broader than has been previously demonstrated. While the distribution of interreinforcement intervals is different in Conc VI VI and Conc FI FI, the schedules are similar in that in both schedules the probability of reinforcement on a key increases as a bird spends time responding on the other key. However, there are quantitative differences in the way in which this increase comes about in Conc VI VI and Conc FI FI.

The major outcome of the present experiment is the suggestion that matching may be obtained in a broader class of schedules than Conc VI VI. Perhaps ratio schedules, etc., also could be used in place of the VI schedule to generate matching with the present method of programming concurrent schedules.

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A new coordination test of visual-motor deprived visually experienced cats*

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Cats with extensive binocular visual experience but with only monocular visual-motor experience were found to have visual-motor deficits in both deprived and experienced eyes when tested on a new apparatus requiring smooth negotiation of a series of barriers.

Currently used methods for measuring visual-motor behavior in immature, deprived, or lesioned animals are still relatively primitive. Simple observation of obstacle avoidance during free movement and the relatively crude visual placing response test are frequently used. Recently Hein & Held (1967) described a version of the latter modified to measure behavior requiring more precise visual guidance.

The barrier apparatus described here allows one to make qualitative observations and objective measurements of the complex movements required in the cat's visually guided locomotion among obstacles. The task can be made sensitive enough to detect differences between a normal S's eyes. The apparatus will be described and its use illustrated by showing how it was adapted to study the effects of providing Ss with visual experience while preventing them from using it in getting about.

BARRIER APPARATUS FOR MEASURING VISUAL-MOTOR COORDINATION

The five 18-in.-high barriers in the apparatus illustrated in Fig. 1 are 18 in. apart and have 14 slats. A racking frame which rests on side pieces can be pushed or pulled from either end to set all the slats so that they lean one way or the other. The slat guide device is shown in the insert. The large nail "lateral restraining pin" in the top of the slat and the "brad pivot" in the bottom allow the slat to rock back and forth but prevent sideways movement. The "support bar" limits the fall of the slats: Tipped forward the slats come to rest against the bar; tipped

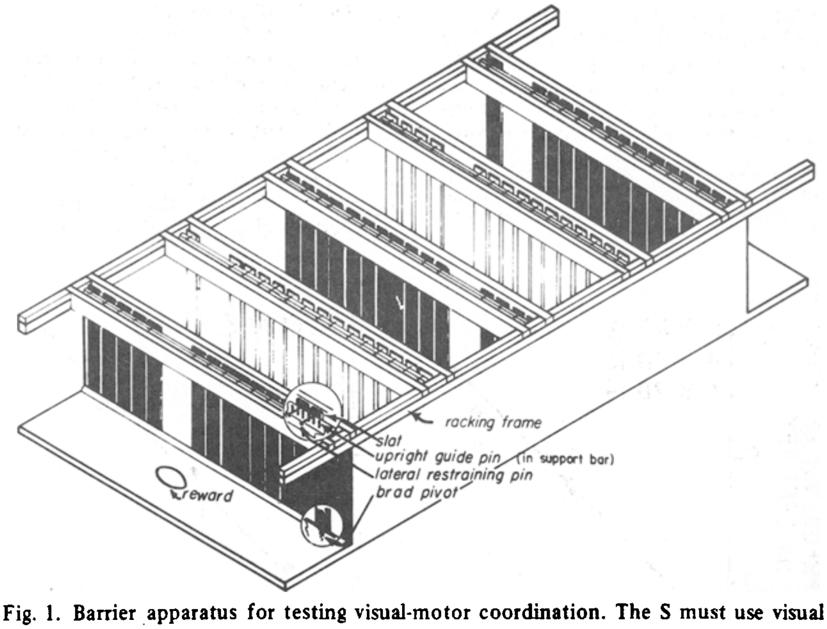

Fig. 1. Barrier apparatus for testing visual-motor coordination. The S must use visual cues in finding the most direct path to the reward and in adjusting movements so that passage through the openings is smooth.

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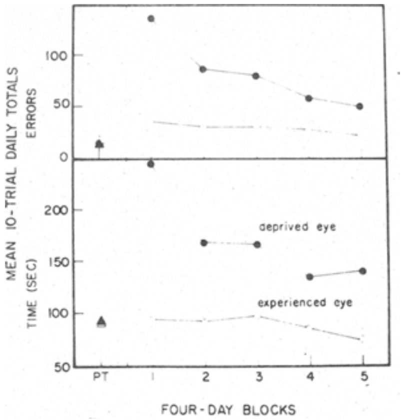

Fig. 2. Scores for the final 4 pretest days and for all 20 test days for the three experimental Ss.

backward the restraining pin head is caught between the "guide pins." The pattern of barrier openings was made irregular as shown in Fig. 1, and was altered from trial to trial to prevent S from learning a specific route which could be run nonvisually, and to force him to rely on direct visual cues in going from one end to the other efficiently (the Ss' vibrissae were cut short to lessen their reliance on cues from this source). Task difficulty can be increased by decreasing the contrast between the barriers and the openings (note the black-white contrast in the illustration) by introducing false barrier openings by making some slats of Plexiglas, or simply by reducing test room illumination.

Testing

An E is stationed at each end of the apparatus, the slats are set so they lean toward the S, and the food dish at the end opposite S is baited. When he traverses the barriers and secures the bait, the slats are reset and the dish at the starting end is baited. The reward contingency is simple traversal rather than error-free or short-duration traversal. A camera on a rail overhead follows S's movements. Efficiency of visually guided behavior is measured by (1) slats dislodged, (2) time for down-and-back traversal (one "trial"), and (3) directness of the opening-to-opening path taken.

BARRIER TRAVERSAL DEFICITS FOLLOWING VISUAL-MOTOR DEPRIVATION

The effect of prolonged visual-motor deprivation on simple and complex discrimination learning, and on the precise visually guided behavior required in the barrier test were studied (Robinson & Fish).[1] A portion of the barrier test results only will be reported here.

Three experimental Ss were allowed unrestricted movement in the laboratory and a large exercise area, using an "experienced eye" (EE) while the "deprived eye" (DE) was occluded with a ping pong ball section mounted in a mask (Robinson & Voneida, 1962). The DE was really only visual-motor deprived because Ss were given binocular exposure to the laboratory for 1 h/day while immobilized in a holder. The S could move his head and eyes but could not see his limbs or body. These maintenance conditions were instituted at 6-8 weeks when the kittens were brought out of the dark-rearing quarters they had occupied since birth (they continued to live in these quarters when not under the above maintenance conditions). Deprivation was continued for 18 months and was terminated on the day testing began; during testing Ss were allowed 6 h of unrestricted activity in the laboratory daily. Testing lasted 20 days so that the experimental Ss had had extensive experience with the deprived eye prior to the last days of testing.

Apparatus and Procedure

The barrier test room illumination was a monochromatic red or green, and S wore a red-green filter mask (i.e., left eyepiece red, right green). Thus, matching of filter color and room color determined which eye saw the barriers. The color conditions were balanced for the two eyes. The three experimental Ss and three control Ss were given 10 trails a day with each eye during test sessions (control Ss had an arbitrarily designated "deprived" and "experienced" eye). The barrier-opening configuration remained the same for four traversals: Traversals 1 and 4 constituted a trial for EE, Traversals 2 and 3 a DE trial. Only the EE was used in a pretest adaptation series (no filter over EE; DE occluded; room illumination changed regularly). There were four traversals per trial in these sessions also; they provide the baseline scores for the EE (Traversals 1 and 4) and the DE (Traversals 2 and 3) shown in Fig. 2.

Results

The pattern of pretest-test and EE-DE results shown in Fig. 2 was obtained with all three Ss. There was no overlap of EE and DE scores throughout the test series. The expected superiority of the control Ss' performance over that of the experimental Ss' DE was found, but it was discovered that their performance was also superior to the experimental Ss' experienced-eye performance (errors, $p < .01$; time, $p < .003$; binomial test). Differences between the control S's two eyes were small and not significant, and the poorer score on any given trial was used in making these comparisons. Differences between experimental and control Ss' pretest scores were small and inconsistent. Experimental Ss' initial test trial performance with the EE was markedly poorer than their terminal pretest performance; control Ss did not show such a change.

Conclusion

The barrier apparatus is capable of objective measurement of precisely guided visual-motor behavior, and of detection of deficits not readily observed in S's free movements. After many days' experience in a lighted environment with free use of the deprived eye, the Ss appeared to casual observation to be able to use it in an essentially normal manner in getting about. The barrier test, however, revealed a substantial, enduring loss in the precision with which the eye could guide behavior.

Ganz & Fitch (1968) studied monocularly form-occluded cats and attributed the deficit found in the fine perceptual-motor adjustment capacity of the deprived eye to the fact that it had never received form stimulation, and as a consequence could not control its normal population of binocular feature extractor cells in the visual cortex. Our Ss showed a similar perceptual-motor loss, but it is unlikely that there was loss of control of visual cortical cells since Ss had extensive binocular form experience. In both studies, however, Ss were visual-motor deprived. It seems reasonable to interpret the similar deficits to this common deprivation condition.

Further study is needed to determine the generality of the *experienced*-eye deficit, but in the barrier test, loss shows that caution should be exercised in considering the experienced eye of a monocularly deprived animal "normal" (Ganz & Fitch, 1968; Held, 1968). The slow discrimination learning exhibited by monocularly deprived Ss using the experienced eye (Ganz & Fitch, 1968) is further evidence that such deprivation produces a deficit in the experienced as well as the deprived eye, although the loss in the former is considerably less severe.

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NOTE

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