trend, with a slope of +1.1 ($r = .075$).

Intervention began for Stephen on session 5. An analysis of the data during the 6-minute intervention phase revealed a range from 37% to 92% with a mean of 66%, an increase from the baseline mean of

46%. The slope of the best fit line also increased to +2.04 (r =.30). The data during the 8-minute intervention phase, which began on session 17, ranged from 58% to 97% with a mean of 77%, with an increase in the slope to +9.5 (r =.48), both of which were marked increases over both the baseline and 6-minute intervention phases.

Four follow-up points were taken on which Stephen demonstrated erect sitting at levels similar to the intervention points. Stephen's percentage of erect sitting was 61% of the time checks at the 3-week follow-up session, 80% at the 6-week follow-up session, 77% at the 10-week follow-up session, and 69% at the 14-week follow-up session.

Percentage of time checks of symmetrical sitting. Performance data on the percentage of time checks of symmetrical sitting (shoulders equal) across all conditions for Stephen are presented in the top graph of Gigure 20. During the baseline condition, the percentage of time checks scored as symmetrical sitting ranged from 0% to 45% with a mean of 26%. An ascending trend was noted with a slope of +2.3 (r =.21).

An analysis of the data during the 6-minute intervention phase revealed a range in symmetrical sitting from 9% to 75% with a mean of 46%, an increase from the baseline mean of 26%. A slightly ascending trend was noted with a slope of +.93 (r =.15). The data points during the 8-minute intervention phase ranged from 60% to 75% with a mean of 67% with the slope of the ascending trend increasing to +4.0 (r =.53), both of which were a marked increase over both the baseline and 6-minute intervention phases.

Data during the four follow-up sessions revealed levels of

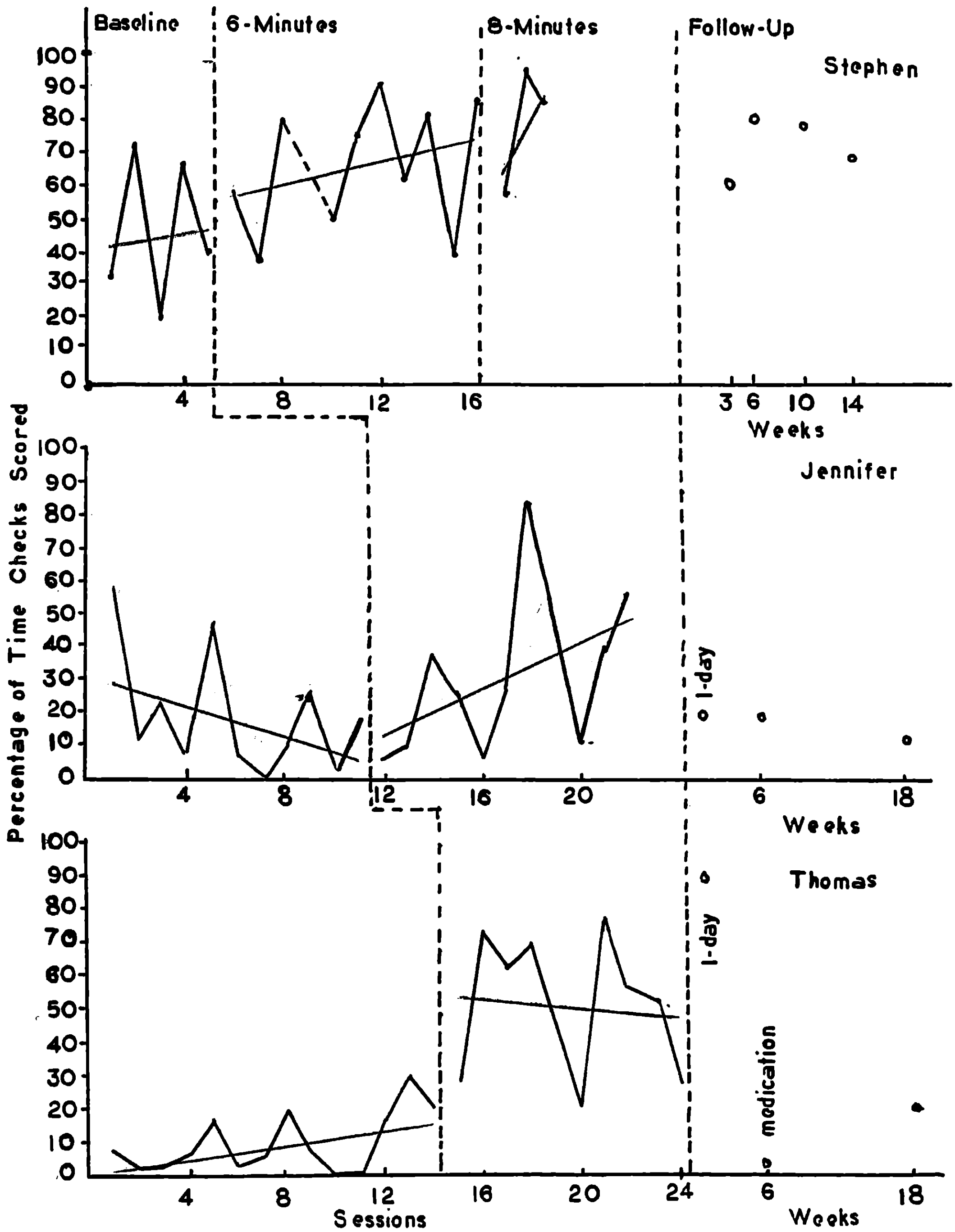


Figure 19. Percentage of erect sitting across all subjects and conditions

symmetrical sitting similar to that observed during intervention, with the exception of the first point. Stephen's symmetrical sitting was 10% of the time checks scored at the 3-week follow-up session, 56% at the 6-week follow-up session, 60% at the 10-week follow-up session, and 40% at the 14-week follow-up session.

Frequency of vocalizations. Performance data on the frequency of speech and non-speech vocalizations per session, across all conditions for Stephen are presented in the top graph of Figure 21. During the baseline condition, frequency of non-speech vocalizations ranged from 26 to 60 with a mean of 42, with an ascending trend at a slope of +10.3 (r =.79). An ascending trend with a slope of +7.3 (r =.76) was also noted in the baseline condition for speech vocalizations, which ranged from 0 to 26 with a mean of 8.

A reversal in the trend of the non-speech vocalizations was noted during the 6-minute intervention phase, with a descending slope of -2.0 (r =.68), and a range from 1 to 29 with a mean of 9, markedly lower than the baseline mean of 42. The trend for the speech vocalizations continued to be ascending at a slope of +.88 (r =.25). The frequency of speech vocalizations ranged from 2 to 32 with a mean of 15, slightly higher than the baseline mean of 8. The inverse relationship between speech and non-speech vocalizations became more pronounced during the 8-minute intervention phase, where non-speech vocalizations continued to decrease with a slope of -3.5 (r =.39), and a range in the frequency from 3 to 21 with a mean of 11. The speech vocalizations, in contrast, dramatically increased with a slope of +27.5 (r = .89), with the frequency ranging from 9 to 64 with a mean of 28.

Subject 2 (Jennifer)

Percentage of erect sitting. Performance data on the percentage of erect sitting (sections 1 and 2) across all conditions for Jennifer are presented in the center graph of Figure 19. During the baseline condition, Jennifer demonstrated a descending tren with a slope of -2.3 ($r = .43$), with her percentage of erect sitting ranging from 0% to 57% with a mean of 19%.

Intervention for Jennifer began on session 12. An analysis of the data during the 6-minute intervention phase revealed a reversal in the trend from the descending slope noted in baseline to an ascending slope of +3.52 ($r = .48$). A marked increase in the percentage of erect sitting over the baseline condition was noted with a range from 6% to 86% with a mean of 32%.

Follow-up data revealed levels of erect sitting similar to the baseline condition. Jennifer's percentage of erect sitting was 17% at the 1-day follow-up session, 17% at the 6-week follow-up session, and 11% at the 18-week follow-up session.

Percentage of time checks of symmetrical sitting. Performance data on the percentage of time checks of symmetrical sitting (shoulders equal) across all condition for Jennifer are presented in the center graph of Figure 20. During the baseline condition, Jennifer demonstrated a slight descending trend with a slope of -.33 ($r = .047$) in her percentage of symmetrical sitting, which ranged from 25% to 90% with a mean of 51%.

An analysis of the data during the 6-minute intervention phase

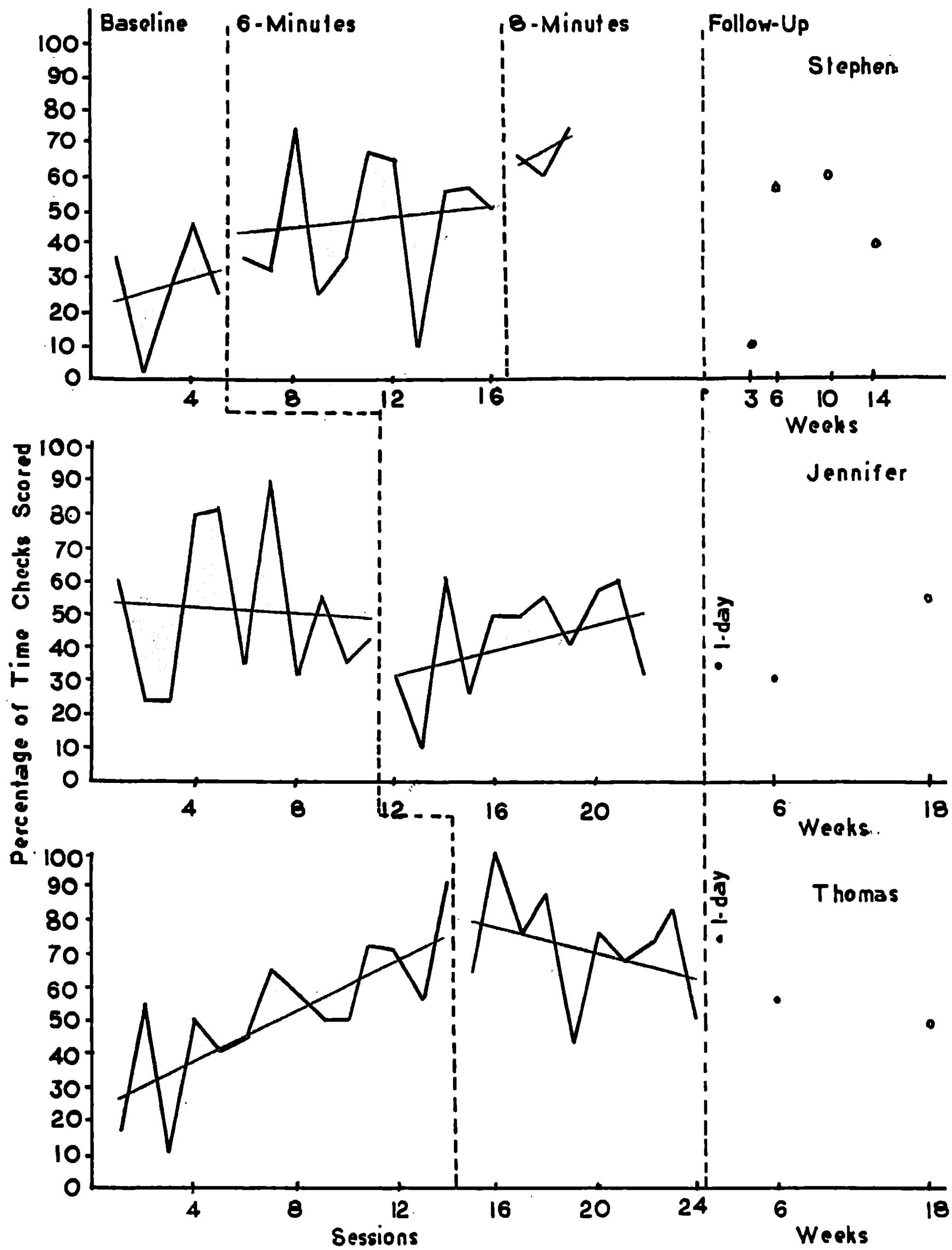


Figure 20. Percentage of symmetrical sitting across all subjects and conditions

revealed a reversal in the trend from the descending trend noted in baseline to an ascending trend with a slope of +1.99 (r =.42) in her percentage of symmetrical sitting, but a range from 11% to 60% with a mean of 43%, which was slighlty lower than the baseline mean of 51%.

Follow-up data revealed levels of symmetrical sitting which were within the range observed during baseline. Jennifer's symmetrical sitting was 36% at the 1-day follow-up session, 33% at the 6-week follow-up session, and 56% at the 18-week follow-up session.

Frequency of vocalizations. Performance data on the frequency of speech and non-speech vocalizations, per session, across all conditions for Jennifer are presented in the center graph of Figure 21. During the baseline condition, Jennifer's frequency of non-speech vocalizations ranged from 21 to 105 with a mean of 58, and a descending trend with a slope of -2.0 (r =.20). Frequency of speech vocalizations ranged from 0 to 56 with a mean of 22 and an ascending trend with a slope of +1.9 (r =.26) during the baseline condition.

During the 6-minute intervention phase, Jennifer's frequency of non-speech vocalizations decreased with a slope of -3.8 (r =.77) to levels lower than noted for speech vocalizations during this condition. Non-speech vocalizations ranged from 2 to 57 with a mean of 21, while her speech vocalizations ranged from 0 to 57 with a mean of 23, with an ascending trend at a slope of +4.9 (r =.75). It was observed that as the non-speech vocalization tren continued to decrease, the speech vocalization trend continued to increase.

Subject 3 (Thomas)

Percentage of erect sitting. Performance data on the percentage of erect sitting (sections 1 and 2) across all conditions for Thomas are presented in the bottom graph of Figure 19. Thomas exhibited low levels of erect sitting during the baseline condition, with his percentage of erect sitting ranging from 0% to 29% with a mean of 10%. A slight ascending tren was noted during baseline, with a slope of +.98 (r = .467).

Intervention began for Thomas on session 15. A sharp increase in the percentage of erect sitting was noted during the 6-minute intervention phase, which ranged from 19% to 78% with a mean of 57%. Although the trend was descending with a slope of -1.04 (r=.15), Thomas' level of erect sitting was markedly higher than the baseline range with the exception of 3 points.

Follow-up data indicate levels of erect sitting above the baseline levels with the exception of the second point, at which time Thomas was receiving medication. Thomas' percentage of erect sitting was 89% on the 1-day follow-up session, 3% at the 6-week follow-up session, and 19% at the 19-week follow-up session.

Percentage of time checks of symmetrical sitting. Performance data on the percentage of time checks of symmetrical sitting (shoulders equal) across all conditions for Thomas are presented in the bottom graph of Figure 20. Thomas demonstrated an ascending trend during baseline with a slope of +3.73 (r =.75). Baseline data ranged from 10% to 90% with a mean of 52%.

An increase in Thomas' symmetrical sitting was noted during the

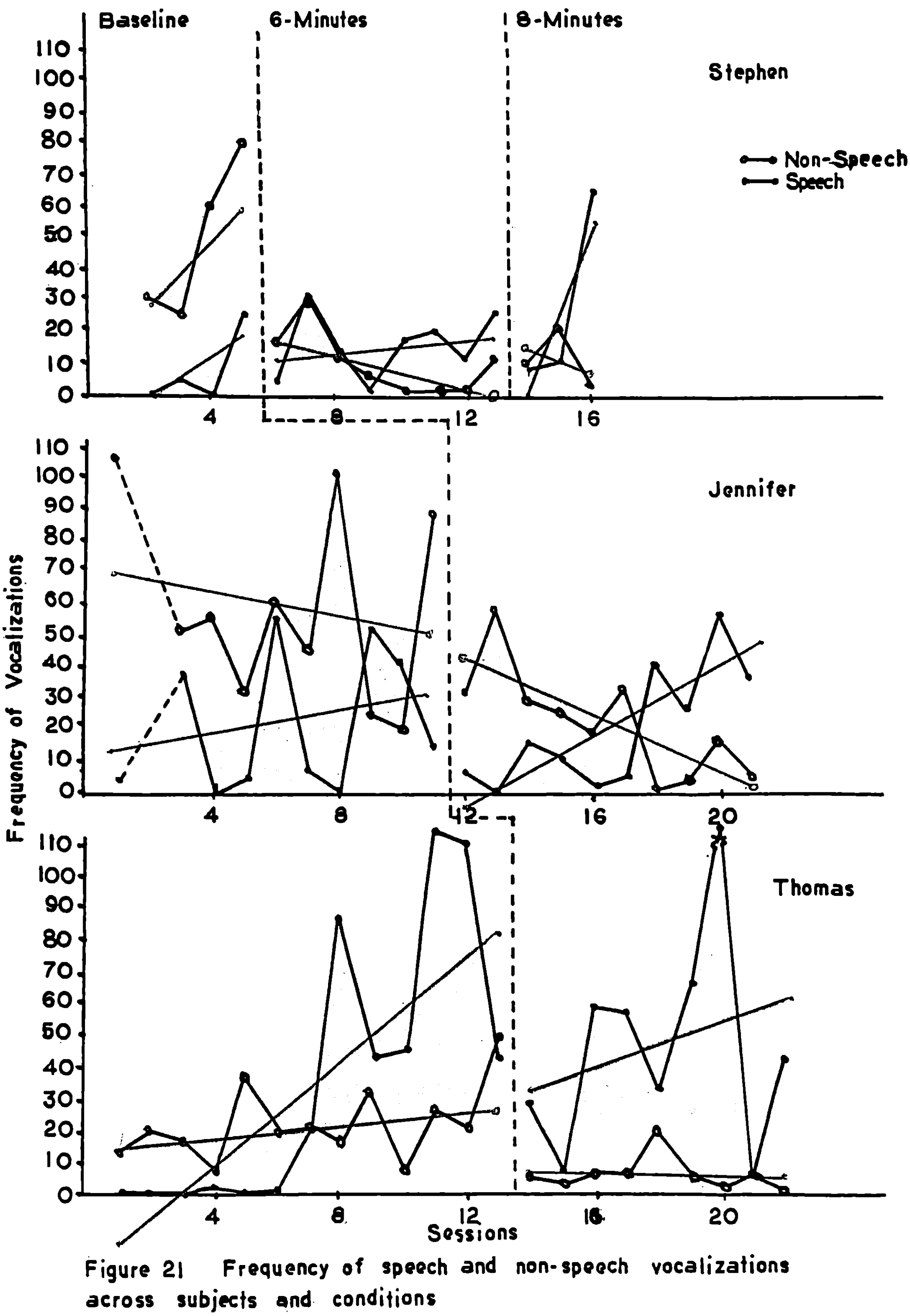


Figure 21 Frequency of speech and non-speech vocalizations across subjects and conditions

6-minute intervention phase, with symmetrical sitting ranging from 42% to 100% with a mean of 71%. Although the trend was descending with a slope of -1.63 (r =.29), Thomas' level of symmetrical sitting generally remained higher than during the baseline condition.

Follow-up data revealed a decrease in symmetrical sitting from the intervention points. Thomas' symmetrical sitting was 75% at the 1-day follow-up session, 58% at the 6-week follow-up session, and 50% at the 18-week follow-up session.

Frequency of vocalizations. Performance data on the frequency of speech and non-speech vocalizations, per session, across all conditions for Thomas are presented in the bottom graph of Figure 21. During the baseline condition, Thomas' frequency of non-speech vocalizations increased with a slope of +1.2 (r =.45) and ranged from 7 to 47 with a mean of 21. Thomas' speech vocalizations ranged from 0 to 113 with a mean of 35, with an ascending slope of +8.0 (r =.77).

During the 6-minute intervention phase, Thomas' non-speech vocalizations dropped to very low levels, ranging from 1 to 19 with a mean of 6, and a descending slope of -.30 (r =.12). His speech vocalizations continued to increase in frequency, ranging from 7 to 124 and a slope of +3.4 (r =.26).

Probe Measures of Covarying Behaviors

The three covarying behaviors (protective extension, postural fixation, and postrotary nystagmus) were evaluated one during baseline, and one during the intervention phase. Table 15 presents the protective extension and postural fixation responses for both probe sessions across all subjects and descriptors. Table 16 presents the postrotary nystagmus data for both probe sessions for all subjects across descriptors.

Subject 1 (Stephen)

Protective extension. Stephen demonstrated decreases in protective extension responses from 100% in the baseline probe to 61% in the intervention (see Table 15). Specifically, Stephen demonstrated protective extension responses on 100% of the trials during the baseline probe for both the quick and slow stimuli, in both the forward and lateral directions. Stephen broke the fall on 50% of the forward trials and 83% of the lateral trials across both stimuli during the baseline session.

A decrease in protective extension responses from the baseline probe was noted during the intervention probe, with Stephen demonstrating protective extension responses on 61% of the trials across both the quick and slow stimuli in both the forward and lateral directions. Stephen broke the fall on 33% of the forward trials, and on 50% of the lateral trials across both stimuli during the intervention probe.

Postural fixation. Stephen demonstrated no change in postural fixation responses, responding on 67% of the trials during both probes (see Table 15). Specifically, Stephen demonstrated postural fixation responses on 33% of the lateral trials and 100% of the forward trials during both the baseline and the intervention probes. No protective extension responses were noted during the baseline probe. An increase in protective extension responses from the baseline data was noted, with protective extension being demonstrated on 33% of the

Table 15

Percent of trials of Protective Extension and Postural Fixation Responses for Individual Subjects.

Response	Probe	Stephen	Jennifer	Thomas
Protective Extension	Baseline	100	0	0
	Intervention	61	0	17
Postural Fixation	Baseline	67	17	75
	Intervention	67	67	17

trials for all directions (lateral and forward) during the intervention probe.

Postrotary nystagmus. Stephen demonstrated no nystagmus response in either direction to the 10 spin stimulus, and a duration of 4 second to the right and 7 seconds to the left to the 20 spin stimulus during the baseline probe.

A decrease in postrotary nystagmus was noted during the intervention probe with no nystagmus being demonstrated in either direction to either the 10 or 20 spin stimuli (Table 16).

Subject 2 (Jennifer)

Protective extension. Jennifer demonstrated no protective extension responses to any of the stimuli or directions during either the baseline or intervention probe. This may be due to the flexor spasticity in her upper extremities (Table 15).

Postural fixation. Jennifer demonstrated an increase in postural fixation responses from 17% in the baseline probe to 67% in the intervention probe (see Table 15). Specifically, Jennifer demonstrated postural fixation responses for 33% of the forward stimuli and on 0% of the lateral trials during the baseline probe.

An increase in postural fixation responses was noted during the intervention probe with postural fixation responses being demonstrated on 100% of the forward trials, and 33% of the lateral trials.

Postrotary nystagmus. Jennifer demonstrated a duration of 12 seconds of nystagmus to the right and 10 seconds of nystagmus to the left to the 10 spin stimulus during the baseline probe.

An increase from the baseline probe was noted in the duration

Table 16

Observations of Postrotary Nystagmus for Subjects in Baseline and Intervention Conditions

Subject	# Spins	Duration in Seconds	Pattern	Excursion
Stephen				
Baseline	10	Right= 0	---	---
		Left= 0	---	---
	20	Right= 4	Oblique	1 cm
		Left= 7	Oblique	1 cm
Intervention	10	Right= 0	---	---
		Left= 0	---	---
	20	Right= 0	---	---
		Left= 0	---	---
Jennifer				
Baseline	10	Right= 12	Horizontal	1-2 cm
		Left= 10	Horizontal	1-2 cm
Intervention	10	Right= 13	Horizontal	2-3 cm
		Left= 16	Horizontal	2-3 cm
Thomas				
Baseline	10	Right= 16	Horizontal	1-2 cm
		Left= 5	Horizontal	½-1 cm
Intervention	10	Right= 8	Horizontal	1-2 cm
		Left= 0	---	---

of postrotary nystagmus during the intervention probe, with Jennifer exhibiting 13 seconds to the right and 16 seconds to the left in response to the 10 spin stimulus (see Table 16).

Subject 3 (Thomas)

Protective extension. Thomas demonstrated an increase in protective extension responses from 0% in the baseline probe to 17% during the intervention probe (see Table 15). Specifically, Thomas demonstrated no protective extension responses to any of the stimuli or directions during the baseline probe.

A slight increase over the baseline data was noted during the intervention probe, with protective extension responses being demonstrated and the fall being broken on 33% of the trials in the forward direction in response to the slow stimulus. No protective extension responses were noted to the quick stimulus in either direction, or to the slow stimulus in the lateral direction.

Postural fixation. Thomas demonstrated marked decreases in postural fixation responses from 75% in the baseline probe to 17% during the intervention probe (see Table 15). Specifically, Thomas demonstrated postural fixation responses on 83% of the lateral trials, and on 66% of the forward trials during the baseline probe.

A marked decrease in postural fixation responses from the baseline probe was noted during the intervention probe, with postural fixation responses being demonstrated on 33% of the lateral trials, and on 0% of the forward trials.

Postrotary nystagmus. Thomas demonstrated a duration of 16 seconds of nystagmus to the right and 5 seconds of nystagmus to the left to the 10 spin stimulus during the baseline probe.

A decrease in the duration of postrotary nystagmus from the baseline probe was noted during the intervention probe, with Thomas exhibiting 8 seconds to the right and 0 seconds to the left in response to the 10 spin stimulus (see Table 16).

CHAPTER IV

DISCUSSION

A multiple baseline across subjects was used to investigate the effects of vestibular stimulation on the acquisition of erect sitting, symmetrical sitting, and vocal behaviors. In this chapter, preformance and probe data across subjects and behaviors are discussed in reference to the effect of vestibular stimulation on the subject's sitting, vocal, and covarying behaviors. Included in this discussion is the relation between the subject's handicapping conditions on performance and reliability data and the effects of the vestibular stimulation.

Reliability Data

The reliability figures appear to be directly related to the subjects' handicapping conditions. Reliability figures for Jennifer, diagnose as spastic quadriplegic cerebral palsy, were excellent for both the erect sitting measure (94%) and the symmetry measure (93%). The reliability figures for Stephen and Thomas, who were diagnosed as athetoid cerebral palsy, were lower, with 89% reliability for the erect sitting measure for both subjects, and symmetry reliabilities of 68% and 74%, respectively. One possible explaination for the depressed reliability figures for these two subjects may be the extraneous movements they exhibited as a result of the athetoid type cerebral palsy. The reliability for the symmetry measure seems to be particularly effected by this extraneous movement, possibly due to the sensitivity of the measurement device. The posture grid measured discrepancies of 2 cm; the rapid fluctuating movements of these two subjects may have caused their shoulders to pass through and across a number of sections during the time check, thus causing the observers to make judgement calls and lowering the reliability.

Performance Data

Erect Sitting

An increase in the percentage of erect sitting occurred across all subjects with the application of vestibular stimulation. These increases were observed to occur differently across subjects. Stephen demonstrated a very gradual acquisition in erect sitting during the 6-minute intervention phase. This rate of acquisition coupled with the absence of any postrotary nystagmus, led the investigator to change the intervention from a cumulative duration of vestibular stimulation of six minutes to a cumulative duration of eight minutes. The effect of this change was noted by a further increase in erect sitting. The rate of acquisition of erect sitting for Jennifer occurred over time, and was marked by a reversal of the descending trend noted during the baseline phase. Thomas acquired erect sitting more abruptly with the percentage increasing markedly by the second day of intervention. Thomas maintained this high level of erect sitting throughout the study. These different patterns of the effects of vestibular stimulation on motor behaviors are consistent with the previous findings of Cook (1982) and Campbell (1983), both of whom studied the effects of vestibular stimulation on the acquisition of head erect behavior.

The follow-up data may indicate the differential effects of vestibular stimulation on subjects with different diagnoses. The two subjects with athetoid cerebral palsy (Stephen and Thomas) appear to have long term beneficial effects of vestibular stimulation while the observed gains for the subject with spastic quadriplegic cerebral palsy (Jennifer) seem to be short term.

Stephen maintained the level of erect sitting he achieved during intervention across the 4-month follow-up period. Thomas' erect sitting dropped from 89% on the initial follow-up session to 19% on the final follow-up session, which was still higher than the baseline mean of 10%, but considerably lower than the intervention mean of 51%.

Vestibular stimulation appeared to have dramatic effects during intervention, but no long term benefits for Jennifer, the subject with spastic quadriplegic cerebral palsy. Jennifer's erect sitting immediately dropped to 17% from the intervention mean of 32% and remained low across the 4-month follow-up period.

These data are consistent with the follow-up data reported by Cook (1982). Cook found the increase in the cumulative duration of head lifts was maintained by the subject with athetosis, but not by one of the subjects with spacticity. The head erect behavior of the other subject with spastic cerebral palsy appeared to be controlled throughout the study by social reinforcement. These data may indicate that long term beneficial effects of vestibular stimulation may be a function of the individual's handicapping condition, but much more conclusive evidence is required.

Two other possible explainations for both Jennifer's lack of maintenance and Thomas' decreased maintenance may be either the relatively short period of intervention (10 to 14 sessions) resulting in a maximum of 90 minutes of total stimulation, or, it may be that none of the subjects actually attained the sitting behavior (80% or better). Stephen, who maintained his level of sitting over the 4-month follow-up period, had demonstrated erect sitting on the average of 77% of the time during intervention. Thomas had averaged erect sitting 57% of the time. He demonstrated maintenance of erect sitting above baseline levels, but considerably below intervention levels. Jennifer, in contrast, did not maintain her previous level of erect sitting (32%) over the follow-up period. It may be that Stephen had acquired the behavior at a level that could be sustained over time, where as Jennifer may not have, and Thomas may have been beginning to acquire the behavior.

Symmetry of Sitting

The effects of vestibular stimulation on the symmetry of sitting were less apparent than for erect sitting, but they followed a similar pattern. Stephen showed a slight increase in symmetrical sitting during the 6-minute intervention phase, but a marked increase in both the trend and the level of symmetrical sitting was observed with the onset of the 8-minute intervention phase. The mean level of Jennifer's symmetrical sitting during the 6-minute intervention phase was lower than baseline, but remained within the range observed during baseline, and was marked by a reversal in the decreasing trend noted in the baseline phase. Thomas demonstrated an increase in symmetrical sitting during baseline, which may be a result of his propping on his elbows causing him to virtually lay on his legs, creating a quite stable symmetrical posture. The introduction of vestibular stimulation appeared to increase his extended arm propping, producing a more erect, but less stable sitting posture. This less stable sitting and the observation of his increased use of sign language during intervention may have resulted in the observed decreasing symmetrical trend during intervention. It is noted, however, that Thomas maintained a fairly high level of symmetrical sitting despite his decreasing trend.

Vestibular stimulation appeared to have long-term benefits on the symmetrical sitting of Stephen and Thomas, the two subjects with athetoid cerebral palsy, as both of these subjects maintained their levels of symmetrical sitting during the 4-month follow-up period. Stephen's symmetrical sitting was maintained across the 4-month follow-up period at levels virtually equal to the 6-minute intervention mean of 46%, but considerably lower than the mean of 55% during the 8-minute intervention phase. The follow-up levels were markedly higher than the baseline mean of 26%. Thomas symmetrical sitting was maintained across the 4-month follow-up period at a level lower than the mean of 71% during intervention, but higher than the mean of 52% during baseline.

Jennifer, the subject with spastic quadriplegic cerebral palsy did not demonstrate these long-term benefits, in that her symmetrical sitting remained at the level observed during the intervention phase (43%), which was much lower than the baseline mean of 51%.

Vocalizations

All three subjects had bilateral hearing losses. Stephen and

Jennifer were normally bilaterally aided, Thomas was usually unilaterally aided. Stephen's aids were removed midway through intervention due to his removing and dismantelling them during the sessions. Jennifer's aids were being repaired during most of the intervention phase. She was not aided at all for half of the intervention phase. She was then aided unilaterally for two sessions and again bilaterally for the final two sessions of intervention. Thomas was without his aid for only on baseline session. No changes were noted in the frequency of either the speech or non-speech vocalizations as a result of the subjects being bilaterally aided, unilaterally aided, or without aids.

Mavilya (1972) and Cairns and Butterfield (1976) have previously reported that vocalizations produced by hearing impaired infants differ from those produced by normally hearing infants, in that the hearing impaired infants decreased the duration of both their speech and non-speech vocalizations over time, while the duration of the normally hearing infants' speech vocalizations increased and the non-speech vocalizations decreased over time.

Although no comparisons can be made between the frequency measure of the preschoolers' vocalizations in the present study and the duration measure of the infants' vocalizations in the previous studies, it should be noted that there was an increase in the speech vocalizations and a decrease in the non-speech vocalizations over time for all three subjects in the present study.

It may be that the vestibular stimulation promoted these increases in speech vocalizations and decreases in non-speech vocalizations. Stephen and Jennifer's levels of speech vocalizations became higher than their non-speech vocalizations during the intervention phase. The change in Stephen's vocalizations occurred by the second day of intervention, while the transition in levels of vocalizations for Jennifer began on the third day of intervention with markedly higher levels of speech vocalizations being noted by the seventh day of intervention. Thomas' level of speech vocalizations increased dramatically during baseline, and became markedly higher than his non-speech vocalizations which remained at the same level throughout baseline. The onset of vestibular stimulation appeared to markedly decrease the level of his non-speech vocalizations to a near zero level while his speech vocalizations remained at a high level.

These results may implicate vestibular stimulation as an appropriate technique for promoting speech vocalizations in individuals with hearing impairments. Further studies need to be conducted to determine the effectiveness of vestibular stimulation on the speech development of individuals with a wider range of ages and diagnoses.

Covarying Behavior Data

Protective Extension and Postural Rixation

The data for the covarying behaviors of protective extensionand postural fixation are inconsistent across subjects. No changes were noted from the baseline probe to the intervention probe for Stephen's postural fixation, but decreases were noted in his protective extension responses. Jennifer demonstrated no protective extension responses for either probe. This may be due to the flexor spasticity in her upper extremities. During the intervention probe, increases were noted in Jennifer's use of postural fixation from the baseline probe levels. Thomas demonstrated increases in forward protective extension, but no change was noted in the lateral direction. Thomas' use of postural fixation decreased for both the lateral and forward directions. These data indicate little or no changes for protective extension and postural fixation as a result of vestibular stimulation. One possible explaination for these findings may be that the subjects became familiar with the experimenter and assistants and realized that they would be caught before they actually fell. A more accurate record of the subjects' use of protective extension and postural fixation might have been obtained by having unfamiliar persons provide the stimuli, thus avoiding this trust relationship. It should be noted that these data are inclusive due to the fact that only a few data points were collected.

Postrotary Nystagmus

The effects of vestibular stimulation on the subjects' postrotary nystagmus are consistent with the findings presented for the measures of erect and symmetrical sitting, indicating that postrotary nystagmus may be an accurate indicator of the subjects' responsiveness to the vestibular stimulation. It was noted that during the intervention probe, the two subjects with athetoid cerebral palsy, Stephen and Thomas, demonstrated decreases in the duration of postrotary nystagmus as compared to the baseline durations, while Jennifer, the subject with spastic quadriplegic cerebral palsy demonstrated an increase in the duration of her postrotary nystagmus. According to normative data reported by

Punwar (1982), the decreases observed in Stephen and Thomas' durations of postrotary nystagmus placed them within the hyporeactive range for boys their age, while the increase noted for Jennifer's postrotary nystagmus placed her within the hyperreactive range for girls her age. Ayres (1978) stated that hyperreactive nystagmus may indicated less than normal inhibition from higher levels of the brain upon the vestibular nuclei in the brain stem. Ayres further stated that subjects with hyporeactive nystagmus are more responsive to sensory integration therapy than those subjects with hyperreactive nystagmus. The data from the present study appear to follow this pattern, in that the two subjects with hyporeactive nystagmus, who were both athetoid, demonstrated long-term gains in sitting, while the subject with hyperreactive nystagmus, who had spastic quadriplegic cerebral palsy, did not. Further studies need to be conducted to determine the relationship between diagnoses, duration of nystagmus, and responsiveness to sensory integration therapy.

Contra-indications

No adverse side effects to the vestibular stimulation were noted for any of the subjects. Stephen fell asleep during two of the sessions, but, upon consulting with the classroom teachers, this appeared to be a function of the time of day.

Limitations of the Study

Limitations are discussed in relation to number of subjects and methodology that was utilized. A larger number of subjects would provide better information on the effects across handicapping conditions. For example, the participation of more hypertonic children may have lent additional support to the finding that vestibular stimulation may not produce lasting benefits with this population. The posture grid for the symmetry measure may have produced greater reliability and still have provided accurate measurement, had the lines on the grid been set at 3 cm rather than the 2 cm utilized. The absence of a duration recording for the coded vocalizations made the data analysis difficult. For example, Jennifer's vocalizations were less frequent, but were typically of a longer, sustained quality than were Thomas'. These qualitative factors were unable to be expressed in a frequency measurement. A duration measure would also have permitted the collection of data during the follow-up period that would be comparable to that collected in baseline and intervention, despite the difference in the time sample. This follow-up data on vocalizations would also have provided more information as to the effects of vestibular stimulation on the vocal behavior of the subjects. This study is also limited by the relatively short intervention period, especially for the 8-minute intervention phase implemented for Stephen.

Implications for Future Research

Further research in this area is needed to address several areas. Further quantification of the effects of vestibular stimulation across handicapping conditions is indicated. For example, a comparison of the effects on athetoid versus spastic children. Secondly, the probe of postrotary nystagmus should be conducted more frequently as the results of this study indicate it as a fairly accurate indicator of the effectiveness of the vestibular stimulation. Thirdly, the sequence of development for children with handicapping conditions needs further study, as the data in the present study appear to indicate developmental progress different than children without handicaps. For example, the subjects in the present study demonstrated little or no use of protective extension or postural fixation, yet attained considerable amounts of sitting ability. The progression of sitting in non-handicapped children indicate that these behaviors are acquired and refined prior to the acquisition of sitting behavior. Further studies need to be conducted to determine the effects of vestibular stimulation on the vocalizations of non-hearing impaired subjects and of hearing impaired subjects who are with, and without their hearing aids. Further studies need to be conducted to determine if sustained periods of stimulation will increase the maintenance of motor behaviors of the subjects, especially those who may have spastic cerebral palsy, over time. Finally, further studies need to be conducted to determine the effects of providing vestibular stimulation twice a day, as well as determining an optimal duration of vestibular stimulation for children with handicapping conditions.

CHAPTER V

SUMMARY

Vestibular stimulation as a therapeutic technique is often used in the treatment of children with handicapping conditions. The purpose of this study was to assess the effectiveness of vestibular stimulation on the acquisition of sitting and vocal behaviors in children with severe and multiple handicaps utilizing a multiple baseline design across subjects. Subjects were positioned on a platform swing in three different positions: upright sitting, right sidelying, and left sidelying, and provided with specific vestibular stimulation through spinning. The child was spun for two minutes in each position, one minute clockwise, and one minute counter-clockwise. Each spin consisted of a rapid 1-2 second angular acceleration, a 1-minute period of constant velocity at 180 /second (30 RPM), an impulsive stop in less than one second, followed by a 10-second rest period. Data on the erectness and the symmetry of sitting were recorded during separate 3-minute observation sessions immediately following the final 10-second rest period for each session. Vocalizations (speech and non-speech) were recorded on blank tapes during the positions on the swing and during the two measures of sitting ability. Probe measures were taken on the covarying behaviors of protective extension, postural fixation, and postrotary nystagmus.

Results of this study indicated increases in both the percentage of erect and symmetrical sitting and in the frequency of speech vocalizations across subjects with the application of vestibular stimulation. The two subjects with athetoid cerebral palsy maintained percentages of erect and symmetrical sitting across the 4-month follow-up period at levels higher than those observed during baseline. The subject with spastic quadriplegic cerebral palsy did not maintain the gains achieved during intervention across the follow-up period. The data from the probes of the covarying behaviors of protective extension and postural fixation are inconclusive and may have been influenced by a possible trust that the subjects may have developed in the examiner and assistants. The data from the postrotary nystagmus probes appear to correlate with the follow-up data from the sitting measures, and may be an accurate indicator of an individual's responsiveness to vestibular stimulation therapy.

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APPENDIX A

Consent Form, Parent Authorization

Dear______________________________,

I am a graduate student in special education interested in conducting a study using vestibular stimulating activities (such as spinning and swinging) to improve the ability to sit.

In the proposed study, I plan to spin your child on a platform swing while s/he is sitting up, lying on his/her right side and then on his/her left side. I plan to spin your child for 1-minute in a clockwise direction, and then for 1-minute in a counter-clockwise direction in each of these three positions. I plan to include short rest periods in between spins. Information concerning your child's sitting ability will be taken following the spinning. This whole procedure will take 15-30 minutes and I plan to do this two to three times a week for one semester. The following semester, I plan to record information on your child's sitting ability without spinning him/her for two to three sessions.

Possible side effects from this type of stimulation can include dizziness, nausea, sweating, hyperventilation, vomiting, and an increase or decrease in the occurrence of seizures. If your child displays any of these side effects, you will be informed immediately and the spinning will be stopped.

Your child will not be identified by name in this study and any tape recordings, photographs, or videotapes will be used only for purposes of collecting information, training other students to take information on sitting, and for presentation to my thesis committee. These tapes and photographs will be filed at the Children's Rehabilitation Unit at The University of Kansas Medical Center, and used only to train new students to take information on sitting. They will not be used for any other purpose without your written consent.

If you are interested in your child participating in this study, please indicate on the attached sheet. I will be available throughout the study to discuss any information about this study or your child's sitting behavior.

Sincerely,

Tracy L. Kuharski

INFORMED CONSENT

1. As legal guardian for this patient, I, ______________________ (name of legal guardian) hereby consent to the inclusion of ____________________ (name of patient) in the study of the Effects of Vestibular Stimulation therapy on the ability of handicapped children to sit as described on the previous pages.
2. I acknowledge that no guarantees have been made to me regarding the results of these procedures.
3. I have been informed that certain side effects may result from the therapy, these include: dizziness, nausea, sweating, hyperventillation, vomiting, or an increase in the frequency of seizures in seizure-prone children. I understand that I will be informed if my child displays more or less seizure activity.
4. I understand that I may terminate the procedures at any time.
5. I understand that the University of Kansas Medical Center, College of Health Sciences and Hospital does not maintain a policy of medical treatment or compensation for physical injuries incurred as a result of participating in a biomedical or behavioral research.
6. I grant permission for the researcher to do the following:

A. Take photographs of the patient	yes	no
B. Take videotapes of the patient	yes	no

7. This form has been fully explained to me and I certify that I understand its contents.

INFORMED CONSENT

____ ________________
(signature of person legally authorized to consent for the patient) (date)

____
(relationship to patient)

______________________________ ______________________________
(signature of witness) (signature of researcher)