gardless of the correctness of each response, the control group received cards containing neutral statements relevant to one of the 20 topics about which they held extreme attitudes. Examples are: "Most modern religions are monotheistic"; "Political conventions are held in large cities." Trials were continued until the subject reached a criterion of eight consecutive correct responses or until 96 trials were completed. Responses were scored according to the number of correct responses per block of eight trials.

The results are depicted in Fig. 1. Analysis of variance yielded a number of significant $F$ ratios. Two findings were critical in confirming the hypothesis. Both in terms of overall performance scores [$F=14.35$, degrees of freedom $(df)=1/54$, $p<.001$] and in terms of the linear trend ($F=16.38$, $df=1/54$, $p<.001$), the attitude similarity-dissimilarity group was superior to the control group. The presentation of statements with attitudes similar and dissimilar to those of the subject acted to change response probability; hence, the reinforcement interpretation of similar and dissimilar attitudes is on considerably firmer theoretical ground. The particular research design employed in this investigation makes it impossible to determine if similar and dissimilar attitudes are both necessary to bring about learning or if just one of these conditions would be sufficient.

None of the other significant findings is directly relevant to the hypothesis under investigation. The traditional reinforcement group performed better than the other two groups ($F=26.78$, $df=1/54$, $p<.001$), but this is hardly surprising. In addition, there was a small but significant difference ($F=5.04$, $df=1/54$, $p<.05$) between the small and large condition; large was easier to learn as the correct response than small. Since this variable was controlled across groups, it could have no effect on the major findings.

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### References and Notes

1. D. Byrne and D. Nelson, *J. Abnorm. Soc. Psychol.*, in press.
2. D. Byrne, *J. Personality* **30**, 164 (1962); T. M. Newcomb, *Am. Psychol.* **11**, 575 (1956); R. D. McDonald, thesis, Univ. of Texas (1962).
3. This research was supported in part by the U.S. Air Force Office of Scientific Research of the Air Research and Development Command grant AF-AFOSR 261-64.

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## Visual Function of the Forebrain Commissures in the Chimpanzee

Abstract. *Interocular transfer of learned pattern discrimination tasks in chimpanzees with sectioned optic chiasma is dependent on the forebrain commissures. This function is sustained by the splenium and the anterior commissure, the former pathway being the more capable.*

That the commissures of the forebrain play a vital role in the transmission of patterns of visual experience between the cerebral hemispheres has been established in the cat and in the monkey (*1*). In a study of the localization of this visual function in the commissure of the cat, the posterior half of the corpus callosum was found to participate (*2*). This distribution probably relates to the disposition of visually related cortex on gyrus lateralis of the cat. Work with the monkey suggested that the anterior commissure, as well as corpus callosum, may transmit visual information (*3*). Apart from the suggestion that the anterior commissure may participate in visual transmissions, the contribution of the various segments of corpus callosum to transfer of visual information in the primate has not been analyzed previously. The present study was therefore undertaken to determine the pattern of localization of visual transfer functions in the forebrain commissures of a higher primate.

Eight young adult chimpanzees were subjected to midsagittal section of the optic chiasma, whereby the visual sensory input from the two eyes was restricted to the separate hemispheres over the remaining uncrossed pathways. To assess the role of particular parts of the forebrain commissures, seven of the animals underwent surgical section of varying portions of the corpus callosum. In four of the seven, the anterior commissure was also sectioned. One animal served as a control, with only the optic chiasma sectioned.

Training on visual discrimination problems began 2 weeks after surgery. The training apparatus was designed to limit the subject's viewing of the discriminanda to one eye. The visual stimulus-objects consisted of pairs of patterns mounted on two separate lids covering adjacent metal cups. The cup covered by the "correct" lid was baited with food. An opaque sliding door between the animal and the stimulus objects was raised to permit response. The animals were allowed to use the hand contralateral to the viewing eye, both the visual afferent and motor efferent projections thereby being related to the same hemisphere. The location of the lids containing the two stimulus choices was shifted from right to left positions according to a chance sequence. Each animal was given 100 trials daily. When an animal achieved 17 or more correct trials in 20 (criterion of learned performance), it received four additional days of "overtraining" to stabilize performance through the eye and hand receiving the training.

Transfer-of-training tests were then carried out through the, heretofore, untrained opposite eye and hand. High-level transfer-of-training occurred when there was immediate recognition of the discrimination task through the second eye and hand. Interocular transfer was impaired or absent when additional trials were required for learning.

For the discrimination training, a series of two pairs of black and white, flat patterns were employed: problem A, two rectangles versus a single rectangle; and problem B, a triangle versus a square. The first-mentioned member of each pair was arbitrarily select-

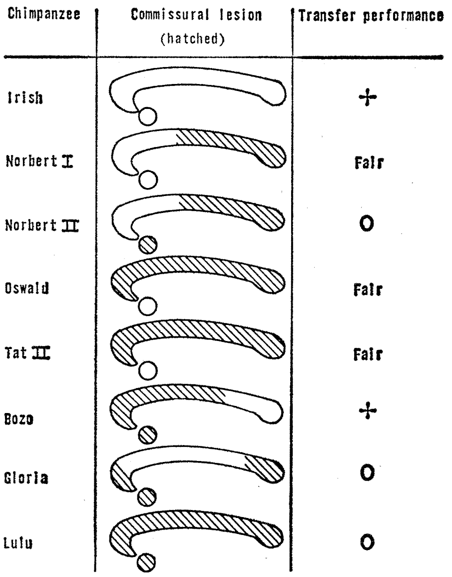

Fig. 1. Correlation of extent of transection of corpus callosum and anterior commissure with the degree of transfer of pattern discrimination training between the two eyes in chiasma-sectioned chimpanzees. Symbols: +, 90 to 100 percent saving of learning on transfer-testing; fair, 60 to 85 percent saving; 0, virtual failure—that is, minus 7 percent to plus 15 percent saving of learning.

Table 1. Scores for learning and transfer-of-learning on each of two visual pattern discrimination problems, A and B.

| Problem | Trials for: |  | Percentage of saving in relearning |
|---|---|---|---|
|  | Primary learning | Transfer |  |
|  | *Irish* |  |  |
| A | 880 | 20 | 98 |
| B | 80 | 0 | 100 |
|  | *Norbert I* |  |  |
| A | 380 | 120 | 68 |
| B | 260 | 40 | 85 |
|  | *Norbert II* |  |  |
| A | 40 | 40 | 0 |
| B | 300 | 320 | −7 |
|  | *Oswald* |  |  |
| A | 1500 | 600 | 60 |
| B | 1700 | 280 | 84 |
|  | *Tat II* |  |  |
| A | 340 | 120 | 65 |
| B | 60 | 20 | 67 |
|  | *Bozo* |  |  |
| A | 520 | 0 | 100 |
| B | 200 | 20 | 90 |
|  | *Gloria* |  |  |
| A | 400 | 340 | 15 |
| B | 360 | 340 | 6 |
|  | *Lulu* |  |  |
| A | 1200 | 1060 | 12 |
| B | 400 | 420 | −5 |

ed as "correct"—that is, it would yield a reward. The patterns of each pair were equated as to the total areas of black and white surfaces, so that luminous reflectance was balanced. The animals were trained and tested on problem A before going on to problem B. After achieving criterion performance on transfer-testing for the first problem, the animals were given additional trials in order to expose each cerebral hemisphere to equal amounts of direct experience with the problem. By thus assuring equivalent training for the two hemispheres, generalization effects from one problem to the next were thereby balanced for the two brain halves.

The scores of training and transfer-testing for each animal are presented in Table 1. The set of 20 trials in which criterion performance was achieved is excluded; thus, a score of "0" indicates that performance at criterion level or better was attained during the very first set of 20 trials. The percentage saving of learning is derived by dividing the difference between the scores for primary learning and learning on transfer-testing by the score for primary learning, and multiplying by 100. A minus value indicates that a greater number of trials was required for relearning than for primary acquisition. The degree of transfer-of-training is schematically correlated with the type of commissural lesion in Fig. 1.

Complete transection of the forebrain commissures virtually abolished interocular transfer of the pattern discrimination tasks, as seen in animal Lulu. Division of a 1-cm segment of splenium (24 percent of corpus callosum) combined with division of the anterior commissure likewise eliminated interocular transfer in Gloria. On the other hand, the intact splenium alone (Bozo) sustained pattern transfer-of-training at a high level. The anterior commissure, by itself, also supported visual transfer, though at a reduced level (Oswald and Tat II). Other than the splenium and anterior commissure, the remaining sectors of the interhemispheric pathways did not contribute to transfer of pattern discrimination learning (see particularly Gloria). It seems clear, then, that of the fiber bundles of the forebrain commissures, it is splenium and anterior commissure that participate in visual transfer. Of the two, the splenium appears the more potent in information transmission, since in isolation it supported a higher level of transfer of pattern discrimination learning than did the anterior commissure alone.

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### References and Notes

1. R. E. Myers, in *Brain Mechanisms and Learning*, A. Fessard, R. W. Gerard, J. Konorski, Eds. (Blackwell, Oxford, 1961); R. W. Sperry, *Science* **133**, 1749 (1961); R. E. Myers, in *Interhemispheric Relations and Cerebral Dominance*, V. B. Mountcastle, Ed. (Johns Hopkins Press, Baltimore, 1962).
2. R. E. Myers, *Arch. Neurol.* 1, 74 (1959).
3. J. L. de C. Downer, in *Interhemispheric Relations and Cerebral Dominance*, V. B. Mountcastle, Ed. (Johns Hopkins Press, Baltimore, 1962).
4. Supported by USPHS grant B2627 and by Friends of Medical and Scientific Research Institute, Baltimore, Md.

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## Stereopsis Suppression: Addendum

In correspondence with Lloyd Kaufman, of the Sperry Rand Research Center, who was trying to replicate my recent demonstration of loss of stereoscopic depth perception during the contralateral suppression of one eye's view [*Science* **145**, 1334 (1964)], it appeared that following the published specifications produced stereograms which would display the stereopsis loss only unreliably and within very narrow fixation limits.

Although we have not been able to pinpoint the missing factors, Kaufman and Colin Pitblado (also at Sperry Rand) have devised a somewhat different stereogram which offers a much more reliable replication of the stereopsis-loss phenomenon, and which is far less dependent on maintenance of fixation.

Each eye's view contains an outer circle of 3-degree diameter and an inner circle of 2 degrees, with a horizontal disparity between the inner circles of approximately 10 minutes of visual angle. The area within the 3-degree circle in one view (preferably the dominant eye's view) is filled with vertical stripes, and the corresponding area in the other view is filled with horizontal stripes. If the pattern containing the horizontal stripes is viewed through a filter which reduces the illumination by about 70 percent (a reduction which fails to affect a control stereogram from which both sets of stripes were omitted), that view is suppressed for seconds at a time, and during such periods stereodepth is clearly lost. This held true even for those observers who had failed completely to obtain this loss of stereodepth with attempted reproductions of the original stimuli.

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