Effects of Maternal Mobility on the Development of Rocking and Other Behaviors in Rhesus Monkeys: A Study with Artificial Mothers

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Mechanically driven mobile artificial mothers effectively prevented the development of stereotyped body-rocking in rhesus monkeys. Monkeys were maternally separated at birth and assigned to 2 groups. Both groups were placed with surrogates, identical in construction except that for 1 group the surrogate was in motion 50% of the time from 0500 hours to 2400 hours each day, and for the other group the surrogate was stationary. All but 1 of the 10 monkeys raised with stationary artificial mothers developed rocking as an habitual pattern whereas none of the 9 monkeys raised with mobile mothers did so. The data also suggest that emotional responsiveness was reduced in monkeys raised with mobile mothers, compared to monkeys raised with stationary devices.

In Harlow's initial experiments with artificial mothers, rhesus monkeys developed a strong and abiding attachment to a cloth-covered cylinder, similar in many respects to the attachment formed to the natural mother (Harlow, 1958). In spite of their effectiveness as a source of emotional reassurance, however, cloth surrogates seemed to have no significant long-range constructive influence on behavioral development. Surrogate-raised monkeys displayed the characteristic syndrome of the socially-deprived macaque: they clutched themselves, engaged in nonnutritive sucking, developed stereotyped body-rocking and other abnormal motor acts, and showed aberrant social responses (Harlow & Harlow, 1962; Harlow, Joslyn, Senko, & Dopp, 1966).

Monkey mothers, of course, provide their infants with massive amounts of patterned and variable stimulation, as compared with that received from inanimate surrogates. Part of this stimulation occurs during highly structured interactions between mother and infant, and part of it occurs as a mere consequence of the fact that the infant is in intimate contact with a moving body. During the first few weeks of life, it is carried

constantly by the mother and continues to be transported by her frequently until several months of age, long after it is capable of walking alone (Hinde, Rowell, & Spencer-Booth, 1964; Kaufmann, 1966). Thus, the natural mother is a rich source of relatively nonspecific "passive movement stimulation." The purpose of this research was to assess the effects of this aspect of maternal behavior on the development of the infant rhesus monkey.

The experiment compared 2 groups of monkeys raised with identical artificial mothers, except the surrogates of 1 group were stationary and those of the other group were mobile, designed to simulate the varied input created during maternal transport of young. We were interested in the general developmental consequences of surrogate mobility, of course, but we also had a more focused concern. Macaques, chimpanzees, baboons, geladas, and gibbons—whether raised alone or with inanimate artificial mothers—develop a distinctive and individually stereotyped pattern of body-rocking in a high percentage of cases. Similar behaviors are exhibited by many humans within certain diagnostic groups—the severely retarded, blind, and autistic children—and by some children who show no other signs of abnormality (Kravitz & Boehm, 1971). The developmental antecedents of stereotyped body-rocking in man are seemingly diverse. In the nonhuman primates, however, strong presumptive evidence links this behavior to early maternal deprivation (see Berkson, 1967, for review).

We hypothesized that a mobile artificial mother would establish the critical condition for preventing the development of habitual body-rocking in rhesus monkeys. Affirmative evidence would support the view that stereotyped rocking is the expression of a stimulus need and/or motor urge, normally present in the infant macaque, which assumes an atypical form in the deprived monkey owing to the absence of inputs and constraints that a moving mother provides. Body-rocking, like thumbsucking and self-clasping—2 other common stereotyped behaviors of deprived rhesus monkeys—could thus be considered a self-generated reaction induced or distorted by demonstrable deficiencies in the maternal environment.

Method

Subjects and Rearing Conditions

Nineteen rhesus monkeys, separated from their wild-born mothers within the first 2 days post-partum, were housed in cages measuring 1.1 m on a side, constructed of welded wire over a wood frame. Each cage contained an artificial mother made from a plastic bottle (height 27 cm; diameter 13 cm), covered by brown acrylic fur with strands approximately 3 cm long, and having a metal pie pan base 4 cm deep and 25 cm across.

The surrogates of the Stationary group (5 males, 5 females) were fixed in the right front corner of the cage by a .6 cm metal rod passing from the ceiling to the floor of the living cage. The surrogates of the Moving group (5 males, 4 females) were mobile. This was accomplished by suspending the surrogates from the top of the cage by a .6 cm rod attached outside the cage to a mechanism that moved the surrogate up and down and around the cage. When in motion the surrogate described a circle approximately 43 cm in diameter. The rate of movement was 9 rpm. The distance between the surrogate and the cage floor was 2.5 cm and 15.0 cm at the points of lowest and highest excursion in the

vertical plane. The rod connecting the surrogate to the mechanism was equipped with a universal joint within the cage so that the surrogate moved freely in all directions in the horizontal plane in response to external force. From 0500 hours to 2400 hours each day the mobile surrogate was activated on an irregular schedule that provided movement 50% of the time. The shortest period of continuous movement was 15 sec, and the longest period was 45 sec. Stationary periods ranged between 15 and 120 sec.

The surrogates of 7 monkeys in the Moving group and 8 monkeys in the Stationary group were equipped with spring-loaded switches that activated clocks when closed by the weight of the monkey. This provided a measure of time on the surrogate by 24-hr periods.

Members of both groups were housed in the same room, usually in adjacent cages. They could see and hear but not touch each other. The room was lighted continuously. From Days 1-25, animals were bottle-fed milk formula at 2-hr intervals between 0800 hours and 2000 hours. Bottle feedings occurred on the surrogates and at this time the moving devices were stopped. Solid foods and cup feedings were introduced as soon as the animal had made an effective transition to the cup. Seven monkeys in the Moving group (3 males, 4 females) and 8 monkeys in the Stationary group (4 males, 4 females) were weighed daily (before the 1st morning feed) for the first 2 weeks of life and at weekly intervals thereafter. At a mean age of 311 days (302-343) the surrogate was permanently removed.

Situations and Observation Procedures

The primary behavioral data for analysis of rearing effects were obtained in 6 situations:

1. Observations in Living Cage. Observations of behavior in the living cage were made regularly, mornings and afternoons, 5 days a week, beginning on the 1st or 2nd day of life. The length of each observation period was 10 min. A total of 200 observation days was completed before the surrogate was removed and 60 observation days thereafter. The observer sat in plain view of the subject, about 1 m from the living cage.

2. Effects of Surrogate on Responses to Test Cage. The monkeys were observed in an enclosed cage (63 x 122 x 71 cm) from behind a 1-way screen. Observation periods were 5 min; 2 observations were made per day, twice a week, for a total of 50 observation days. The surrogate was present on one of the daily observation periods and absent on the other, in balanced order. Mean ages at the beginning and end of testing were 37 and 214 days, respectively.

3. Effects of Surrogate and Environment on Response to Novel Objects. Responses to 8 objects (human-like doll, painted block of wood, toy stuffed animal, stick, rope, diaper, coffee can, surrogate cover) were measured in the living cage with the surrogate present or absent, and in the test cage (see Situation 2) with the surrogate present or absent. The objects were presented singly, in the order listed above, for 2.5 min in each of the 4 conditions. Each object was presented on 1 day in each condition and the order of conditions (living cage/test cage; alone/with surrogate) was balanced. The mobile surrogate was stopped during tests in the living cage. Mean ages at the start and end of testing were 243 and 254 days, respectively.

4. Responses to a Novel Room. This test was designed to replicate as closely as possible the procedures of Mason and Green's (1962) comparison of nursery-raised and

wild-born rhesus. The subjects were observed in an enclosed test room approximately 3.7 x 2.4 m. Four small objects (screen door hook, wood block, short length of chain, red plastic reflector) were fixed to one wall 20 cm above the floor; the floor was marked off into squares (70 cm on a side) to provide a measure of locomotor activity. Each animal received one 5-min trial a day for a total of 10 days beginning at a mean age of 264 days, and ending at a mean age of 276 days. A comparable series was administered after removal of the surrogate, beginning and ending at the mean ages of 341 days and 354 days, respectively. The monkey was allowed 10 sec in which to enter the room, following which entry was forced (if necessary) by sliding forward a panel at the rear of the carrying cage. In addition to the check-list data (see below) locomotor activity was measured by a counter.

5. *Responses to Role-Playing Humans.* This test was conducted in the same room used in the preceding test. Each subject received two 5-min sessions per day, for a total of 10 days. On each session a stimulus-person, wearing coveralls, gloves, and a fencing mask, sat on the floor of the room within a 1.2 m square with his back against the wall. Two distinctive costumes were used, one indicating that the subject would be played with (tickling, pushing, manipulation of limbs) and the other indicating that it would be held in a ventro-ventral clinging position upon entering the square occupied by the person. Each role was presented once a day in balanced order. This test was completed after the surrogate had been permanently removed from the living cage. Mean ages at the beginning and end of the test were 365 days and 379 days, respectively.

6. *Social Behavior with Wild-Born Monkeys.* This test was completed after the surrogate had been permanently removed from the living cage. One male in the Stationary group was not available for testing. Each of the remaining subjects was paired once a day for a total of sixteen 10-min periods with a wild-born male and for the same number of periods with a wild-born female. The wild-born animals were selected to match the size and weight of the surrogate-raised subjects. The first 5 pairings were in the test chamber used in Situations 4 and 5, the next 6 pairings were in the living cages (the subject was "host" and "guest" equally often), and the final 5 pairings were in the test room. Testing began at a mean age of 408 days and terminated at a mean age of 432 days.

Data Analysis

Unless otherwise indicated behaviors in all situations were recorded by 15-sec intervals on time-ruled check lists, and frequency of response refers to the percentage of intervals in which a behavior occurred at least once. No behavior was scored more than once per interval. Response categories, reliabilities (based on percent agreement per observation period) and the situations in which each category was scored are shown in Table 1.

Overall group differences were analyzed first (combined conditions), then intergroup differences within conditions, and finally intergroup differences in between-condition change scores. Change scores were evaluated by the Mann-Whitney test. Unless otherwise indicated, all other comparisons were based on the *t* test. The .05 significance level (2-tailed) was accepted throughout.

TABLE 1.   Response Definitions and Reliabilities.[a]

Self-directed responses

Crouch: Ventral surface close to floor, head at or below the level of the shoulders. Scored in all situations. (95%)

Self-Clasp: Hand or feet closed on fur or some body part. Scored in Situations 1, 2, 3, 4, 5. (85%)

Self-Biting: Discrete biting action, usually directed to the limbs and often accompanied by a threat face. Scored in Situation 6. No reliability data.

Manipulate Self: Any movement of the hand or foot over some body surface, as in scratching, rubbing, picking or pulling. Scored in all situations. (76%)

Rock: Unbroken rhythmic movements of the upper body while the animal is in a sitting position. Scored in all situations. (77%)

Suck: Insertion into the mouth of fingers, toes and other body parts. Scored in all situations. (91%)

Vocalization

Coo: Medium-pitched, moderately intense, clear call. Scored in all situations. (85%)

Screech: Intense, very high-pitched. Scored in all situations. (81%)

Distress Vocalizations: Composite measure of coo and screech. Scored in all situations. (84%)

Bark: Gruff, abrupt, low-pitched vocalization. Scored in all situations. (73%)

Contacts with physical environment

Manipulate Environment: Any discrete contact by hand or mouth with the physical environment. Scored in all situations. (86%)

Manipulate Objects: Any contact by hand, foot, or mouth with test objects. Scored in Situations 3, 4. (89%)

Social response[b]

Approach: Movement to within 16 cm of another. Scored in Situation 6.

Passive: No response to social contact initiated by another. Scored in Situation 6.

Proximity: Within 16 cm of another. Scored in Situation 6.

Withdrawal: Abrupt movement away from another, except during play-fighting. Scored in Situation 6.

Contact: Any contact between 2 monkeys (Situation 6), the monkey and a stimulus-person (Situation 5), or the monkey and the artificial mother (Situations 1, 2, 3). (95%)

Aggression: Vigorous biting, clasp-pulling of fur, cuffing of another, often accompanied by piloerection. Scored in Situation 6.

Cling: Ventral contact and embrace of surrogate or another animal. Scored in Situations 1, 2, 3, 6. (81%)

Groom: Systematically picks through another's fur with hands. Scored in Situation 6.

Huddle: A relaxed posture involving leaning against another. Scored in Situation 6.

Mount: Male sexual posture, with proper body orientation toward partner. Scored in Situation 6.

Other Mount: Male sexual posture, not in proper orientation toward partner. Scored in Situation 6.

Play-Fighting: A complex pattern involving tumbling, mauling, wrestling, mouthing with another. More variable, less vigorous and intense than aggression; is not accompanied by intense vocalization. Scored in Situations 1, 6.

TABLE 1.   *Response Definitions and Reliabilities.*[a]   *(Continued)*

Social response

Social Facilitation: Activity of 1 animal with respect to some inanimate feature of the environment elicits approach, observation, and display of similar behavior from another. Scored in Situation **6.**

Social Investigation: Close visual, manual and/or oral investigation of the partner. Scored in Situation **6.**

Thrusting: Piston-like pelvic movements accompanying mounting. Scored in Situation 6.

Sexual Present: Female sexual posture. Animal stands on all fours, with legs extended, tail elevated, hindquarters directed toward partner. Scored in Situation 6.

Facial expressions

Grimace: Lips are drawn back revealing the teeth. Scored in all situations. Too few data for reliability check.

Lipsmack: Rapid, rhythmic opening and closing of the lips. Scored in all situations. Too few data for reliability check.

Threat: Retraction of the ears, raising and/or lowering of brow ridges, lower jaw pulled down. Scored in all situations. (71%)

Other

Defecation: Scored in Situations 2, 4. (100%)

Gross Motor Activities: Jumping, back-flips, etc. Scored in Situation 4. (94%)

Locomotion: Movement of a full body length or (Situation 4) entering a square up to the midline of the body. Scored in Situations 1, 2, **3, 4.** (93%)

Sleep: Motionless with eyes closed for 2 or more consecutive 15-sec intervals. Scored in Situation 1. (95%)

Urination: Scored in Situations 2, 4. (100%)

[a] Percent agreement $= \dfrac{\text{agree}}{\text{agree} + \text{disagree}}$, null agreements excluded.

[b] No reliabilities obtained in Situation 6. Reliabilities for most categories, based on a comparable method, reported in Mason, 1960.

Results

Rearing Effects

Body Weight. Birth weights were comparable in the 2 groups (Moving, .456 kg; Stationary, .471 kg) and both showed the initial loss typically found in nursery-raised macaques (Jacobson & Windle, 1960). Weight gain was slightly more rapid in the Stationary Group, however, and by Days 8-10 they had regained birth weight (100.5%), whereas the Moving group was still below this value (95.3%). Although the difference was small, it was significant at the .02 level. The Stationary group maintained a slight superiority throughout the first 250 days of life and when the data for this period were analyzed by 10-day blocks, intergroup differences were significant for blocks 51-60, 61-70, and 71-80. Following Day 250, however, percentage of birthweight was greater in the Moving group, although the differences were not significant.

Living Cage Observations (Situation 1). The most obvious effect of surrogate mobility was on stereotyped body-rocking. All but 1 of the monkeys in the Stationary group rocked with sufficient regularity to be considered an habitual performer of this pattern, whereas none of the monkeys in the Moving group did so $(p \leqslant .002$, Mann-Whitney). The course of rocking over the first 200 observation days is shown in Figure 1G. Rocking appeared in the Stationary group at a mean age of 28.5 days, increased in frequency over the next several months, and declined somewhat during the 3 blocks preceding removal of the surrogate.

Crouching was shown occasionally by all individuals in both groups; no developmental trends were indicated for this measure and intergroup differences were not
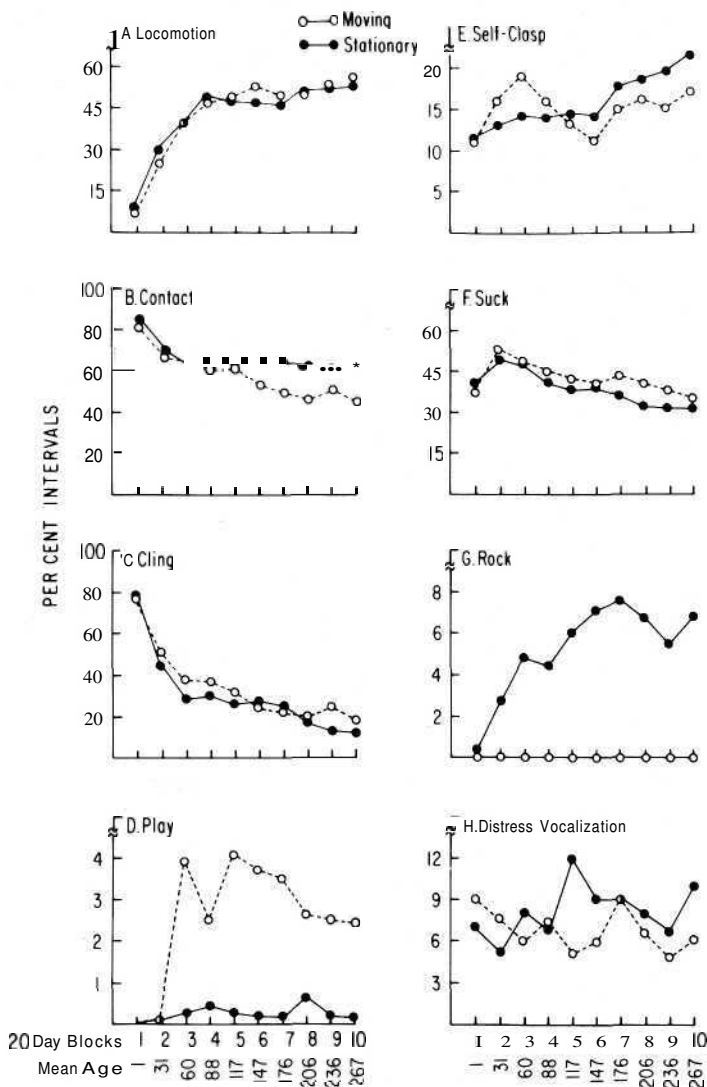

Fig. 1. Percentage of intervals in which the indicated responses occurred. Based on observations in the living cage (Situation 1).

significant. Self-clasping (Fig. 1E) and nonnutritive sucking, the other major "self-directed" responses usually seen in socially deprived monkeys (Berkson, 1968; Mason & Green, 1962), were also shown by all individuals in both groups; the frequency of these behaviors was not differentially related to rearing conditions. The developmental course for sucking was similar in both groups, and was characterized by a slow but steady decline from an initial high during the first 2 months of life (Fig. 1F).

The amount and form of contacts with the surrogate differentiated groups, particularly after the first few months of life (Fig. 1B, 1C, 1D). As would be expected, clinging to the surrogate was most frequent during the first month of life, dropped off rapidly over the next few weeks, and showed a gradual decline thereafter. At no point did the groups differ significantly on this measure. Total contacts with the surrogate, however, were higher in the Stationary group than in the Moving group, following Observation Day 120. The highest scores were made by the Stationary females, who differed reliably from Moving females (72.1% vs 50.1%, $p \leqslant .01$) and males (72.1% vs 49.6%, $p \leqslant .05$), but not from Stationary males (72.1% vs 54.7%). The reduction in contacts between the 1st and 2nd blocks of 100 observation days was significant for the Moving group, but not for the Stationary group. Clock measures of duration of contact per 24-hr period are presented in Figure 2. The comparatively low scores in the first 10-day block reflect the difficulties of the newborn infant in maintaining contact with the surrogate. Duration measures for the subsequent periods are in good agreement with the check-list data. Duration of contact was initially high, then declined in both groups, but starting at about 100 days of age was consistently lower in the Moving group, reliably so for the final block of 100 days $(p \leqslant .02)$. Finally, monkeys in the Moving group more often directed rough-and-tumble play responses toward their surrogates than did monkeys in the Stationary group. Play was not seen in either group in the 1st block of 20
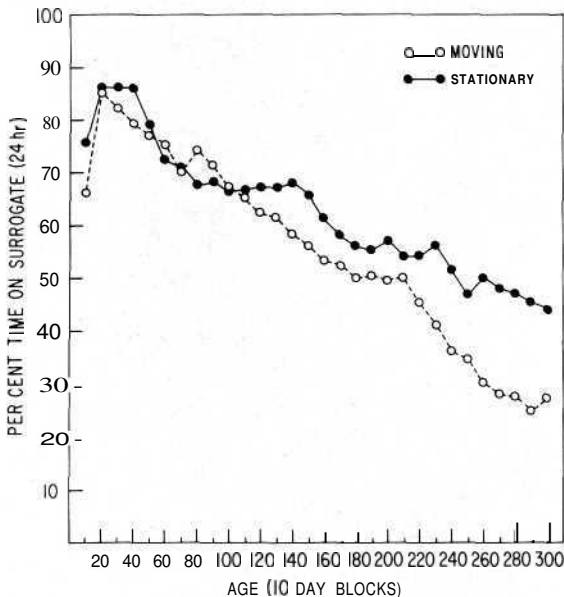

Fig. 2. Percentage of time on the surrogate by 10-day blocks. Based on mechanically recorded duration measures by 24-hr periods in living cages.

observation days, appeared very infrequently in the 2nd block of 20 days, and occurred about 10 times more frequently in the Moving than in the Stationary group in the 3rd and subsequent 20-day blocks (Fig. 1D). The difference between groups was significant.

Locomotion (Fig. 1 A), self-manipulation, and manipulation of the environment all increased from birth through the first 120 days of life and showed little change thereafter. Sleep dropped from an average level of about 55% during the first 20 observation days (62% on Days 1-10) to 20-30% during Observation Days 61-80. and remained near this level thereafter (combined groups). Intergroup differences were not significant for any of these measures.

Permanent removal of the surrogate from the living cage caused an increase in locomotion (significant for the Moving group, $p \leqslant .05$) on the first post-removal day as compared to the day preceding it. Rocking dropped sharply in the Stationary group on the first day post-removal $(p \leqslant .05)$, then increased steadily over the next several weeks. Most rocking occurred while the monkeys were in contact with the surrogate, and its absence probably accounts for the initial decrease in this behavior; the subsequent rise reflects the development of alternate modes of rocking. No monkey in the Moving group developed rocking after the surrogate was removed, lending further support to the view that the critical events associated with the onset of this behavior in macaques occur before the end of the first year of life (Berkson, 1968).

Test Cage (Situation 2). Only 3 measures reliably differentiated groups in this test (combined conditions): body-rocking, defecation, and locomotion. Rocking occurred on 17.6% of intervals in the Stationary group and was scored on only 1 interval for 1 monkey in the Moving group. Defecation was higher in the Moving group, occurring on 37.9% of the sessions, as compared with 22.2% in the Stationary group $(p \leqslant .01)$. Although locomotion did not differentiate the groups as a whole, it was reliably lower in Stationary females than in Moving females (27.4% vs 47.4%, $p \leqslant .05$).

The response to the test conditions was similar in the 2 groups. For both, the surrogate was an effective source of emotional reassurance, as evidenced by reliably higher levels of distress vocalizations $(p \leqslant .001)$, self-clasping $(p < .01)$, defecation $(p \leqslant .001)$, and urination $(p \leqslant .01)$ when the animals were alone, compared with surrogate present. As in the living cage, Stationary monkeys rocked mainly when in contact with the surrogate. Thus, rocking was reliably higher when the surrogate was present (surrogate, 31.6% vs alone, 3.6%, $p \leqslant .01$). Intergroup comparisons of the magnitude of change between the surrogate-present and alone conditions were not significant for any measure except defecation where the increase in the Moving group was reliably greater than that in the Stationary group $(p \leqslant .01)$.

Object Test (Situation 3). The only measures differentiating groups for the combined conditions were rocking and locomotion. Rocking was scored for only 1 member of the Moving group (on 1 session), but it occurred in 9 members of the Stationary group (18.1% of intervals, $p \leqslant .001$). Locomotion was significantly higher for males in the Stationary group than in the Moving group (75.9% vs 50.3% $p \leqslant .01$). Total frequency of object contact was similar in the 2 groups (Moving, 19.9% vs Stationary, 22.4%). Separate analyses by test conditions produced no additional significant rearing effects, except for sucking, which was reliably higher in the Moving group in 1 condition (living cage, surrogate present).

The test conditions were clearly effective and the pattern of responses was similar in the 2 groups. Absence of the surrogate (combined cage conditions) resulted in reliable

increases in both groups in locomotion, self-clasping, distress vocalizations, barking, and contacts with the test objects, compared with the surrogate-present condition. Manipulation of the environment (chiefly picking at the cage) increased in both groups but was significant only for the Stationary group ($p \leqslant$ .01). Change scores in the 2 groups were similar in magnitude and direction, and intergroup differences were not significant.

Differential responses to test- and living-cage were also clear. As would be expected, the test cage (combined surrogate conditions) was more stressful than the living cage, evidenced by increases in both groups in distress vocalizations (significant for the Moving group, $p \leqslant$ .05), self-clasping (significant for the Stationary group, $p \leqslant$ .01), and lipsmacking (significant for both groups, $p \leqslant$ .02). Locomotion and environmental manipulation were lower for both groups in the test cage (significant for both measures for the Stationary group, $p <$ .05), as was self-manipulation (significant for the Moving group, $p \leqslant$.05). Analysis of change scores indicated that the reduction in locomotion between the living cage and test cage was significantly larger in the Stationary group than in the Moving group ($p \leqslant$ .02).

Novel Room (Situation 4). Four measures—rocking, forced entry, defecation, and locomotion—differentiated groups for the combined phases (pre- and post-surrogate removal). Rocking was observed only in the Stationary group and was performed by 6 animals ($p \leqslant$ .05, Mann-Whitney). The Stationary group had to be forced to enter the room on more sessions than the Moving group and intergroup differences were significant for each phase, as well as the combined phases (pre-removal: Stationary, 52.5% vs Moving, 20.0%, $p \leqslant$ .05; post-removal: Stationary, 43.7% vs Moving, 5.7%, $p <$ .05). Defecation was reliably higher in the Moving group than in the Stationary group for the combined phases (18.9% vs 7.5%, $p \leqslant$ .05) and for the pre-removal phase (28.3% vs 9.0%, $p \leqslant$ .05), but not for the post-removal phase. Locomotor activity tended toward extreme levels in the Stationary group, and the direction was apparently related to sex. In both phases, the 2 highest activity scores were made by Stationary males, whereas the lowest scores were made by 2 Stationary females, of which one crouched in the same location on nearly every session and the other spent most of the time sitting and rocking. Mean activity count of the Stationary females was reliably lower than that of the Moving females and Moving males (43.5 vs 219.7 and 168.9, respectively; $p \leqslant$ .05, combined phases).

Few significant differences were obtained between the 1st and 2nd phases of testing in either group. Both groups showed a reliable reduction in distress vocalizations between the pre- and post-removal test phases, a decrease in barking (significant for the Stationary group, $p \leqslant$ .05) and an increase in locomotion (significant for the Moving group, $p \leqslant$ .02). Intergroup differences in change scores were not significant.

These results may be compared with the Mason and Green (1962) data on nursery-reared and wild-born macaques. As compared to Mason and Green's nursery-reared monkeys, both groups showed lower levels of crouching, self-clasping, and sterotyped movements, and higher levels of distress vocalization, locomotion, gross motor activities (climbing, jumping, backflips), object contact, defecation, and urination. In these respects, both groups resembled wild-born monkeys more closely than the original lab-born subjects. The similarity to wild-born monkeys was closer in the Moving than in the Stationary group, however, in respect to the absence of body-rocking, lower scores for crouching, and higher scores for gross motor activities, object contact, urination, and defecation.

Stimulus-Persons (Situation 5). All but 1 member of the Moving group contacted the stimulus-persons on more than 1 session, whereas 6 of the 10 Stationary monkeys failed to do so. This result approaches significance $(p \leqslant .10$, Fisher Exact Probability Test). In neither group did the stimulus-person's role have a reliable effect on the amount of contact, although it did affect the form of contacts, particularly in the Moving group. As expected, more than 85% of clinging occurred with the stimulus-person in the "hold" role. Among the animals making contact, those in the Moving group displayed a greater variety of social responses—including play and grooming, neither of which occurred in the Stationary group. The difference was particularly evident with the "play" person, toward whom 31.3% of total contacts by the Moving group involved specific responses other than clinging. The comparable value for the Stationary group was 1.4%. As in previous tests, rocking was limited to the Stationary group, except for 2 sporadic occurrences in a single Moving monkey $(p \leqslant .05)$. Other "self-directed" responses (clasping, sucking, crouching) were also more frequent in the Stationary group, although intergroup differences were not significant. Change scores did not differentiate groups.

Pairings with Wild-Born Monkeys (Situation 6). Rocking again provided the sharpest contrast between groups. Six Stationary monkeys rocked in 5% to 37% of total intervals, whereas 1 Moving monkey rocked in 1 interval $(p < .001)$.

Stationary monkeys appeared to react more strongly to wild-born companions, as evidenced by higher scores for threat, aggression, lipsmacking, grimace, bark, and distress vocalization, but none of these differences was significant. One quasi-social response, self-biting (which usually occurred in the context of play or aggression), was much more frequent in the Stationary group (Moving, .2% vs Stationary, 2.5%, $p < .01$). Stationary monkeys made fewer approaches, more withdrawals, and more passive responses to social contact, and less often clasped or huddled against other monkeys than did Moving monkeys. They also engaged in more rough-and-tumble play (some of which was so vigorous and intense as to be difficult to distinguish from aggression), and showed more mounting attempts and grooming. None of these differences was reliable, however, nor was any significant new information added to these findings by separate analyses of data from test chamber and living cage.

Few differences between the 1st and 2nd series of exposures to the test chamber occurred in either group, and change scores did not differentiate groups on any measure. Social responsiveness was clearly higher in the living cage than in the test chamber in both groups, and change scores did not differentiate groups.

The contrasts between the host and guest conditions in the living cage series were clear, particularly for the Moving group. Moving monkeys made significantly higher scores as host than as guest for measures of proximity, approach, total contact, play, and social facilitation, and significantly lower scores for coo vocalizations. Differences were in the same direction for the Stationary group, but only approach scores reliably differentiated conditions. The reduction in play between host and guest conditions was significantly larger in the Moving than in the Stationary group $(p \leqslant .05)$, but with this exception, change scores did not differentiate groups.

Wild-born animals appeared to respond similarly to Moving and Stationary monkeys and differed reliably from both groups on a number of measures. Scores for wild-born monkeys were significantly lower than those of either lab-raised group for approach, social facilitation, grimace, and distress vocalization, and significantly higher for threat. Appropriately oriented mounting occurred in both lab-raised and wild-born monkeys, but

only the wild-born monkeys showed the characteristic adult male mating pattern (mounting properly oriented toward the partner accompanied by foot-clasping and thrusting). In further contrast to the lab-raised monkeys, they seldom crouched $(p \leqslant .05)$, and never engaged in nonnutritive sucking $(p \leqslant .01)$ or body-rocking.

Sex Differences. Data from all situations were analyzed for sex differences. Sex differences were most consistent and pronounced in Situation 6 in which lab-raised monkeys were paired with wild-born males and females. Males scored reliably higher than females on proximity, approach, total contacts, play, social investigation, and mounting, and reliably lower than females for grimaces and screeches (combined lab-raised groups). Responses of both sexes varied with the sex of the wild-born partner. With female companions, lab-raised monkeys obtained reliably higher scores for proximity, approach, social investigation, social facilitation and mounting, and reliably lower scores for withdrawal, sexual presentation, grimaces, and screeches, as compared with male companions. Contrasts between the sexes were also evident among wild-born subjects, although only the differences in withdrawal (higher for females) and play (higher for males) reached significance.

No strong pattern of sex differences is suggested by results for other test situations. Males tended to have higher scores for locomotion, and the contrast between the sexes was greatest within the Stationary group. Males also had higher scores for barking and distress vocalizations, but only barking reliably differentiated the sexes on more than 2 tests, or for the series as a whole $(p < .01)$.

Discussion

This research demonstrates that the addition of mechanical mobility to a cloth artificial mother effectively prevents the development of stereotyped body-rocking as an habitual act in rhesus monkeys. The separation between rearing groups was virtually complete. Although several of the animals raised with mobile mothers occasionally performed rocking movements, these were isolated, sporadic events, rather than persistent patterns. In more than 22,000 15-sec observation intervals available on each monkey, only 4 individuals rocked, and none of them did so on more than 8 intervals. In contrast, all but 1 of the 10 monkeys raised with stationary surrogates showed rocking as a frequent response, which they displayed in 524 to 3,906 observation intervals. These findings offer strong support for the view that a primary factor in the genesis of the stereotyped body-rocking shown by so many isolation-raised primates is the absence of tactile-proprioceptive stimulation, such as a mother imposes on her infant while she carries it about.

Although the effectiveness of the mobile surrogates in preventing the development of body-rocking is most likely the result of the proprioceptive-kinesthetic stimulation they supplied, it is also possible that the moving devices potentiated the development of more mature forms of behavior that interfered with rocking. This notion is consistent with the general finding that alternative activities tend to reduce the level of body-rocking (Berkson, 1967), and with the fact that monkeys in the Moving group spent more time playing in the living cage than did animals in the Stationary group. The higher level of play suggests that the mobile surrogates were more effective in stimulating interaction

with the environment than the stationary devices, and thus provided a better condition for the development and exercise of behavior patterns incompatible with rocking.

Whatever the exact mechanism accounting for the reduction of rocking, the absence of maternal stimulation seems to be important and is often included among those factors believed to contribute to the development of rocking in human infants, although so far as we know, a firm causal relation has never been demonstrated (reviewed in Berkson, 1967). One fact that creates difficulties for a social deprivation theory of the genesis of stereotyped rocking in man is that these behaviors are prominently associated with several distinct and seemingly unrelated conditions—notably, infantile autism, severe mental retardation, congenital blindness, and early placement in institutions. In spite of the diversity of these conditions, however, we have reasons to suppose that the variable of maternal stimulation may be a significant factor in the development of stereotyped rocking in each of them.

In the first place, many such children may in fact be living in institutions and thus experiencing fairly severe maternal deprivation. The importance of this factor is suggested by Kaufman's (1967) finding that the incidence of body-rocking was several times higher among institutionalized retardates than among those living at home. Second, even when the child remains at home, it may be deprived of maternal stimulation because the mother does not interact with it as freely or as often as she might with an unafflicted child. This is clearly suggested by Fraiberg and Freedman's case studies of mother-infant relations in families with congenitally blind children. They also found a relation between the incidence of stereotyped activities and the amount and quality of maternal interaction with the child (Fraiberg & Freedman, 1964; Freedman, 1966). Third, the afflicted child may be more dependent upon the mother for initiating interaction than the unimpaired child, because it is less able to take the initiative itself. Thus, the development of stereotyped rocking in a blind, retarded, or autistic child can perhaps be prevented, but only by adding to the caretaking burden. This is particulary true in our culture, in which intermittent contact between caretaker and child is the rule. In societies in which infants are carried everywhere, and physical contact between mother and child is frequent and prolonged, the implication is that body-rocking would rarely become habitual in any child. Some support for this suggestion is derived from recent studies of macaques with severe visual deficits, raised either with their mothers (with whom contact is typically frequent and prolonged) or alone. Blindness has no effect on the development of stereotyped rocking: blind infants raised by their mothers do not rock, whereas those raised in isolation do so, but at the same level as their sighted controls (Berkson, 1973; Berkson & Karrer, 1968).

Although the evidence suggests that rocking is a response to a particular kind of deficiency in the social environment, the tendency to develop and perform such movements is only partly determined by experience. This was plainly the case even within our small sample of rhesus monkeys. In spite of the fact that rearing conditions were essentially the same for all Stationary animals, 1 of them did not develop habitual rocking. Among the other monkeys in this group, individual variation in the level of rocking under relatively undisturbed conditions in the living cage ranged from about 1% to more than 19%. Although rocking was generally more frequent than this in novel test situations, wide inter-individual variability remained a prominent feature. The response to permanent removal of the surrogate from the living cage also varied with individuals. A marked reduction in rocking immediately followed removal of the surrogate, probably

because the monkeys usually rocked while in contact with the surrogates. For the majority of individuals this was a temporary effect, and by the end of testing (some 17 weeks after the surrogates had been removed) they were rocking at approximately pre-removal levels. Two monkeys, however, both of whom rocked frequently while living with their surrogates, seldom or never did so after the surrogates were removed. The important implication of these findings is the "need" for early tactile-proprioceptive stimulation (or the tendency to develop compensatory activities when it is experienced in limited amounts) varies with individuals, perhaps explaining why some children in our society become habitual body-rockers. Even though they are carried and handled and show no sign of disability, their need presumably exceeds that which customary practice provides.

Turning to the effects of surrogate mobility on other aspects of behavioral development, our findings indicate broad similarities between rearing groups, but they also suggest some important contrasts. Attachment to the surrogates was a point of similarity. The surrogates were sought and clung to in novel situations, and vocalizations and other accepted measures of distress were sharply reduced by their presence. In spite of the fact that the mobile surrogates received fewer contacts in the living cage and many more play responses, they were apparently equivalent to the stationary devices as sources of emotional reassurance.

The groups also resembled each other in displaying most of the stigmata of the socially deprived macaque. Rocking appeared as an habitual response only in the Stationary group, of course, but the other patterns characteristic of the isolation-raised rhesus, including nonnutritive sucking, self-clasping, and crouching, were present in both groups and, in both, social behavior was patently deviant as compared with wild-born norms. Neither lab-raised group showed the fully integrated male mating pattern seen in the wild-born monkeys, in spite of many mounting attempts. The behavior of both groups during social pairings suggested a high level of arousal, indicated by distress vocalizations, grimaces, and withdrawals from social contact.

Despite such similarities, however, indications were that rearing groups differed in their reactions to pairings with wild-born companions, as well as to other test situations. For example, self-biting was significantly higher in the Stationary group. Notes accompanying these episodes often indicate that self-biting was part of an "explosive" outburst, frequently set off by threat or mild aggression from a wild-born companion. During social pairings Stationary monkeys also showed higher levels of other agonistic responses, including facial threats, barking, aggression, grimaces, lipsmacking, and distress vocalizations, and they more frequently withdrew from social contact than did members of the Moving group. Although these differences were not significant, they do suggest a general pattern of higher arousal in the Stationary monkeys. This is consistent with findings from the other test situations (except for defecation which was higher in the Moving group). Stationary animals more often required forcing to enter the test chamber, and generally made fewer and less varied contacts with costumed stimulus-persons than did the Moving group. The extreme variations in activity level—with a tendency toward high scores for males and low scores for females—is perhaps a further indication of high arousal in the Stationary group. Finally, subsequent tests of visual exploration indicated that Stationary animals spent less time looking at other monkeys than did members of the Moving group, and were less sensitive to variaitons among these stimuli (Eastman & Mason, in press).

In summary, the clearest effect of surrogate mobility was the suppression of stereotyped rocking. Quite possibly, some of the other differences between groups are a direct consequence of the presence of absence of rocking, but not all of them can be so construed. A conclusion more in keeping with the facts is that the addition of movement to artificial mothers not only affected the development of specific behavior patterns, and the topography of responses to stressful situations, but the level of responsiveness as well.

Notes

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