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26. We are grateful to Drs. Peter Parsons and Ralph Meyer, both of this laboratory, for many helpful discussions and advice. Supported by grants from the American Cancer Society (P-421) and the Public Health Service (7 ROI AM11317).

25 June 1968

Monocular Compared to Binocular Depth Perception in Human Infants

Abstract. *Human infants were made temporarily monocular with an eye patch. They performed like bginocular infants on the visual cliff at visual depths of 25 centimeters or more. At a visual depth of 12.7 centimeters infants younger than 9 months of age revealed a monocular weakness by turning toward the uncovered eye.*

Monocular perception of depth has been shown by a number of investigators. Of these, the classical investigations are those of Canella (*1*) who found that monocularization produced little behavioral disturbance in many animals, including predators whose lives depend upon accurate distance perception. Recently, the visual cliff has been used to demonstrate monocular depth perception in such animals as chicks, ducklings, and rats (*2*).

Nevertheless, monocular depth perception in human infants has not been adequately investigated. Only one study of a monocular infant—who had had little experience with binocular depth perception—has been reported (*3*). Normal human infants must be more intensively studied under a variety of conditions to understand strengths and limitations of monocular depth perception. I now describe observations on human infants made temporarily monocular by an elastic eye patch. Monocular as compared to binocular depth perception was studied by the use of several visual depths and stimulus conditions.

The visual cliff for human infants (Fig. 1) consists of an enclosed box (2.44 m in length, 1.52 m in width, and 1 m in height) topped with 1.6-cm Herculite glass (*4*). A center board bisects the glass into two equal segments. Directly under the glass of one side (the shallow side) a textured pattern is placed; at some distance below the glass on the other ("deep") side of the visual cliff another visual surface is placed. The 1.52-m center board was 35.3 cm wide at the end, where the infant was placed, and it tapered to a width of 7.6 cm at the other end. The inside of the apparatus was painted a homogeneous gray. A light meter reading of about 14.3 lu/m^2 was secured by measuring light directly reflected from the patterns. The illumination source was a homogeneous white ceiling with the light diffused through white cotton cloth. Curtains surrounded the apparatus to present a relatively standard plain view of the surrounding environment.

Monocular data were collected gradually over a 4-year period. The distances under the glass for the deep pattern were 1 m, 50 cm, 25 cm, and 12.7 cm. The shallow pattern was usually 1.9-cm red and white checks, but 0.6-cm checks were occasionally used. The deep side contained 1.9-cm or 7.6-cm red and white checks, or a nontextured gray.

The procedure offered the infant a "choice" of the shallow or the deep sides of the visual cliff (Fig. 1). The infant was placed on the wide end of the center board and was called by the mother from the narrow end. To reach the mother the infant almost always left the center board and crawled to her over either the shallow or the deep side (a few straddled).

Binocular infants responded similarly to all of the patterns noted above when the mother offered them such a "choice"; they averaged 96 percent choice of the shallow side with visual depths of 25 cm or more (*4*), and 78 percent choice of the shallow side with the visual depth of 12.7 cm (*5*).

The "choice" constituted the first test trial. After this, infants were called by the mother from both the shallow and the deep sides of the cliff, and were actually placed on the glass and called by her from the shallow end. For the second test trial some of the infants were made monocular at the end of the session by the use of a regular commercial eye patch (with an elastic band to hold it in place). Latencies on the first test trial were often long, with a substantial minority over 1 minute, and the eye patch might not be accepted at all if it was given first. Three classes of infants were represented on the second test trial: (i) those who accepted the eye patch (monocular), (ii) those who took it off (binocular), and (iii) those given the last trial without trying the eye patch at all (binocular). The last group was studied to determine whether infants who accept or reject the eye patch differed from each other in some way (*6*).

Because monocular infants with visual depths of 25 cm (10 inches) or more responded similarly and stimulus patterns seemed to make no difference, these data are presented first. The results with the 12.7 cm (5 inches) of depth follow.

Table 1 presents the data for babies

with a depth on the deep side of 25 cm or more. In the monocular patch trial 93 percent of the infants who made a choice (one straddled) went to the shallow side. This compares to a choice of shallow by 94 percent of the binocular infants who took the patch off before leaving the center board, and 97 percent of the infants not given the eye patch test. Thus, the depth perception of experimentally monocular infants is about the same as the binocular depth choices on the first trial of the experimental session, despite experience in crawling on the glass of the deep side between the first test trial (binocular) and the last test trial (monocular).

The eye patch procedure for the 127 monocular and "patch off" infants (Table 1) was relatively uncoercive. The elastic eye patch was simply placed by the experimenter on the infant, and he was released. The infant may have been more likely to take the eye patch off, but the coordination of some infants was adversely affected by the eye patch. Fifteen infants of the last of the 127 tested were rated as having coordination "unaffected" ($N = 7$), "slightly affected" ($N = 4$), or "markedly affected" by the eye patch. The four youngest were markedly affected, and ages of the three groups differed significantly ($F_{2,12} = 9.74$, $P < .01$). Yet, nine of ten of the infants accepting the eye patch went to the shallow side, including the three in the youngest group (the other five took the patch off).

A more adequate system to make the infant respond monocularly was devised for the visual depth of 12.7 cm (5 inches). Two experiments were used; one kept the infant's arms pinned to his body while the other applied the eye patch. The arms were restrained while the infant was once again placed on the center board in a crawling position. As the child was released, the mother called to him. Thus, the child had more time to become accustomed to the eye patch. Of the 56 infants on whom the patch

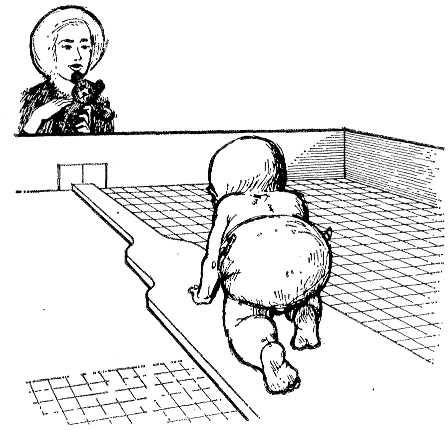

Fig. 1. An infant on the visual cliff center board crawls toward his mother. The deep side is to the left, the shallow side to the right. Both sides are covered with glass and the center board is placed on top of it.

was placed in this manner, 42 accepted it long enough to be considered monocular for the testing session, a much higher percentage than is represented in Table 1.

Forty-two monocular infants were tested on the visual depth of 12.7 cm, and of these 28 went to the shallow side and 14 to the deep side. The binocular "patch off" infants numbered 19. Sixteen of these went to the shallow and three went to the deep side. The difference between monocular and binocular infants is not statistically significant. The monocular choices are also not significantly different from the binocular choices on the first test trial. The significant difference concerned the side toward which the uncovered eye faced. Of the 42 monocular infants, 20 had the uncovered eye facing toward the deep side and 22 had it facing toward the shallow side. With the uncovered eye toward the deep side ten infants went shallow and ten went to the deep side. The average age of the infants crawling to the shallow side was 10.4 months, and the average age of those going to the deep side was 8.3 months. The age differences are significant using a Mann-Whitney test ($U_{10,10} = 10$, $P < .01$). Only one of the infants that chose the deep side was over 9.0 months of age, and only two of the infants that went to the shallow side were 9.0 months of age or younger. The older infant that went to the deep side was the one that crawled latest in that group; the two young infants that chose the shallow side were among the earliest in that group to begin to crawl (*7*). The infants with the uncovered eye looking toward the shallow side chose the shallow side 18 times and the deep side four times. Average age of the infants making a shallow choice was 10.0 months, and, of the infants making a deep choice, 11.8 months. The age differences are not significant ($U_{4,18} = 14$, n.s.).

The results can be considered in terms of two related hypotheses. The simpler one is that the younger infant is less mobile, and he turns toward a side with adequate visual stimulation. To him, the depth of 12.7 cm (5 inches) is not discriminably different enough from the shallow depth for him to pause and look around for a better place, as he would with a visual depth of 25 cm or more. A second, not completely unrelated hypothesis comes from Fraenkel and Gunn's (*8*) analysis of the effects of unilateral blinding of insects. Phototropic insects circle toward the source of light stimulation. A phototropic insect blinded in the left eye circles to the right, one blinded in the right eye circles to the left. Circling movements have been observed in our laboratory in young dark-reared rabbits that could discriminate depth binocularly but not monocularly. The circling movements were both toward and away from the uncovered eye. Monocular kittens 28 days of age, only 4 or 5 days after the development of depth perception, circled predominantly toward the uncovered eye, but depth perception was not so adversely affected (*9*). Tucker (*10*) observed circling movement (both toward and away from the covered eye) in visually deprived monocular chicks. Only one human infant in the monocular group was observed to make circling movements. He was 7½ months old and had just started to crawl; he executed a full circle toward the uncovered eye.

The behavior of the 42 temporarily monocular infants tested with the 12.7 depth can be examined with the hypothesis that an infant either seeks adequate visual stimulation by going to the uncovered side or, relatedly, that he circles to that side. Results on 13 of 14

Table 1. Behavior of the two groups of binocular infants and the group with an eye patch on the second test trial (visual depth 25 cm or more).

Choice	Binocular infants				Monocular infants*	
	No patch sequence		Patch removed			
	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Shallow side	22	30	61	58	57	55
Deep side	0	1	0	4	2	4
Straddles	3	2	1	1	0	1
No descent	8	0	5	4	1	0
Median latencies						
	24 sec	6 sec	40 sec	20 sec	32 sec	9 sec

* For trial 2 only.

infants 8½ months old or younger agree with such an hypothesis: the infants go toward the uncovered eye. That is, a young infant with a patch on the left eye goes to the right, one with a patch on the right eye crawls to the left. Only 15 of the 28 older infants chose the side toward the uncovered eye. Thus, a monocular weakness that depends on the age of the child is revealed, and this weakness is related to data secured on animals. The younger infants can discriminate visual depth, but they are more likely to go toward the side of effective visual stimulation near the threshold depth of 12.7 cm. At greater visual depths, the increased motion parallax overcomes the visual weakness.

The results secured by Eichengreen, Coren, and Nachmias (*11*) can be compared to these. They found that young monocular rats reared in standard laboratory cages (that is, experience "deprived") performed at a chance level on the visual cliff, whereas binocular animals of the same age could discriminate depth; yet, monocular animals of the same age given extra climbing experience discriminated depth. Lore, Kam, and Newby (*12*) found that the handicap of the "deprived" rats (*11*) could be overcome by raising the center board 1.27 cm. Under this condition the monocular "deprived" animals discriminated depth. Likewise, this study shows that monocular infants of all ages can discriminate depth as long as the visual depth is great enough. But, near a threshold the younger infants, with less maturation and (or) less visual and visual motor experience, were handicapped when the eye was facing toward the source of ambiguous stimulation.

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6. Infants who allow the patch to stay on tend to be younger ($\chi^2 = 11.41$, 3 d.f., $P < .01$).
7. The age at onset of crawling is supplied as a possible hint concerning the importance of crawling experience in depth perception, not as conclusive evidence. Amount of crawling experience has been shown before (*4*) to influence depth discrimination: binocular infants who crawl "late" were more easily coaxed across the deep side of the visual cliff with some kinds of visual stimulation than were infants of the same chronological age who crawl "early."
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9 July 1968

Functional Asymmetry of the Human Brain

Abstract. *Verbal and nonverbal memorization skills were tested before and after electroconvulsive shocks to the left, right, or both cerebral hemispheres of neurologically normal patients. As predicted, decrements for the left-hemisphere–shocked group were larger on the verbal than nonverbal tasks, while the reverse was true for the right-hemisphere–shocked group. Largest decrements on both tasks were shown by the bilaterally shocked group.*

It is an old observation that damage to structures of the left cerebral hemisphere is linked to the impairment of verbal abilities, at least in right-handed persons; but comparable damage to the right hemisphere does not have the same psychological effects. More recently, evidence has been adduced suggesting that a unilateral relation also exists between the right hemisphere and nonverbal abilities (*1*). To date, these relations between hemisphere and function have been inferred from the cumulative clinical study of persons suffering brain damage due to illness or injury.

In a study of the immediate postictal effects of a single electroconvulsive shock treatment (EST), Gottlieb and Wilson (*2*) found that right-handed mental patients, given EST unilaterally to the left hemisphere, required more postshock time to report correct answers to a nine-item orientation and memory checklist than did patients given right-hemisphere EST. The obtained difference was consistent with the notion of left-hemisphere "dominance" in right-handed persons; but, in the absence of nonverbal test items, the experiment did not test the specific relation of verbal skills to the left hemisphere. That is, nonverbal skills might also have been disrupted in the patients given dominant-hemisphere EST—particularly during the immediate postictal period.

The present study provides a simultaneous experimental demonstration of both asymmetries. We assessed the differential effects, on certain verbal and nonverbal associative learning tasks, of EST administered either to the left, or the right, or both cerebral hemispheres of neurologically normal patients being treated for affective depression (*3*).

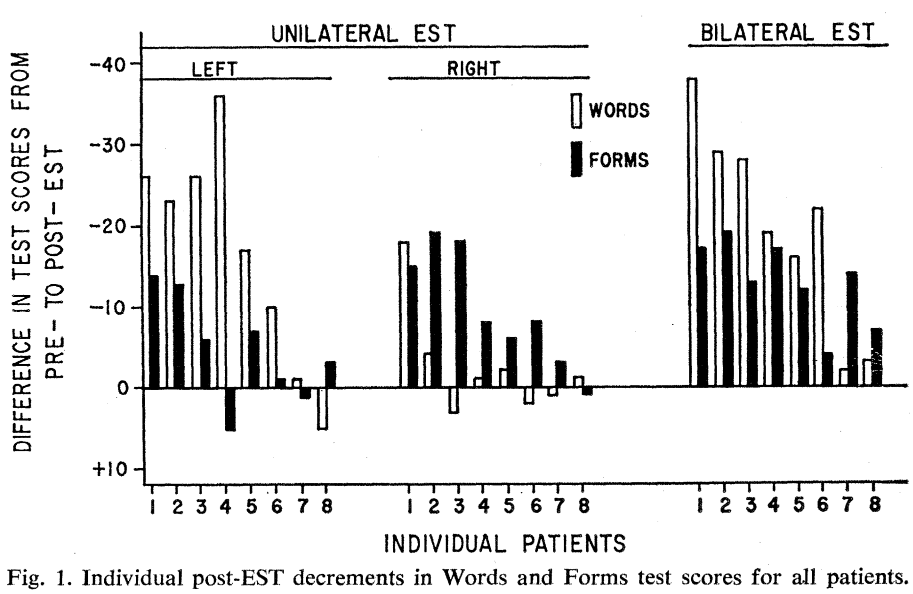

Fig. 1. Individual post-EST decrements in Words and Forms test scores for all patients.