

## TOTAL SOCIAL ISOLATION IN MONKEYS\*

BY HARRY F. HARLOW, ROBERT O. DODSWORTH, AND  
MARGARET K. HARLOW

DEPARTMENT OF PSYCHOLOGY PRIMATE LABORATORY AND REGIONAL PRIMATE  
RESEARCH CENTER, UNIVERSITY OF WISCONSIN

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Human social isolation is recognized as a problem of vast importance. Its effects are deleterious to personal adjustment, normal heterosexual development, and control of aggressive and delinquent behaviors. Isolation generally arises from breakdowns in family structures resulting in orphaned or semi-orphaned children or in illegitimate children who, for one reason or another, are raised in institutions, inadequate foster homes, or, occasionally, in abnormal homes with relatives.

It is difficult or impossible to study scientifically the impacts of culturally produced social isolation at the human level. The variables are multitudinous and recalcitrant to experimental manipulation and control. Our research has consequently been concerned with the effects of social deprivation in rhesus monkeys. Previously published research has established parallels in the normal social development of human and monkey young.<sup>1-3</sup> There is every reason to believe that the same basic laws operate for these two closely related species and that social conditions which produce abnormality in one species will have comparable effects on the other. Although human behavior is more complex, more variable, and subtler than that of subhuman primates, one should, nevertheless, find insights into the problems created by human social isolation from study of social isolation in monkeys.

For the past ten years we have studied the effects of partial social isolation by raising monkeys from birth onward in bare wire cages such as those shown in Figure 1. These monkeys suffer total maternal deprivation and, even more important, have no opportunity to form affectional ties with their peers. We have already reported the resulting progressively deepening syndrome of compulsive nonnutritional sucking, repetitive stereotyped movements, detachment from the environment, hostility directed outwardly toward others and inwardly toward the animal's own body, and inability to form adequate social or heterosexual attachments to others when such opportunities are provided in preadolescence, adolescence, or adulthood.<sup>4</sup>

More recently, we have initiated a series of studies on the effects of *total* social isolation<sup>5</sup> by housing monkeys from a few hours after birth until 3, 6, or 12 months of age in the stainless-steel chamber illustrated in Figure 2. During the prescribed sentence in this apparatus, the monkey has no contact with any animal, human or subhuman. Although social isolation is total, no attempt is made to maximize *sensory* deprivation. The chamber is constantly illuminated, transmits sounds, and affords relatively adequate opportunities for cutaneous-proprioceptive expression and exploration. The room outside the living cage was sound-masked by a 70-db white noise source, but loud sounds from the corridor produced attentive and even freezing responses.

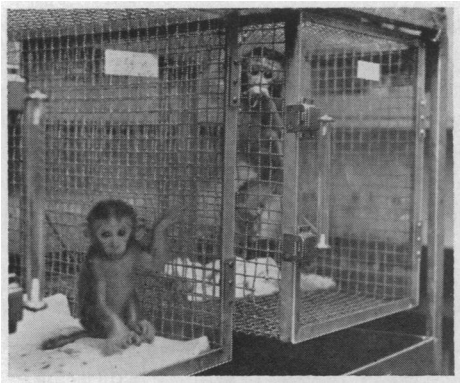


FIG. 1.—Semisocial isolation living cage.

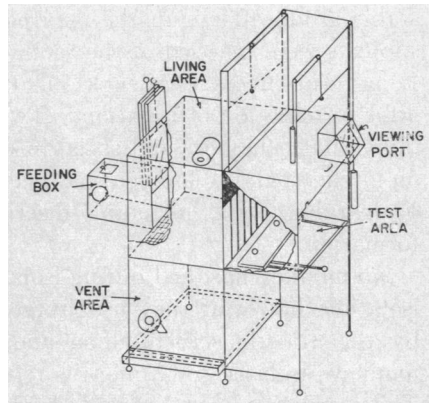
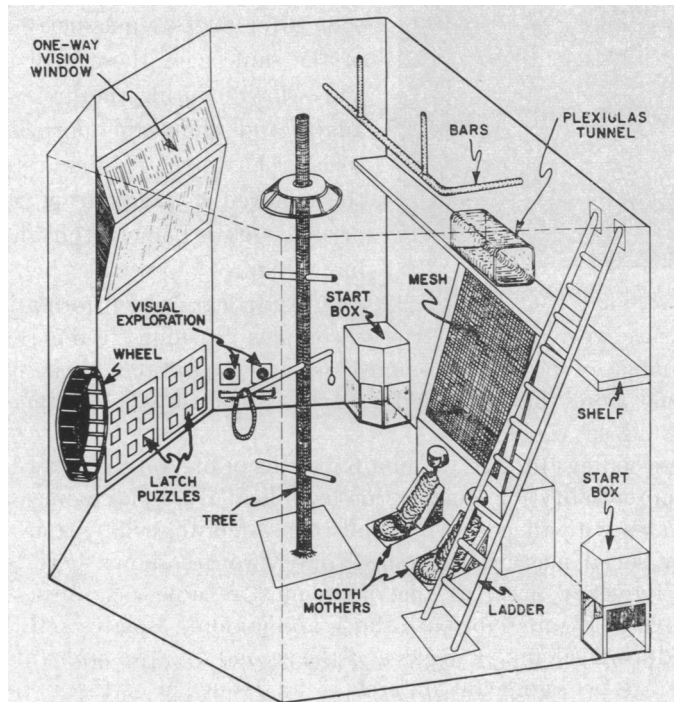


FIG. 2.—Total social isolation chamber.

Three groups of newborn monkeys were isolated in individual chambers for 3, 6, and 12 months, respectively. In addition, one group was kept in partial isolation in individual cages in the laboratory nursery for the first 6 months, then placed in the isolation chamber for 6 months. There were six monkeys in the 3-month group and four monkeys in each of the other groups. Isolation effects were measured by comparing the social behavior of pairs of isolated monkeys after release from the chambers with that of pairs of equal-aged monkeys raised in partial isolation. Each experimental pair and its control pair were tested together as a



**SOCIAL PLAY ROOM**

FIG. 3.—Playroom situation.

stable group of four in the playroom situation illustrated in Figure 3. The four subjects were released in the room for 30 min a day, 5 days a week, for 32 weeks. Long-term effects were subsequently assessed in the playroom from 1 to 2 years after termination of isolation. Two observers recorded the occurrence of selected individual behaviors and social interactions.<sup>6, 7</sup> In addition, the effect of isolation on intellectual development has been assessed by means of a comprehensive battery of learning tests, including discrimination, delayed response, and learning-set formation.<sup>8</sup>

No monkey has died during isolation. When initially removed from total social isolation, however, they usually go into a state of emotional shock, characterized by the autistic self-clutching and rocking illustrated in Figure 4. One of six monkeys isolated for 3 months refused to eat after release and died 5 days later. The autopsy report attributed death to emotional anorexia. A second animal in the same group also refused to eat and would probably have died had we not been prepared to resort to forced feeding. This phenomenon of extreme emotional anorexia has not appeared in the 6- or 12-month groups.



FIG. 4.—Autistic self-clutching pattern.

Our data indicate that the debilitating effects of 3 months of social isolation are dramatic but reversible. If there is long-term social or intellectual damage, it eludes our measurements. Given the opportunity soon after release to associate with controls of the same age, these short-term isolates start slowly during the first week and then adapt and show the normal sequence of social behaviors. In human terms they are the children salvaged from the orphanage or inadequate home within the first year of life. Figure 5 presents their postisolation progress in learning-set formation—the most reliable measure we have of relatively complex learning in the rhesus monkey. The performance of both the 3-month isolate group and their controls is indistinguishable from that of equal-aged monkeys tested in other experiments utilizing learning-set problems.

Isolation extending through the first 6 months of life, on the other hand, severely impairs the potentiality for socialization as indicated by playroom data comparing 6-month isolates with their controls and with 3-month isolates and their controls. Of the many social measures obtained, only two are shown here for illustrative purposes. Frequency of threat, one of the most reliable social measures, is graphically presented in Figure 6 for both the 3- and 6-month isolates and their appropriate controls during the first 4 weeks and the second 4 weeks after total social isolation. There are no significant differences in frequency of threat between the 3-month isolates and their controls during either test period; there is no reason to believe that the slightly higher frequency of threat by the isolates is other than a

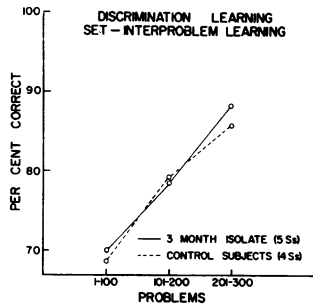


FIG. 5.—Postisolation learning-set formation.

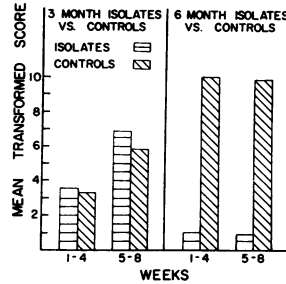


FIG. 6.—Incidence of social threat in the playroom.

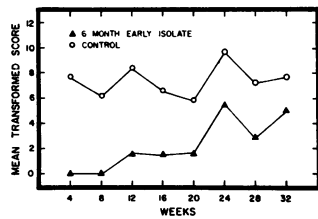


FIG. 7.—Developmental social threat trends.

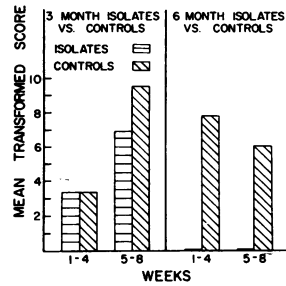


FIG. 8.—Incidence of contact play.

chance difference. These data contrast strongly with the differential frequency of threat behavior by the 6-month isolates and their controls during both observational test periods. Transformed scores were used for statistical reasons. The ratio of the actual frequencies of threat for the 6-month isolates and their controls was approximately 1-4. The differences were significant far beyond the 0.05 level. During the next 6 months the 3-month isolates and their controls showed no differential trends in frequency of social threat. The curves for the 6-month isolates and their controls over the 8 months of observation in the playroom are shown in Figure 7. From the 24th week on, frequency of social threat increased somewhat in the 6-month isolates, but these social threats were consistently directed to other isolates.

A comparison of the frequency of contact ("rough-and-tumble") play (Fig. 8) for the 3-month isolates and their controls showed no difference during the first 4-week period and no subsequent differential developmental trend. These data differ sharply from those for the 6-month isolates and their controls. Essentially no contact play was observed in the 6-month isolate monkeys during either of the first two 4-week postisolation periods, whereas a large amount of such play occurred for the controls. The level of contact play increased materially in the 6-month isolate group (Fig. 9) during the course of the 32 weeks of testing, but again the contact play that was exhibited was play between isolates and not between isolates and controls. Actually, social interaction throughout the entire 32-week test period between the 6-month isolate monkeys and their controls was for all practical

purposes nonexistent except for bursts of aggression which the controls occasionally directed toward the isolate animals.

The effects of 6 months of total social isolation were so devastating and debilitating that we had assumed initially that 12 months of isolation would not produce any additional decrement. This assumption proved to be false; 12

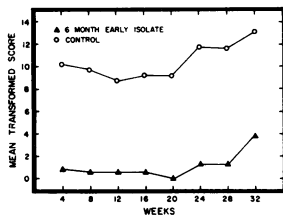


FIG. 9.—Developmental trends in contact play.

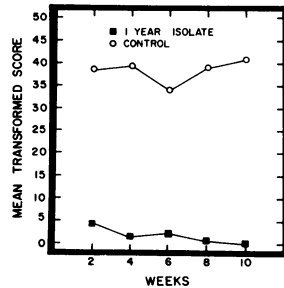


FIG. 10.—Activity play of 12-month isolates.

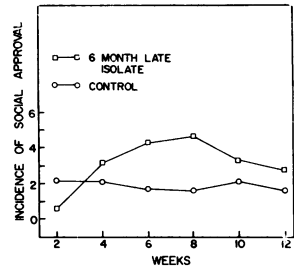


FIG. 11.—Incidence of social approach in 6-month late isolates.

months of isolation almost obliterated the animals socially, as is suggested by the playroom data for activity play, the simplest form of play, shown in Figure 10.

Activity play was chosen as a prime measure since it represents a primitive play level involving minimal interanimal contact. The 12-month isolates showed practically no activity play, and the trend was a decrease with time. The control monkeys, on the other hand, displayed a relatively constant, high level of activity play. Observation of the 12-month isolated animals and their controls had to be terminated after 10 experimental weeks because the controls became increasingly aggressive toward the helpless isolate animals and might have killed them had we continued social testing.

A striking difference between the 6-month and the 12-month socially isolated monkeys occurred in the frequency of autoerotic behaviors. Such behaviors occurred, although with low frequency, in the 6-month isolate group; they were virtually nonexistent in the 12-month socially isolated subjects. Control monkeys, on the other hand, displayed a high level of such behaviors.

Total social isolation during the second half year of life produced a radically different syndrome from that for the first half year. Within a relatively short period of time after release from isolation, the 6-month late isolates adjusted adequately to equal-aged playmates. This finding is indicated in Figure 11 by the frequency of social approach exhibited by these subjects as compared with their controls. Although the differences are not statistically significant, the 6-month late isolates made more approaches than the controls, no doubt reflecting the somewhat greater aggressiveness of the isolates and the consequent caution of the controls. Observational data show that the 6-month late-isolate group was hyper-aggressive compared with its control group whereas both the 6- and 12-month socially isolated subjects were characterized by a marked lack of aggression compared with their controls.

The effects of 6 and 12 months of total social isolation on learning are confounded in our studies since we attempted, with success in some cases, to measure by remote-

control test methods, the isolated monkeys' ability to solve learning problems during their periods of confinement. Thus, even when the infants failed to progress during isolation, they were being given intellectual stimulation which could have played a significant role in their apparent intellectual normality after release. The learning data obtained on delayed-response and learning-set tasks after removal from total social isolation disclosed no significant differences between 6- and 12-month isolated monkeys and their equal-aged controls, but the consistency of the small differences that did occur suggests the possibility that larger samples might support a difference. The learning-set data are presented in Figure 12. The performance of the control monkeys tends to be higher than that of the 6-month isolates, and the performance of the 6-month isolates tends to be higher

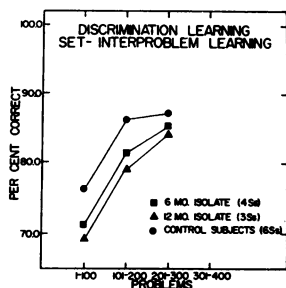


FIG. 12.—Postisolation learning-set formation.

than that of the 12-month isolates. The striking fact, however, is that all the socially isolated monkeys learned effectively after being removed from the social isolation cages. We cannot, at the present time, adequately assess the effect of prolonged total social isolation on the intellectual capabilities of rhesus monkeys. The ultimate appraisal must await experiments in which no training is given during isolation. We can, however, state with confidence that the "intellectual mind" is far less crippled than the "social mind" by prolonged total social deprivation if adequate experience is provided subsequently. Inasmuch as this intellectual sparing is contrary to the current theory of the effects of social deprivation on the intellectual development of human children, a review of the human data may be in order. The so-called intellectual deficits reported for deprived children may well be social deficits in large part rather than intellectual ones.

An experiment presently being prepared for publication by G. D. Mitchell<sup>9</sup> provides data on the social behavior of members of our total-isolation groups toward more normally raised macaque monkeys over long time periods. Eight isolated subjects were assembled, two from the 12-month isolated group, and three each from the 6-month early- and 6-month late-isolation groups. They ranged in age from 2 years and 4 months to 3 years and 5 months. The other members of our totally socially isolated groups were not available because of various research commitments. Studies investigating the long-term social behavior of all members of all the groups subjected to total social isolation are presently in progress.

Mitchell tested the social behaviors of individual isolates and normal monkeys toward age mates, adults, and 1-year-old infants. The 12-month isolates showed no play, no aggression, almost no sex behavior, but a high level of fear to adults, to age mates, and even to the infants. Two of the 6-month early isolates showed no play, but one—a female—showed adequate play with adults, age mates, and infants. One of the three showed aggression toward adults, age mates, and infants. One showed aggression only toward adults. The third—the female—showed aggression only toward age mates and infants. Sex behavior was almost non-existent except for scattered, diffuse sex responses directed toward infants. Two of the three showed extreme fear toward adults but not toward age mates or infants, while the third showed no fear at all.

The 6-month late isolates differed from the 6-month early isolates primarily in only one aspect of behavior: two of the three showed uncoordinated sexual responses toward age mates and one of these showed the same kind of responses to adults. In play, one of the 6-month late group showed essentially normal responsiveness with age mates and also with infants and adults. One showed virtually no play at all, and the third played only with infants. Two of the three showed the same suicidal aggression toward adults as did two of the 6-month early isolates, a behavior rarely seen in normal monkeys. All three showed hostility toward infants, even though two of them were females. This behavior is essentially non-existent among normal monkeys. Perhaps most surprising was the finding that none showed much hostility toward age mates even though they had been hostile to age mates in the initial observations following isolation. One showed almost no fear to any age range of subjects, while the third showed moderate fear to adults but not to age mates or infants.

In summary, on the follow-up tests, the 12-month isolates were highly fearful and showed almost no positive social behavior and no aggression. Except in sexual behavior, the 6-month early and late isolates were highly similar, as groups, in their social responses. One member of each group showed essentially normal play behavior, and two of each group showed little or no play. Two members of each group showed suicidal aggression toward adults, and five of the six members of the combined groups showed the abnormal phenomenon of aggressing against infants. None of the six was a socially normal animal, for even the two that played with the test animals were hostile to infants and none of the six showed adequate sex behavior. The adjustments of the members of these two groups were highly individual in that a number adapted adequately to specific situations, but none adapted adequately to all or even most types of situations. The effects of isolation in the first year thus were clearly evident 12–24 months (mean, 18 months) after removal from isolation in spite of the prolonged social experience provided the subjects following isolation.

The findings of the various total-isolation and semi-isolation studies of the monkeys suggest that sufficiently severe and enduring early isolation reduces these animals to a social-emotional level in which the primary social responsiveness is fear. Twelve months of total social isolation is apparently sufficient to achieve this result consistently in rhesus monkeys. In contrast, short periods of total social isolation leave no permanent deficits in potentialities or social adjustment. For the rhesus monkey, this period of sparing is at least 3 months. Periods of total isolation somewhere between 3 months and 12 months or prolonged periods of semi-isolation result in different degrees of social damage and permit variable behavioral adaptations, perhaps as a function both of basic individual differences and of social learning experiences. Individuals subjected to the same deprivation conditions can thus emerge as generally fearful or fearless, generally hostile or without aggression, or selectively fearful or selectively hostile. Placed in a free-living situation, most of these animals would be driven off or eliminated before they could have an opportunity to learn to adapt to the group.

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University of Wisconsin Department of Psychology Primate Laboratory and Regional Primate Research Center, respectively.

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<sup>6</sup> Rowland, G. L., doctoral dissertation, University of Wisconsin, 1964.

<sup>7</sup> Griffin, G. A., M.S. thesis, University of Wisconsin, in preparation.

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## CAPACITY FOR PHOTOPERIODIC RESPONSE AND ENDOGENOUS FACTORS IN THE REPRODUCTIVE CYCLES OF AN EQUATORIAL SPARROW\*

BY ALDEN H. MILLER

MUSEUM OF VERTEBRATE ZOOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY

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In previous reports<sup>1, 2</sup> on the reproductive cycles of an equatorial population of the Andean sparrow, *Zonotrichia capensis*, I have shown that males in their natural environment, where significant seasonal changes in photoperiod are not encountered, undergo cycles of regression and recrudescence that reflect an innate rhythmic attribute. Such males normally show 4 months of sustained reproductive capacity followed by regression and regrowth of the testes, which events together occupy 2 months. Therefore, two complete cycles normally occur in a 12-month period. The cycles of different individuals are imperfectly coordinated by environmental factors so that some males may be found to be reproductively active in the population at all periods of the year. In females, which control the culminative stage of breeding, nest building and ovulation may occur throughout the year in the population, but egg laying shows two peaks at 5- and 7-month intervals. These peaks are correlated with the rainfall cycle and probably are mediated by the molt cycle, which is influenced particularly by the dry periods.<sup>2, 3</sup>

The question arises, then, whether this equatorial race of *Zonotrichia capensis* has the mechanism to respond to seasonal photoperiodism as do its north-temperate relatives, *Zonotrichia leucophrys*,<sup>4</sup> *Z. atricapilla*,<sup>5</sup> and *Z. albicollis*.<sup>6</sup> Is it positively stimulated by long days and inhibited by short days and does it possess the post-breeding refractory period of its northern relatives which adaptively blocks<sup>7</sup> late summer and autumnal breeding?

*Methods.*—Birds from the study area in the Western Andes of Colombia were brought to Berkeley, California, in 1959 and maintained in aviaries until early 1965. The sparrows were housed in units approximately 8 × 8 × 7 feet, with outdoor exposure. From 1960 on, they were isolated by pairs. The initial six birds were augmented by three young, hand-raised in 1960. The birds nested frequently, re-