

with FUDR must participate in the replication mechanism of adeno virus, but should not play so great a part for the replication of the virus.

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- ¹ Toyoshima, S., Seto, Y., and Ueda, T., *Keio J. Med.*, **11**, 33 (1962).
² Flanagan, J. F., and Ginsberg, H. S., *J. Exp. Med.*, **116**, 141 (1962).
³ Green, M., *Virology*, **18**, 601 (1962).
⁴ Smith, C. W., Marshall, J. D., and Eveland, W. C., *Proc. Soc. Exp. Biol. Med.*, **102**, 179 (1959).
⁵ Philipson, L., *Virology*, **15**, 263 (1961).
⁶ Green, M., and Daesch, G. E., *Virology*, **13**, 169 (1961).
⁷ Salzman, N. P., *Virology*, **10**, 150 (1960).

PSYCHOLOGY

Lateralization of Learning of Colour and Brightness Discriminations following Brain Bisection

SEVERAL investigations dealing with interocular transfer of learning of visual discriminations in split-brain cats and monkeys support the general conclusion that brain bisection including the optic chiasm and posterior corpus callosum restricts the learning and memory of the discriminations to the trained hemisphere. These tasks cannot be correctly performed through the other eye until it has received comparable training, in contrast to the immediate interocular transfer usually shown by normal or chiasm-sectioned controls¹⁻³. This generalization has been qualified by more recent studies indicating that transfer of learning of brightness^{4,5} and pattern⁶ discriminations in split-brain cats, and of brightness and colour discriminations in split-brain monkeys⁷, does occur under certain conditions. Transfer of colour and brightness learning in split-brain monkeys would, therefore, seem to be dependent on the conditions used. It appeared advisable, in reference to future studies on vision, to see if transfer of these tasks takes place under the conditions at present being used in this laboratory.

Nine monkeys (8 *Macaca nemestrina* and 1 *M. mulatta*) were tested for transfer of learning on brightness (grey/white, relative intensity difference = 1 log unit) and colour (red/indigo, green/yellow, blue/orange) discriminations. Seven cases had the optic chiasm, anterior commissure, and corpus callosum sectioned; one control case had the chiasm alone sectioned, and one was normal. Histological verification of the surgery has been obtained for two of the experimental cases (fourth and last experimental animals in Table 1).

Table 1. TRIALS TO CRITERION FOR EACH EYE

	Red/Indigo		Green/Yellow		Blue/Orange		Grey/White	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Normal	280	0	80	0			200	0
Chiasm	1,520	0	1,280	80	200	0	300	80
Split	1,320	1,200	480	680			680	800
	60	70	400	80	360	360	1,440	320
			130	150	160	80		
	120	200	200	200	240	80	600*	800
	60	260	160	30	80*	40	80	160
	100	40	70	170			320	240
	880	240			480*	240	360†	560

* Train contralateral eye-hand; change eyes and test ipsilateral eye-hand.
† Train ipsilateral eye-hand; change eyes and test contralateral eye-hand.

The stimulus-pairs were projected side-by-side on to two translucent screens, $1\frac{1}{2}$ in. \times $1\frac{1}{2}$ in., which the monkey could push to indicate his choice. The possibility of cues arising from brightness differences was controlled in the blue/orange task by unpredictably altering gross intensity differences during training and testing. The

animals were kept in their home cages, each of which was equipped with a training compartment. Sliding panels restricted the eye and hand use to specific combinations. The trials were programmed, rewarded, and recorded by an automated system. All animals had previously learned at least one black/white pattern discrimination, trained with this apparatus, and had shown no evidence of interocular transfer. As a rule, one contralateral (intra-hemispheric) eye-hand pair was used during the initial training, then the opposite contralateral pair was tested and trained to criterion if transfer was not immediate. This procedure was varied in four cases by training or testing an ipsilateral combination (Table 1). For the longer learning curves the trials were grouped in blocks of 40 and for the shorter ones in blocks of 10. Criterion was arbitrarily set at 90 per cent correct responses during 40 consecutive trials.

The results in Table 1 show that after reaching criterion with the first eye the normal monkey immediately performed colour and brightness discriminations correctly with the untrained eye. The chiasm-sectioned animal showed full transfer for two of the tasks, although some retraining through the second eye was required for the other two problems. In the split-brain monkeys, on the other hand, immediate transfer of learning to the second eye was never seen and retraining through the second eye was always required. For the cases trained and tested with contralateral eye-hand combinations, the average number of correct responses on the first 40 trials, with the first and second eye, respectively, was 18.7 and 19.8 (colour) and 16.2 and 14.0 (brightness). Relearning with the second eye showed median savings of 0 per cent for the colour task and 3.5 per cent for the brightness problem. It should be noted, however, that with a criterion of 85 per cent instead of 90 per cent correct responses, the median savings were 20 and 6.5 per cent respectively, the former being significantly greater than zero (sign test, $\alpha=0.01$). Therefore, the possibility of some savings should not be definitely excluded. The scores of the four cases involving an ipsilateral eye-hand combination suggest that interocular transfer is not increased when both eyes are tested with the same hand.

The results recorded here support the earlier work of Sperry⁸ and Downer⁹ in which learning of discriminations involving coloured and black or white objects failed to transfer interocularly in split-brain monkeys. The immediate transfer of colour and brightness discrimination-learning reported by Trevarthen⁷ remains puzzling. The main difference between his experimental conditions and ours is his use of simultaneous training of contradictory tasks to the two hemispheres, which would appear, at first glance, to hinder rather than induce interocular transfer.

This work was supported by grant No. M-3372, a predoctoral fellowship (M. S. G.) and a predoctoral training grant (C. R. H.), all from the National Institutes of Health, U.S. Public Health Service. The surgery was performed by Dr. R. W. Sperry with the assistance of Miss Lois MacBird, and the histology was done by Mrs. Ruth Johnson.

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¹ Sperry, R. W., *Fed. Proc.*, **20**, 609 (1961).

² Myers, R. E., in *Brain Mechanisms and Learning*, **481** (Blackwell Scientific Publications, Oxford, 1961).

³ Downer, J. L. de C., in *Interhemispheric Relations and Cerebral Dominance*, **87** (The Johns Hopkins Press, Baltimore, 1962).

⁴ Meikle, T. H., and Sechzer, J. A., *Science*, **132**, 734 (1960).

⁵ Meikle, T. H., *Science*, **132**, 1496 (1960).

⁶ Sechzer, J. A., Paper presented at Eastern Psychological Association, Atlantic City (1962).

⁷ Trevarthen, C. B., *Science*, **136**, 258 (1962).

⁸ Sperry, R. W., *Anat. Rec.*, **131**, 297 (1958).

⁹ Downer, J. L. de C., *Fed. Proc.*, **17**, 37 (1958).