The Relative Efficacy of Vestibular-Proprioceptive Stimulation and the Upright Position in Enhancing Visual Pursuit in Neonates

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GREGG, CLAUDETTE L.; HAFFNER, M. ELLEN; and KORNER, ANNELIESE F. *The Relative Efficacy of Vestibular-Proprioceptive Stimulation and the Upright Position in Enhancing Visual Pursuit in Neonates.* CHILD DEVELOPMENT, 1976, 47, 309–314. 48 healthy neonates born to multiparae were randomly assigned to view a moving stimulus either in the horizontal or the upright position, with or without added vestibular stimulation and with or without pacifier sucking. The infant was shown a moving black line inside a strictly controlled visual environment provided by an apparatus which permitted horizontal and upright positioning and displacement of the infant. Visual tracking was recorded by a concealed TV camera positioned at a constant distance and angle from the infants' eyes in both positions. Quality of tracking during each of 4 trials was scored on a 7-point scale. Results indicate that vestibular-proprioceptive stimulation provided to the infant either horizontally or semivertically significantly enhanced his visual tracking, whereas the upright position did not. Pacifier sucking also improved his performance.

Recent studies have attempted to delineate the stimulus components inherent in common maternal ministrations to which newborns are most responsive (Korner & Grobstein 1966; Korner & Thoman 1970, 1972). When interventions replicating common maternal soothing techniques which entailed singly or in combination contact and vestibular-proprioceptive stimulation with and without the infant in the upright position were made with crying neonates, it was found that the interventions entailing vestibular-proprioceptive stimulation and the upright position were far more effective in soothing and in evoking visual alertness than was contact. Yet the anthropological and early-stimulation literature has stressed primarily the importance of body contact and tactile stimulation for early development. The fact that, less visibly, vestibular-proprioceptive stimulation is involved in almost every contact between mother and child had not been generally recognized.

The above studies did not, however, clarify the differential efficacy of vestibular-proprioceptive stimulation and the upright position in bringing about behavioral changes in neonates. Studies by Harper (1972) and by others stressed the primary effect of the upright. Since vestibular-proprioceptive stimulation is a much more pervasive form of stimulation in the interactions between mother and child and is indeed already highly prevalent in prenatal life, it seemed important to us to sort out whether it is this form of stimulation or the upright position which brings about attentiveness to the environment. This then was the first question to be clarified in the experimental study described below.

There were several additional questions this study sought to answer. For example, our previous studies assessed primarily the effectiveness of various maternal types of interventions in bringing about a *state of visual alertness* in the neonate and not their relative efficacy in evoking *attentiveness to a visual stimulus.* It was inferred that the state of visual alertness predictably brought about by

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vestibular-proprioceptive stimulation and/or the upright position would lead to visual attentiveness to specific stimuli within the environment. One of our objectives was to test whether this inference was correct and whether indeed these forms of stimulation would lead to visual scanning of a specific stimulus. Also, while an attempt was made in the previous study to control the visual environment by illumination levels so low that the infant's eyes were exposed to only 3 foot-candles in each of the positions tested, the naturalistic approach of this study with its emphasis on replicating typical maternal ministrations did not allow for complete control of the visual surround. Conceivably, the different interventions could have exposed the infant to more or less visible moving shadows, leading to differential levels of alertness. To preclude this possibility, the study described below was done in a strictly controlled visual environment.

Because other studies, such as Wolff and White's (1965) and one from our laboratory (Thoman & Korner, Note 1), have shown that visual attentiveness is enhanced when the infant is allowed to suck on a pacifier, we tested half our subjects with a pacifier, half without. Also, our previous studies had been done in the context of soothing infants, which required a prestimulus state of crying. In order to have a better chance for maintaining visual attentiveness once it was elicited, we chose the state of wakefulness without crying as a precondition for including an infant in the present study. We thus could assess whether vestibular-proprioceptive stimulation and/or the upright position evokes visual behavior, given two different prestimulus states.

Finally, our design permitted exploration of whether our experimental procedures differently affected the sexes, breast- or bottle-fed babies, and infants born to primiparous or multiparous mothers.

Method

Subjects.—In order to ensure the normality of infants included in the study, stringent subject selection standards were applied. To be included, infants had to meet the following criteria: maternal analgesic drug intake less than 200 mg 6 hours prior to delivery; duration of first and second stages of labor combined between 2 and 20 hours, followed by spontaneous or low forceps delivery from vertex presentation; Apgar score of 8 or more at 1 minute of age; normal prenatal course, uncomplicated by maternal pathology; perinatal and postnatal status free of signs of anoxia, injury, anomalies, or other complications. Additionally, all subjects had to be free of eyelid edema, forceps marks or bruises near the eyes, and excess drainage resulting from silver nitrate prophylaxis.

The sample consisted of 72 full-term Caucasian neonates divided into two groups depending on parity. The 48 infants born to multiparae consisted of 23 males and 25 females. Twenty were bottle-fed, and 28 were breast-fed. The average labor for this group was 6.2 hours. The mean birthweight was 7.5 pounds. Nine of the males were uncircumcised; 14 had been circumcised. Average elapsed time between circumcision and testing was 22.9 hours. The 24 infants born to primiparae consisted of 11 males and 13 females. Seven were bottle-fed, and 17 were breast-fed. Average duration of labor for this group was 9.9 hours. Mean birthweight was 7.4 pounds. Three males were uncircumcised. The average elapsed time since circumcision for the eight others was 17.6 hours. The average age at testing for all infants was 33.0 hours (range 12.0–77.0 hours).

Apparatus.—Our aim in constructing the apparatus illustrated in figure 1 was to provide an evenly illuminated "white box" in which the only event of interest would be the appearance and movement of the stimulus. In addition, we wanted to be able to vary the position of the infant seat from horizontal to upright to provide vestibular stimulation and to record the infant's response in an unobtrusive manner.

Some features of the apparatus devised deserve special comment. A metal plate was mounted 13 inches above an assembly containing a standard infant seat. On the exterior side of this plate a television camera was mounted over a camouflaged lens hole; on the interior side of the plate were lubricated tracks for silent manual sliding of the stimulus screen. A television monitor allowed observation of the infant's visual behavior. At the same time, a recorder videotaped the infant's performance for later scoring. The stimulus panel consisted of a white fine mesh screen in a white aluminum frame with a 1½-inch black spray-painted stimulus line. This line was parallel to the infant's position and 10 inches from his face. The screen was wide enough so that the black line could be entirely removed from the infant's field of vision without exposing the edges of the aluminum frame. All interior surfaces were painted white, except the area behind the stimulus screen which was painted black. This allowed the screen to have the appearance of being a solid black line which moved across a white field, yet the mesh permitted clear recording of the infant's responses through the screen by the camera.

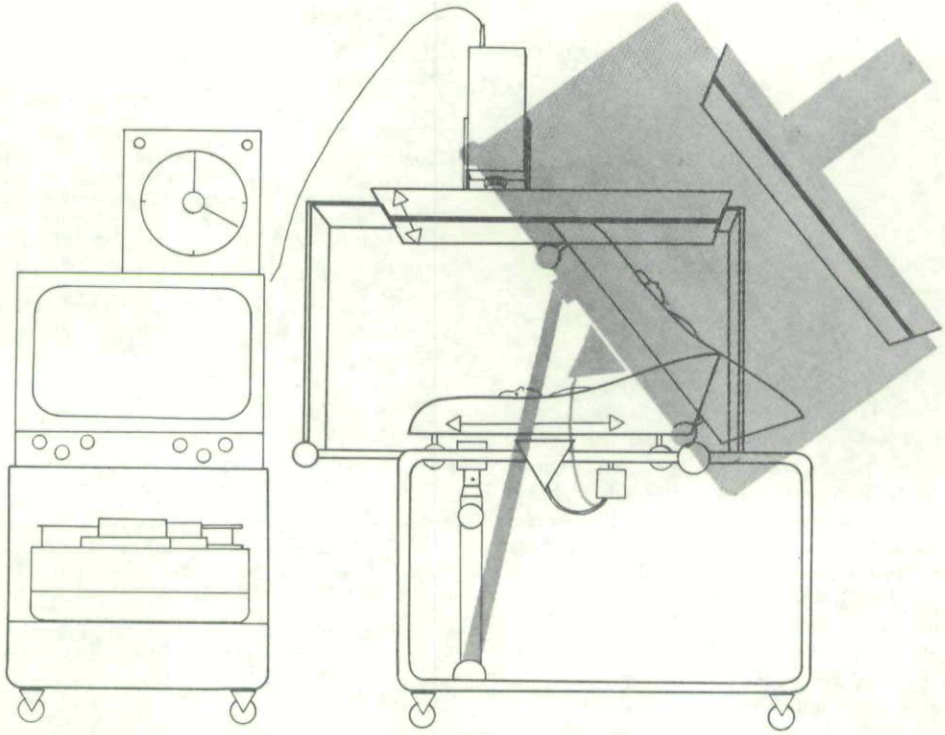


FIG. 1.—TV apparatus permitting horizontal and upright positioning and displacement

The infant's cubicle was surrounded by plain white curtains stretched around four sides. The open area under the infant allowed sliding of the infant seat along lubricated metal tracks for the vestibular stimulation condition without the experimenter becoming visible to the infant. The baby remained within the curtains during the movement. Illumination was provided by two small lamps mounted below and behind the infant and outside the curtain. The effect was diffuse, even, low level (between 4 and 6 foot-candles at the site of the screen).

The entire assembly could be placed in the horizontal or upright position by a simple adjustment. All parts of the infant's cubicle moved in a parallel fashion, as illustrated. We were thus able to provide the same smooth movement of the infant seat along the lubricated tracks whether the apparatus was in the upright or the horizontal position. The upright was 52° above the horizontal. This was the maximum angle we could obtain without resorting to a complicated system of head restraints necessitated by the neonate's weak neck musculature. To help support the baby's head in a general frontal position, small white cloth-covered foam cushions were placed on both sides of the head between the side of the infant seat and the infant's ear. These cushions were designed to be small enough to be outside the range of the baby's peripheral vision and to allow free head movements as the baby pursued the moving stimulus.

Design.—The main portion of the study involved 48 infants born to multiparous mothers. These infants were randomly assigned to one of eight conditions derived by varying three factors: (*a*) the position of the infant's body, (*b*) the use of movement stimulation, and (*c*) the use of a pacifier (see table 1).

All infants were given four 2-minute trials of the moving stimulus. A trial consisted of eight consecutive 15-second excursions of the stimulus (four in each direction) across the visual field. Each trial was preceded by a 15-second intertrial interval during which the stimulus was not visible. During these intertrial intervals the infants in the movement groups received 15 seconds of vestibular-proprioceptive stimulation, whereas infants in the no movement groups were given a control period of equal duration. Vestibular-proprioceptive stimulation consisted of sliding the infant seat to and fro on the tracks approximately 6 inches eight times in succession.

Since we were interested in the contribution

TABLE 1

EXPERIMENTAL DESIGN OF MAIN STUDY

	Pacifier		No Pacifier	
Movement	Horizontal	Upright	Horizontal	Upright
No movement	Horizontal	Upright	Horizontal	Upright

of the moving stimulus itself to visual attention, we did a subsidiary study with the 24 firstborn Ss where only the position of the infant and the movement of the stimulus were varied. The experimental design is displayed in table 2.

None of the infants in the subsidiary study received vestibular-proprioceptive stimulation, and all were allowed to suck on a pacifier throughout the session. Those in the moving stimulus conditions were treated in the manner described above. In the stationary stimulus condition the stimulus line remained in the middle of the infant's visual field during the experimental session. We decided to let the stimulus remain visible during the intertrial intervals since in this condition moving the black line out of the visual field during these periods would have changed the stimulus condition to that of a "moving stimulus" situation.

Procedure.—When Ss were observed to be visually alert in their nursery cribs, they were diapered, wrapped loosely in a blanket, and brought into the dimly lit experimental room within the nursery. Here they were placed in the apparatus which had been set up previously in either the horizontal or upright position according to the random order assignment of conditions. Pacifiers were given to the infants in the pacifier condition at this time. The side curtains were closed, the camera was focused on the infant's face, and the experimental session was begun.

Eye behavior was scored from the videotape monitor during the session by one of the experimenters and again after the session from the tapes by both experimenters for reliability. Because of the greater accuracy possible through use of the videotapes, the scores derived from their playback were used in the data analysis.

Scoring.—Tracking behavior was scored for completeness and smoothness in following each excursion of the stimulus. Also, the degree of eye opening was assessed for each stimulus excursion.

The rating scales below were used to quantify the tracking behavior and the degree of eye opening.

VISUAL TRACKING BEHAVIOR

5.5 ...	Full tracking of stimulus excursion
5.0 ...	Tracking, but eye lagged behind stimulus movement, or missed portion of excursion
4.5 ...	Tracking of half of excursion of stimulus, glance at stimulus during other half
4.0 ...	Tracking of half of excursion only
3.0 ...	Minimal attention to stimulus, but eyes open
2.0 ...	No attention to stimulus, but eyes open
1.0 ...	Eyes barely open, could not judge where pupil was
0.0 ...	Eyes closed

EYE OPENING BEHAVIOR

5.0 ...	Eyes wide open and alert
4.5 ...	Less wide open but alert
4.0 ...	Eyes three-fourths open, fairly alert
3.0 ...	Eyes one-half open but wider than slit opening
2.5 ...	Less than one-half open but wider than slit opening
2.0 ...	Open barely wider than slit
1.5 ...	Slit opening
1.0 ...	Minimal opening during interval or some closure
0.0 ...	Eyes closed

These scales differentiate the various ocular behaviors by either full-point or half-point differences. This enabled us to reflect smaller behavioral differences with the half-point steps than those indicated by the whole-point differentiations.

These scales were tested for interobserver reliability in blind ratings. Complete agreement was

TABLE 2

EXPERIMENTAL DESIGN OF STUDY WITH FIRSTBORN INFANTS

	Stationary Stimulus		Moving Stimulus	
Body position	Horizontal	Upright	Horizontal	Upright

obtained in 79% of the visual tracking scores and 75% of the eye opening scores. Reliability within a half point was 99% and 100%, respectively, for tracking and eye opening scores.

Results

An analysis of variance was used to assess the effects of body position, movement stimulation, use of pacifier, and interactions between these factors. In the main group ($N = 48$), the following four variables were analyzed: (1) initial eye opening and (2) initial tracking—the data for the first 15-second excursion of each trial were used to provide separate scores of the initial level of eye opening and tracking for the four trials; (3) average eye opening and (4) average tracking—data from the eight 15-second excursions were averaged to form an average eye opening score and an average tracking score for the four 2-minute trials.

Table 3 displays the means and standard deviations of the scores of the eight groups of subjects in the main study.

Significant differences were found in the overall comparison of the eight conditions for initial tracking and average tracking, $F(7,40) = 2.78$, $p < .05$ and 2.79, $p < .05$, respectively. Movement stimulation and the pacifier significantly enhanced initial tracking scores, $F(1,7) = 4.23$, $p < .05$ and 10.76, $p < .01$, respectively. For average tracking, the effects of movement stimulation and the pacifier also significantly enhanced visual behavior, $F(1,7) = 4.10$, $p < .05$ and 5.47, $p < .05$, respectively. There was no significant interaction effect between pacifier and movement. The upright or horizontal orientation of the body did not lead to significant differences between the groups. Eye opening scores were too variable within the conditions to show statistically significant differences.

Factors involving sex, parity, type of feeding, type of obstetrical analgesia and anesthesia, length of labor, age of the Ss at testing, and time since last feeding were run against the initial tracking scores in a multivariate regression analysis. Initial tracking was chosen since it would show the greatest differentiation across conditions. None of these factors in the infant's life history proved to affect the magnitude of his initial tracking score significantly.

In the subsidiary study of the 24 firstborn Ss, initial eye opening and average eye opening scores were analyzed. Comparisons of the eye opening scores of the firstborn Ss who viewed a stationary stimulus with those of the Ss who viewed the moving stimulus yielded no significant differences.

Discussion

The major purpose of this study was to compare the relative efficacy of vestibular-proprioceptive stimulation with the upright position in evoking visual attentiveness to a moving stimulus in neonates. It was found that, after the infants had been exposed to vestibular-proprioceptive stimulation by being moved either horizontally or semivertically, they engaged in significantly more efficient visual pursuit than did infants who had not been moved and who, throughout the experiment, were in a stationary position. It was also found that infants who viewed the visual stimulus from a stationary upright position performed no better than infants lying in the supine. The results thus clearly show that it is not the upright position which significantly influences the infant's visual behavior but that it is the vestibular-proprioceptive stimulation which enhances this response. This finding is indirectly confirmed in a recent study by Fredrickson and Brown (1975), who found that an infant sitting upright in an in-

TABLE 3

MEAN TRACKING AND EYE OPENING SCORES FOR THE FOUR TRIALS

Conditions	Mean Initial Tracking	SD	Mean Average Tracking	SD	Mean Initial Eye Opening	SD	Mean Average Eye Opening	SD
H	4.44	1.29	4.28	0.91	3.89	1.34	3.73	1.03
U	4.83	1.02	4.96	0.44	4.06	0.79	4.06	0.50
HM	4.94	0.54	4.88	0.48	4.42	0.54	4.34	0.37
UM	5.02	0.67	4.94	0.44	4.47	0.33	4.20	0.50
HP	5.13	0.52	4.99	0.48	4.32	0.60	4.13	0.72
UP	5.10	0.55	4.89	0.79	4.24	0.64	3.92	0.86
HMP	5.19	0.44	5.11	0.30	4.43	0.38	4.29	0.38
UMP	5.27	0.29	5.10	0.37	4.26	0.69	3.93	0.84

Note.—H = horizontal position, U = upright position, M = movement, P = pacifier.

fant seat did not significantly improve his visual pursuit of a schematic drawing of the human face over his performance while lying supine. The finding that the upright position does not significantly improve the infant's visual performance may appear to contradict the results of a previous study from our laboratory (Korner & Thoman 1970) in which it was found that maternal types of interventions entailing the upright significantly increased the occurrence of the *state* of visual alertness as observed during a 30-second observation period. This contradiction is only apparent since both the procedure and the visual measures differed in the two studies. In the previous study, the infant's highest level of alertness was scored during 30 seconds immediately after the infant was *moved into the upright*, a maneuver which entailed vestibular-proprioceptive stimulation. By contrast, in the current study, the infant's visual pursuit was measured after he had been sitting in the upright for at least 30 seconds before the first trial began, and he was kept stationary in this position until he had completed four 2-minute trials.

The present study not only clarified that it is the vestibular-proprioceptive stimulation rather than the upright which enhanced visual behavior, it also extends our previous findings in several other respects. By strictly controlling the visual environment within the apparatus, it was possible to attribute the effects seen to the experimental conditions rather than to possibly differing opportunities for gleaning moving shadows in the environment. Also, by taking wakeful, noncrying rather than crying infants as subjects, we found that the effects of vestibular-proprioceptive stimulation on the infants' visual behavior generalized over two prestimulus states. In both situations, the effect probably came about through the infant responding by orientating to the changing stimulation. In the crying infant the vestibular-proprioceptive stimulation interrupted the infant's crying, and the reduced arousal made it possible for the infant to become visually alert. In the wakeful, noncrying infant the vestibular-proprioceptive stimulation also may have caused the infant to orient to the changing conditions, thereby facilitating the focusing of his attention on the only stimulus in his visual field.

This study also showed that sucking on the pacifier had at least as great an effect in enhancing visual attentiveness as did vestibular-proprioceptive stimulation. In each position, the pacifier significantly augmented the infant's visual performance. This supports previous findings by Wolff and White (1965) and Thoman and Korner (Note 1). Observations of our subjects in the pacifier versus nonpacifier groups indicated that those without a pacifier often became fretful and changed states to that of wakefulness with motor activity or crying, states that are less conducive to attention and visual exploratory behavior. Use of the pacifier seemingly allowed the infants to remain more quietly alert and to continue visually tracking the moving stimulus, a result also reported by Wolff and White (1965).

Reference Note

1. Thoman, E. B., & Korner, A. F. Unpublished study.

References

Fredrickson, W. T., & Brown, J. V. Posture as a determinant of visual behavior in newborns. *Child Development*, 1975, **46**, 579–582.

Harper, L. V. Early maternal handling and pre-school behavior of human children. *Developmental Psychobiology*, 1972, 5(1), 1–5.

Korner, A. F., & Grobstein, R. Visual alertness as related to soothing in neonates: implications for maternal stimulation and early deprivation. *Child Development*, 1966, **37**, 867–876.

Korner, A. F., & Thoman, E. B. Visual alertness in neonates as evoked by maternal care. *Journal of Experimental Child Psychology*, 1970, **10**, 67–78.

Korner, A. F., & Thoman, E. B. Relative efficacy of contact and vestibular-proprioceptive stimulation in soothing neonates. *Child Development*, 1972, **43**, 443–453.

Wolff, P. H., & White, B. L. Visual pursuit and attention in young infants. *Journal of Child Psychiatry*, 1965, 4(3), 473–484.

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