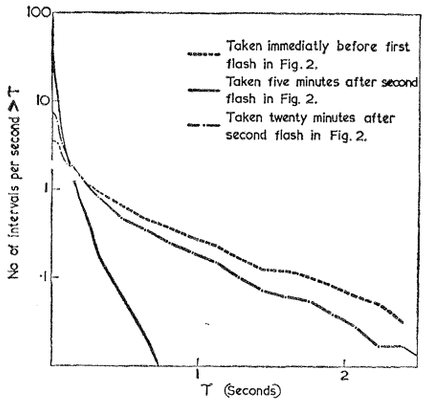

Fig. 2. Three-minute interval histograms taken immediately before first flash in Fig. 1*B*, 5 minutes after second flash in Fig. 1*B*, and 20 minutes after second flash in Fig. 1*B*, respectively.

control period of 30 minutes of firing, an intense flash was given to the contralateral retina; this emanated from a 1000-joule flash-bulb located 15 cm from the cat's eye, the pupil of which had been dilated with atropine. Room illumination was kept low and constant throughout the experiment.

Figure 1*A* indicates the change in rate of firing following the flash. The firing rate increased gradually to a relatively high peak after 10 minutes; next followed a slow decline until the original control level was roughly matched after 30 minutes. Figure 1*B* shows data for a second unit; two flashes were given 5 minutes apart, and the figure shows an apparent summation effect. Once again, after approximately 30 minutes, firing fell to the mean pre-flash level. The interval histograms in Fig. 2 indicate that not only did the overall firing rate increase, but that the firing rate within bursts also increased.

These responses showed an unusually long time course. The unit responses built up gradually, taking up to 10 minutes to reach their maximum; they then declined slowly to the control level for another 10 to 20 minutes. Relatively long effects of this sort have always been hard to produce and usually involved dramatic alterations of a cell's environment by, for example, topical application of strychnine or local polarization. Further, neither polarization nor stimulation with a regularly flashing light have been found to alter the slope of the short interval component of a histogram recorded from a visual cortical unit (*7*). In other words, the frequency of a unit's firing within bursts has hitherto seemed to be inflexible, even though the frequency and length of bursts have both increased. With an after-image which is known in the human to produce a persistent though varying and intermittent light sensation, changing information must pass up the optic tract for a considerable time. It seems likely that, if Burns's hypothesis of self re-exciting networks (*9*) is correct, an increased rate of firing within bursts reflects great increase in the amount of information circulating in networks of neurones within the visual cortex. [There is some evidence that a rise in intra-burst frequency represents increase in the number of impulses reaching a neurone from its neighbors (*10*).]

The question arises whether conclusions valid for the intact animal may be drawn from experiments on *cerveau isolé* preparations. Our preparations were responsive to visual stimuli and showed an electrocorticogram (ECG) with high frequency components. We believe that with healthy preparations the cortex is in an alert state and does not have slow, "spindly" wave forms in its ECG. The two most significant sensory pathways are still entirely intact, and several authors have commented on the efficacy of olfactory stimuli alone in producing arousal patterns in electroencephalograms recorded from *cerveau isolé* preparations (*11*).

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Choice Behavior in Rhesus Monkeys: Effect of Stimulation during the First Month of Life

Abstract. *Monkeys reared from birth away from other monkeys and handled by humans during the first month of life preferred humans to monkeys when tested at the age of 2 to 3 years. Animals having both early human handling and physical contact with other monkeys, or physical contact with other monkeys and no human handling, preferred monkeys. Subjects reared in complete isolation from humans and monkeys spent less time with either choice stimulus, but also preferred monkeys to humans.*

Persistent effects of early stimulation on later behavior have been demonstrated in many species. Studies of imprinting reveal effects of stimulation at "critical" periods in the life of the organism (*1*). Studies of primate behavior reveal persistent effects of early restriction on social, sexual, and maternal responses (*2–4*). This study concerns the effects of very early human handling on the preference of monkeys for humans or monkeys later in life.

We used six groups of rhesus monkeys that were reared in the laboratory. Some of these groups were reared in the laboratory nursery by the methods of Blomquist and Harlow (*5*). The important factor in nursery rearing for this study was the feeding of the monkeys by hand. The infant, cradled in the arms of the nursery worker (usually female), was fed from a baby's bottle. On the average, each infant was hand-fed once every 4 hours for 10 to 12 days after birth. When 11 to 25 days old the infant took its formula from a bottle on a wire rack where initially the infant was held in place by the nursery worker. When the infant could climb the rack, physical handling was minimal. Some animals were slow in developing ability to feed from the rack; to maintain their food intake, they received supplementary hand-feeding between days 12 and 20. Thus, for the first 10 days of life there was intimate physical contact between the infant monkey and the human, with progressively less physical contact thereafter, although close visual contact continued.

Animals in group 1 (handled, no peers) were nursery-reared from day 1 to approximately day 21. About day 22 they were placed in bare wire cages

and had no physical contact with other monkeys until they were 1 year old; other monkeys could be seen and heard from the cages. Animals in group 2 (handled, peers) received nursery experience from birth until about day 25 when they were housed in wire cages, in pairs, until they were 2 years old. Animals in group 3 (mother, peers) were reared by their mothers to the age of 1 year; during the first 6 months they had physical contact with other infants in daily social testing sessions (*3*). Animals in group 4 (1 year of isolation) were placed in isolation cages on the 1st day of life (*4*) and were fed through portholes during the 1st month. The infants could feel the nursery worker's hands at feeding time, but there was no intimate contact; they could neither see nor hear monkeys or humans for 1 year. Monkeys in group 5 (0 to 6 months of isolation) were treated exactly like those in group 4 until the age of 6 months, when they were placed singly in wire cages for the rest of the 1st year. Animals in group 6 (6 to 12 months of isolation) were reared in the nursery until day 25 and then placed in wire cages until they were 6 months old; from 6 months to 1 year they lived in isolation cages.

During the 2nd year all subjects except group 2 lived in wire cages and received intensive "playroom" testing involving daily interaction with other monkeys (*2*); all subjects had physical contact with other monkeys during the 2nd year of life. Numbers, sexes, and average age of the subjects in each group are given in Table 1.

Apparatus used for preference testing consisted of a six-sided frame of aluminum channels having six outer chambers, each adjoining the central chamber (Fig. 1). Materials forming the walls, floor, and ceiling of each chamber were inserted into the channels. Each chamber was 32.7 cm high and enclosed a maximum horizontal distance of 4.4 m. The walls of the central chamber formed guillotine-type doors, raised by cable. Two exactly opposed outer chambers were used in this experiment, the outer walls of which were of plexiglass, as were the walls adjacent to the center. Gray wood partitions blocked physical and visual access to the remaining four chambers. Translucent plexiglass partitions, inserted horizontally at the top of each chamber, blocked physical egress from the top. Light was provided by an upright incandescent bulb in a ceramic fixture attached to the outside of the plexiglass atop each chamber.

Table 1. Subject composition and summary of results for the six rearing conditions.

Group	Sex and age*	Mean time score (sec)			Mean entries		Preference ratio	
		Human	Monkey	Center	Human	Monkey	Time†	Initial choice‡
1	5M–2F, 2 yr 9 mo	226	36	38	5.1	1.4	1/7	0/7
2	4M–8F, 2 yr 2 mo	27	165	108	1.1	2.5	10/12	9/12
3	7M–5F, 3 yr 1 mo	11	191	98	1.8	8.5	12/12	9/12
4	3M–1F, 2 yr 10 mo	4	99	197	2.8	8.8	4/4	3/4
5	3M–1F, 2 yr 10 mo	0	126	174	0.0	1.8	4/4	4/4
6	1M–2F, 2 yr 11 mo	104	151	45	3.0	4.0	2/3	1/3

* Mean age at time of test follows the sexual composition. M, males: F, females. † Proportion of subjects in each group spending majority of time with monkey. ‡ Proportion of subjects in each group whose first entry was into the monkey compartment.

One stimulus was a female laboratory attendant wearing a laboratory coat and seated 13.1 cm from the outer plexiglass wall of the "human" chamber (Fig. 1) and facing it; she sat quietly and did not respond to any actions by the subject. The second stimulus was one of three monkeys, aged 3 years, who were chosen for their relatively nonaggressive behavior in previous testing; they were of the same average size as the subjects. One of the stimulus monkeys was placed in a cage (26.2 by 26.2 by 32.7 cm) entirely constructed of wire mesh, the front of it being 1.1 cm from the plexiglass wall of the "monkey" compartment.

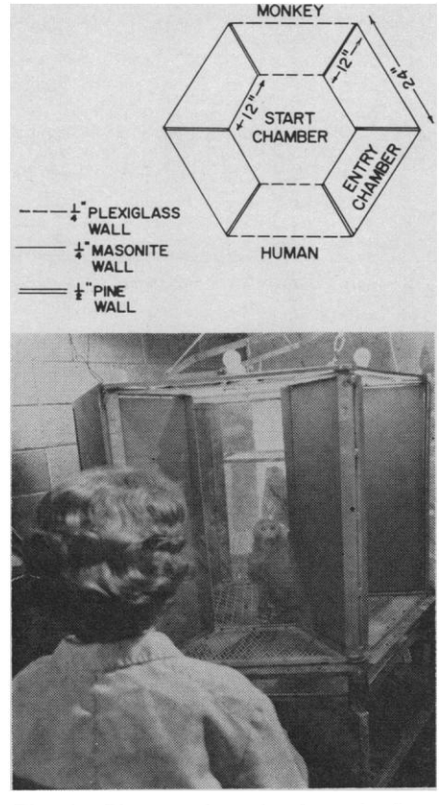

Fig. 1. Photograph and schematic floor plan of the apparatus used for preference testing.

To ensure relatively neutral behavior by the stimulus animals, a 1 mg/kg intramuscular injection of tranquilizer (promazine hydrochloride) was given 30 minutes in advance of a test day; the relatively low dose made the monkey mildly responsive—neither aggressive nor overly timid. One stimulus monkey was used each test day to test six or seven subjects. Each stimulus monkey was rested for 2 days; testing was stopped for the day if an animal appeared to be recovering from the effects of the drug.

Subjects were placed in the apparatus through the "entry" chamber; the 7-minute trial commenced when the animal left a transport cage and entered the central or "start" chamber, and the wall of the entry chamber was closed. For the first 2 minutes the walls of the start chamber remained closed, allowing the subject to see both human and monkey but not allowing it to enter the other chambers. After this exposure, the two inner walls were raised, and for 5 minutes the subject was free to enter and reenter any chamber or to stay in the center. The number of entries of and the time spent in each of the three chambers were recorded by the closure of switches mounted in the floor of each chamber. The apparatus was washed after each trial.

The results are summarized in Table 1. Analyses of variance for unweighted means (*6*), with groups as uncorrelated variables and stimuli (monkey versus human) as correlated variables, revealed that there were significant interactions of groups with stimuli for both time

spent in each stimulus chamber ($F = 5.20$; $df = 5, 36$; $p < .005$) and number of entries into each chamber ($F = 8.13$; $df = 5, 36$; $p < .001$).

Table 1 shows that (i) the animals in group 1 spent 600 percent more time with the human than with the monkey; (ii) monkeys in group 6 (who also had early handling, with no early peer contact) spent the second greatest amount of time with the human, although they spent more overall time with the monkey; and (iii) all other groups spent at least six times more time with the monkey than with the human. The same general result was obtained for the number of entries. The consistency of these results is shown by the proportion of subjects in each group making the monkey compartment their first choice, and the proportion spending more time with the monkey than with man.

A further point is the amount of time spent in the "neutral" central chamber. Both the 1-year and the 6-month early isolate animals spent almost two-thirds of the time in the center, while all other groups spent most of their time with either human or monkey. However, when these two isolate groups did choose a stimulus, they picked the monkey. In interpreting this result it was assumed that introducing a monkey into a completely novel environment without prior adaptation produces at least mild fear; choice of either monkey or human is therefore thought to be a response to the most fear-reducing stimulus available. Time spent in the center chamber would thus indicate the relative degree to which both choice stimuli failed to reduce fear.

These data lead to the conclusion, not well established in the primate literature, that the very early experience of a monkey with a specific type of stimulus can have lasting effects upon later preferential choice concerning that stimulus. Thus, a phenomenon perhaps related to imprinting may be operative in primate behavior. However, unlike the theoretically irreversible effects of imprinting in birds, learning in the first month by monkeys is apparently overcome by experience with other stimuli after the 1st month; this is shown by the strong preference by animals in group 2 for a monkey. Thus, effects on the monkey of early learning may be reversible, or the duration of an imprinting-like process leading to the formation of long-lasting "social" stimulus preferences may be much longer in monkeys than in birds.

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Feminine Behavior in Neonatally Castrated and Estrogen-Treated Male Rats

Abstract. *Male rats castrated within 4 days after birth are behaviorally feminized. On the other hand, intact or castrated males given estrogen neonatally show little estrous behavior in adulthood. Thus, feminization is induced by lack of neonatal androgen rather than by the presence of estrogen. Estrogen administered to newborn rats suppresses feminization.*

Male rats injected with estrogen on the 4th day of postnatal life show reduced male sexual behavior as adults (*1*); such estrogen-treated males are also said to display some female behavior in adulthood. It was suggested that these animals might have been feminized, perhaps by a chemical castration attributable to the injected estrogen. The work described here was done, in part, to determine whether estrogen actually does induce behavioral feminization when injected into newborn male rats.

The presence of androgen during the period of differentiation of the neural tissues mediating sexual behavior prevents the full display of female sexual behavior in adulthood. This period of neural differentiation occurs prenatally in guinea pigs (*2*) and during the 1st week of postnatal life in rats (*3*). Females treated with androgen during these periods fail to show normal feminine behavior as adults (*2, 3*). On the other hand, male rats castrated no later than 1 week after birth, and thereby deprived of testicular androgen during neural differentiation, are capable of displaying female behavior in adulthood (*4*). The question was asked whether rats castrated during the 1st week would be further feminized by injecting estrogen during this time. Thus, our second aim was to assess the relative roles of absence of androgen and presence of estrogen in the feminization of sexual behavior in the rat (*5*).

In experiment A the following four groups were used: group 1A, rats castrated 16 to 32 hours after birth; group 2A, rats castrated 16 to 30 hours after birth and given 100 μg of estradiol dipropionate subcutaneously on day 5; group 3A, rats sham-operated 16 to 30 hours after birth and given 100 μg of estradiol dipropionate on day 5; and group 4A, rats sham-operated 16 to 30 hours after birth. Animals in groups 3A and 4A were castrated when 60 days old. Tests were begun when the animals were 80 to 95 days of age. To induce estrous behavior each rat was injected with 4 μg of estradiol dipropionate and 40 hours later with 0.5 mg of progesterone. One hour after the progesterone injection, each animal was "fingered" for the lordosis response by lightly stroking the back between the iliac crests. Each subject was then placed with three stimulus males for 3 minutes or until it had been mounted 10 times. This process was repeated every 2 hours until 13 hours had elapsed from the time of progesterone injection. This entire procedure constituted one test. Animals underwent three such tests at 2-week intervals. Frequency of lordosis, ear-wiggling, and crouching (all indications of receptivity) were recorded. Frequency of mounting by stimulus males was also used to measure the stimulation value of the subjects.

Four groups of rats were also used in experiment B: group 1B, rats castrated 96 hours after birth; group 2B, rats castrated 96 hours after birth and then given 200 μg of estradiol benzoate subcutaneously; group 3B, rats given