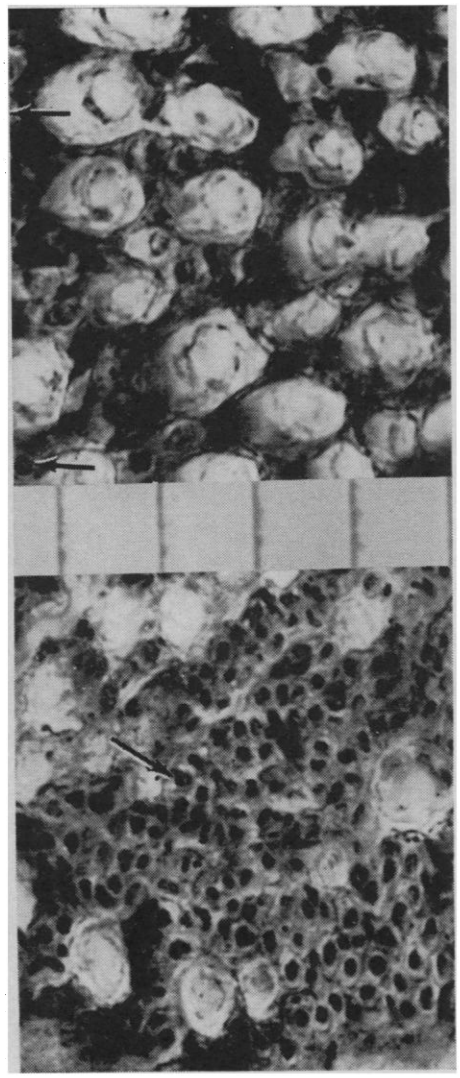

Fig. 2 (top). Cross section of ventral root C7. Fig. 3 (bottom). Cross section of ventral root T1. Arrows indicate small myelinated fibers. De Castro technique was used. Scale, 10 μ between lines.

dicate the presence of preganglionic sympathetic fibers in the ventral roots of these cervical nerves, stimulation of which resulted in vasoconstriction in the footpad.

Preganglionic sympathetic axons are small myelinated fibers from 1 to 3 μ in diameter. If such fibers are present in the ventral roots of cervical nerves, appropriately stained sections of these roots must reveal them. Figure 2 is a cross section of the seventh cervical ventral root of the dog which was stimulated to produce the functional responses shown in Fig. 1 (C7 stimulation). The photomicrograph reveals numerous small myelinated fibers scattered among much larger and heavily myelinated motor axons. When measured on the 10-μ scale included in the photograph, it is apparent that these small fibers are 1 to 2 μ in diameter and are, therefore, of the appropriate size to be classified as sympathetic preganglionic B fibers. Although at first glance the large motor fibers seem more numerous, an actual count reveals that small myelinated fibers outnumber large ones about three to one. Similar small fibers were found scattered throughout the sections made from the ventral roots of the C5, C6, and C8 nerves.

Figure 3 is a cross section of the first thoracic ventral root taken from the same animal and reveals the expected large population of small, thinly myelinated fibers. This photomicrograph was made at the same magnification as that in Fig. 2, and comparison of the small fibers reveals identical size and staining characteristics.

We conclude that in some dogs there are preganglionic fibers leaving the cervical spinal cord through the ventral roots of the lower cervical nerves. A comparable anatomical arrangement in humans would explain both the sweating patterns in patients with cervical cord lesions and the continued sympathetic innervation to the head after surgical removal of the inferior portion of the stellate ganglion.

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References and Notes

1. W. C. Randall, L. Guttman, J. Silver, *Physiologist (Washington)* **6**, 260 (1963).
2. L. T. Palumbo, *Management of Disorders of the Autonomic Nervous System* (Year Book, Chicago, 1955), p. 106.
3. R. O. Rawson and W. C. Randall, *Amer. J. Physiol.* **199**, 112 (1960).
4. Supported by grant HE 08682 from NIH.
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Optomotor Response in Human Infants to Apparent Motion: Evidence of Innateness

Abstract. *Human infants were placed inside a stationary cylinder containing a columnar pattern like that used to elicit the optokinetic reflex. By sequential illumination of the columns, the pattern was made to appear to rotate. Optokinetic nystagmus was clearly evoked in 64.7 percent of the subjects, with a weak-positive response in an additional 11.8 percent.*

The newborn infant reacts innately to a truly moving striped field with optokinetic nystagmus (OKN) (*1*). Recent study of newborn guppies and newly hatched praying mantids provided evidence of an innate optomotor response to a truly moving striped pattern and to a stroboscopically flashed columnar pattern simulating true rotation (*2*). It was predicted that optomotor response to stimulation by apparent motion would also prove to be innate in newborn humans; our study was designed to test this prediction.

Since infants cannot report a perceptual experience, a device capable of eliciting motor response to stroboscopic stimulation had to be constructed. The design called for a columnar device flashing stroboscopically to simulate true movement. In stroboscopic stimulation there is no movement of the image across the retina. If it could be demonstrated that a columnar pattern in apparent movement elicited the OKN response in the infant, one could conclude that the response is innate.

A stroboscopic device was constructed comprising an optical presentation unit and an electronic control unit (*3*). The former consisted of a series of Sylvania electroluminescent light panels 61 cm long and 4.6 cm wide, mounted on a sheet of plastic, 61 cm wide and 2.4 m long, bent to form a cylinder 76 cm in diameter; the latter controlled the sequence and duration of light presentation. Additional controls allowed adjustment of the on-off times of the lamp from 0.01 to 1.1 seconds. The intensity of the illumination also could be regulated. The electroluminescent panels were free of glare, and maximum brightness intensity of the unit (24.7 lumen/m^2) was optimal for the experiment. Durations of lamp-on and dark intervals could be adjusted over a fairly broad range, although systematic analysis of the various combinations was not attempted. A lamp on-off ratio of 200 to 300 msec was selected for the experiment. Stripes of black adhesive tape, 2.5 cm wide and 61 cm long, were laid down the length of the cylinder at 2.5-cm intervals.

Placed horizontally, the cylinder formed a 61-cm-long tunnel into which the baby could be introduced. An L-shaped hospital table, adjustable for height, its table surface inserted into the stroboscopic cylinder, and its vertical support post outside, provided a "bed" for the subject.

Each subject was placed on the table inside the cylinder. The room was immediately darkened, and the stroboscopic device was actuated. The subject was so placed that its eyes were approximately in the geometric center of the cylinder (76 cm in diameter), that is, 38 to 40 cm from the inner surface; this position was best for equidistant viewing of the stripes if the head moved (as it occasionally did) during stimulation. The stroboscopic enclosure was large enough to permit the experimenter to watch the eye movements without obstructing the subject's inspection of the stimulus array. One observer watched the subject, noting whether OKN occurred and, if so, in which direction; the second, at the electronic control unit, controlled the direction of sequencing. The observer watching the infant had to predict correctly the direction of the "moving" stripes from the direction of the slow phase of the subject's eye movements. Each subject was observed at least once by each experimenter. Each subject was also exposed to a stationary striped field so that the experimenters could observe its eye-movement patterns in the absence of specific stroboscopic stimulation.

Scoring was on the basis of positive, weak-positive, negative, or indeterminate response. A response was considered negative if the eye-movement pattern elicited by the stroboscopic stimulation was indistinguishable from the type of pattern seen at zero speed of flashing. Random nystagmoid movements of the eyes, even when correlated with the direction of the "moving" columns, were not considered significant.

For a response to be considered positive, the infant had to respond with sustained OKN appropriate to the direction of the apparent movement, and the response had to be independently observed by both experimenters. The reaction had to be reversible: that is, when the stripe "movement" was changed so that the columns appeared to be moving in the opposite direction, the slow phase of the OKN had to be in the direction of "movement"; the saccadic phase, in the opposite direction. A response was rated weak-positive if the OKN was not sustained or if it could be observed in only one direction of stripe "movement." In some instances in which the slow component was clearly present but in which the fast return did not follow immediately (or was incomplete), weak-positive response was recorded. Some infants could not be induced to attend to the stimulus and were not tested; persistent criers and sleepers comprised the indeterminate group.

All 19 subjects (*4*) had been judged normal on routine pediatric examination; ages ranged from 10 hours 48 minutes to 4 days 10 hours; the largest number being in the 21- to 30-hour group. Attempts were made to rouse the babies that were asleep and to quiet the agitated. Generally, the experimental procedure appeared to "interest" the infant; a substantial number of seemingly poor candidates immediately became amenable to testing when the stimulus was presented.

Eleven subjects were classed positive; two, weak-positive; four, negative; and two, indeterminate (the last two were discarded before percentages were calculated on the basis of 17 subjects). Thus 64.7 percent were clearly positive and 23.5 percent were clearly negative. Inclusion of the two weak-positives brings the positive percentage to 76.5, but we chose not to combine the groups (*5*).

Our results indicate that the optomotor response to apparent (stroboscopic) motion is innate in humans. This conclusion is primarily based on comparison of responses (i) at on-off durations of 200 and 300 msec and (ii) when the strobe pattern was present but not flashing. Crucial differences between eye-movement patterns at zero speed of flashing and at 200:300-msec ratio were the quality, amplitude, and duration of nystagmoid movements accompanying the two conditions. The bursts of OKN that occurred when the lit columns appeared to move did not occur when the lit columns were stationary. For the clearly positive subjects the train of OKN was appropriate to the direction of the columnar "movement," and the speed of the pursuit phase was rhythmically coordinated with the apparent movement of the columns. This finding sharply contrasted with the occasional, randomly occurring, unsustained, nystagmoid jerks elicited by the steady stimulus. There was no directional pattern to these spontaneous nystagmoid jerks; they were equally likely to occur to right or left; most significantly, in some infants they never appeared. It was concluded, therefore, that in this study the independent variable most closely connected with the presence of optokinesis was the flashing of the columns in the 200:300 ratio. In that the subjects reacted to the stroboscopically flashed columnar pattern as if it were a truly moving stimulus (*1*) (that is, with the optokinetic reflex), one may infer that the flashing lights were experienced or perceived as columns of light in real rotation (*6*).

Our results do not favor a learning hypothesis with respect to the neonate's ability to perceive apparent motion. If learning were the critical factor in perception of apparent motion, it would follow that the greatest percentage of positive responses should occur in the more mature group. This was not the case: the responses in all four categories (positive, weak-positive, negative, indeterminate) showed no specific trend with regard to age; older infants did not tend to show greater effect. The results sustain the hypothesis of innateness.

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References and Notes

1. G. O. Dayton, Jr., M. H. Jones, P. Aiu, R. A. Rawson, B. Steele, *Arch. Opthalmol.* **71**, 871 (1964); J. J. Gorman, D. G. Cogan, S. S. Gellis, *Pediatrics* **19**, 1088 (1957); J. M. McGinnis, *Gen. Psychol. Monogr.* **7**, 321 (1930).
2. I. Rock, E. S. Tauber, D. Heller, *Science* **147**, 1050 (1965).
3. Stroboscopic equipment by Scientific Prototype Mfg. Corp., New York.
4. Full-term babies from Columbia-Presbyterian Hospital, New York.
5. In a pilot study of 18 subjects, the stroboscopic device was redesigned for this work. The original optical presentation unit used neon bulbs in a semicylindrical frame; flashing columns were separated by vertical stripes of black tape. The unit was placed over the bassinet on a special supporting bracket and was viewed by a supine subject in a darkened room. The control unit, consisting of relay switches, actuated the sequencing, direction, and rate of flashing.
6. Whether or not the infant perceives motion cannot be directly apprehended by an observer. To our knowledge, the visually elicited optomotor response in child and adult is always accompanied by the perception of a moving articulated field. Therefore we infer that the stimulus is perceived by the infant as a truly moving pattern.
7. Assisted by a grant from the William A. White Institute of Psychiatry, Psychoanalysis, and Psychology, New York. We thank H. Roffwarg and J. Schacter, Department of Psychiatry, College of Physicians and Surgeons, Columbia University, for providing facilities.

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