learned responses, or for new learning.

Both subjects showed interference effects indicating transfer of learning when they were working on tasks which involved recognition of color or brightness differences. Figure 2C shows the case of a brightness-discrimination test in which there was good retention with the right eye. The significantly-belowchance performance with the left eye indicates interference on this side from the learning on the right side. Training with the left eye alone led to reversal of the transferred habit in 100 trials. Closely similar results were obtained with the second monkey on the same brightness discrimination task. These findings are in accord with the recent report of Meikle and Sechzer on the transfer of easy brightness discriminations with cats sectioned in the optic chiasm and corpus callosum (8). They are also to be compared with the survival of a simple visual conditioned response, after extensive midline surgery, reported by Voneida and Sperry (9).

Both these subjects also showed definite transfer of a blue-orange discrimination, although they failed to show transfer when they were subsequently trained to comparable color discriminations.

Further tests with an additional two monkeys, in which the posterior commissure, habenular commissure, and rostral two-thirds of the quadrigeminal plate had been sectioned (7), failed to show transfer of this same color discrimination learning. Tests for brightness-discrimination transfer in the two latter cases revealed, first, a seeming impairment in the ability to learn this task, and later, a pronounced but transitory transfer effect in spite of the more extensive surgery.

The occurrence of simultaneous learning in these experiments suggests that two relatively independent perceiving and attending processes can be sustained simultaneously in the separated hemispheres of the split-brain monkey. The alternative possibility, that this double visual learning depends upon a rapid switching of attention from eye to eye during the binocular training, suggests that further tests, with tachistoscopic presentation of stimuli, should be made. In cases where unequal learning occurs, some central processes, possibly associated with the selection of the mechanism of response, may confine the learning to one visual system (10). C. B. TREVARTHEN

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- 6. A criterion was set at the p = 0.002 level. This is satisfied if all trials in a group of ten are chosen correctly, or if two successive groups of ten trials contain but one error each.
- 7. Postmortem examination of the brains of two subjects, one with forebrain commissures sectioned and the other with the midbrain connections cut in addition, showed that surgery was complete. The two remaining cases have been kept for further experimental work.
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Early Experience and Sexual

Behavior in the Domestic Chicken

Abstract. Newly hatched chickens were imprinted to one of two moving objects. From the fifth day of life on, the chickens were injected with male sex hormone. When later presented with a choice between the two objects, they addressed induced sexual responses to the object to which they were imprinted.

By manipulating the environment of a bird, it is possible to cause it to respond to biologically inappropriate objects (1). Manipulations have always included exposure of the bird to the object during very early life (for nidifugous birds during the critical period for following), as well as prolonged contact with the object during adolescence. It has not, therefore, been possible to determine whether the relevant learning takes place during a particular period of the bird's life or whether the learning is dependent merely on length of contact with the object. It has not been demonstrated that either imprinting on an artificial model or lack of

experience of their own species during the critical period will produce abnormal fixations or prevent normal sexual development (2).

My experiment was designed to compare induced sexual behavior of birds imprinted within the critical period with that of birds given the same treatment outside the critical period.

Male chickens were placed in individual 3-by-11/2-by-2-foot boxes containing a light, food and water trays, a gauze-covered one-way observation panel, and a rotating arm which carried a suspended model around a circle 14 inches in diameter. The chicks were placed in the boxes as soon as they had dried in the incubator (approximately 12 to 18 hours after hatching) and remained in the boxes except for daily removal for an intramuscular injection of 0.5 mg testosterone propionate (3) in 0.1 ml sesame oil from the fifth day of life on. The model was half a cellulose toilet float, 41/2 by 11/2 inches, painted blue or yellow. The model traveled for 1/2 minute, was still for 2 minutes, then moved for $\frac{1}{2}$ minute, and so on. Lights were on for 10 hours a day, during which time the model, if present, traveled according to schedule.

Each chick was observed for four periods of 11/2 minutes at 2-hour intervals each day; observation periods were scheduled so that the model moved during the middle of the period. Every 10 seconds a bird's position was scored as less than or more than 4 inches from the model, giving a total of 40 records per bird per day. Thus a bird which was within 4 inches of the model at each observation would score 40 for that day.

On days 19 and 20 both the yellow and the blue models were placed in the box 1 foot apart, the chick's sexual behavior was observed for 10 minutes, and then the models were removed. An estimate was made of the number and direction of treads during each minute of observation.

Three experiments were run, the first

Table 1. Following and treading scores of different groups of chicks exposed to a model during the critical period for imprinting (group 1), after the critical period (group 2), or during both periods (group 3).

Group	No. of birds trained on		Model in box	Follow	No. of birds	
	Yellow model	Blue model	on days	Mean	Range	treading training model
Group 1	5	6	2-9	28.0	24 0-34 0	0
Group 2	5	5	10-17	4.5	0.1-13.1	1
Group 3	6	6	2-17	25.7	19.8-31.5	9

two with New Hampshire X Barred Rock chicks, the third with Barred Rock chicks. Birds in each experiment were assigned at random to one of three groups. Birds in group 1 were exposed to the model during the critical period for imprinting. Birds in group 2 were exposed to the model for the same length of time but after the critical period for imprinting. The exposure period of group 3 covered that of both group 1 and group 2.

From Table 1 it can be seen that the birds in groups 1 and 3 were within 4 inches of the model during about half the observations. Birds in group 2 followed hardly at all. Most of them remained at the opposite end of the box from the model, although two birds in this group scored about half the mean for the other groups (13.1 and 12.9).

Birds imprinted within the critical period (groups 1 and 3 combined) trod much more than those imprinted outside the critical period ($\chi^2 = 10.6$, p < .01), and the difference between group 1 and group 2 is also significant (p = .002, Fisher's exact test).

Of the 19 birds which exhibited sexual behavior, 18 trod only their training model. The remaining bird trod the training model 12 of 13 times.

Most of the birds which exhibited sexual behavior did so within the first minute of the first test, although one did not start until the second test on day 20. Typically, a bird would tread the model several times during each of the first few minutes of the test, and then sporadically toward the end of the session. Non-treaders in groups 1 and 3 did not differ significantly in their following scores from the treaders (26.9 for treaders and 26.8 for nontreaders). However, the one bird in group 2 which trod the model had a high following score (13.1). There were no observable differences in behavior between the different strains or replications.

Birds in groups 1 and 2 were exposed to the model for the same length of time, and differences can therefore be attributed only to the different times at which the models were introduced into the boxes. The two groups differed also in the length of time between their last exposure to the model and the sex tests, but it is unlikely that this variable caused the difference in behavior since birds of group 2, which had seen the model only 2 days before the sex tests, did not tread, and group 3 birds, having the same interval between last exposure and sex tests, did tread. Under the conditions of this experiment, experience during the critical period for following is of particular significance in determining the sexual object (4). **R. BAMBRIDGE**

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Alimentary Responses Evoked from Forebrain Structures in Macaca mulatta

Abstract. Previous work on the mechanisms of hunger-satiety in mammals has led to the localization of these functions in the lateral and ventromedial hypothalamic areas. The present work indicates that portions of the frontal lobe, temporal lobe, cingulate gyrus, septum, and thalamus are involved as well.

The results of numerous experiments on alimentary mechanisms in the past 25 years (1) have led to the proposal that hunger and satiety are critically dependent on discrete, mutually antagonistic centers located in the hypothalamus. This evidence has provided strong support for the concept of diencephalic control of basic physiological needs and has had an important influence on theories relating to a variety of visceral functions.

The possibility that the mechanisms of hunger-satiety are somewhat less discretely organized than is implied by this concept of hypothalamic control has been suggested recently by at least two different lines of evidence. First, sexual behavior, which in the past has also been closely linked with the hypothalamus, is now known to have components-for example, penile erection -which can be elicited by stimulation from many areas outside as well as inside the hypothalamus (2). Second, that alimentary mechanisms may resemble sexual mechanisms in having a widely dispersed neural representation in the forebrain has been suggested by recent experiments implicating the orbital cortex and the amygdala in various forms of alimentary behavior (3).

The following experiment (4) was undertaken to search for those areas in the forebrain of the monkey (Macaca mulatta) from which food and water intake could be directly modified by electrical stimulation. The brains of 8to 12-lb rhesus monkeys were explored stereotactically with movable electrodes while the unanesthetized animal was confined temporarily in a primate chair (5). Food and water were always present, and the animal could obtain them directly without using its hands. The electrode was advanced through the brain in 1-mm steps, and at each locus the behavior evoked was studied for its relationship to alimentation. Over 5800 loci distributed among 220 tracks in 15 animals have been explored in this fashion. The stimulating electrode consisted of Teflon-coated, stainless-steel wire 0.005 inch in diameter, bare at the tip for 0.5 to 1.0 mm. A large stainless-steel screw inserted into the skull served as an indifferent electrode. The stimulus was usually a 50-cy/sec, 1-msec unidirectional pulse. The stimulating electrode was the cathode, with threshold current intensities for the behavior patterns to be described ranging from 0.05 to 0.5 ma per pulse. Reconstruction of the electrode tracks was aided by utilizing measurements of imped-

Table 1. Number of points (N) which were stimulated and the number which yielded alimentary effects.

	Ν	Effect		
Structure		Intake	Ejection	Vomiting
Lateral hypothalmus	67	28	3	0
Posteror hypothalmus	79	34	9	0
Sentum	75	4	5	18
Medal preoptic area	85	14	14	0
Anterior cingulate gyrus	200	33	2	0
Olfactory tubercle-diagonal hand-substantia innominata	75	16	21	23
Amundala		3	38	63
Allyguala Midling thelmus	88	24	6	3
Ventralis anterior	102	0	24	59

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