The relation of visual fixation and pursuit to posture in four month infants

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THE RELATION OF VISUAL FIXATION AND PURSUIT TO POSTURE IN FOUR MONTH INFANTS

A Thesis
Presented to the
Department of Special Education
and the
Faculty of the Graduate College
University of Nebraska at Omaha

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

by
Nancy M. Fieber
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Accepted for the faculty of The Graduate College of the University of Nebraska at Omaha, in partial fulfillment of the requirements for the degree Master of Arts.

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Chapter 1

INTRODUCTION

The frozen posture of a young child as he visually attends to something of interest, or the very young infant's wide open eyes and mouth as he fixes on a stimulus, illustrate dramatically the close relationship between the visual system and the total action system. The two appear to be inseparable and interdependent.

When vision is impaired, control of posture may be impaired as evidenced by the typical delay in head righting in prone and all-fours postures of the blind infant. (Gesell and Amatruda, 1941; Gesell et al, 1949) In other children with severe visual impairment a peculiar head posture may be assumed in order to fix the eyes to receive the object stimulus on the most favorable part of the retina. (Gesell et al, 1949) Certain children with learning disabilities may also reflect visual problems either of oculomotor or perceptual causes in peculiar postures as they perform visuomotor tasks.

When postural control is impaired as in the child with cerebral palsy, vision may be handicapped by difficulty in the fixation of the head or eyes necessary for visual fixation, or in the mobility of the head or eyes necessary for visual pursuit. The oculomotor muscles may show incoordination or imbalances, resulting in problems in convergence necessary for normal depth perception, problems in version movements necessary for visual pursuit or tracking, or in the fine movements used in
following the contours of form or focus. (Abercrombie, 1964, 1969; Bobath, 1966, 1972)

THEORETICAL BACKGROUND

Gesell et al (1949) and Peiper (1963) have described the ontogenesis of the visual system and its skeletal, autonomic, and cortical components in interrelation with the total action system of the growing child. The role of the developing action system or postural reflex mechanism of the infant and young child in orienting the head and eyes for vision reception, and the role of vision in postural control have been emphasized by many. (Gesell and Amatruda, 1941; Gesell et al, 1949; Fulton, 1949; Peiper, 1963)

Even in the neonate a close relationship exists between the postural reflexes of the vestibular system and the eyes. (Andre-Thomas et al, 1960; Prechtl, 1964; Peiper, 1963; Paine, 1962) In the "Doll's Eyes Phenomenon" which is elicited the first 10 days of life, as the infant's head is rotated or tilted, the eyes stay fixed on the target by moving in the opposite direction. This phenomenon disappears as fixation develops. Nystagmus occurs when the infant is held vertical and rotated about the examiner. In the "Eye-Neck Reflex" a sudden light stimulus to an infant held erect without head support may cause the head to jerk back and be held in extension. The "Lid-Opening Reflex" may occur when a lightly sleeping newborn is brought rapidly from lying to vertical position. These and other early visual responses may have diagnostic significance in neurological examination of the infant.

As the postural reflex mechanism develops in the first months enabling the infant to raise his head against gravity and to align his
trunk, limbs, and head appropriately, the first important regulators of posture are: the vestibular organs, which are the semicircular canals and otoliths; the proprioceptors of muscles, tendons, and joints; and the touch and pressure receptors of the skin. They are described in detail and order of appearance by Fulton (1949), Peiper (1963), Gesell et al (1949), Andre-Thomas et al (1960) and others. They sequentially prepare for upright posture against gravity, movement between postures, and locomotion. Although the original animal experiments of Magnus (1926) and observations of corresponding reflexes in humans, have suggested that optic reflexes assisting in control of antigravity posture do not occur until approximately six months, earlier participation in humans may be reflected by blind infants' difficulties with anti-gravity head control. Increasingly in the development of the infant the movement of the eyes leads the supporting action system.

At approximately four months most infants, according to Gesell and associates (1941, 1949), Bayley (1969) and others, have achieved a significant degree of control of the head against gravity in both fixation and mobility. In prone the head is steady at 90°; in sitting it is fairly steady, although it is still set forward a little and likely to bob when swayed. A slight lack of ventral control remains and the head lags slightly as the baby is pulled up to sit. Held in the air in suspension, or tilted in space, the head attempts to remain in line with the body or upright in space. Maturation of the vestibular or labyrinthine righting reactions are chiefly responsible for these gains in head control.

Neck righting and other rotation reactions, and a symmetrical stage of posture have replaced the asymmetric tonic neck reflex. In
supine the infant's head is held predominately at the midline rather than the former head turned to side position. (Gesell and Amatruda, 1941; Gesell et al, 1949; Peiper, 1963; Bobath, 1966, 1972; Andre-Thomas et al, 1960)

The infant has new planes of regard in each position, and can pursue a stimulus vertically, circularly, and horizontally 180°. With midline posture convergence develops, making possible depth perception. (Gesell et al, 1949) Accommodation has developed and is comparable to that of a normal adult by four months. (Vernon, 1969) The fovea centralis of the retina is well developed at four months, with granules of cones arranged in three to four layers as compared with one layer in the newborn (Peiper, 1963), making color vision possible.

Soon a chain of reflexes as described by Peiper (1963) will develop and the infant will grasp a stimulus, roll to change position, and begin locomotion in prone. Four months is a key age according to Gesell and Amatruda (1941), both as a ceiling for accomplishment of some basic patterns, and as readiness for a new stage of development.

The typical disappearance or weakening of the asymmetric tonic neck reflex by age four months may have important implications for postural control and vision. According to Gesell et al (1949), while this pattern exists the infant tends to focus monocularly with the occipital eye and is unable to pursue or track beyond a 90° arc. While Gesell suggests this reflex may have some importance in the development of eye-hand coordination in the normal infant, Bobath (1966, 1972) and Finnie (1968) emphasize the development of midline head posture with symmetrical limbs as being particularly important for future development of eye-hand coordination.
In the infant or child with cerebral palsy, the asymmetric tonic neck reflex may be retained in an exaggerated form, interfering with bringing the hands in front of the body, with rolling over, and with simply turning the head. (Bobath, 1966, 1972) Visual pursuit may be limited not only by head fixation in the abnormal posture, but by fixation of the eyes toward the side to which the face is turned. An asymmetric tonic neck reflex of the eyes has been described by Peiper (1963) as occurring in normal newborns. When the head was fixed and the body rotated, both eyes turned to the side of body rotation. Similar responses occurred in vertical deviation of the eyes by moving the body backward toward the occiput, or forward toward the face with head fixed. The possible role of such reflexes in the cerebral palsied child with a disordered postural reflex mechanism has not been fully explored. The possible effects of other abnormal postural patterns which occur in cerebral palsy on visual fixation or pursuit are still largely unexplored.

PURPOSE OF STUDY AND ITS DELIMITATIONS

The purpose of this study is to explore some of the possible relationships between development of the visual system and the total action system of the young child. Because of the importance of the postural mechanisms of head control and the visual abilities described in the four month old infant, the study focuses on this key age. The readily observable attributes of visual behavior, visual fixation and visual pursuit, are the behaviors measured. The postural measures of head control include: spontaneous behaviors in supine, prone, and upright sitting postures as described in developmental scales; induced
postural reactions which are related; and two tilted postures used in infant management—supine tilt in an infant seat, and prone tilt over a wedge. The latter is sometimes used in the therapeutic management of infants with cerebral palsy or developmental delay. (Finnie, 1968; Scrutton, 1971)

When these visual and postural abilities are deficient, the implications for restriction of early visual experiences and learning are of utmost importance. If these abilities are deficient in later life, the implications for education are significant. (Hauesser, 1958; Abercrombie, 1964) Understanding of possible relationships between vision and posture are also important as a variable in infant research, and in design of infant stimulation programs.

STATEMENT OF PROBLEM

The questions asked are:

1) Is there a correlation between visual fixation and pursuit with various parameters of head control in four month old infants in, A) a normal full-term group, B) a normal premature group, and C) a group of infants classified as "sick infants" or requiring early treatment in the intensive care nursery?

2) Is there a significant difference in visual fixation and pursuit measures between positions, and is this related to the relative maturity of postural control in that position?

HYPOTHESES

1) It is hypothesized that duration of visual fixation and frequency and quality of pursuit are correlated with the level of
development of postural control in supine, prone, and upright sitting, supine tilt, and prone tilt. Negative correlations are expected between visual scores in supine and strength of the asymmetric tonic neck reflex.

2) It is further hypothesized that ability for fixation and pursuit may vary between postures. This may be related to the postural position itself, or alternatively to the degree of head control in the various positions.

DEFINITION OF TERMS

The following terms are arranged in an order to help understanding, rather than in alphabetical order.

OCULOMOTOR SYSTEM. This refers to the visual receptors or end organ, the eye, the oculomotor muscles, their sensory and motor innervation, and their central connections.

FOVEA CENTRALIS. The area of most acute vision of the retina. This area contains the cones, specialized receptors for both color and colorless vision. The surrounding areas of the retina contain rods also, which function in colorless vision.

OCULOMOTOR MUSCLES. The muscles of the eye. These include:

EXTRINSIC OCULAR MUSCLES. These are skeletal muscles external to the eye which move the eyeball in various directions. Each eyeball is moved by six muscles, which are innervated by 3 cranial nerves. They are: the medial rectus, superior rectus, inferior rectus, and inferior oblique muscles, innervated by the 3rd cranial or oculomotor nerve; the superior oblique muscle, innervated by the 4th cranial or trochlearis nerve; and the lateral rectus muscle innervated by the...
6th cranial or abducens nerve.

INTRINSIC OCULAR MUSCLES. These are within the eye and are responsible for constriction of the pupil and accommodation of the lens. They are innervated by the autonomic nervous system.

VERSION. Eye movements in the same direction, laterally, vertically, or circularly. These are also called conjugate movements.

CONJUGATE DEVIATION ABNORMALITIES. Both eyes deviate in one direction, or are unable to move in one direction.

NYSTAGMUS. Fine, lateral, jerking movements of the eyes, which can be produced by vestibular stimulation, certain types of optokinetic or visual stimuli or central lesions.

VERGENCE. Movements of the eyes either toward each other as in convergence, and movements of the eyes away from each other as in divergence.

CONVERGENT SQUINT. This and esotropia, esophoria, and strabismus are all terms for "crossed-eyes."

DIVERGENT SQUINT. This and exotropia and exophoria are terms for outward movement disorders.

PHORIAS. Measurement of the position of the visual axis of the eyeball.

STEREOPSIS. Achievement of depth perception, which is dependent on movements of vergence.

FUSION. The blending of images seen by the two eyes into one perfect image, producing binocular vision.

DUCTION. The measurement of fusion amplitude or the ability to maintain binocular vision.

FIXATION. The orienting of the visual and postural mechanisms so that the image can be received on the fovea of the retina of the eye.
This implies a "holding still," but very fine ocular movements occur, enhancing stimulation of the foveal area.

PURSUIT. Conjugate or version movements of the eyes following a stimulus. They are of two types, gliding or continual, and saccadic, in which short movements and fixations alternate.

ELECTRO-OCULOGRAPHY. Recording of the action potential between the cornea and posterior surface or retina of the eye as detected by periorbital electrodes—as the eye moves, the field is displaced. Used for analyzing central and peripheral paralysis of oculomotor functions. When used to measure and record nystagmic movements, it is called electronystagmography.

ELECTROMYOGRAPHY. Recording of the action potential of extrinsic eye muscles, detected by electrodes placed on the respective muscles. More detailed analysis of functions of individual muscles is possible.

CEREBRAL PALSY. A persistent but not unchanging disorder of movement and posture, appearing in the early years of life, and due to a non-progressive disorder of the brain as a result of interference during its development. (Abercrombie, 1964: p. 17. Based on definition of the National Spastics' Society.)

SPASTICITY. (Spastic) A type of cerebral palsy with specific neurological signs and manifestations of increased stretch reflex. Stiffness of muscle tone, resistance to movement, and immobility are characteristic.

ATHETOSIS. (Athetoid) A type of cerebral palsy manifested by fluctuations of postural tone or extraneous movement, contributing to lack of fixation and inaccurate movements.
ATAXIA. (Ataxic) A type of cerebral palsy in which poor sensory control of balance is the chief manifestation.

VESTIBULAR SYSTEM. Refers to the organs of postural control of the inner ear—the semicircular canals and the otoliths, which respond to movement in space and to gravity.

POSTURAL REFLEX MECHANISM. Refers to the automatic underlying controls of posture and movement which provide the basis for voluntary and skilled movements, and which mature in an orderly sequence in the normal infant.

ASYMMETRIC TONIC NECK REFLEX. An automatic response of the infant occurring typically between one and four months, in which the sideways turning of the head elicits specific limb postures as follows: the limbs of the face side are extended or straighter; limbs of the occipital or back of head side, are flexed or bent.

FUSSING. Intermittent protest sounds of low level and/or shallow quality.

CRYING. A state of intense, unequivocal vocalizations that are often shrill, strident, or paroxysmal in quality, and may be associated with vigorous motor activity.

ALERT INACTIVITY. A state in which the eyes are open, bright and shining, and capable of pursuing moving objects, and making conjugate eye movements. The infant is relatively inactive.
Chapter 2

REVIEW OF RELATED LITERATURE

The labyrinthes are generally recognized as contributing to motor control of both eyes and posture. Clinical and experimental deficits of the vestibular apparatus are recognized as producing motor abnormalities. It is generally accepted that vestibular receptors contribute significantly to stabilization of visual images on the retina via the "fixation reflexes." Animal experiments have also demonstrated the influence of neck reflexes in biasing the effect of either semicircular or otolith stimuli on muscle tension. (Kim and Partridge, 1969) Clinicians in neurology and ophthalmology are utilizing research relating the oculomotor and vestibular systems in clinical application.

Visual abilities and postural abilities have often been investigated separately in reports of infant research. Oculomotor skills have been investigated as observable manifestations of the attending or discriminatory areas of interest to the investigator. Other studies of infants have described incidence of ophthalmological defects in medical or neurological complications of infancy, and incidence of long term impairment. Except for the inclusion of prematures in some of the psychological studies, there has been little application of what has been learned about early visual perception to infants with any impairments. More recently, through interest in the variables of state as related to infant behavior, and to the effects of maternal-infant inter-
action, the possible relationship of posture to visual abilities has been suggested.

With the school age child, there has been considerable interest and opinion regarding the possible role of ocular problems in children with learning disabilities, but a shortage of sound research. Research in cerebral palsy has increased in the past ten to fifteen years in the areas of perceptual problems, and of oculomotor problems as they may relate to perception, although a great deal of work remains to be done.

**NEURO-OPHTHALMOLOGY**

Complex oculomotor system connections with the vestibular system and somato-sensory systems have been described by Szentagothai (1950), Whitteridge (1960), Cohen (1961), and Kornhuber (1970). Although nystagmus may be produced by vestibular stimulation, optokinetic stimuli such as a rotating striped drum, or central causes, and all use the same final common pathway to the oculomotor muscles, neural pathways diverge widely. Neurologists utilize electro-oculography recordings of corneo-retinal action potentials occurring during nystagmic eye movements to study various forms of nystagmic stimuli in interaction, producing directional movements useful in locating central nervous system lesions. (Monnier, 1970; Benitez, 1970) Bergmann and Costin (1970) have investigated the use of certain forms of light stimuli to inhibit vestibular nystagmus, with possible application to problems of orientation and equilibrium in space.

Soriano (1970) has described different cortical eye fields involved in different types of conjugated movements of the eyes. The saccadic movements of the eyes in reading, examining the shape of an ob-
ject, or in maintaining an image on the fovea of the retina, are dependent on the frontal eye fields. Smooth pursuit movements, as in following a moving object, are thought to involve the occipital oculomotor fields.

While most animal and human research with the oculomotor system has emphasized the role of the stato-kinetic vestibular reflexes produced by movement, rotation, or linear acceleration, some research has been concerned with the static or positional reflexes. Dusser de Barenne and De Kleyn (1931), in animal experiments, demonstrated tonic labyrinthine reflexes attributed to otolithic stimulation acting on the oculomotor muscles. McGabe (1964), in animal experiments, was able to demonstrate nystagmic eye movements on vertical linear acceleration when semicircular canals had been negated with streptomycin. He concluded that these represent otolith-ocular reflexes, which under normal circumstances contribute to eye movements with the semicircular reflexes, and also may lay the basis for understanding postural vertigo as an otolith system disease.

Coats and Smith (1967), in experiments with caloric stimulation of the semicircular canals, in which nystagmus was produced, found that results varied with positional factors which were attributed to otolithic effects interacting with semicircular canal mechanisms. Congenital or spontaneous nystagmus has been found by Monnier (1970) and others to vary in different positions of the head and eyes. Compensatory postures of the head were described as developing in an effort to keep nystagmus at a minimum.

Clinical tests useful to the ophthalmologist have been described by Scott (1967) in which true ocular muscle paresis can be dif-
differentiated from other causes of deficits in eye rotation. Electromyography is used to record ocular movements of countertorsion when the head is tilted. These movements are attributed to stimulation of the otolithic apparatus.

Experiments of Miller and Graybiel (1966) led to the conclusion that the otolith organs in man act to increase accuracy in visual localization, at least in upright and recumbent positions, although in normal circumstances visual cues are more important. Normal and labyrinthine defective subjects' performance in estimating the horizontal were compared in upright, recumbent, and inverted postures with other visual cues present and absent. Although when other visual cues were present the labyrinthine defective subjects were not significantly different, differences were found with visual cues removed in upright and recumbent positions. Both groups were less accurate in the inverted position with visual cues removed.

There is thus some evidence relating the oculomotor and visual system to otolithic influences as well as to the more frequently explored connections with semicircular canal influences.

INFANT RESEARCH

It is now recognized that the newborn is capable of adaptive visual behavior such as discrimination, fixation and following. Electrooculography has demonstrated "fixation" and "following" reflexes are present at birth, with close conjugation of the eyes possible. The saccadic movements which serve to correct for slippage of the image off the fovea, however, show greater amplitude than in the adult, suggesting feedback mechanisms are less well developed. Because of immature foveal
development in the newborn it was formerly assumed that the newborn lacked sufficient visual acuity to allow accurate fixation and following. Visual acuity as determined by optokineticly induced nystagmus has been demonstrated as at least 20/150 in some newborn infants. (Dayton et al, 1964; Kiff and Lepard, 1966)

The visual system begins to function very early during intrauterine life, perhaps as early as 25 weeks gestational age (Watanabe et al, 1972), but the function is immature in the premature infant. This is thought to be due to incomplete myelinization of the nerves, differences in synaptic structures, and metabolic processes. Hrbek and Maren (1965) have studied electroencephalographic recordings of visually evoked responses (flashing light stimuli) and agree with Ellingson, Farber and others that the immaturity of the premature newborn's visual system is indicated by longer latencies, differences in shape of waves, and tendency to fatigue. This was thought to be primarily due to immaturity of central integration, not of the receptor, as retinal responses of the newborn premature as recorded by electro-oculography were not different from those of adults. Differences in the visually evoked responses of the EEG may be useful in distinguishing low-birth-weight infants who are small-for-dates from prematures.

Peiper (p. 66, 1963) has suggested that premature infants of the same conceptional or gestational age as full-term infants may have some initial advantage because of longer postnatal visual experiences. Miranda (1970), in comparative visual preference experiments with premature and full-term neonates, found that the group of premature neonates had sufficient development of the visual system to discriminate between stimuli, and showed close similarity to the full-term group in
fixation times to certain stimuli. Preference for increasing complexity of pattern, however, appeared to be related to conceptional age. It was suggested that preference for patterned stimuli might be used to indicate neurological maturity as well as to estimate visual acuity with Snellen equivalents.

The importance of the visual system in identifying, organizing, and processing the physical stimuli of the external world and in interpersonal relations is emphasized by many authorities. Saint-Anne Dargassies (1972A, 1972B) considers visual fixation and pursuit and the development of convergent movements to be important indicators of psychoaffective development as well as of motor-neurological state in the young infant. Bayley (1969) has included a number of visual fixation and pursuit responses in the mental scale of the Bayley Scales of Infant Development.

Barten et al (1971) describe fixation and following as the primary indicators of attentiveness. Following enables more sustained contact with the visual environment than would be possible with fixation alone. They suggest that early knowledge of persons and things is largely a product of this visual activity, and how much an infant follows moving objects or people may influence how quickly these become stable entities for him. They therefore have been interested in whether or not individual differences exist in these capabilities from birth.

Barten et al (1971) and Barten and Ronch (1971) have explored individual differences in fixation at birth and longitudinally till four months of age. They have found consistency over time in measures of pursuit, indicating significant differences between infants in this capability. In evaluating whether pursuit was ocular pursuit alone or
oculocephalic—with head movement—they felt the latter represented a stronger response to preferred stimuli. Although infants showed increased capacity for longer fixation with maturation, it was found that as an infant approached 3 to 4 months, the length of first fixation did not correlate positively with frequency of pursuit, but negatively. At this age duration of first fixation tended to decrease, suggesting that those with most capable visual abilities tended to look more briefly and assimilate information more rapidly. Lewis et al (1966) in comparing total fixation times, longest fixation and duration of first fixation, suggested the first fixation to be the best index of an infant's discrimination, especially for females.

Many studies have utilized duration or frequency of fixation in visual preference methods to determine the infant's ability to discriminate stimuli, and his preferences at different ages. The work of Fantz (1954, 1961, 1962, 1964, 1966, 1967), Brennan (1966), and Moffett (1969) has found that the infant can discriminate pattern as a neonate and that with increasing age can discriminate and prefers more complex patterns and novel stimuli. Individual differences in preference have been attributed to both maturational processes and experience. Color discrimination versus brightness discrimination in the young infant has been a subject of disagreement, but Spears (1969) demonstrated that some color discrimination is present at least by 4 to 5 months, although shape appears to dominate color in preferences.

The Harvard studies (1967-1968) reporting Trevarthen's work have explored measures of ocular pursuit and oculocephalic pursuit, and found that speed of movement of the stimulus as well as arc of movement were significant factors in determining type of pursuit. Maturation of
a central neural coordinating mechanism was suggested, integrating activities of extra-ocular muscles with those of the neck in producing pursuit movements. The stability of this coordination was suggested as a prerequisite for concerted use of the eyes in tracking or shifting gaze.

Continuation of this work by Aronson and Tronick (Harvard, 1968-1969) with adults and infants, indicated a situational factor in relative amounts of head and eye movement. When intent or accompanying movements of the hands were a factor, head movements led the way. When merely following a moving stimulus of no particular meaning, the faster eye movements took the lead. In either type of situation, there appeared to be a strong tendency for eyes and head to be drawn to central fixation at the midline, suggesting a requirement for centering the visual system for guidance of a bilaterally symmetrical manual system.

Ocular pursuit has also been studied as an observable manifestation of the development of object concept in the infant. Nelson (1968, 1971) has studied anticipation movements following sequences of interrupted lights and a train moving in and out of a tunnel. Bower et al (1971), in studying infants up to 5 months age, have concluded that not until approximately 16 weeks does the infant track a moving object as an object rather than the movement itself.

Posture as a variable has been kept minimal in most of the infant research reported. The earlier work of Fantz, that of Barten, and others, involved supine posture in a molded support, hammock support, or scooped out piece of foam, so that the head was kept more or less midline and stable. Barten et al (1971) stated that it was hoped thereby to some extent reduce any effect of the asymmetric tonic neck reflex.
More recently, researchers in visual abilities have been placing the infant more upright. Spears (1964) held the child in upright sitting on the mother's lap or table. Fantz (1967) has described an improvement in procedure designed to keep the infant more comfortable and enhance alertness. The infant was placed in a semi-reclining posture in an adjustable canvas baby-seat on the lap of the assistant, seated in a rocking chair.

Interest in posture as a variable has increased with exploration of its role in achieving optimum state for visual alertness. State is an important variable in infant research, and can function either as an obstacle or a mediator of stimuli. (Korner, 1972)

Wolff (1966) has described state not only in arousal terms but in terms of qualitatively different internal conditions related to a number of factors. The states frequently described are: 1) regular sleep, 2) irregular sleep, 3) drowsiness, 4) alert inactivity, 5) waking inactivity, and 6) crying. During alert inactivity the eyes are open, bright and shining, and capable of pursuing moving objects and making conjugate eye movements in horizontal and vertical planes. The infant is relatively inactive, the face relaxed, without grimacing.

Some factors commonly studied in relation to state are hunger or time since last feeding, sex differences, and the effects of mother-infant interactions. Moss (1967) attributed maternal differences in interactions with male and female infants to the male infants' shorter sleeping time and greater amount of crying. Attitudes of the mother previously expressed during pregnancy were found to be related to total infant visual fixation times with the females more than the males. It was suggested that the greater variability among the male infants pos-
sibly reflected slower maturation rates. (Moss, 1968) Further research by Moss and Robson (1970) supported the importance of endogenous attributes of the organism as manifested by state variables as the most important determinant of visual behavior for males, whereas social learning was more important in the visual performance of females.

Lewis (1972) in studying interactions between responses of infants and responses of mothers of three month old infants, has also reported differences in maternal responses as a result of the infant's sex. Mothers of boys in the group studied, held, touched, and rocked their infants more frequently. Mothers of girls tended to vocalize and look at their infants more. The role of these interactions in determining state of the infant was emphasized.

Korner and associates (Korner and Grobstein, 1966; Korner, 1970; Korner and Thoman, 1970; and Korner, 1972) have more fully explored posture as a variable contributing to state with their interest in maternal-infant interactions. Their work showed high variance in the capabilities for achieving the state of alert inactivity and visual alertness. Infants who spent a great deal of time in the state of alert inactivity also tended to be most capable of fixating on visual stimuli. Those who alerted most frequently also tended to alert the longest and were most capable of visual pursuit. Earlier studies suggesting to the possibility of increased alerting and scanning behavior when neonates were picked up at the shoulder, led to a study in 1970 assessing the relative effects of handling stimulations provided typically by mothers in ordinary infant care. They assessed the relative effects of body contact and vestibular stimulation in evoking visual alertness in newborns as measured by a scale of alertness and scanning. Factors of con-
tact, vestibular stimulation--movement in space, and upright position were analyzed in several situations. Upright position combined with vestibular stimulation and contact had the most powerful effect in evoking visual alertness as the infant was picked up and held at the shoulder. Side-to-side movement in an infant-seat had a greater effect than upright position alone in the infant-seat. Both had a greater effect than cradling the baby in the arms, cradling on the support, or talking to the baby alone. The authors concluded that if the earliest forms of learning occur mostly through visual exploration, that vestibular stimulation which evokes a good deal of visual alertness in the neonate may be a more important form of stimulation during early development than the more publicized body contact. Komera discusses embryological evidence that the vestibular system is one of the earliest systems to develop, making it logical as a mediator of early stimulation. She refers to evidence of vestibular control over the eyes in early neurological signs described by Peiper (1963) and others.

Scarr-Salapatek and Williams (1972) have reported application of Komera's findings regarding the enhancement of visual alertness with vestibular stimulation. An experimental group of premature infants was given sensory stimulation in the form of handling, rocking, holding up at the shoulders, as well as faces and voices, and patterned visual stimuli within focal distance during the early nursery care period at the hospital. They were followed with a home visitor program for continued stimulation through the first year. Significant differences in alertness, general development and health were noted at the end of both periods in comparison with a control group who received the routine premature care, which may involve some sensory deprivation.
Research reported by the Harvard University Center for Cognitive Studies (1967-1968) described experiments in a group of infants in supine as compared to semi-upright position. More direct reaching for an object on visual inspection occurred in the semi-upright position, with more preliminary looking back and forth between hand and object in supine. It was suggested that the upright position provides the child with more usable proprioception and kinesthesia for guidance.

THE SCHOOL AGE CHILD

Kephart (1960), Cratty (1966, 1969) and Getman (1962) have theorized that disordered eye movements were a deterrent to learning. Various programs for training eye movements and gross motor activity programs have been advocated, based on a number of premises relating movement, perception, and oculomotor skill development to readiness for school tasks. It is not the author's intention at this time to discuss these theories, except to suggest that the subject of this proposed research project may have some relevance to the needed research in the area of learning disabilities.

A recent joint statement prepared by the American Academy of Pediatrics, the American Academy of Ophthalmology and Otolaryngology, and the American Association of Ophthalmology (Winter 1971-1972, Sight-Saving Review) has cautioned against programs purporting to treat dyslexia and associated learning disabilities with solely visual or motor training. The need for thorough multidisciplinary diagnostic and sound educational approach was stressed.

Park (1969) reported a study of clinical comparisons of peripheral ocular functions in a group of 100 dyslexic and 50 normal readers.
Included in the examination were measurements of ductions, phorias, visual acuity, fusion, stereopsis, and ocular dominance. No significant differences were found between the dyslexic and normal readers. No information was given regarding conjugate movements of the eyes, neurological examination, or perceptual or visuo-motor abilities.

It was suggested that ocular functions might be significant in reading failures in a few instances. Reference was made to a group of dyslexic children with abnormal EEG's who showed a higher incidence of deficient fusion and stereopsis compared to normals.

The complexity of the visual process was emphasized, stressing that it was not only affected by peripheral optic mechanisms but by central perceptual and conceptual mechanisms concerned in fixation and reading, which could in turn affect the peripheral optic mechanism through autonomic and skeletal nervous systems.

In another study of dyslexic subjects, Goldberg and Arnott (1970) recorded eye movements during reading with an electronystagmograph. A photographic record of ocular movements was compared for reading materials below frustration level and above. It was found that when the dyslexic children had difficulty in understanding a word or syllable, they would regress in ocular motility, and prolonged fixation accompanied inability to reconstruct the word. When reading material was below frustration level, ocular motility returned to normal. Results were interpreted as demonstrating that while incoordinated eye movements occurred in children who had difficulty reading, this reflected the degree of comprehension rather than ocular motility determining the degree of comprehension. There was no discussion of results in a control group nor of other evaluations.
The above studies have been included to present the view that central perceptual processes are of primary importance in some learning disabilities, and that oculomotor disorders may be mistakenly credited as the cause. At the same time evidence is accumulating in research with cerebral palsied children supporting the effect of oculomotor disorders on central processes.

Breakey (1955) reported evidence that 50% or more of cerebral palsied children have oculomotor anomalies, the commonest being defects of horizontal gaze and esotropia. In a longitudinal study of 100 cases distributed representatively among spastic, athetoid, and ataxic types of cerebral palsy, he found 56 visual abnormalities. Forty-eight were due to muscular imbalances; the others included developmental defects such as optic atrophy, and congenital cataracts. Nystagmus accompanied two cases. Eye conditions could not be correlated with clinical classification in this group.

Guibor (1955) found 75% of a series of 142 cerebral palsied children possessed ocular defects. These were chiefly oculomotor deficits—crossed eyes, conjugate deviations—both eyes deviated to one side or upward. It was the author's opinion that such resultant losses in binocular coordination and depth perception might seriously interfere with the development of hand and eye coordination, walking, and school performance in a cerebral palsied child.

A relationship to general posture control was noted in certain athetoid children. When a child showed improvement of oculomotor problems with treatment, general athetoid movements of the body were decreased. When glasses were removed, athetosis recurred. Children with ataxia were affected similarly.
Both Dr. Breakey and Dr. Guibor stressed the importance of early diagnosis and treatment of ocular defects in the infant, when the capacity for recovery might be greater. It was stated that the ocular status of the child with cerebral palsy was largely ignored because of his more obvious defects.

Although no differences were found in incidence of visual abnormalities in different types of cerebral palsy in Breakey's study, subsequent studies have found a significant relationship of specific perceptual and visuo-motor disorders in the spastic group. Fewer perceptual or visuo-motor disorders have been found in the pure athetoid. (Abercrombie, et al 1964, 1966) Oculomotor problems of fixation and motility may occur in both groups, but it may be that the multiplicity of cortical and motor factors in the spastic group is related to the site of cortical lesions.

A similar study to that of Goldberg and Arnott with the dyslexic group was reported by Abercrombie (1963) with a group of cerebral palsied subjects and normal controls, exploring the possible relationship of eye movements and learning. Version movements were recorded similarly by electro-oculographic methods. Two types of pursuit movements were studied: saccadic movements in a task similar to reading but without conceptual content—a row of spots; and pursuit movements of a gliding type—following a moving object. The cerebral palsied group showed significant incoordination of movement and fixation, with a great deal of time off the target, and extraneous vertical movements. Both types of pursuit movements showed improved precision with chronological age, but correlated even more with mental age. In the normal group there was also a close correlation between regularity of smooth pursuit
and saccadic pursuit movements, but there was less correlation in the cerebral palsied group supporting evidence that the two types are controlled by independent systems.

These simple tasks involved very little thinking and interpretation and imply that oculomotor incoordination is an important factor. Abercrombie suggested that erratic contact with the image might thereby reduce exposure to a learning situation. Training of fixation and version eye movements in early infancy was recommended, with exploration of use of specially attractive targets such as those described in the work of Fantz (1961, 1964) and others.

The results in this study differ from those of Goldberg and Arnott by indicating oculomotor problems independent of conceptual processes, which could interfere with learning tasks in a mechanical way. The results also differ in that these are abnormal movements of pursuit and fixation, while in the former study difficulties were evidenced by maintained fixation.

Sandifer (1963) suggested that although frequently difficulties in reading might appear to be a receptive defect, more careful study might reveal a motor defect. This might be difficulty in scanning, with inability to follow the line of print with normal facility. The act of reading might be too absorbing and effortful to permit a sense of what was read, and could be recognized by cine film or electro-oculographic recordings of eye muscles in action. A syndrome of oculomotor apraxia was described in which a defect in shifting gaze sideways, head jerking and forceful blinking were associated with some general body incoordination. Problems with lateral gaze movements appeared to be situational and when commanded to follow a moving stimulus or look to the side, gaze
was normal. When the eyes were undirected or the child regarded a stationary object while turning his head, gaze was abnormal. This was similar to "Doll's Eye Movements." The child might typically use tricks like shaking the head or blinking to break fixation and enable movement of the eyes sideways.

A number of studies have indicated a possible relationship between squint and various perceptual and visuo-motor disorders in children with cerebral palsy. Reed and Pollock (1963) and Abercrombie et al (1966) have found correlations with squint and figure-ground tests. Correlations were also found by Abercrombie between both squint and scores in block design, coding, and Frostig subtests for eye-motor coordination, form constancy and spatial relationships. Smith (1963) in a review of the literature, and Abercrombie in a number of sources suggest that the absence of stereopsis or depth perception as a result of squint in otherwise normal children may be compensated for by other senses. In the child with cerebral palsy the other senses may often be abnormal, with accompanying deficits in manual dexterity, and would affect his ability to compensate. Spatial perception and squint problems are so frequently found in cerebral palsied children that this is an important area for research.

Douglas (1963) suggests that squint may be due to either motor or central obstacles, with both being factors in some children. The work of Gesell et al (1949) supports these multiple factors.

Hardin (1966), presenting a neurological viewpoint, states that stable and accurate oculomotor control is essential for formation of a proper image. He discusses the evidence supporting the relation between poor oculomotor control and fixation reflexes with figure-ground tests.
He reviews laboratory experimental evidence from work with infant cats and monkeys suggesting that a temporary absence of pattern vision during a critical stage in maturation leads to failure of nerve cell growth and synaptic connections. He suggests that amblyopia—inhibition of one eye as a result of deficits in binocular coordination—developing from uncorrected squint in childhood, may lead to central nervous system structural deficiencies as well as subtle impairment in spatio-temporal synthesis. He also postulates that the mere presence of movement disorders or spasticity in early infancy or childhood may lead to a perceptual disturbance because of restriction of the flow of stimulation and distortion of feedback from abnormal tone falsely programming the maturing central nervous system.

Smith (1963) in a review of the literature on strabismus in cerebral palsy suggests growing opinion that the supranuclear lesions causing the postural and movement disorders of the entire body might also cause spasticity, athetosis or ataxia in the extrinsic ocular muscles. Although there is some beginning evidence supporting this, as yet histological evidence is not available.

Abercrombie (1964) in discussing increasing evidence of close interaction between sensory and response systems, refers to a 1961 study by O'Connor and Hermelin on shape perception and reproduction in groups of normal, Mongoloid, and non-Mongoloid retarded children with comparable mental ages. They were similar in the ability to match designs visually, but the Mongoloid group was poorer in recognizing shapes by touch and in copying shapes. The authors suggested that the deficiency was related to low muscle tone and lack of proprioceptive feedback.

The importance of eye movements in the development of visual-
motor reproduction functions has also been suggested in a study of congenital ophthalmoplegia, or Moebius Syndrome by Kalverboer et al (1970) in which there was a paralysis of the eye muscles. Visual perception, reading, and oral spelling were intact in a boy of low average intelligence, but copying from models and drawing were impaired. The authors referred to the work of Zaporozhets who differentiated between the eye movements involved in recognition or perception of a figure and those involved in copying. In recognition the eye movements fixate on a few conspicuous parts of the figure—in reproduction a tracing of the outline by the eyes has been observed, with modelling and comparative or corrective functions.

Serra (1970) has studied the proprioceptive processes of the extraocular muscles with electromyography and presented data which appears to confirm the importance of eye muscle proprioceptive feedback in shape perception and recall, spatial location and movement perception. He has presented evidence that these perceptions are also linked with proprioceptive feedback from the neck muscles and semicircular canals.

Other studies have also suggested that motor-sensory feedback is important for normal development of space perception. Hein (1972) in reviewing the literature on the adult human experiments of Held (1958), emphasized the importance of active self-produced reaching movements in compensating for prism distortions of the visual field. Hein's own work with young kittens also suggests the importance of self-produced movements in acquiring visually guided behaviors. Churchill (1969), in experiments with visual estimates of kinaesthetic localization and kinaesthetic estimates of visual localization, found the two to be
equally accurate, whether subjects were allowed head movement or not. The experiments suggest a close integration of sensory systems.

In the visuo-motor disorders of cerebral palsy, and its oculo-motor disorders, multiple sources of sensory distortion may be present— proprioceptive feedback from the entire body and oculomotor muscles, and cortical perceptual processes. Available evidence seems to show that some children with no defects of the eyes show perceptual or visuo-motor disorders, and in other children possible relationships are indicated. These are complex—in some instances oculomotor and postural patterns may reflect cortical or perceptual problems, in other instances oculomotor and postural disorder may contribute to perceptual problems, or both directional relationships may exist at the same time. There is a great need for exploring these relationships in the developing infant and child.

Abercrombie (1964) emphasizes the tendency for too much generalization in research on perceptual and visuo-motor disorders. She points out that most studies of perceptual and visuo-motor disorders neglect to comment on the ocular condition of the subjects. Few studies of cerebral palsied children have related perceptual and visuo-motor impairment to diagnostic type, degree of motor handicap, let alone to specific postural patterns. General statements should not be made about the relation of tests in general to brain damage in general, but should be made about reactions of specific kinds of people with specific kinds of brain dysfunction to specific tests.

There is thus evidence that positional reflexes effect the oculomotor system. There is also an increasing interest by infant researchers in the role of posture and vestibular stimulation in achieving
optimum state for visual alertness and learning. One can only conjecture, on the basis of the research available, on the oculomotor and perceptual problems of the child with cerebral palsy, and what effect an early neuromuscular disorder must have on the child's early learning.
Chapter 3

METHODOLOGY

Visual and postural parameters of three groups of ten subjects each were examined in the outpatient clinics of the Pediatric Department of the University of Nebraska Hospital. Group A of normal four month old full-term infants, was drawn from the regular pediatric clinics. Group B, of four month postnatal age pre-term infants without other identified complications, was drawn from the Maternal and Infant Care newborn clinics, formerly called "Preemie and Problem" clinics. Group C, of other four month postnatal age infants diagnosed as "sick infants" neonatally, or formerly treated in the Newborn Intensive Care Nursery because of complications or illness, was drawn from the Maternal and Infant Care newborn clinics.

VARIABLES

Independent and Dependent Variables

In evaluation of possible correlation relationships between the measured visual abilities and the measured parameters of postural control of the head, no cause-effect relationship was specifically assumed. In testing the hypotheses regarding significant differences in visual measurements between postures, however, there were independent and dependent variables. The independent of manipulated variables were that of the postures in prone, supine, upright sitting, prone tilt, and
supine tilt. The dependent variables were the visual abilities—duration of first visual fixation, and type and range of visual pursuit.

Subject Criteria and Variables

Selection of subjects was according to the following criteria as they became available in the clinics. Insofar as birthdate is random, selection may be considered random.

Subject selection criteria that were the same for all three groups were postnatal age, sex, race, time since feeding, and initial state. Age was approximately four months postnatal, or 120 days plus or minus seven. Because of reported sex differences in visual performances due to maternal-infant interactions or maturity (Lewis, 1972; Moss, 1967; Moss and Robson, 1970; Moss, 1968), sex was controlled for by including equal numbers of males and females in each group and consideration in the statistical treatment. Differences on the basis of race were controlled for by including only white subjects. Only infants fed within the previous two hour period were included. Subjects were seen on routine well-baby clinic visits or arranged appointments and excluded for visits because of acute illness or infection. Only infants meeting the initial criteria of state—awake and not fussing or crying—alert and inactive (Korner, 1972; Moss and Robson, 1970) were included.

Criteria for Group A, the normal full-term infants, were gestational age at birth 38 weeks or more, appropriate birthweight for gestational age, Apgar score at 1 minute eight or above (Apgar, 1953), delivery and neonatal course normal, and physical health good. Gestational age is determined in the University of Nebraska Pediatric Department by physical examination, and weight for gestational age by the Colorado
Criteria for Group B, the pre-term infants without identified illness or complications, were gestational age 36 weeks or below, and appropriate birthweight for gestational age ranging between 1500-2500 grams. It was expected that pre-term infants of four months postnatal age would have less mature postural control than the full-term group, but appropriate for corrected age unless there were neurological abnormalities. (Gesell and Amatruda, 1941; Parmalee and Schulte, 1970)

Criteria for Group C were neonatal diagnosis of "sick infant" or treatment in the Newborn Intensive Care Nursery because of complications or illness, irrespective of gestational age, weight, or illness. This heterogeneous group might be expected to include such conditions as prematurity with complications, very low birthweight below 1500 grams, low birthweight for gestational age, respiratory distress, cardiac defects, anoxia, hypocalcemia and jaundice. Although both Groups B and C might be expected to experience less sensory stimulation than the full-term group in the intensive care period (Scarr-Salapatek and Williams, 1972), a number of other relevant variables such as transient or permanent neurological abnormalities and ophthalmological problems might be present. (Drillien, 1972A; Drillien, 1972B; Steward, 1972; Koivisto et al, 1972; Masland, 1970; Lubchenco et al, 1972A, 1972B)

Other relevant subject variables were considered for all groups in the statistical treatment. Parity has been shown to have some effect on maternal-infant interaction or visual alertness. (Thoman, 1970; Korner and Grobstein, 1966; Scarr-Salapatek and Williams, 1972) Head shape may influence the postural control of the head and range of visual
pursuit in supine in the early months. (Gesell et al, 1949) Round-headed infants may regard in the midline and pursue past the midline earlier than long-headed infants. According to Baum and Searls (1971) the long head shape, or flattening from side-to-side, is associated with pre-term or low birthweight infants. It has been suggested that this moulding is due to the increased time the infant lies with head turned to side, relatively large head mass, and soft and thin skull bones. (See Table 1, page 36.)

Experimental Variables

Infants were seen at regularly scheduled clinic times, with an attempt at avoiding wide differences in time of day. They were examined in inside rooms without windows to maintain temperature and illumination variables as closely as possible. Clothing was kept constant with diaper and rubber pants only.

There was one examiner only, controlling for sex of examiner as a variable, and consistency of handling was kept as constant as possible. Examination procedures were done following weighing before any other clinic procedures, and the order of postural changes was varied systematically as described in the section on procedure. The dangling red ring was originally considered for the visual stimulus because of the norms available for its presentation by Bayley (1969), Gesell and Amatruda (1941), and Gesell et al (1949). Barten and Ronch (1971) have also used the dangling red ring and found it to be a strong stimulus for infants of three to four months age. Pilot examinations, however, found considerable satiation to the red ring with the subjects used. A round red Christmas tree ornament of approximately 3 inches diameter, decor-
<table>
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<th>Gestation Weeks</th>
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<tr>
<td>21</td>
<td>M</td>
<td>Primip</td>
<td>Round</td>
<td>38+</td>
<td>4026</td>
<td>Hypoglycemia, aspiration pneumonia, systolic murmur</td>
</tr>
<tr>
<td>22</td>
<td>M</td>
<td>Multip</td>
<td>Round</td>
<td>38+</td>
<td>2951</td>
<td>Hyperbilirubinemia, failure to thrive</td>
</tr>
</tbody>
</table>
Table 1. (continued)

<table>
<thead>
<tr>
<th>Subject</th>
<th>Sex</th>
<th>Parity</th>
<th>Head Shape</th>
<th>Gestation Weeks</th>
<th>Birth Wt. Grams</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>M</td>
<td>Primip</td>
<td>Round</td>
<td>38+</td>
<td>3402</td>
<td>Atelectasis, pneumonitis, transient seizure disorder</td>
</tr>
<tr>
<td>24</td>
<td>M</td>
<td>Multip</td>
<td>Long</td>
<td>38+</td>
<td>3340</td>
<td>Atelectasis, RDS*, patent ductus arteriosus</td>
</tr>
<tr>
<td>25</td>
<td>M</td>
<td>Multip</td>
<td>Long</td>
<td>38+</td>
<td>3260</td>
<td>Rh incompatibility, hyperbilirubinemia, hypocalcemia</td>
</tr>
<tr>
<td>26</td>
<td>F</td>
<td>Primip</td>
<td>Round</td>
<td>38+</td>
<td>2977</td>
<td>Hypocalcemia</td>
</tr>
<tr>
<td>27</td>
<td>F</td>
<td>Multip</td>
<td>Round</td>
<td>38</td>
<td>2098</td>
<td>Pneumonia, empyema, anemia</td>
</tr>
<tr>
<td>28</td>
<td>F</td>
<td>Primip</td>
<td>Round</td>
<td>Post Mat</td>
<td>3544</td>
<td>Postmaturity, transient RDS*, trauma sec. to dystocia</td>
</tr>
<tr>
<td>29</td>
<td>F</td>
<td>Multip</td>
<td>Long</td>
<td>Prem</td>
<td>2080</td>
<td>Twin, dysmaturity, low birth wt. for gest. age</td>
</tr>
<tr>
<td>30</td>
<td>F</td>
<td>Primip</td>
<td>Long</td>
<td>37</td>
<td>2820</td>
<td>Hypoglycemia, diabetic mother</td>
</tr>
</tbody>
</table>

* RDS - Respiratory distress syndrome.
ated with white pearls and red beads in vertical stripes, appeared to be a stronger stimulus. This stimulus appeared to incorporate the elements of round form, red color, pattern, brightness, movement and novelty. Because of the need for a strong stimulus to reduce the role of the stimulus as a variable, this red ball was used.

For the supine, prone, and upright sitting postures the infant was placed on a padded table. For the supine tilted posture the infant was placed in an infant seat adjusted to an approximately 55° angle. (Infanseat Co., Eldora, Iowa) For the prone tilted position the infant was positioned over a wedge-shaped bolster support as described by Finnie (1968) and Scrutton (1971). Various types of prone supports have been used in physical therapy techniques for facilitation of antigravity extensor tone of the neck and trunk with children with cerebral palsy or developmental delay. Such supports have also been used for positioning in daily management in the home for play. Their use and size is prescriptive, depending on the child's individual postural patterns and size.

The wedge-shaped bolster was constructed of plastic foam covered with vinyl. The size was designed to enable a four month infant to support on his arms on the table. The front edge was approximately four inches high, length 14 inches, and angle with the horizontal approximately 15°. Side pieces prevented the infant from rolling off. (Appendix A)

The investigator was a physical therapist experienced in developmental assessment of normal and abnormal infants.
PROCEDURE

Personal data was first reviewed in the infant's chart for selection criteria, and other mentioned variables. The reason for the clinic visit was obtained by questioning the clinic personnel or mother to rule out current illness. The investigator explained to the mother the nature and purpose of the examination, and obtained a written consent. (Appendix B) The time of the last feeding was obtained from the mother.

Clothing was removed from the infant except for diaper and rubber pants. The parent(s) of the infant remained in the examination room; other people did not if possible. Toys were available to occupy siblings if necessary.

The initial state of the infant was observed and recorded. During the procedure the infant was soothed by talking or handling by either the examiner or parent when this was necessary to maintain an alert state. Fussing and crying (Moss and Robson, 1970; Korner, 1972) were allowable between scoring periods or during the last two items of the induced postural responses, but not during the scoring periods. If the infant could not be soothed to enable an alert scoring period, the examination was terminated and excluded from the data.

Order of Examination

Order of postural and visual examinations was determined randomly. (Appendix C) When the child was placed in each posture, a three minute period was allowed for observation and scoring for the posture. If the infant demonstrated the maximal score for that posture in less than three minutes, the investigator proceeded to the visual examina-
tion immediately. If the infant did not demonstrate the maximal score for the posture within the three minute period, the examiner proceeded with the visual examination at that point.

Due to the possibility of upsetting the infant through handling, the induced postural responses were done at the end of the examination in the following order: 1) pulling to sit; 2) tilting in space; 3) ventral suspension; 4) neck righting; and, 5) asymmetric tonic neck reflex. These were ordered for ease of administration, consistent amount of handling of the infant, and placing those involving restrictive manipulation of the head last because of likelihood of irritating the infant.

The examination required from 20-35 minutes depending on times needed for scoring posture and need for soothing the infant.

Administration and Scoring

POSTURAL DATA

Spontaneous postures observed and scored as follows:

SUPINE POSTURE. Infant placed in supine posture on examination table by examiner.

Head Posture: 0—to one side only; 1—turned head to other side one time; 2—changed sides more than one time; 3—rested briefly in midline, but still rested to side; 4—rested in midline; 5—rested in midline, turned actively; 6—turned head and body to side-lying. (Gesell and Amatruda, 1941) Maximum score 6.

Asymmetric Tonic Neck Reflex: Arms were scored for presence of spontaneous Asymmetric Tonic Neck Reflex (ATNR) attitude as
follows: 0—symmetrical or other posture not consistent with ATNR attitude; 1—partial ATNR attitude, relative difference in flexion and extension of the arms consistent with more extension on face side, or more flexion of occipital side; 2—full ATNR attitude of arms, elbow extension of face arm, elbow flexion of occipital arm, but not sustained; 3—full ATNR attitude sustained. (Gesell and Amatruda, 1941) Maximum score 3.

PRONE POSTURE. Child placed in prone by examiner.

Head Posture: 0—head remained turned to one side only; 1—unsuccessful attempt to lift or turn as discerned by posterior neck muscle contraction; 2—turned head to other side; 3—raised and maintained below 45°; 4—raised and maintained 45-90°; 5—maintained at 90° over ten seconds; 6—maintained at 90° and turned actively. Degrees of range were determined by angle of face plane with horizontal supporting surface. (Gesell and Amatruda, 1941; Milani-Comparetti and Gidoni, 1967; Illingworth, 1962) Maximum score 6.

UPRIGHT SITTING. Child supported in sitting on table by mother, held around trunk.

Head Posture: 0—head sagged forward completely; 1—unsuccessfully attempted to lift as discerned by posterior neck muscle contraction; 2—bobbed partially erect; 3—head upright and erect briefly; 4—maintained upright and erect, but oscillated; 5—maintained upright and steady for more than ten seconds; 6—maintained upright, turned actively. Maximum score 6.

SUPINE TILT. Child placed in infant seat at approximately 55° angle with horizontal, and safety strap fastened.
Head Posture: 0— to one side only; 1— turned head to other side one time; 2— changed sides more than one time; 3— rested briefly in midline, but still rested to side; 4— rested in midline; 5— rested in midline, turned actively; 6— turned head and body to side-lying. Maximum score 6.

**PRONE TILT.** Child placed in prone over wedge bolster, arms freed forward.

Head Posture: 0— head sagged or turned to side; 1— unsuccessful attempt to lift or turn as discerned by posterior neck muscle contraction; 2— lifted slightly or turned head to other side; 3— raised and maintained below 45°; 4— raised and maintained 45°—90°; 5— maintained at 90° over ten seconds; 6— maintained at 90° and turned actively. Maximum score 6.

Induced responses scored as follows:

**HEAD RIGHTING ON PULLING TO SIT.** The examiner grasped the hands or lower arms of the supine infant and pulled slowly to sit, noting head participation as follows: 0— complete head lag; 1— partial lifting; 2— slight lag only; 3— head lifting in line with body, or leading. Trial was repeated twice and score averaged for a maximum of 3. (Milani-Comparetti and Gidoni, 1967; Illingworth, 1962)

Note: Head in line with body, or slight lag only, typical responses expected for age. Head leading was included for the possible early developer.

**HEAD RIGHTING AS TILTED IN SPACE.** The infant was supported with the examiner's hands around his trunk and under his arms. He was lifted in the air vertically and facing the examiner.
was then tilted slowly approximately 45° forward, 45° to each side, 45° backwards, returning to upright vertical between each tilt. Compensatory righting of the head was scored for each direction: 0—no response; 1—partial response; 2—head maintained in line with body axis; and 3—head tilted toward vertical. Scores for each direction were averaged for a maximum of 3. (Milani-Comparetti and Gidoni, 1967; Bayley, 1969)

**HORIZONTAL VENTRAL SUSPENSION.** The infant was held with the examiner's hands around trunk, horizontally and face down in space. Head righting was scored as follows: 0—head sagged or hung down; 1—bobbed up briefly to line of body plane; 2—maintained in body plane, or bobbed above; 3—maintained above body plane. Maximum score was 3. (Milani-Comparetti and Gidoni, 1967; Illingworth, 1962)

**NECK RIGHTING.** The child was returned to supine position. The examiner grasped the head on either side, lifted it in flexion, and then turned it to the side. If the child's head was resting in the midline, the face was turned to the right first, then to the left. If the face was turned to the side, this determined the direction of the first maneuver. Response was scored for each direction as follows: 0—no following; 1—after some initial retraction or holding back of the occipital arm, the arm and body crossed to follow the head to side-lying; 2—the limbs and body followed with the head as one unit, or like a log; 3—the arm and body followed across, but sequentially, with some pause between the head and body response. The score was noted for each direction, face right, and face
ASYMMETRIC TONIC NECK REFLEX. With the child in supine, the examiner grasped the head on either side, but kept it in line with the body's horizontal plane, and turned it to each side. If the head was resting in the midline it was turned first to the right, held for a latency period of 15 seconds; turned to the left, held for a latency period of 15 seconds; and returned to the right for a period of 15 seconds. If the head was resting to the side, the direction began to the opposite side, and was repeated in the same 1, 2, 3 sequence. The latency period was to allow for the slower response time for the passively induced reaction. (Denhoff, 1967) The return test to the first tested side allowed for a phenomenon sometimes occurring in the investigator's clinical experience, where the reflex may not occur on the first turn. Scoring was as follows for the second and third directions: 0—arms in symmetrical or other posture not consistent with ATNR attitude; 1—arms assumed partial posture with a relative difference in flexion and extension, with more extension of face arm, or more flexion of occipital arm; 2—arms assumed full ATNR posture with face arm elbow extended, occipital arm elbow flexed, but not sustained; 3—full ATNR posture sustained. Scores for the two directions were averaged for a maximum of 3. (Gesell, 1938; Gesell and Amatruda, 1941; Gesell and Ames, 1950; Paine et al, 1964; Bobath, 1972; Milani-Comparetti and Gidoni, 1967)

The total postural score was computed by adding the above spon-
taneous and induced scores, excluding the Asymmetric Tonic Neck Reflex items, with a maximum of 42. The Asymmetric Tonic Neck Reflex score was computed by adding the spontaneous and induced scores for a maximum of 6. It was expected that many subjects would score less than the maximum, especially in groups B and C.

**VISUAL DATA**

**Presentation of stimulus:** The dangling red ball was presented to the infant's line of gaze, jiggling it to attract his attention, as described in procedures of Gesell and Amatruda (1941) and Bayley (1969) for the red ring. The ball was suspended at a distance of approximately eight inches from the infant's eyes. Duration and pursuit trials were carried out in each of the described positions.

**Duration of visual fixation:** The examiner timed the duration of the first fixation with a stopwatch. Two trials were given, with a few seconds between each to record the data and reset the watch. The two scores were added for the total duration of visual fixation score for each posture, and all added for the grand total duration of visual fixation score.

**Visual pursuit:** Procedures and scoring were based on modifications of procedures described by Gesell and Amatruda (1941), Bayley (1969), Barten et al (1971) and Barten and Ronch (1971). The ball was moved into the infant's line of gaze, and when attention was secured, it was moved in a horizontal 180° arc at a distance of approximately 12 inches and speed of approximately three to four seconds per foot. If the head rested in the middle, the ball was first moved to the right, then left, then
again to the right so that a full excursion was made in each
direction. If the head rested to the side, the first direction
was accordingly determined and two full excursions made. Each
two full excursions constituted a trial. Two to three seconds
were allowed at the end of an excursion to allow the infant to
refixate if necessary. At the end of a trial several seconds
elapsed while the examiner scored the two excursions of the
trial. Four trials were given. Scoring considered both type
of pursuit and range for each directional excursion as follows:
0—none; 1—OP, ocular pursuit only; 2--OCP, oculocephalic pur-
suit less than 90°; 3--OCP, oculocephalic pursuit 90°; 4--OCP,
ско(Truehead movement pursuit more than 90°; 5--OCP, oculocephalic pur-
suit 180°. Maximum score per posture was four trials x two
excursions x five or 40. Maximum total visual pursuit score
for all five postures was 120. It was anticipated that many of
the subjects would have less than the maximum score.

LIMITATIONS

A number of limitations or weaknesses were present in this
study. Both observer reliability and opportunity to score more than one
factor at a time were limited by the method of a single examiner-
observer. Separate observer(s) would have been preferable. The use of
electronic equipment to record duration of fixation would have increased
the possibility of accuracy. Electro-oculographic recordings and poten-
tiometer recordings of head movements as described in the literature
would offer more exact measurements of eye and head movements. Filming
or videotaping all examinations would have facilitated observer reliabil-
ity procedures through multiple observers, or test-retest scorings, as well as made possible the scoring of more than one variable at a time.

The small group studied may not have been large enough to reflect the range of differences in maturation of postural control. In the investigator's experience a wide range of postural deviations occur in the infants followed in the Maternal and Infant Care newborn clinics.

Individual differences in stimulus preferences could have affected response to the stimulus. It would have been desirable to compare results with another stimulus such as a patterned card, schematic face (Fantz, 1961, 1964, 1967), or a red ring. Because of possible factors of fatigue and the practicalities of time in the clinical situation, this was not attempted in the present study.

The factors of differences in innate intelligence or maturation of visual perception were unknown. They might have played a significant role in total responsiveness. Some control of such variables might be possible by first testing a group for stimulus preference, complexity, etc. and indices of frequency and duration of fixation, and then carrying out this study with a group of infants of similar responsiveness.

The limitations of a single test as compared with a test-retest procedure are obvious. Longitudinal observations of infants as they acquired better head control would also have strengthened the conclusions.

STATISTICAL TREATMENT

Null Hypotheses

Stated in the null form, the hypotheses to be tested were:

1) There would be no significant difference in duration of visual
fixation scores or visual pursuit scores as a function of the different postures tested, group, or sex.

2) Duration of visual fixation scores and visual pursuit scores would not correlate significantly with postural scores:

   A. Total visual fixation scores and total visual pursuit scores with total postural scores.

   B. Scores for each posture for visual fixation and visual pursuit with postural score.

   C. Supine posture: visual fixation and visual pursuit scores for that posture with Asymmetric Tonic Neck Reflex score.

3) Total duration of visual fixation scores, total visual pursuit scores, and total postural scores would not differ significantly as a result of parity of the mother. (Primiparae vs Multiparae)

4) Visual pursuit scores for supine posture would not differ significantly as a result of difference in head shape (round or long) or group.

5) There would be no significant difference between duration of visual fixation scores and visual pursuit scores as a function of place in order of the postures, and of sex or group.

   A. Duration of visual fixation scores for first and last postures.

   B. Visual pursuit scores for first three trials of examination and last three trials.

6) Observer reliability: Scoring the first half of the normal group would not differ significantly from scoring of the last half of the group.

Groups B and C might show wider range of individual differences and
not be useful for this purpose. Although postnatal age would be four months, the latter two groups might be expected to have a number of subjects with varying corrected ages if prematurity was considered.

Statistical Analysis

The experimental arrangement for the testing of the first hypothesis regarding the effects of the five postures on the visual scores corresponded to a 3 (Group) x 2 (Sex) x 5 (Postures) factorial design. Group, Sex and Postures were the independent variables, Visual Fixation Scores and Visual Pursuit Scores the dependent variables. A mixed model analysis of variance with repeated measures for postures was used. (Johnson and Leone, 1964; Duncan, 1959; Biomedical Computer Program EMD02) A similar factorial design was used for testing the effect of Order of the Postures on the dependent variables of Visual Pursuit Scores and Visual Fixation Scores with a 3 (Group) x 2 (Sex) x 2 (Order—First and Last) analysis of variance with repeated measures for order. A p.05 level of significance was required.

Tests on differences between means for significant effects of the above analyses of variance were done using Duncan's Multiple Range Tests. (Duncan, 1955; Winer, 1962) A p.05 level of significance was required.

The effects of Parity of the mother (Primiparae vs Multiparae) on Visual Pursuit Scores, Visual Fixation Scores, and Postural Scores was tested with a 3 (Group) x 2 (Sex) x 2 (Parity) mixed model analysis of variance for unequal cell sizes. (Kemphorne et al, 1961; Scheffe, 1959) A similar model, 3 (Group) x 2 (Sex) x 2 (Head shape) was used to
test for effect of Head shape—Round or Long—on Visual Pursuit Scores in
the supine posture. A p.05 level of significance was required.

Pearson Product-Moment Correlations were computed for Visual
Fixation Scores and Visual Pursuit Scores against Postural Scores for
total scores and for scores in each posture separately. Product-Moment
Correlations were also computed for Visual Fixation Scores and Visual
Pursuit Scores in supine posture against Asymmetric Tonic Neck Reflex
Scores. (Nie et al, 1970)

A p.05 level of significance was required.

Observer reliability was tested by comparing scoring of the
first half with the second half of the Normal Group A for each of the
measures—Total Postural Scores, Total Visual Pursuit Scores, and Total
Visual Fixation Scores—utilizing Fischer Exact Probability Tests.
(Siegel, 1956)
Chapter 4

RESULTS

Observer Reliability

Null Hypotheses: Scoring of the first half of the Normal Group A does not differ significantly from scoring of the last half of the group.

Data collection for the study took place from March 8, 1973 to May 29, 1973. The Group A subjects were scattered throughout this time with the first being observed March 8, 1973 and the last May 8, 1973. The scoring for the first half and the second half of Total Visual Fixation Scores, Total Visual Pursuit Scores, and Total Postural Scores did not differ significantly by Fisher's Exact Probability Tests. (Posture, \( p = .48 \); Visual Fixation, \( p = .40 \); Visual Pursuit, \( p = .40 \)) The null hypothesis was not rejected. Observer reliability was good as indicated by scoring over time.

Description of Distributions of Scores

Means of total scores for Postural Control, Visual Fixation and Visual Pursuit were consistently highest in Group A (Normal), with Groups B (Premature) and C (Intensive Care) varying in rank order for the different scoring measures. Group C means were higher than B for Postural Control and for Visual Pursuit; Group B showed a higher mean than C for Visual Fixation. Means, standard deviations, and ranges for total scores for each group are summarized in Table 2. Of special interest among the Visual Fixation Scores are the large standard devia-
tions of Group B (M = 164.50, S.D. = 75.70) and Group C (M = 157.90, S.D. = 81.0). These two groups included scores both lower and higher than in Group A.

Table 2. Distributions of Total Postural Control Scores, Total Visual Fixation Scores, and Total Visual Pursuit Scores in Groups A, B, and C.

<table>
<thead>
<tr>
<th>Distribution</th>
<th>Mean</th>
<th>S.D.</th>
<th>Low and High Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Postural Control</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-Normal</td>
<td>37.40</td>
<td>2.50</td>
<td>32.50-40.50</td>
</tr>
<tr>
<td>B-Normal Premature</td>
<td>23.60</td>
<td>5.61</td>
<td>16.50-32.50</td>
</tr>
<tr>
<td>C-Intensive Care</td>
<td>31.98</td>
<td>3.73</td>
<td>27.25-40.00</td>
</tr>
<tr>
<td>Total Visual Fixation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-Normal</td>
<td>190.60</td>
<td>26.36</td>
<td>161-246</td>
</tr>
<tr>
<td>B-Normal Premature</td>
<td>164.50</td>
<td>75.70</td>
<td>77-323</td>
</tr>
<tr>
<td>C-Intensive Care</td>
<td>157.90</td>
<td>81.00</td>
<td>58-298</td>
</tr>
<tr>
<td>Total Visual Pursuit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A-Normal</td>
<td>176.70</td>
<td>22.11</td>
<td>117-206</td>
</tr>
<tr>
<td>B-Normal Premature</td>
<td>74.80</td>
<td>33.50</td>
<td>45-159</td>
</tr>
<tr>
<td>C-Intensive Care</td>
<td>111.10</td>
<td>35.30</td>
<td>59-167</td>
</tr>
</tbody>
</table>

EFFECT OF GROUP, SEX AND POSTURES

Duration of Visual Fixation

Null Hypothesis: Duration of Visual Fixation Scores do not differ significantly as a function of Group, Sex or Postures.

Results of a 3 x 2 x 5 analysis of variance of Visual Fixation Scores are shown in Table 3. The main effect of Postures was highly significant (F = 13.74, 4/96 df, p < .01). Visual Fixation Scores did not differ significantly as a result of Group, Sex, and their interactions. The null hypothesis was rejected for posture data only, which was the primary interest of this study.

Further analysis of means for the different postures by
Duncan's Multiple Range Tests indicated the following rank order: Prone, 
M = 19.67; Prone Tilt, M = 23.97; Upright Sitting, M = 32.13; Supine 
Tilt, M = 37.63; Supine, M = 57.29.

Low P PT U ST S High

Those underlined with a common line were not significantly dif­
erent; means which are not underlined with a common line were different
at p < .05 level. Visual Fixation Scores across groups were significantly
highest in Supine posture. Although Supine Tilt Scores were next
highest, they were not significantly different from Upright Sitting
Scores. Supine Tilt Scores were significantly higher than both Prone and
Prone Tilt. Upright Sitting Scores were significantly higher than Prone
scores, but not significantly higher than Prone Tilt Scores.

Table 3. Results of Analysis of Variance of Visual Fixation Scores as
a Function of Group, Sex and Postures.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>466.26</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>233.13</td>
<td></td>
</tr>
<tr>
<td>Posture</td>
<td>4</td>
<td>6491.88</td>
<td>13.74**</td>
</tr>
<tr>
<td>Interaction Effects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group x Sex</td>
<td>2</td>
<td>348.93</td>
<td></td>
</tr>
<tr>
<td>Group x Posture</td>
<td>8</td>
<td>409.63</td>
<td></td>
</tr>
<tr>
<td>Sex x Posture</td>
<td>4</td>
<td>360.96</td>
<td></td>
</tr>
<tr>
<td>Group x Sex x Posture</td>
<td>8</td>
<td>263.55</td>
<td></td>
</tr>
<tr>
<td>Error (Between)</td>
<td>24</td>
<td>1054.50</td>
<td></td>
</tr>
<tr>
<td>Error (Within)</td>
<td>96</td>
<td>472.56</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05
** p < .01

Visual Pursuit

Null Hypothesis: Visual Pursuit scores do not differ signifi-
cantly as a function of Group, Sex, or Postures.

Results of a 3 x 2 x 5 analysis of variance of Visual Pursuit Scores are shown in Table 4. The main effects of Group (F = 24.02, 2/24 df, p < .01), and Postures (F = 7.47, 4/96 df, p < .01) were significant, but were not significant for Sex. The interaction Group x Posture was also significant (F = 2.30, 8/96 df, p < .05). The null hypothesis was rejected for Group, Posture, and the interaction Group x Posture.

Duncan's Multiple Range Tests were used to further clarify differences between means for the significant effects of Group, Posture, and the Group x Posture interaction. The results are summarized in Table 5.

Table 4. Results of Analysis of Variance of Visual Pursuit Scores as a Function of Group, Sex, and Postures.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>2</td>
<td>5114.18</td>
<td>24.02**</td>
</tr>
<tr>
<td>Sex</td>
<td>1</td>
<td>36.51</td>
<td></td>
</tr>
<tr>
<td>Postures</td>
<td>4</td>
<td>208.64</td>
<td>7.47**</td>
</tr>
<tr>
<td><strong>Interaction Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group x Sex</td>
<td>2</td>
<td>201.12</td>
<td></td>
</tr>
<tr>
<td>Group x Postures</td>
<td>8</td>
<td>64.13</td>
<td>2.30*</td>
</tr>
<tr>
<td>Sex x Postures</td>
<td>4</td>
<td>25.41</td>
<td></td>
</tr>
<tr>
<td>Group x Sex x Postures</td>
<td>8</td>
<td>11.48</td>
<td></td>
</tr>
<tr>
<td>Error (Between)</td>
<td>24</td>
<td>212.89</td>
<td></td>
</tr>
<tr>
<td>Error (Within)</td>
<td>96</td>
<td>27.94</td>
<td></td>
</tr>
</tbody>
</table>

*p < .05
**p < .01

Group Differences. Duncan's Multiple Range Tests on means applied to the main effect of Groups (independent of Postures) showed
the following rank order of means of Visual Pursuit scores. Group B (Premature), $M = 14.96$; Group C (Intensive Care), $M = 22.22$; Group A (Normal), $M = 34.94$. These were each significantly different from the others ($p < .05$).

When Multiple Range Tests on means were applied to the Group x Postures interaction, Groups for each posture showed the same rank order of means. All differences between Groups A, B, and C were significant ($p < .05$) except in the Upright Sitting posture, where Groups B and C were not significantly different in Visual Pursuit Scores.

Postural Differences. Means for Visual Pursuit Scores in each posture are compared in Table 5 and Figure 1. Means for scores in each posture (independent of groups) showed the following rank order: Prone, $M = 21.10$; Prone Tilt, $M = 21.43$; Supine Tilt, $M = 24.70$; Upright Sitting, $M = 26.43$; Supine, $M = 26.53$. Multiple Range Tests demonstrated that the mean in Supine was significantly higher ($p < .05$) than all postures except Upright Sitting, which was not significantly different. Upright Sitting and Supine Tilt were not significantly different from each other, but were significantly higher ($p < .05$) than Prone Tilt and Prone, also not significantly different from each other. Significant variations in the rank order of postures for each group occurred when means of Visual Pursuit Scores in each posture were compared according to Group in the tests on the Group x Postures interaction.

For Group A (Normal): Prone Tilt, $M = 31.50$; Prone, $M = 33.50$; Supine, $M = 35.10$; Supine Tilt, $M = 37.10$; Upright Sitting, $M = 37.50$. Upright Sitting, Supine Tilt, and Supine means were not significantly different from each other, although Upright Sitting and Supine Tilt were

<table>
<thead>
<tr>
<th>Differences</th>
<th>Rand Order Means</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lowest . . . . . . Highest</td>
</tr>
</tbody>
</table>

**Group Differences**

<table>
<thead>
<tr>
<th>Groups (independent of Postures)</th>
<th>B C A</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Groups x Postures (Groups for each Posture)</th>
<th>Supine</th>
<th>Prone</th>
<th>Upright Sitting</th>
<th>Supine Tilt</th>
<th>Prone Tilt</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B C A</td>
<td>B C A</td>
<td>B C A</td>
<td>B C A</td>
<td>B C A</td>
</tr>
</tbody>
</table>

**Postural Differences**

<table>
<thead>
<tr>
<th>Postures (independent of groups)</th>
<th>P PT ST U S</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Group x Postures (Postures for each group)</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PT P S ST U</td>
<td>P PT ST S U</td>
<td>PT P ST U S</td>
</tr>
</tbody>
</table>

**Group x Postural Differences**

- PT/A P/A S/A ST/A U/A
- PT/C P/C U/B ST/C U/C S/C
- P/B PT/B ST/B S/B

Close Sig.

Means underlined with common line are not significantly different; means which are not underlined with common line are different at $p < .05$ level.
Figure 1. Postural Differences in Means of Visual Pursuit Scores with Comparison of Groups and Total Sample.
significantly higher than Prone and Prone Tilt \((p < .05)\). Supine and Prone were not significantly different.

Group B (Premature): Prone, \(M = 9.70\); Prone Tilt, \(M = 13.00\); Supine Tilt, \(M = 15.70\); Supine, \(M = 16.20\); Upright Sitting, \(M = 20.20\). The Visual Pursuit mean in Upright Sitting was significantly higher than all other postures \((p < .05)\). Supine and Supine Tilt means were not significantly different from each other, but Supine was significantly greater than both Prone Tilt and Prone, and Supine Tilt greater than Prone \((p < .05)\). This was the only situation in which Prone Tilt was significantly higher than Prone, probably accounting for that order in the across-groups tests.

Group C (Intensive Care): Prone Tilt, \(M = 19.80\); Prone, \(M = 20.10\); Supine Tilt, \(M = 21.30\); Upright Sitting, \(M = 21.60\); Supine, \(M = 28.30\). The Visual Pursuit mean was significantly higher in Supine than all other postures in this group \((p < .05)\). Means for the other four postures did not differ significantly from each other.

**Group x Postures.** The results of the tests between means for the fifteen means involved in the Groups x Postures interaction may be seen in Table 5. The consistent significant differences between groups are apparent, with the means for the five postures for Group A being significantly higher than all other Group x Posture combinations \((p < .05)\). The means for Groups B are all at the lower end of the rank order, with the exception of Upright Sitting which is grouped with the means from Group C and not significantly different from them.
EFFECT OF GROUP, SEX AND ORDER

Visual Fixation

Null Hypothesis: Duration of Visual Fixation Scores do not differ significantly as a function of Group, Sex, or place in Order of the postures.

The sequence of postures was varied randomly. Visual Fixation Scores for the first and last postures were compared with a 3 x 2 x 3 analysis of variance shown in Appendix G, Table 11. Visual Fixation Scores did not vary significantly according to place in the order or sequence of postures for any group or sex. The null hypothesis was not rejected.

Visual Pursuit

Null Hypothesis: Visual Pursuit Scores do not differ significantly as a function of Group, Sex, or place in Order of the postures.

Visual Pursuit Scores for the first three trials of the first posture were compared with the last three trials of the last posture with a 3 x 2 x 2 analysis of variance shown in Appendix G, Table 12. A significant Group effect \((F = 26.07, 2/24 \text{ df, } p < .01)\) was again apparent for Visual Pursuit Scores, but not for Sex, Order and their Interactions. Visual Pursuit Scores did not vary significantly according to place in Order or sequence of the postures. The null hypothesis was rejected on the basis of the Group effect.

EFFECT OF GROUP, SEX AND PARITY

Visual Fixation

Null Hypothesis: Total Duration of Visual Fixation Scores do
not differ significantly as a result of Group, Sex, or Parity of the mother (Primiparae vs. Multiparae).

Results of a 3 x 2 x 2 analysis of variance did not show significant differences among Total Visual Fixation Scores as a result of Group, Sex, or Parity of the mother. Two interaction effects, Group x Parity and Sex x Parity produced F ratios above 1.0 but these were not significant at the \( p < .05 \) level. (See Appendix H, Table 13.) The null hypothesis was not rejected.

**Visual Pursuit**

Null Hypothesis: Total Visual Pursuit Scores do not differ significantly as a result of Group, Sex or Parity of the mother (Primiparae vs. Multiparae).

A significant Group effect was again demonstrated for Visual Pursuit in this 3 x 2 x 2 analysis of variance \( (F = 17.64, \ 2/18 \ df, \ p < .01) \), but no other significant effect was demonstrated. The null hypothesis was rejected on the basis of Group differences. (See Appendix H, Table 14.)

**Postural Scores**

Null Hypothesis: Total Postural Scores do not differ significantly as a result of Group, Sex or Parity of the mother (Primiparae vs. Multiparae).

A 3 x 2 x 2 analysis of variance demonstrated a significant effect of Group \( (F = 17.06, \ 2/18 \ df, \ p < .01) \), but no significant effects for Sex or Parity. The null hypothesis was rejected on the basis of Group Differences in Postural Scores. (See Appendix H, Table 15.) Multiple Range Tests on means showed significant differences between each
of these means: Group B, M = 23.60; Group C, M = 31.98; Group A, M = 37.40

**EFFECT OF GROUP, SEX AND HEADSHAPE**

Null Hypothesis: Visual Pursuit Scores for Supine posture do not differ significantly as a result of Group, Sex, or Headshape (Round or Long).

Results of a 3 x 2 x 2 analysis of variance are shown in Table 6. Of the main effects only Group was significant (F = 9.73, 1/19 df, p < .01). There were no significant effects for Sex, nor for Headshape. (It should be noted that there was a computer reading of 0 for both these effects, probably because of a cell size of zero for male-long heads.) Two interaction effects were significant, however: Group x Sex (F = 16.80, 1/19 df, p < .01) and Group x Sex x Headshape (F = 5.00, 1/19 df, p < .05). The null hypothesis was rejected for Group, and for the interactions of Group x Sex and Group x Sex x Headshape.

A comparison of means according to Group, Sex and Headshape is shown in Figure 2. General group differences are apparent. Group A (normal) differences were not great between sexes or headshapes. Only 2/10 of this group had long heads. In Group B (Premature), 8/10 of the subjects had long heads. The one male-round head subject had a higher Visual Pursuit Score than the four male-long heads and the females, but differences among the male-long heads and the females in this group did not appear to be great. Group C (Intensive Care) had 4/10 long heads. In this group females had higher Visual Pursuit means, and round heads higher means than long heads for both sexes. Because of small and unequal cell sizes, test of significant differences between these means
Figure 2. Visual Pursuit Scores in Supine Posture as a Function of Group, Sex, and Headshape (Round or Long).
were not performed.

Table 6. Results of Analysis of Variance of Visual Pursuit Scores in Supine Posture as a Function of Group, Sex and Headshape.

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group</td>
<td>1</td>
<td>243.21</td>
<td>9.73**</td>
</tr>
<tr>
<td>Sex</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Headshape</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Interaction Effects</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group x Sex</td>
<td>1</td>
<td>420.01</td>
<td>16.80**</td>
</tr>
<tr>
<td>Group x Headshape</td>
<td>1</td>
<td>55.21</td>
<td>2.21</td>
</tr>
<tr>
<td>Sex x Headshape</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Group x Sex x Headshape</td>
<td>-</td>
<td>125.13</td>
<td>5.00*</td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td>19</td>
<td>25.01</td>
<td></td>
</tr>
</tbody>
</table>

* p < .05
** p < .01
Lack of values for effects of Sex, Headshape and Sex x Headshape in computer analysis probably due to cell value of 0 for Group A, Sex-Male, Headshape-Long.

CORRELATIONS

Visual Fixation and Postural Control

Null Hypothesis: Total Duration of Visual Fixation Scores do not correlate significantly with Total Postural Scores.

Pearson Product-Moment correlations were computed for each group separately and for the whole sample. Results are shown in Table 7. Significant correlation between Total Duration of Visual Fixation Scores and Total Postural Scores was found only for Group B (r = .737, p < .01), providing partial rejection of the null hypothesis.

Null Hypothesis: Duration of Visual Fixation Scores for each posture do not correlate significantly with Postural Scores for the
Product-Movement correlations were computed for each group separately and for the whole sample. (See Table 7.) Group A (Normal) showed a significant correlation only in the Prone Tilt posture ($r = .646, p < .05$). Group B (Premature) showed significant positive correlations in Upright Sitting ($r = .893, p < .001$) and Prone Tilt ($r = .907, p < .001$), and a near significance in Prone ($r = .528, p < .058$). Group C (Intensive Care) showed negative correlations in Supine, Upright Sitting and Supine Tilt, of which only the latter was significant ($r = -.881, p < .001$). When data were pooled for the whole sample there were positive significant correlations for Prone ($r = .458, p < .01$) and Prone Tilt ($r = .359, p < .05$), and a negative correlation for Supine Tilt ($r = -.339, p < .05$), probably on the influence of Group C. The null hypothesis was partially rejected.


<table>
<thead>
<tr>
<th>Group</th>
<th>Scores in Each Posture</th>
<th>Total Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supine</td>
<td>Prone</td>
</tr>
<tr>
<td>A (N 10)</td>
<td>.441</td>
<td></td>
</tr>
<tr>
<td>B (N 10)</td>
<td>.528</td>
<td>.893***</td>
</tr>
<tr>
<td>C (N 10)</td>
<td></td>
<td>-.418</td>
</tr>
<tr>
<td>Total (N 30)</td>
<td>.232</td>
<td>.458**</td>
</tr>
</tbody>
</table>

* $p < .05$
** $p < .01$
*** $p < .001$
Visual Pursuit and Postural Control

Null Hypothesis: Total Visual Pursuit Scores do not correlate significantly with Total Postural Scores.

Product-Moment correlations as computed for each of the three groups and for the total sample are shown in Table 8. Highly significant positive correlations between Visual Pursuit Scores and Total Postural Scores were found for each group and for the total sample. (Group A Normal, $r = .740, p < .01$; Group B Premature, $r = .810, p < .01$; Group C Intensive Care, $r = .878, p < .001$; Total Sample, $r = .907, p < .001$.) The null hypothesis was rejected.


<table>
<thead>
<tr>
<th>Group</th>
<th>Supine</th>
<th>Prone</th>
<th>Up Sit.</th>
<th>Sup Tilt</th>
<th>Pr Tilt</th>
<th>Total Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (N 10)</td>
<td>.477</td>
<td>.810**</td>
<td>-.428</td>
<td>.659*</td>
<td>.740**</td>
<td>.763***</td>
</tr>
<tr>
<td>B (N 10)</td>
<td>.654*</td>
<td>.640*</td>
<td>.854***</td>
<td>.811**</td>
<td>.810**</td>
<td>.858***</td>
</tr>
<tr>
<td>C (N 10)</td>
<td>.556*</td>
<td>.513</td>
<td>.425</td>
<td>.878***</td>
<td></td>
<td>.761***</td>
</tr>
<tr>
<td>Total (N 30)</td>
<td>.763***</td>
<td>.858***</td>
<td>.665***</td>
<td>.538***</td>
<td>.907***</td>
<td></td>
</tr>
</tbody>
</table>

* $p < .05$
** $p < .01$
*** $p < .001$

Null Hypothesis: Visual Pursuit Scores for each posture do not correlate significantly with Postural Scores for the postures.

Correlations for the three groups and for the total sample are also shown in Table 8. Group A (Normal) demonstrated significant positive correlations for Prone ($r = .810, p < .01$) and Prone Tilt ($r = .659$, 


A negative but non-significant correlation was present in Upright Sitting as it was for Visual Fixation. Group B (Premature) had significant positive correlations for all postures except Prone Tilt. (Supine, $r = .654$, $p < .05$; Prone, $r = .640$, $p < .05$; Upright Sitting, $r = .854$, $p < .001$; Supine Tilt, $r = .811$, $p < .01$.) Group C (Intensive Care) showed a significant positive correlation for Prone ($r = .556$, $p < .05$) and near significance in Upright Sitting ($r = .513$, $p < .065$). Correlations between Visual Pursuit Scores and Postural Scores were highly significant in all postures when computed for the Total Sample (Supine, $r = .763$, $p < .001$; Prone, $r = .858$, $p < .001$; Upright Sitting, $r = .761$, $p < .001$; Supine Tilt, $r = .665$, $p < .001$; Prone Tilt, $r = .538$, $p < .001$). The null hypothesis was rejected.

**Visual Scores in Supine with Asymmetric Tonic Neck Reflex Scores (ATNR)**

**Visual Fixation and ATNR.** Null Hypothesis: Visual Fixation Scores in Supine posture do not correlate significantly with Asymmetric Tonic Neck Reflex Scores.

Product-Moment correlations as computed for each of the three groups and for the total sample are shown in Table 9. There were no significant correlations, but Group C (Intensive Care) demonstrated a positive correlation near significance ($r = .502$, $p < .07$), suggesting possible association between higher ATNR Scores and higher Visual Fixation Scores for that group in Supine. The null hypothesis was not rejected, however, on the basis of these results.

**Visual Pursuit and ATNR.** Null Hypothesis: Visual Pursuit Scores in Supine posture do not correlate significantly with Asymmetric Tonic 
Neck Reflex Scores.


<table>
<thead>
<tr>
<th>Group</th>
<th>Visual Fixation-ATNR</th>
<th>Visual Pursuit-ATNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Normal (N 10)</td>
<td></td>
<td>-.500</td>
</tr>
<tr>
<td>B Premature (N 10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Intensive Care (N 10)</td>
<td>.502</td>
<td></td>
</tr>
<tr>
<td>Total Sample (N 30)</td>
<td></td>
<td>-.381*</td>
</tr>
</tbody>
</table>

* p < .05

Product-Moment correlations were computed for each of the three groups and for the total sample as shown in Table 9. Visual Pursuit Scores and ATNR Scores showed a significant negative correlation for the total sample (r = -.381, p < .05). Separate group correlations were also negative, but not significant, although Group A was near significance (r = -.500, p < .07). There was support for the prediction that a negative correlation would exist. The null hypothesis was rejected for the total sample.
Chapter 5

DISCUSSION AND CONCLUSIONS

DISCUSSION

The results of this study provide support for the hypotheses that duration of Visual Fixation and frequency and quality of Visual Pursuit may differ in the four month old infant as related to posture as well as with level of head control. These are in general agreement with the emphasis of Gesell et al (1949) on the interdependence of the visual system and the total action system of the child.

Group differences were also found between the Normal, Premature, and Intensive Care Infants. These were significant for Postural Control and for Visual Pursuit, with the Normal Group scoring highest in both, the Intensive Care Group next highest, and the Premature Group lowest. Visual Fixation means for the three groups were not significantly different.

Postural Control

The relations of Visual Fixation and Visual Pursuit Scores to the various postures and to level of head control are made clearer by considering the quality of head control found in each group. (See Master Data Sheet, Appendix F, Table 10.)

Factors in postural control. Postural control is discussed in terms of two main aspects or factors—fixation and mobility (Bobath, 1972). These factors have also been termed static and dynamic or kinetic.
tone (Gesell and Amatruda, 1941). In this study fixation of the head refers to the ability to stabilize the head in a steady position relative to the body. This can be achieved by external support such as the table surface or infant seat, or by static muscle contraction. Mobility refers in this study to the ability to turn or rotate the head on the body by dynamic muscular contraction. Fixation and mobility are interdependent. If fixation is inadequate, mobility may be present but inadequately controlled; if fixation is abnormally increased, mobility may be inadequate.

Development of fixation and mobility in head control. During the first four months the infant develops the ability to erect and fix the head against gravity and to rotate it with control. The very young infant lies with head to side in supine and the support provides some fixation of the head as well as allowing him to turn his head from one side to the other. He must develop midline fixation, however, before he can control the speed or stop at various points of the range. Similarly the newborn lies in prone with head to side, supported by the surface, and has sufficient mobility to turn the head from one side to the other. As he develops antigravity fixation in the midline, he is able to turn his head with control in the raised position. When the infant is held in upright sitting, he increasingly demonstrates the antigravity fixation necessary for controlled mobility to occur.

Level of head control of infants in this study. In the Normal Group head control was steady in all postures such that the infants turned their head freely in all postures, however, no subject achieved the maximum score of 42. In this group, Asymmetric Tonic Neck Reflex
Scores were low, indicating the decrease of the reflex expected at this age. They were active infants, not safe in the infant seat at 55° without close supervision. Several were able to roll from prone to supine, and when placed in the Prone Tilt posture on the wedge, tended to struggle.

The Premature Group demonstrated less mature head control, with some inability to erect and fix the head in midline antigravity postures. Their level of head control appeared fairly appropriate for corrected age, with a corrected age range of seven weeks to three months (Parmalee and Schulte, 1970; Gesell and Amatruda, 1941). In Supine seven of the ten infants rested head to side or only briefly in the midline. All except one actively turned the head at least once during the observation period. In Prone their head control ranged from barely turning the head from one side to the other, to some midline fixation at 45-90°. In Upright Sitting they held their heads upright briefly or oscillated, with little spontaneous turning during the observation period. In Supine Tilt in the infant seat several not only could not hold midline posture, but flexed their heads laterally. In Prone Tilt on the wedge seven of the ten scored higher postural scores for head control than they did in Prone, demonstrating some facilitation of antigravity extension. These infants also demonstrated fairly good antigravity extension in the induced responses for ventral suspension and head in space as body was tipped dorsally. They showed a corresponding disparity in head control ventrally in pulling to sit and in space. Asymmetric Tonic Neck Reflex Scores were higher than for the Normal Group, but generally not inappropriate for corrected age. None was grossly abnormal in quality according to such criteria as marked asymmetry or obligate posturing that the
infant could not overcome (Denhoff, 1967; Paine et al, 1964). Although abnormal neurological reflexes were not noted in these infants' records, this group may be at risk for cerebral palsy or other central nervous system dysfunction (Drillien, 1972a, 1972b; Stewart, 1972).

The Intensive Care Group showed considerable variety in performance, although mean Postural Scores and mean Visual Pursuit Scores were significantly lower than the Normal Group. Supine head control was well established for this group with midline fixation, turning, and a few rolling to the side. In Prone their head control ranged from raising 45-90° to maintaining head erect at 90° and turning. Some showed a steady erect head in Upright Sitting, others still showed oscillation of the head. In Supine Tilt in the infant seat all demonstrated midline fixation, and some turned their heads spontaneously. Their performance in Prone Tilt was generally similar to Prone. Only one infant demonstrated the facilitation of extension that occurred in the Premature Group.

Their Induced Postural Scores were lower than those of the Normal Group. Their Asymmetric Tonic Neck Reflex Scores, though similar to the Premature Group scores in mean, included the highest Asymmetric Tonic Neck Reflex Scores of infants in this study. This is of interest considering that this was largely a full-term group. None of these was grossly abnormal according to criteria such as asymmetry or obligate posturing that the infant could not overcome. The responses differed from those of the Premature Group in that the Intensive Care Group rested in midline symmetrical posture and demonstrated the Tonic Neck Reflex as they turned their heads actively or passively. The Premature Group tended to rest in the asymmetric posture, however, the scoring method
used did not differentiate between these.

During the postural observations they demonstrated less active visual exploring than the Normal Group, and several infants had a dull look to their eyes. Although no neurological or ophthalmological abnormalities had been noted in the records, this group should also be considered at risk for central nervous system damage or ophthalmological problems (Koivisto, 1972; Drillien, 1972b). The possible effects of sensory deprivation due to their illness and subsequent management at home might also have contributed to their poorer performance.

Visual Fixation

Group differences. Although significant group differences for Visual Fixation were not found in the data analysis, some discussion of group differences is indicated. The large standard deviation for Visual Fixation Scores for Premature and Intensive Care Groups indicates that the groups were not homogenous. These groups included scores both lower and higher than those of the Normal Group, which averaged as means did not reflect this lack of homogeneity. The analysis of variance of Group differences in means was thus less powerful.

There is research evidence that the infant's capacity for visual fixation increases with age in the early months until approximately four months when the length of first fixation times tends to decrease (Barten and Ronch, 1971). This decrease has been suggested as possibly being due to ability to process visual stimuli faster as a manifestation of increased mental alertness or maturation of the visual system. Decrease in fixation times at four months may also be due to the development of the ability to release visual fixation easily and shift gaze
freely, which Gesell et al (1949) compare to the sequence of development for manual grasp and release.

It is possible that in the Premature Group both the very low and very high scores represent general immaturity. In this group the two very low scores were from younger infants (30 weeks gestational age and 32 weeks gestational age) with low Total Postural Scores. The three very high scores were "older" infants (34-36 weeks gestational age) with higher Total Postural Scores. The Intensive Care Group included four very low fixation scores and three very high scores. There did not seem to be any obvious relation to Total Postural Scores on inspection of raw data. It may be that the very low and very high scores represent different degrees of immaturity, for this group also, or they may represent deviations in the visual fixation mechanism—those unable to fix their eyes very long, and those unable to release or inhibit visual fixation.

Some differences in oculomotor coordination for fixation were apparent in the different groups. During the periods for observation of postures, the Normal Group appeared visually alert, actively exploring the environment, and frequently shifting gaze. Presented with the visual stimulus they fixed on it quickly. Several tried to reach for the stimulus. They were active lookers—knit foreheads, pursed lips, vocalized and panted. The Premature Group did not visually explore the environment or shift gaze as frequently during the observation periods. They tended to fix on faces as described for younger infants in the stimulus preference studies of Fantz (1961, 1967). When the experimental stimulus was presented, seven of the ten infants required longer effort by the investigator, jiggling the stimulus, etc., to obtain fixation. Most of the Intensive Care Group also showed less active visual explora-
tion of the environment, but two did noticeably shift gaze. Although two were slow to fix on the stimulus, most did so fairly easily. Beginning squint, or turning in of one eye was noticeable in two infants. Some were face watchers and all showed less readiness for reaching for the stimulus.

Most of the infants in the study appeared to coordinate binocularly, but one of the youngest female premature infants showed obviously poor binocular coordination. Gesell et al (1949) describe visual fixation in the very young infant as being monocular with the head in side position, with binocular fixation not being established until after two months age as midline posture develops. Other researchers, however, have determined with electrooculographic studies that conjugate coordination in visual fixation and following is present even in the newborn (Dayton et al, 1964; Kiff and Lepard, 1966). Midline support may have made the difference.

The effect of postures. Visual Fixation Scores varied significantly with the different postures in which the infants were placed. (Table 5) The order or sequence of the postures was varied randomly, and no significant effect for Order indicated that fatigue, stimulus satiation, or previous postural set did not bias the results. The possibility that experimental technique in stimulus presentation caused lower scores in certain postures should be noted.

Means for Visual Fixation Scores were significantly highest in Supine posture for the whole group, suggesting the important role of fixation of the head in visual fixation. The next highest means for Visual Fixation Scores occurred in Supine Tilt and Upright Sitting, and
these were not significantly different from each other for the whole group. Upright Sitting, although it did not provide external support or fixation for the head, may have provided some additional vestibular effect. Supine Tilt provided combined fixation for the head and possible vestibular effect. Although group differences in rank order were not tested, it is interesting that the normal infants, with their good head control for age, demonstrated second highest means in Upright Sitting, whereas the Premature and Intensive Care infants performed second best in Supine Tilt, which provided some fixation for the head. Visual Fixation means were generally lowest in Prone Tilt and Prone. This was true even for the normal group where Prone Postural Scores were good. These postures provided no external support for the head except at the lowest level of head to side development, and possibly a different vestibular effect. There was no significant difference between scores for these two postures for the whole group. Had means for rank orders for the different groups been tested individually, it would be interesting to find out whether Prone Tilt provided any advantage over Prone for the Premature infants who responded to some facilitation of more erect head control in that posture.

Relation to postural control. Visual Fixation Scores were associated with postural control in several ways. For the whole sample, the ability to fix visually in Prone or Prone-Tilt was related to the degree of Postural Control in those postures. The Normal Group did not show other significant correlations, probably due to a ceiling effect, but it was interesting to note that in Upright Sitting a negative, though insignificant correlation occurred. The Premature Infants showed a general
positive correlation of ability to fix the eyes with degree of head control, with significant relationships especially in those postures requiring antigravity postural control—Upright Sitting, Prone, and Prone Tilt. In Supine and Supine Tilt postures, where the supporting surface provided fixation for the head, visual fixation did not correlate with head control for the Premature Group. In the Intensive Care Group a significant negative correlation occurred for Supine Tilt, with higher Postural Control being associated with lower Visual Fixation times. This probably contributed to the negative correlation for the whole sample in Supine Tilt. The Intensive Care Group also showed negative correlations in all other postures except Prone and Prone Tilt. These negative correlations may reflect the tendency for visual fixation times to decrease as infants approach four months (Barten and Ronch, 1971). In general in the present study, for the antigravity postures, where postural control was deficient or incomplete, a positive correlation occurred; when postural control was fairly adequate, as the infant approached the necessary maturation of the visual system, a negative correlation occurred. This may indicate that efficient visual fixation requires adequate fixation of the head whether from external support or adequate antigravity postural control.

Level of Postural Control and Visual Fixation Scores may reflect a common factor, or either could be the cause of the other. Therefore, caution is needed in interpretation. A common factor of general maturity might explain the positive correlations for the Premature Group in which as head control increased, so did visual fixation times. This also could explain the negative correlations for the more mature Intensive Care Group, in which as head control increased, visual fixation times were de-
creasing. The findings regarding positive correlations for Prone and Prone Tilt for the whole group, including the Normal Group infants, are less easy to explain by a general maturity factor, and suggest the dependence of visual fixation on adequate head control at least in these postures. In a group with greater disparity between level of postural control and chronological age due to motor deficits, such a relationship might be more clearly defined. One might also argue that postural control of the head is dependent on visual fixation. During maturation the eyes assume an increasingly directive role in determining head, limb, and body attitudes, but present information on maturation of the postural reflexes has suggested that optic reflex control of antigravity posture does not occur until approximately six months (Magnus, 1926; Fulton, 1949).

Relation to Asymmetric Tonic Neck Reflex Scores (ATNR). The results of the correlation of Asymmetric Tonic Neck Reflex Scores with Visual Fixation Scores in Supine posture do not clearly support any relationship. The suggestion of Gesell et al (1949) that the ATNR contributes to visual fixation was not supported by the results of this study. ATNR Scores for the Normal Group were low. In the Premature Group the higher ATNR Scores in resting postures seemed appropriate to corrected age and a nonsignificant negative correlation occurred \( r = -0.416, p = .116 \). The Intensive Care Group had comparable ATNR Scores to the Prematures though these occurred with head turning rather than predominant resting postures. This group demonstrated a nonsignificant positive correlation \( r = 0.502, p = .07 \). These results are not indicative of any trend.
They may, however, reflect different degrees of immaturity, or possible central nervous system dysfunction. Normally, the ATNR is not strong during the first month, but becomes stronger during the second and third months, decreasing or becoming inhibited at approximately four months (Peiper, 1963; Bobath, 1966, 1972; Andre-Thomas et al, 1960). Visual Fixation times have also been described as increasing, then decreasing at about four months (Barten and Ronch, 1971). General maturity of a younger infant might be reflected in increases in both, or an infant closer to four months by decreases in both. When the ATNR is exaggerated in strength or retained beyond the usual age for disappearance, possible central nervous system dysfunction may be indicated, which could result in either poor or exaggerated visual fixation reflexes.

Visual Pursuit

Group differences. Visual Pursuit Scores reflected Group differences more clearly than Visual Fixation Scores. Although the Premature and Intensive Care Groups included some very low pursuit scores, their high scores were still within the range for the Normal Group, and the means were significantly different. In rank order, the Premature Group was lowest and Normal Group highest. This rank order existed for all postures.

Differences in Visual Pursuit Scores reflected the quality of pursuit as well as frequency. Higher scores reflected oculocephalic pursuit over a wider arc, and lower scores more ocular pursuits and oculo-occephalic pursuits over a smaller arc. These differences in pursuit responses may have been related to general maturity either in terms of oculomotor coordination or cognitive processes.
The infants in the present study demonstrated varying degrees of maturity of oculomotor coordination. The Normal Group followed the moving stimulus accurately and without overshoot. They typically demonstrated oculocephalic pursuit more than 90° or a full 180°, and showed few ocular pursuits. The Premature Group did not pursue accurately; they tended to get ahead of the stimulus and to lose it on change of direction. This group showed many ocular pursuits, and many oculocephalic pursuits tended to be under 90°. Several of the Intensive Care Group tended also to lose the stimulus on pursuit, and a number of ocular pursuits occurred in this group also.

These observations were in agreement with the findings of Trevarthen (Harvard, 1968) who has studied the coordination of eye and head movements in visual pursuit both in infants and adults. Shortly after birth the newborn infant tracks slowly moving close objects with ocular pursuit alone. By two months he shows increased participation of the head in tracking, but head mobility for tracking is deficient. Gesell et al (1949) attribute this restricted range to the effect of the Asymmetric Tonic Neck Reflex. Before four months the infant's head moves unsteadily, appears to wander, and overshoots. By four months the infant's head movements are stronger, more deliberate, and accurate tracking at increasing speeds is possible. The improved coordination reflects the maturation of the proprioceptive feedback control of the muscles which rotate the neck.

Research evidence indicates that the type of visual pursuit shown by an infant may also be related to interest or to cognitive processes. The findings of Barten et al (1971) indicated that ocular pursuit and oculocephalic pursuit lie on a continuum of response strength
even in the newborn. In a comparison of stimuli strengths a greater amount of oculocephalic pursuit occurred with the stronger stimulus. In the present study the stimulus should thus be considered a possible factor in Group Visual Pursuit differences. It is possible that they responded to the stimuli according to maturity and that the stimulus was more effective with the more mature infants. The stimulus as a variable could only be ruled out by replication with several stimuli or with a group matched for stimulus preference.

Nelson (1971) and Bower (1971) have explored the infant's development of object concept or central representations in visual tracking experiments. Their results suggest that ocular pursuit alone is tracking of a movement stimulus, and oculocephalic pursuit is tracking of a moving object as an object. They suggest that the younger infant may not relate the moving object to the same object when it is static. By four months infants may perceive the object as moving from place to place.

**Effect of postures.** Visual Pursuit Scores varied significantly in the postures in which the infants were placed. There was no significant effect for Order of the postures, suggesting no bias because of fatigue, stimulus satiation, or previous postural set. Experimental technique in stimulus presentation may, however, be a possible factor in differences.

Visual Pursuit Scores for the whole group were highest in Supine and Upright Sitting, which were not significantly different from each other. Supine Tilt was next highest in the rank order, and Prone Tilt and Prone lowest. Rank order and significant differences between postures varied somewhat in the different groups. (See Table 5.)
Highest means in the Normal Group occurred in Upright Sitting, then Supine Tilt, Supine, Prone and Prone Tilt. Although Upright Sitting and Supine Tilt showed significantly higher means than Prone or Prone Tilt, there was no significant difference between Upright Sitting, Supine Tilt, or Supine, nor between Supine and Prone. These results suggested that when head control is adequate, fixation by a supporting surface is no longer as important and that the mature four month infant is capable of good oculocephalic pursuit in all of these postures with some advantage for the Upright Sitting and Supine Tilt as compared with Prone. This may reflect some vestibular effect or less complete head control in Prone.

Upright Sitting was significantly the best posture for Visual Pursuit for the Premature Group in spite of some unsteadiness in head control. In rank order Supine and Supine Tilt means were next highest, and Prone Tilt and Prone means lowest. Higher Visual Pursuit Scores in Upright Sitting may have been due to some vestibular effect or to a special problem with pursuit motions. In Supine and Supine Tilt their long flat-sided headshape (eight of ten infants) and weaker muscular control may have caused pursuit to be more difficult. Head position was predominately to the side in these postures as compared with midline in Upright Sitting. The Visual Pursuit mean for Prone Tilt was significantly higher than Prone for the Prematures, possibly related to the facilitatory effect on postural control of the head.

Supine was significantly the best posture for Visual Pursuit for the Intensive Care Group. The other postures were not significantly different from each other, although Upright Sitting and Supine Tilt were next in rank order. Supine posture reflects some advantage for fixation,
but postural control against gravity in this group should have been adequate to support pursuit. This lack of clear differences may reflect a problem of visual interest or general alertness. It may also be due to a variety of postural and visual score profiles within the group. (See Master Data Sheet, Appendix F, Table 10.)

**Effect of headshape.** According to Gesell et al (1949) round-headed infants may regard in the midline and pursue past the midline earlier than long-headed infants. Headshape (round or long) did not emerge as a significant main effect on Visual Pursuit Scores in Supine in the present study. Significant effects for Group, Group x Sex and Group x Sex x Headshape are described graphically in Figure 2. The analysis may have been affected by the younger gestational age of several Premature females, as well as a zero cell size for Normal Male Headshape Long. The Normal Group included only two long-heads, the Premature Group eight, the Intensive Care Group four. While headshape appeared to be a mechanical factor for the Premature Group during the experiment, it was not an obvious factor to the investigator in observing the Intensive Care Group. The graphic comparison for this group shows the possible differences more clearly. Round-heads appeared to have the higher visual pursuit scores as did the females in this group.

The occurrence of long flat-sided heads in low birthweight infants due to weak muscles and molding of the skull has been described by Baum (1971). In the Intensive Care Group relatively long headshape could be the result of normal variations, or secondary to illness, weakness or possible neurological involvement causing head to side postures for longer than the usual time. Although head control in the midline was
established for this group, any deterrent to pursuit may have been significant. In the Normal Group, apparently any variation in headshape was no longer a significant factor when head control was well established. An objective measure for determining degree of differences in headshape might also have clarified this effect.

Relation to postural control. The highly significant correlations between Total Visual Pursuit Scores and Total Postural Control Scores appear to indicate that oculocephalic pursuit over a wide arc with accuracy requires adequate postural control of the head—both fixation and mobility. The correlations of postural control and visual pursuit seem to be especially associated with positions requiring antigravity head control—Upright Sitting, Prone, and Prone Tilt. Supine and Supine Tilt only show significant correlation for the Premature Group, where head control for midline fixation was immature and long headshape a probable factor. In these postures external fixation is provided by the surface, although controlled rotation depends on development of postural fixation in the midline. The Normal Group did not show a significant correlation for Upright Sitting, possibly because of a ceiling effect with control well established. Although all groups showed significant correlations in Prone, only the Normal Group showed significant correlation in Prone Tilt. This result was somewhat a surprise as the other two groups did demonstrate higher means for Visual Fixation in this posture, and the Premature Group also showed better pursuit than in Prone. The facilitated fixation and the restraint of the wedge itself may have in some way not encouraged pursuit for the full-term infants.

The strong relationship between Visual Pursuit and Postural
Scores might also be interpreted as manifestation of the general maturity of the infants. Again, the specificity of the results in different groups and postures may argue for a more direct relationship. It is also possible that visual pursuit, as a reflection of mental alertness, may contribute to postural control. As previously discussed for visual fixation, we do not yet have evidence that optic righting is developed at age four months.

Caution should be observed in any assumptions of mental development on the basis of motor control. Illingworth (1962) points out that some affective tasks may depend on motor development. The results of this study point to such dependence for visual pursuit.

Relation to Asymmetric Tonic Neck Reflex (ATNR). The significant negative correlation for the whole group of Asymmetric Tonic Neck Reflex Scores and Visual Pursuit Scores in Supine, supports the original prediction and is in agreement with Gesell et al (1949) on the effects of this reflex. Other factors such as general alertness and headshape undoubtedly were also contributory.

Sex and Parity

Sex and Parity were not significant effects on Visual Fixation or Visual Pursuit Scores in the data analysis. In the analysis of variance of Visual Pursuit Scores in Supine as a function of Group, Sex, and headshape, the significant interactions for Group and Sex, and Group, Sex, and Headshape are not clear in meaning. There is a suggestion that female infants may have had higher Visual Pursuit Scores in Supine than male infants.

Sex differences in visual functions have not been reported in
neonatal studies (Korner, 1970; Korner and Thoman, 1970). They may emerge gradually, however, due to possible differences in developmental rates and to differences in experiences. Present evidence indicates that sex differences in visual behavior develop in the early months as a result of maternal responses varying with sex of the infant (Moss and Robson, 1968, 1970; Lewis, 1972). Time-sampling techniques for studying maternal-infant interactions in the home have shown that male infants at three weeks and three months may have longer fixation times than female infants. This may have been an effect of slower maturation rate by male infants contributing to more fussing and crying, and leading to more handling and rocking of males in the early months. Slower maturation rates of male infants may also have been interpreted as indicating slower visual system processing for male infants. In the present study the suggestion of higher fixation times for females may have reflected differential responses to adversity. Some decrease in sex differences for visual behavior seems to occur by three months (Moss and Robson, 1968, 1970; Lewis, 1972), which may explain why in the present study differences for the Normal Group were less obvious. (See Figure 2.)

The lack of significant sex differences in the present study, other than the unclear ones in the headshape analyses, may be due to the difference in procedures. Time-sampling studies of maternal-infant interactions involve a longer period of time and may more accurately reflect the infant's spontaneous frequency of looking. The present study, involving a briefer time sample and an administered visual stimulus, may have been an indication of the infant's motor ability to look.

Korner and Grobstein (1966) suggested a tendency for primip infants to scan and alert more than multip infants in response to soothing,
but effect for parity did not reach significance. Later work by Korner (1970) studying variables associated with neonates' capacity for visual alertness, did not demonstrate any effects for parity.

Perhaps maternal-infant interactions were made more similar for the Premature and Intensive Care Groups by the special care needs of the infants both in the hospital and home. Illness or prematurity of both sexes may have reduced any maturational lag for males and caused care interactions to be more similar. Any differences which might be due to parity of the mother, involving attitudes, availability, or skills, might also be reduced by special care needs or concern for these infants. It is possible that the suggestion of sex differences in Supine Visual Pursuit for the Intensive Care Group especially, were revealed in the most favorable posture for pursuit for this group. In the other postures varied profiles of postural and visual functioning may have erased the effect of Sex as well as the differences between the other postures. Postural and other variables could be more important than sex at this age.

**Vestibular Effects**

The findings of this study regarding Visual Pursuit for the Premature and Normal Groups provide only limited agreement with the work of Korner and Grobstein (1966) and Korner and Thoman (1970) in which it was suggested that vestibular stimulation as administered in upright postures and rocking movements, enhanced visual alertness and scanning movements in newborns more than supine posture with tactile or auditory stimuli. In their experiments visual alertness and frequency of scanning movements were scored as they occurred spontaneously during a 30 second period in
the posture and immediately after, in contrast to the longer periods for postures and stimulus presentation of the present study. Differences in handling may have occurred because of the infant's age, with more supporting of the newborns' heads. It is also possible that the "Lid-opening Reflex" as described by Peiper (1963), which occurs when a lightly sleeping newborn is brought from lying to vertical position, contributed to the results of Korner's studies. Her findings may have been the result of the vestibular stimulation of semicircular canals and otoliths occurring in angular and linear acceleration, rather than the gravity stimulation of the otoliths as a position is maintained. It is not known how long the effect of semicircular canal stimulation may last following movement, nor if this continues to be a significant factor in visual alertness in the older infant.

Two types of otolithic postural reflexes which are positional may be pertinent to the results of the present study—labyrinthine righting reactions and tonic labyrinthine reflexes. The significant correlations of Postural Control of the head with Visual Fixation and Pursuit in antigravity postures may be related to the maturation of the labyrinthine righting reactions. The development of the ability to erect the head in upright, in prone, and as pulled to sit in the first months is attributed to the maturation of these reactions (Peiper, 1963; Fulton, 1949). These reactions might not only contribute to the head control needed for visual fixation and pursuit in antigravity postures, but could also exert some alerting effect on the visual system. The righting of the head in space has often been described as serving the purpose of orienting the distance receptors. Enhancement of pursuit movements in Upright Sitting in the Normal and Premature Groups suggests such a possibility. The generally
lower visual scores in Prone and Prone Tilt postures could be indicative of relatively less mature righting mechanisms in these postures at four months. Optic righting reactions may also begin to function at an earlier age in upright than in prone.

It is also possible that differences according to postures for Visual Fixation and Visual Pursuit Scores have some relationship to tonic labyrinthine reflexes in the young infant. Some knowledge of the effects of abnormal or released tonic labyrinthine reflexes on general static postural tone is available, but the normal role of these reflexes in early human infant development is not yet fully understood (Peiper, 1963). The abnormal tonic labyrinthine reflex as demonstrated in laboratory animals and brain damaged humans is considered to exert its strongest effect on static muscle tone in supine posture (Magnus, 1926; Fulton, 1949; Bobath, 1966, 1972). One might conjecture that enhancement of visual fixation in supine is somehow related.

There is evidence that tonic labyrinthine and neck reflexes are involved in countertorsion movements of the eyes when the head is tilted or turned in newborns and in adults (Peiper, 1963; Scott, 1967). These normal compensatory eye movements and postures involve semicircular canal mechanisms for the actual eye movement, and are maintained by otolithic positional reflexes. These are slow-adapting and may have contributed in the present study to some of the postural differences in visual functions, particularly pursuit.

When the head is tilted or rotated on the body, the eyes move in a direction opposite to that taken by the head and serve the purpose of maintaining the position in space and visual field existing prior to the head movement. With the head raised in prone, the gaze deviates down-
ward, contracting the inferior recti and superior oblique muscles, and reciprocally relaxing the superior recti and inferior oblique muscles. If the head is flexed forward, as it may be in very immature Upright Sitting, the opposite would occur and the eyes would be maintained in an upward gaze. In supine head to side posture similar effects would occur with the internal and external recti of the two cycs cooperation. Lateral flexion of the neck, as occurred in the infant seat with the Premature Group, would cause a similar countertorsion. Although these countertorsions may not be obvious on observation, they can be demonstrated by electro-oculography (Scott, 1967).

In the present study when the head was held midline, and not tilted at the neck, these compensatory tonic reflexes acting on the eyes were probably inactive or minimal. These conditions seemed to occur in midline Supine and Supine Tilt postures and Upright Sitting. Perhaps pursuit movements and the accompanying fixation movements involved in establishing the image on the fovea were easier with the eye centered in the orbit and free for quick adjustments rather than deviated in the contraction and reciprocal relaxation of the countertorsions. This is consistent with the description of the reciprocal innervation of the eye muscles as designed for rapid adjustment (Whitteridge, 1960). Electromyographic recordings have demonstrated considerable resting discharge in all eye muscles of man with the eye centered. During slow movement, antagonistic muscles show decreasing discharge, and on faster movements there is complete reciprocal relaxation of antagonists at the onset of movement, with no "checking" action to halt a movement. Speed of these reciprocal adjustments may be enhanced when the eye is centered.

Complex relationships between the visual system and vestibular
system have been identified and are being utilized in the diagnosis of central nervous system and peripheral oculomotor conditions (Kornhuber, 1970; Monnier, 1970; Benitez, 1970; Bergmann and Costin, 1970; Scott, 1967). Other experiments have related the vestibular and visual systems to visual perception of localization in space (Miller and Graybiel, 1966). A number of neonatal reflexes relate the two systems, enabling the measurement of visual acuity in the very young infant (Andre-Thomas et al., 1960; Prechtl, 1964; Peiper, 1963; Paine, 1962; Dayton et al., 1964; Kiff and Lepard, 1966). A close relationship between the vestibular system and oculomotor coordination for everyday looking and seeing in the growing infant seems probable. While the present study was not designed to test specific vestibular effects, they may be an important factor in the results demonstrating significant differences in visual fixation and pursuit between postures and the relationships with head control.

CONCLUSIONS

Primary Conclusions

The results of this study suggest that several postural factors are related to the capability of four month infants for visual fixation and horizontal visual pursuit in different postures.

1. Fixation or stability of the head is a necessary prerequisite for efficient fixation reflexes of the eyes and to support the controlled rotation or mobility necessary for efficient and accurate oculoccephalic pursuit. Fixation can be provided by the supporting surface, however, adequate head control in the midline is necessary for efficient pursuit movements, especially in antigravity postures.
2. The mobility necessary for efficient pursuit requires freedom from mechanical interference by the supporting surface and of limitation of head and/or eye movements by the asymmetric tonic neck reflex.

3. Centering of head and eyes is necessary for most favorable pursuit movements. Optimal centering is provided by midline postures in which the head is not tilted laterally, ventrally, dorsally, or rotated on the body.

These conclusions may be generalized from this group to other infants of approximately four months of age who do not exhibit obvious disorders of muscle tone. Some cautious applicability to infants of a younger age, or with delays in head control not associated with abnormal tone may be justified. Any generalization to the child with cerebral palsy is tentative. The neuromuscular disorder of cerebral palsy in the young child is expressed in both developmental delay and abnormal postural tone with maximal to apparently no effects on head control in early infancy. Defects in oculomotor coordination have also been attributed to the abnormal tonic reflexes (Bobath, 1966, 1972). While the conclusions regarding the need for fixation, mobility and centering of head and eyes may be applicable to infants and children with cerebral palsy, it is possible that these conditions may best be met in different postures than those indicated in the present study.

Secondary Conclusions

Group differences in this study indicate that infants with early illness or conditions requiring intensive care may function below normal infants in postural control and in visual coordination. Close follow-up of total developmental and ophthalmological condition is indicated. Re-
suits support the generally accepted premise that premature infants function according to corrected age rather than postnatal age.

Although sex and parity were not clearly significant main effects in this study in determining the capability of four month infants for visual fixation and pursuit, these results do not indicate that they are not factors in the spontaneous visual behavior that occurs in everyday maternal-infant interactions in the home.

**INFERENCES**

The development of a mechanism for release of fixation and shift of gaze may be inferred by the decrease in fixation times that seemed to be associated with the most mature four month infants in this study. This ability appears to be related to the development of midline fixation, antigravity head control, and controlled pursuit.

Although direct vestibular effects on visual fixation and visual pursuit were not the subject of this study, differences in visual functions in different postures and relationships to head control could be attributed to vestibular effects. Labyrinthine tonic and righting reflexes may exert direct effects on fixation of the oculomotor mechanism or alerting of the general visual system.

The postures demonstrated as optimum for visual fixation and pursuit under the experimental conditions of this study, may also be optimum for self-initiated or spontaneous visual experiences and learning. Everyday observations might demonstrate capability for visual fixation and pursuit in different postures more strongly, or that many more factors are involved. The visual environment of the infant, maternal-infant interactions and what is available to look at within the visual field, is
undoubtedly also important.

IMPLICATIONS

Management and Stimulation

The results of this study may provide some relevant guidance for the enhancement of visual fixation and pursuit in intervention programs designed to provide infant developmental stimulation or to test its effects. The infant who lacks postural control of the head requires adequate external support to be able to fix his eyes. Support providing midline posture of the head is suggested to assist visual pursuit, should midline posture be delayed. Without this the infant may be able to fix on a stimulus in his visual field, but be limited in ability to seek out or happen upon visual experiences. As a child of four months is rarely placed in a high chair because of insufficient trunk control, other equipment which adequately supports the infant in a tilted up position, as well as holding him on the lap in sitting, may provide optimum experiences. Recommendations regarding optimum postures do not imply that an infant should be placed only in these postures, or provided visual stimulation only in these postures. Some caution is needed lest a visual stimulation program contribute to postural and oculomotor developmental problems. In a crib environment stimuli might be placed within appropriate focal distance in locations appropriate for centering of vision, such as directly above the supine infant's face. Other stimuli might be varied in positions on sides and ends of the crib, and at different distances. Changing the position of the stimulus may be a novelty too.

Physical and occupational therapists and others involved in remedial management of infants with motor handicaps or motor delay should
be aware of the need to vary positioning to provide optimal visual experiences. When therapeutic management indicates prone or prone tilt positioning for encouragement of antigravity extension of the neck, trunk, and hips necessary for achieving erect upright posture, or for countering hip flexion deformities, the therapist should keep in mind that positioning over a wedge may enhance the opportunity for visual experiences more than prone. Visual capabilities may be less in these postures, however, and need for time in other postures with appropriate visual stimulation should be recognized. Equipment modification to provide midline fixation and tilt upward may be designed to facilitate visual experiences for the infant with inadequate head control or deviations in headshape and size. Until general principles relating the abnormal postural patterns of the cerebral palsey child and visual functions are available, the therapist should explore oculomotor coordination in the individual child. Visual fixation times, pursuit in different directions, and focal distance should be explored in various postures in order to discover the optimum situation for visual functions for that child. In the school situation appropriate positioning and chair modifications providing fixation in the midline, mobility, and centering of head, and eyes should be considered to facilitate visual learning opportunities. When a child has unstable head control, special cerebral palsy chairs with suspension apparatus for the head may fulfill these requirements better than those chairs where the child can only fix his head by leaning against a side-piece.

Posture as a Variable in Psychological Research

The posture in which an infant is placed, as well as his level
of head control, may influence the results of experiments with visual fixation and pursuit as criteria. In visual discrimination experiments utilizing duration or frequency of visual fixation as criteria, the optimum posture for visual fixation is indicated with minimizing of postural control of the head as a variable. The results of this study support the experimental procedure described by Kantz (1967) in which a supportive canvas baby seat in a semi-reclining posture was used for visual preference experiments. Supine posture with the head supported in the midline may provide the optimum conditions for visual fixation as an indicator of visual discrimination or preference for the very young infant with poor head control. A supine tilt or semi-reclined posture, however, is recommended in any across-age or longitudinal study where differences in fixation times may reflect visual processing efficiency or release mechanisms. In experiments using visual fixation times as criteria, upright sitting at four months could perhaps reflect individual differences in head control. In studies of individual differences reflecting an infant's capability for visual fixation, prone posture could be the most revealing.

Where visual pursuit criteria are used as indicators of perceptual or cognitive processes, midline head posture and freedom for head rotation may be important factors for oculocephalic pursuit. The newborn or very young infant may perform best placed in supine with a molded support of the head in the midline. Supporting the infant in upright sitting is suggested when the infant can maintain the head erect. In the procedure described by Nelson (1968, 1971) for visual tracking experiments as indicators of the development of object concept in infants of three to nine months, the infants were held in the upright sitting posture on their mothers' laps. This was the optimum position according to the re-
suits of the present study for the normal and premature infants. If the head is still bobbing in upright or cannot be maintained, a supine tilt posture is suggested, preferably contoured to enhance head rotation. If the headshape is very long or flat-sided as with some premature infants, upright sitting may be preferable even if some unsteadiness of the head is still present. In an across-age or longitudinal study, supine tilt posture with provision for midline support may be the optimum position. Prone posture would again reflect individual differences in capability for pursuit.

Recommendations for Research

Replication of the present study is recommended with larger numbers of normal full-term infants representative of the normal variations in head control. Clearer findings might be obtained for a premature group by including infants of the same gestational age at birth. If "sick-infants" are included, a large enough sample to take into account some classification of diagnoses or time in the intensive care nursery could provide clearer results. Matching for discrimination ability or stimulus preference could reduce variations due to differences in perceptual processes.

Further research on the effects of postures and head control on visual fixation and pursuit in different directions could be conducted across ages or longitudinally. Correlation and follow-up studies of visual discrimination or mental scales could provide information as to whether motor capability for visual fixation and pursuit affected visual learning. Confirmation of the significance of postural variables in spontaneous visual behavior might be studied by replication of the present
study in correlation with findings of time-sampling of visual behavior in
the home.

Much work is needed in clarifying vestibular effects on the
visual system. The question of whether the labyrinthes exert a direct
alerting effect on the visual system might be tested by examining visual
criteria in upright head posture under two conditions: 1) with head and
body fixed to a support, and 2) with the head free for active postural
reactions.

Further information is needed on the effects of semicircular
canal stimulation, or angular and linear acceleration, on visual alert­
ness in infants of different ages, and how long these effects operate as
a posture is maintained. Interventions such as rocking the infant in the
arms as well as with equipment such as cradles, wind-up swings or infant
seats might be studied.

Oculomotor coordination in infants and children with cerebral
palsy should be studied as a function of degree of head control, postures,
and presence of abnormal tone or tonic reflexes in various postures.
Visual fixation, pursuit in different directions, voluntary gaze, and
vergence might be included as dependent variables in such a study. Elec­
tromyography would provide the most accurate technique for observation.
The differential effects of tonic labyrinthine and tonic neck reflexes
should be clarified as they occur in the abnormal form. Deviations of
gaze to the same direction as the face have been attributed to asymmetric
tonic neck reflexes (Bobath, 1966, 1972), and observed in the investiga­
tor's clinical experience. Deviations of gaze similar to exaggerated
countertorsions have also been observed in children with strong tonic
patterns. Implications for positioning in management should be explored.
SUMMARY

The purpose of this study was to explore some of the possible relationships between development of the visual system and the total action system of the young child. When these visual and postural abilities are deficient, the implications for restriction of early visual experiences and learning are of the utmost importance. The key age of four months was chosen as a time in development when significant maturation of postural control of the head and of the visual system has occurred. It was hypothesized that the infant's capability for visual fixation and visual pursuit vary between postures in which the infant is placed, and that visual scores correlate with the development of postural control of the head. Headshape (round or long) and the asymmetric tonic neck reflex were predicted as factors in visual functioning.

The subjects included three groups of ten infants of approximately four months age, equally divided for sex, all of the white race. The groups were: normal full-term infants; premature infants; and "sick-infants" requiring early intensive care treatment. Infants were placed in a random order of five postures—supine, prone, upright sitting, supine tilt in an infant seat, and prone tilt over a wedge cushion. Postural control of the head was scored both for spontaneous behavior in each posture and for induced responses. Tests for visual fixation and visual pursuit were administered in each posture. A factorial design was used with three way analyses of variance to test effects of postures, group and sex. Other factors tested were headshape and parity of the mother. Correlations were performed between visual fixation and visual pursuit scores with postural scores and with asymmetric tonic neck reflex
Results of the study provided support for the hypothesized differences in visual fixation and pursuit in different postures. Supine, supine tilt and upright sitting were more favorable postures than prone and prone tilt, with variations according to group, head control, head shape and the asymmetric tonic neck reflex.

Results suggested several basic factors related to the capability of four-month infants for visual fixation and pursuit in different postures: 1) Fixation or stability of the head as provided by either active head control or external support is a prerequisite for visual fixation and to support controlled pursuit; 2) Mobility necessary for efficient pursuit requires freedom from mechanical interferences and of limitation of head and/or eye movements by the asymmetric tonic neck reflex; 3) Centering of head and eyes is necessary for most favorable pursuit movements and is best provided by midline postures without neck tilt or rotation. Generalizations are made to four-month infants without known disorders of muscle tone, with cautious applicability to infants of a younger age or with delay in head control. While these basic factors may have some application to infants with cerebral palsy, the presence of abnormal tonic reflexes may cause differences in optimum postures. Implications for developmental stimulation, and physical occupational therapy management of infants are discussed, and suggestions for control of posture as a variable in psychological research with infants made. Implications for further research are discussed.
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**Books**


Other Sources


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Cratty, Bryant J. (1966). The Perceptual-Motor Attributes of Mentally Retarded Children and Youth. Monograph, Mental Retardation Services Board of Los Angeles County.


SELECTED BIBLIOGRAPHY


Figure 3

Prone Wedge

Materials: Foam rubber 4" thickness for base

3" thickness for side pieces

Vinyl-coated fabric

Use: The infant is placed in the prone position over the wedge, with arms and head over the higher end.
APPENDIX B

PERMISSION FORM

Thesis Study - Nancy M. Fieber, R.P.T.

I give my permission for Mes. Fieber to examine my baby __________________ for the purpose of her thesis study "The Relation of Visual Fixation and Pursuit to Posture in Four Month Infants." I have been fully informed as to the methods and procedures involved, the question of risk or safety of my baby, and the benefits to be gained by the study in understanding of infant development. I understand that I am free to withdraw my baby's participation at any time without jeopardy.

Date ____________________________

Signature

Your relationship to patient

Witness

I also give my permission for photographing or filming my baby and myself during the examination, and the use of this material in the research project, in publication in professional literature, or for educational purposes.

Signature
APPENDIX C

Order of Postures

The following are the orders of the postures administrated to 30 subjects as determined by random selection:

Supine - S  Supine Tilt - ST
Prone - P  Prone Tilt - PT
Upright Sitting - U

- PT-U-S-P-ST  ST-PU-U-S-P  ST-S-U-P-PT
- P-S-U-PT-ST  ST-P-U-PT-S  P-PT-ST-S-U
- S-U-P-PT-ST  P-ST-S-PT-U  ST-S-PT-U-P
- P-S-U-ST-PT  U-ST-P-PT-S  S-U-PT-U-ST
- U-PT-P-S-ST  U-P-S-ST-PT  S-ST-PT-U-P
- U-P-S-PT-ST  P-PT-U-ST-S  ST-P-S-PT-U
- P-S-PT-ST-U  P-U-S-PT-ST  PT-ST-P-U-S
- U-S-P-PT-ST  P-S-ST-PT-U  U-P-PT-S-ST
- U-ST-S-PT-P  ST-PT-P-U-S  U-ST-S-P-PT
- PT-P-ST-U-S  S-ST-U-P-PT  P-S-PT-ST-U
## APPENDIX D

### Data Sheet Posture

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</table>

**SUPINE:** 3 min. HEAD: (0) one side; (1) changes lx; (2) more lx; (3) midline; (4) midline only; (5) midline, turns; (6) turns body.

ATNR: ARMS (0) sym., other; (1) partial; (2) full, not sust.; (3) full, sust.

**PRONE:** 3 min. HEAD (0) side; (1) attempts; (2) turns; (3) raises less 45°; (4) raises 45-90°; (5) 90° over 10 sec.; (6) 90°, turns.

**UPRIGHT SITTING:** 3 min. HEAD (0) sags; (1) attempt; (2) partial; (3) up brief; (4) up, oscill.; (5) up steady; (6) up, turns.

**SUPINE TILT:** 3 min. HEAD (0) side; (1) changes lx; (2) more lx; (3) brief midline; (4) midline; (5) midline, turns; (6) turns body

**PRONE TILT:** 3 min. HEAD (1) sags, side; (1) attempts; (2) turns; (3) raises less 45°; (4) raises 45-90°; (5) 90° over 10 sec.; (6) 90°, turns.

### INDUCED RESPONSES

**HEAD, PULLED TO SIT:** (0) compl. lag; (1) partial; (2) sl. lag; (3) in line, or lead.

**HEAD, TILTED IN SPACE:** (0) none; (1) partial; (2) in line; (3) tilt up.

**VENTRAL SUSPENSION:** (0) sags; (1) bobs; (2) in line; (3) above.

**NECK RIGHTING:** (0) none; (1) delayed; (2) lag; (3) Seq. follow.

**ATNR:** ARMS (0) none; (1) partial; (2) full, not sust.; (3) full, sust.

### TOTAL POSTURAL SCORE (less ATNR)  ATNR TOTAL

### COMMENTS:
# APPENDIX E
## Data Sheet Vision

<table>
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<th>Name</th>
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Score Duration Visual Fixation: number seconds.

Score Visual Pursuit: (0) none; (1) OP only; (2) OCP less 90°; (3) OCP 90°; (4) OCP more 90°; (5) OCP 180°.

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**SCORE DVF:**

**SCORE VP:**

VP 1st 3 trials ____ last 3 trials ____

Comment: ________________________________
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APPENDIX G

Table 11. Results of Analysis of Variance of Visual Fixation Scores as a Function of Group, Sex, and Place in Order of Postures (First-Last).

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* p < .05
** p < .01

Table 12. Results of Analysis of Variance of Visual Pursuit Scores as a Function of Group, Sex, and Place in Order of Postures (First 3 Trials - Last 3 Trials).

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* p < .05
** p < .01
Table 13. Results of Analysis of Variance of Visual Fixation Scores as a Function of Group, Sex, and Parity of the Mother (Primiparae vs. Multiparae).

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α Significant F 1/18 df .05 = 4.41; .01 = 8.28.
* p < .05
** p < .01

Table 14. Results of Analysis of Variance of Visual Pursuit Scores as a Function of Group, Sex, and Parity of the Mother (Primiparae vs. Multiparae).

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>df</th>
<th>MS</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main Effects</strong></td>
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<tr>
<td>Group</td>
<td>2</td>
<td>21967.32</td>
<td>17.64**</td>
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<tr>
<td>Sex</td>
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<td>242.60</td>
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</tr>
<tr>
<td>Parity</td>
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<td>1259.08</td>
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<tr>
<td><strong>Interaction Effects</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Group x Sex</td>
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<td>763.49</td>
<td></td>
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<tr>
<td>Group x Parity</td>
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<tr>
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<td>1.08</td>
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<tr>
<td>Group x Sex x Parity</td>
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<td>53.78</td>
<td></td>
</tr>
<tr>
<td><strong>Error</strong></td>
<td>18</td>
<td>1245.33</td>
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* p < .05
** p < .01
Table 15. Results of Analysis of Variance of Total Postural Scores as a Function of Group, Sex, and Parity of the Mother (Primiparae vs. Multiparae).

<table>
<thead>
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<td>17.06**</td>
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<tr>
<td>Parity</td>
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</tr>
<tr>
<td><strong>Interaction Effects</strong></td>
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</tr>
<tr>
<td>Group x Sex</td>
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<td>18.51</td>
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</tr>
<tr>
<td>Group x Parity</td>
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</tr>
<tr>
<td>Sex x Parity</td>
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<tr>
<td>Group x Sex x Parity</td>
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<tr>
<td>Error</td>
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<td>23.89</td>
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* p < .05  
** p < .01