Thus, at room temperature at least, metarhodopsin I appears to be involved mainly in the production of the negative component of the reverse potential, while metarhodopsin II contributes primarily to the positive component. These conclusions are supported by our experiments in which the time interval between the bleaching flash and the test flash is varied. At short intervals between flashes (approximately 1 msec) the negative component predominates; at longer intervals (100 to 1000 msec), on the other hand, the positive component is the dominant potential.

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Selection of Social Partners as a Function of Peer Contact during Rearing

Abstract. *Three groups of monkeys were raised with different degrees of contact with their peers. The first group was allowed no contact, the second only visual and auditory contact, and the third was allowed complete and normal contact with their peers. Animals of all three groups were allowed to interact socially; they were then tested for their preference for monkeys raised under the same conditions or for monkeys raised under different conditions. Monkeys raised under the same conditions preferred each other, even if the stimulus animals were completely strange to the test monkey.*

The early experiences of primates often have profound consequences on later behavior. In rhesus monkeys exploratory, maternal, sexual, and social behaviors appear extremely vulnerable to early social and sensory restriction (*1*). Monkeys reared in isolation tend to withdraw from other animals and huddle by themselves in social situations prefer each other to monkeys interact with more normal monkeys, they may not be effectively exposed to the stimuli which might lead to some degree of social adjustment. The fact that socially normal monkeys may avoid contact with monkeys reared in isolation further retards rehabilitation. We varied the amount of peer contact during rearing and investigated its effect on physical approach to a social partner, in order to determine whether monkeys reared under identical conditions prefer each other to monkeys reared under different conditions.

Three groups of rhesus monkeys were reared from birth in the laboratory without mothers. Each group contained four males and four females. Sets of three animals were matched across groups for age, sex, and test experiences after rearing was complete. The first group (A) was reared from birth to 9 months in individual closed cages. On the first 5 to 7 days they experienced physical, but minimal visual, contact with a human during feeding. No other physical or visual contact with humans or live monkeys occurred during rearing. Changing visual experiences throughout rearing were limited to presentation of pictures of monkeys engaged in various behaviors and pictures of people and inanimate objects (*2*). From months 9 through 18 the monkeys in group A were housed individually in bare wire cages from which they could see and hear other isolates and humans, but physical contacts were unavailable.

Subjects in the second group (B) were reared individually in a large nursery room in bare wire cages from birth to 9 months. Other monkeys and humans could be seen and heard, but physical contact was not available. From month 9 through 18 the monkeys in group B were housed in the same room as the monkeys in group A; they were in wire cages where they could see and hear, but not touch, one another.

The third group (C) lived in wire cages in peer groups of varying sizes during the first 18 months of life. Rearing conditions and social behavior tests provided physical peer contact during this period. In summary, group A had no early contact with live peers, group B had visual and auditory but no physical contact with peers, and group C had complete peer contact during the rearing period.

When they were 18 months old, sets of monkeys from all groups interacted during social behavior tests in a large playroom (*3*). Each animal was tested weekly for 12 weeks in three 30-minute sessions. In one weekly session a constant set of one group A, one group B, and one group C monkey of the same sex interacted together; the same animals were always tested together. On the two other weekly sessions constant pairs of groups A and B, A and C, and B and C subjects interacted in groups of four monkeys. After social testing, each subject had received equal playroom exposure to one monkey from its own rearing condition and to two monkeys from each of the other rearing conditions. After playroom testing was completed, the monkeys were tested for their preference for other monkeys reared under the same conditions or for those reared under different conditions.

Testing was done in the "selection circus" (Fig. 1), which consists of a central start compartment that bounds the entrances to six adjoining choice compartments. Wire-mesh cages for the stimulus animals were attached to the outside of appropriate choice compartments. The front walls of the stimulus cages, the outside walls of the choice compartments, and the guillotine doors separating choice compartments from the start compartment were all made of clear plexiglas.

For the testing, the subject was placed in the center start compartment with the plexiglas guillotine doors down for a 5-minute exposure period. The subject could see and hear the stimulus animals, but could not enter the choice compartments near them. Unused choice compartments were blocked off by plywood walls inserted in place of the plexiglas guillotine doors. After the exposure period, a 10-minute choice trial was given. The plexiglas guillotine doors were raised by a vacuum system; this procedure allowed the subject to enter and reenter choice compartments or to remain in the start compartment. The total time spent in each choice compartment during the test trial was recorded over a closed-circuit TV system.

The monkey's entry into different choice compartments served as our index of social preference. This measure of preference involves visual orientation, but, more importantly, it also involves locomotion toward a specific social object. It may be argued that a measure of viewing time, such as that used by Butler (*4*) in which monkeys inspected various objects through a small window, is not a proper index of social preference. Although actual physical contact was not available to our subjects, a great deal of nontactile social interaction was possible. Thus, our measure of preference based on physical approach toward a social object seems to be more analogous to an actual social situation than would be a simple viewing response.

Two types of trials were given. In the first, the stranger trial, one stimulus animal from each of the rearing groups was randomly positioned in a stimulus animal cage outside choice compartments 1, 3, or 5. These stimulus animals had received no previous social contact with the test subject but they were the same age and the same sex. A second test was identical with the stranger trial except that the three stimulus animals had received extensive social experience with the test subject during the playroom tests. Before the start of these tests, all 24 subjects had been adapted to the circus during nonsocial exploration tests. The order of serving first as a stimulus animal or as a test subject was randomized across groups.

Table 1. Mean number of seconds spent with each type of stimulus animal for each rearing condition, averaged over the two test trials.

Rearing condition of experimental animal	Rearing condition of stimulus animal		
	A (totally deprived	B (partially deprived	C (peer-raised)
A (totally deprived)	156	35	29
B (partially deprived)	104	214	103
C (peer-raised)	94	114	260

Analysis of variance of the total time spent in the choice compartment had rearing condition as an uncorrelated variable, and type of stimulus animal and degree of familiarity as correlated variables. Familiarity did not have a significant main effect, and it did not interact with the other variables (all $P > .20$). Rearing condition had a significant effect ($P < .001$), which indicated that total choice time in all compartments differed as a function of early peer contact. Group A subjects spent half as much time (average = 220 seconds) in choice compartments as either group B (average = 422 seconds) or group C (average = 468 seconds) monkeys.

The interaction of rearing condition with type of stimulus animal was also significant ($P < .001$). Table 1 shows this effect, with choice times averaged over the trials with strange and familiar stimuli. These data show that like prefers like—each rearing condition produced maximum choice time for the type of stimulus animal reared under that condition. The data for individual subjects supports this averaged effect. In the group A, two of the eight monkeys did not enter choice compartments. Of the six remaining monkeys, five spent more time in the group A choice compartment than in the other two compartments (two-tailed binomial, $P = .038$, with $p = 1/3$, $q = 2/3$). In the groups B and C all subjects entered choice compartments, and seven out of eight in each group spent more time with the animal reared like themselves than with the other animals (both $P = .0038$, two-tailed binomial).

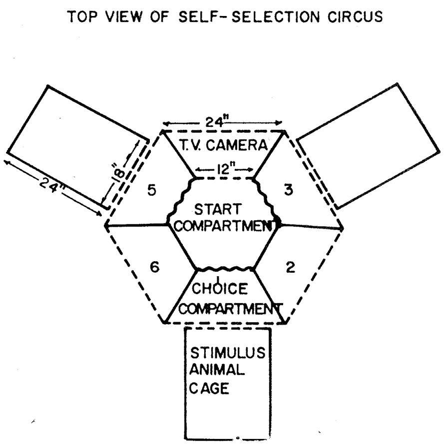

Fig. 1. Scheme of the "circus" which is constructed of aluminum channels containing plexiglas walls (dotted line), plywood walls (solid line), and plexiglas guillotine doors (wavy line). Wire-mesh stimulus cages with a single plexiglas wall are attached outside choice compartments. In testing, the subject is first placed in the start compartment. It can look into and through the choice compartments, but cannot enter them until the plexiglas guillotine doors are raised by a vacuum lift. Plywood walls block physical and visual access to choice compartments that are not used in the experiment.

The data indicate that social preferences are influenced by rearing conditions. In playroom testing the group C monkeys were the most active and socially advanced groups studied. Therefore, it was not surprising that they discriminated and showed large preferences for both strange and familiar group C animals. The group A monkeys, however, were highly retarded in their playroom behavior, and they did not show much progress over the 12 weeks of social interaction. As expected, these animals did exhibit a low degree of choice time in this study. We also thought that group A monkeys would be least likely to show preferences for a particular type of animal. It was, therefore, surprising to find that they did prefer each other to animals reared under other conditions. The group B animals, which were intermediate in social adequacy in playroom testing, also preferred each other. This result seems to strengthen the idea that animals of equal social capability, whether or not they are familiar with each other, can discriminate themselves from others, and not only discriminate but approach each other.

These results have important implications for studies designed to rehabilitate primates from the devastating effects of social isolation. The fact that socially abnormal monkeys prefer each other poses difficulties in the design of social environments which contain experiences appropriate for the development of normal social responses. Further, the finding that socially normal monkeys do not choose to approach more abnormal ones compounds the problem of providing therapy for abnormal animals.

These data also have implications for attachment behavior in mammals. Cairnes (*5*) suggests a learning theory approach to the formation of attachments in which the subject will approach a social object as a function of having made many previous responses while the social object was part of the general stimulus situation. Thus, indices of social attachment toward an object are expected to be higher with increases in the probability that this object occurs as part of the stimulus field in the subject's overall repertoire of responses. Although this seems a reasonable approach, the present data present some difficulties for this view. During rearing, the monkeys in group A did not have the same opportunity to learn the characteristics of other monkeys as did the monkeys in groups B and C. Yet, the monkeys in group A did prefer each other to the alternative choices available. Thus, it is possible that the preference shown by group A monkeys was not based on the conditioning of approach behavior to specific social cues, as is suggested by the stimulus-sampling theory of attachment. It is possible that the behavior of group A was motivated by avoidance of cues contained in the social behavior or countenance of the other two types of monkeys. Thus, there may be at least two distinct kinds of processes in the choice of a social stimulus. The conditioning of specific social cues to the response systems of an animal may be one factor, and the avoidance of nonconditioned cues may be a second important factor in the formation of social attachments.

The specific cues used by the monkeys studied here are not known. Neither do we yet know how our animals differentiated between the stimuli. The discrimination may be based solely on differences in the gross activity of the stimulus animals, or on more subtle and specific social cues. Analysis of the specific stimulus components operating in this situation may clarify the nature of the social cues involved. The important question to be answered is whether the types of cues used in selecting a partner are qualitatively different for different rearing conditions, or whether the same aspects of stimulation are simply weighted differently as a function of an animal's rearing history.

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Mercury: New Observations of the Infrared Bands of Carbon Dioxide

Considerable interest has attached to reports by Moroz (*1*) that the absorption bands of CO_2 at 1.57 to 1.61 μ are enhanced over those in the spectra of the sun and moon. Spinrad *et al.* (*2*) observed the spectrum of Mercury at high dispersion in the region of the weak $5\nu_3$ CO_2 bands in order to determine an abundance value independent of pressure broadening which affects the bands at 1.57 to 1.61 μ. The weak bands were not detected, but an upper limit of 57 meter-atm of CO_2 was established. Then, in order to account for the enhancement found by Moroz, Spinrad *et al.* noted that a surface pressure greater than 3.3 mb is required. The observations of Spinrad *et al.* require that the partial pressure of CO_2 be less than 4.2 mb.

We traced the 1.6-μ bands of CO_2 in the Mercury spectrum on 26 August 1966, using the 61-inch (1.5 m) reflector of the Lunar and Planetary Laboratory of Catalina Observatory and the infrared spectrometer described by Kuiper *et al.* (*3*). Our spectra have a resolution ($\lambda/\Delta\lambda$) of about 500, which is three times that of the Moroz spectra. Mercury was observed at relatively small zenith angles (22° to 43°), and solar comparisons were made at similar zenith distances on the same day. Care was taken to fill the optics in the same way for both Mercury and solar observations, and the same slit dimensions were used. Sunlight was diffusely reflected from a smoked MgO screen.

From our observations the equivalent widths of the 1.57- and 1.61-μ bands are 12.5 ± 1.9 Å and 10.0 ± 2.3 Å, respectively; while for the solar comparisons the equivalent widths are or 12.4 ± 0.7 Å and 10.5 ± 0.8 Å. Thus, within the error of the observations, there is no evidence here of a carbon dioxide atmosphere on Mercury.

We would emphasize that these observations are difficult and that we have far fewer individual tracings than Moroz does, though ours have higher resolution. Our results are to be regarded as preliminary, as many more tracings of these bands are needed (*4*).

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Homing in Pigeons

From data gathered by following individual pigeons during flight, Michener and Walcott [*Science* **154**, 410 (1966)] reason that their pigeons could not have been homing by use of landmarks alone and that their results "strengthen the conclusion that pigeons do not pilot most of their courses by familiar landmarks, even over landscape that they cross frequently." I think their data support the opposite conclusions.

The circuitous tracks flown by their pigeons and the frequent correspondence between consecutive tracks indicate use of landmarks. No highways are shown on their maps, but, when I compared them with my roadmap, 9 of the 11 tracks reported follow major highways, often quite closely; half of another follows the Merrimack River. Only one seems not to follow prominent landmarks; half of this curving track was repeated by the same bird on its next flight. Ten tracks refer to one pigeon; this bird's 21 earlier training flights were not followed, and during these it could have accumulated a knowledge of many landmarks, including "unfamiliar" Worcester. Minor variations in tracks from flight to flight can occur when the same landmarks are used; major variations suggest use of different sequences of landmarks.

During overcast the birds observed by Michener and Walcott did not fly when released more than 10 miles (16 km) from the loft (six releases of unknown individuals were reported), but they cite flocks homing "routinely" from greater distances under overcast. Why should one think that pigeons in flocks use navigational cues different from those used by lone pigeons?

All of Michener and Walcott's data suggest that their pigeons were using landmarks at all times when homing. No evidence is presented to show that the sun had any effect other than what they observed—that is, of stimulating