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Visual-Cliff Preference by Infant Rats: Effects of Rearing and Test Conditions

Abstract. *In monocular tests, normally reared infant rats, aged 21 to 22 days, fail to show a side preference on the visual-cliff apparatus. Rats of the same age, but reared in an "enriched" environment, prefer the shallow side of the apparatus. In binocular tests, even normally reared animals prefer the shallow side, although experimentally reared animals show a stronger preference. The results appear to reopen the question of what cues are employed on the visual cliff.*

When placed in the visual-cliff apparatus, young animals of many species prefer to descend to the glass plate covering the shallow side rather than the deep side (*1*). Full understanding of this phenomenon may go far toward clarifying the genesis of depth perception. To this end we compared binocular and monocular performance on the visual cliff of infant rats having different early environmental histories. Both these factors have been investigated before, but never jointly (*2, 3*). Our results indicate that, in monocular tests, normally reared infant rats show no preference on the visual cliff, whereas rats reared in an "enriched" environment prefer the shallow side. In binocular tests, even normally reared animals prefer the shallow side.

The subjects in this experiment were 246 male and female hooded rats, aged 21 to 22 days, bred and reared in the University of Pennsylvania colony. They were housed until 10 days of age in normal maternity cages (38 by 23 by 23 cm). Then before the infants' eyes had opened, the litters and mothers were transferred to one of two rearing environments: for the control rats, the transfer was to a clean maternity cage; for the experimental rats, to a larger cage (63 by 23 by 23 cm) containing three hardware-cloth climbing platforms and a feeder suspended on one side, which could be climbed upon. The climbing platforms and suspended feeder were intended to provide the experimental animals with greater opportunities to experience cues as to depth and distance. In both types of cage the floor was covered with wood shavings.

On the test day the members of each litter were assigned to the various testing conditions. Half the rats were tested monocularly; half, binocularly. The animals were rendered monocular by application of a few drops of flexible collodion in 50-percent solution with equal parts of ether and ethyl alcohol, a technique used previously on chicks (*4*) but not on rats. The collodion was applied with a long cotton swab to the hair immediately above the eye, which closed as the swab approached. The collodion-covered hair was spread over the closed eye and made to adhere to the hair below the eye. Another drop or two was then applied, which soaked in and secured the eyelid shut. The entire procedure took no more than 1 minute; its only observable side effects were some squealing at the time of first application and some scratching for a few minutes thereafter. To control for these side effects, as well as for the effects of handling, we applied collodion solvent to one (closed) eye of each binocularly tested rat, and collodion solution directly above and below that eye. In every subgroup approximately equal numbers of animals had the left or right eye treated. Before being placed on the cliff, every rat was held and prevented from scratching for 100 seconds, and was then kept in an adaptation cage for 5 minutes. While the rat became accustomed to the collodion, the glass surfaces of the cliff were cleaned and interchanged to equate any olfactory cues from previous animals. After each animal was removed from the cliff, its eyes were examined to check that they looked the same as when the rat was placed on the cliff.

We performed a control experiment to ascertain the efficacy of the occlusion procedure. Thirty-one infant rats from the two rearing conditions were prepared as in the monocular testing condition but with both eyes covered. Of the 20 that descended from the start-board, 11 went to the deep side and 9 to the shallow side. These results, taken with the observation of solidly covered eyes, indicated that the collodion preparation successfully occluded vision.

The visual cliff used in this experiment, patterned after Walk and Gibson's model II cliff (*1*), consisted of two 38- by 48-cm glass plates that were separated by a 48- by 10-cm start-board located 4.5 cm above the glass surface. On the shallow side the pattern was placed immediately below the glass plate. On the deep side the pat-

Table 1. Number of rats, by groups, that chose the shallow side or the deep side, or made no choice within 10 minutes.

Conditions		Cliff					
		Normal			Equated texture density		
Rearing	Viewing	Shallow	Deep	No choice	Shallow	Deep	No choice
Normal	Monocular	15	10	6	11	14	13
Normal	Binocular	18	7	3	21	4	8
Experimental	Monocular	17	8	8	19	6	8
Experimental	Binocular	22	3	3	22	3	3

tern was placed on the floor, 78 cm below the glass plate; the pattern was large enough to provide a continuously textured surface when viewed from the start-board. The glass surfaces and the start-board were surrounded by 23-cm-high wooden walls to prevent the rat's escape. The entire apparatus was painted gray and bordered by black curtains from behind which the experimenter could observe the rat's behavior. Incandescent lamps suspended above the start-board and above the deep pattern projected approximately 70 lumen/m^2 on both deep and shallow surfaces.

Each animal was placed on the start-board inside a metal box having a sliding floor. After the bottom of the box was removed, the box itself was raised by a swinging arm controlled by the experimenter behind the curtain. The trial ended either when the rat made a choice (removed all four paws from the start-board) or when 10 minutes had elapsed. Animals that failed to choose within 10 minutes were not used again; they were replaced until 25 rats in each subgroup had made a choice.

Monocular and binocular rats from the two conditions of rearing were tested with either of two sets of patterns beneath the glass plates. In both sets, the shallow pattern was the same: 12.5-mm-wide black paper strips, crisscrossed 2.5 cm apart, on a white background. For the "normal" cliff the deep pattern also was constructed in this way. In the "equated-texture density" cliff, the elements of the pattern covering the deep side were made to subtend the same visual angle 1.9 cm above the start-board as did the elements on the shallow side.

Table 1 summarizes the choice behavior by subgroups. There is no significant difference between the performance of rats tested on the "normal" and on the "equated texture density" cliffs ($\chi^2(4) = 2.73$); for these animals differences in angular texture density were evidently not the basis of choice between the two sides of the cliff, at least when other cues were available. Trychin and Walk's (*3*) results were similar. Therefore all analyses of effects of the rearing conditions and viewing conditions were carried out on the combined data from the two cliffs (Table 2).

It is evident from Table 2 that only the normally reared, monocularly tested group failed to show significant preference for the shallow side of the visual cliff (*5*). From 72 to 88 percent of the rats in the other groups went to the shallow side, a level of performance quite comparable to that reported previously for adult rats (*1*). We performed a more detailed analysis of the choice behavior of the four groups of Table 2 in order to assess the effects of our two experimental variables. The analysis involves the partition of χ^2 and degrees of freedom in multiple contingency tables of frequency data such as ours (*6*). Side preference proves to be significantly affected by viewing conditions ($\chi^2 = 11.06$, $P < .001$) and by rearing conditions ($\chi^2 = 5.19$, $P < .035$); however, the interaction of these two variables does not approach significance ($\chi^2 = 1.08$). Thus it seems that: (i) experimentally reared rats exhibit stronger preference for the shallow side of the visual cliff than do normally reared ones; (ii) binocularly tested rats exhibit stronger preference than do monocularly tested ones; and (iii) there are insufficient grounds for rejecting the possibility that these two effects are independent of each other. However, it should be borne in mind that the monocularly tested animals showed significant preference only if they had been experimentally reared.

Table 2 also contains the median choice latencies for those animals that left the start-board within 10 minutes. The only striking difference is between the animals that went to the shallow side and those that went to the deep side. In three of the four subgroups, the median latency of the rats going to the deep side is the lower, while in the remaining subgroup there is a small difference in the opposite direction. When data from the four groups are combined, the median latencies of the "deep" and "shallow" animals (17 and 23 seconds, respectively) are significantly different ($\chi^2 = 6.06$, $P < .02$).

While we cannot yet completely dismiss all alternative explanations based on possible emotional and attentional effects of rearing conditions, we believe that the differences found in performance most probably reflect differences in the perception of depth. The results of our experiments (*7*) seem to indicate that, as measured by the visual cliff, depth perception by the rat is influenced by experiential factors. On the other hand, earlier studies have shown that binocular depth perception by the rat does not require prior visual experience (*2, 8*). However, several investigators have asserted that, even in binocular tests, performance on the visual cliff depends on essentially monocular cues. The recent finding by Trychin and Walk (*3*), that adult rats that had been surgically rendered monocular preferred the shallow side of the visual cliff, seems to support this view. However, our results, showing difference in performances by infant rats in monocular and binocular tests, appear to reopen the question of what cues are employed on the visual cliff.

Table 2. Combined data from the two cliffs. Number of rats that chose the shallow side or the deep side, or made no choice within 10 minutes. Numbers in parentheses are the median latencies, in seconds, of rats that left the start-board within 10 minutes. Abbreviations: N, normal; E, experimental; M, monocular; B, binocular.

Conditions		Choice		
Rearing	Viewing	Shallow	Deep	None
		Group 1		
N	M	26 (30.5)	24 (16.0)	19
		Group 2		
N	B	39 (23.0)	11 (16.0)	11
		Group 3		
E	M	36 (21.0)	14 (25.5)	9
		Group 4		
E	B	44 (25.0)	6 (18.5)	6

JEFFREY M. EICHENGREEN
STANLEY COREN*
JACOB NACHMIAS
Department of Psychology, University of Pennsylvania, Philadelphia

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* Present address: Department of Psychology, Stanford University, Stanford, Calif.

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