PRIMATES, 37(2): 167–173, April 1996

The Development of Range of Action in Infant Cynomolgus Monkeys (*Macaca fascicularis*) Reared by Restrained Mothers

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ABSTRACT. In order to study the effects of the mothers' range of action on the development of their infants' range of action during the first year of life, mother cynomolgus monkeys were restrained in their range of action by penning them in a separation cage within the large cage of the harem group they belonged to. The infants, however, could leave their mothers' separation cage. The control group consisted of infants growing up with unrestrained mothers in the same group. It appeared that infants of restrained mothers were initially retarded in the development of their range of action but at the end of the first year they did not differ anymore from infants of unrestrained mothers. It is concluded that the maternal range of action only temporarily affects the development of the infant's range of action.

Key Words: Chimpanzee; Rhesus; Joystick; Video; Learning.

INTRODUCTION

According to several authors the proximity of an attachment figure reduces the young's fear of novelty (e.g. KING, 1966; BRONSON, 1968 a, b; DOLHINOW & BISHOP, 1970; BALDWIN & BALDWIN, 1977; MILLER et al., 1986). This enables the young to become more and more familiar with the environment resulting in an increase in the distance between the young and its mother (BALDWIN & BALDWIN, 1977). This increase in distance can be taken as an indication of a growing independence of the young (RIJT-PLOOY & PLOOY, 1987).

Though it is well known that a monkey mother carries her young about in the environment, thus providing the young with opportunities to come into contact with all kinds of environmental stimuli with its mother nearby, the role of the mother's range of action in the behavioural development of the young has not been experimentally studied until recently (VOCHTELOO et al., 1993).

We previously reported that, during the first half year of their lives, infants of mothers that were restrained to a small part of the large cage of the harem group they belonged to, spent more time within arm's reach of their mothers than infants of unrestrained mothers living in the same group, although maternal behaviour of restrained and unrestrained mothers did not differ (VOCHTELOO et al., 1993). Because it was of interest to know whether this difference in behavioural development was persistent, we continued to study the development of the infant's radius of action for another half year.

METHODS

SUBJECTS AND HOUSING

Eighteen cynomolgus monkeys born in the laboratory were used as subjects. The subjects and their mothers were members of harem groups each consisting of one adult male, four to nine adult females, and a number of young between 0–3 years of age. The harem groups were housed in separate rooms in identical wire netting cages, measuring 4.0 × 3.8 × 2.0 m (Fig. 1).

Against the rear side of the left compartment of each cage a wire-netting separation compartment was constructed (1.3 × 1.0 × 1.0 m), which was used to confine mothers; the infants, however, could pass through a slit in the netting (see Fig. 1).

The subjects grew up in one of the following conditions: 1) with their mothers that freely could move about in a harem cage (MMR = Mobile Mother Reared), this group consisted of seven females and two males; and 2) with their mothers that were housed in separation cages within a harem cage (IMR = Immobile Mother Reared), this group consisted of three females and six males.

Both groups were part of the same harems. For detailed information about housing conditions and assignment of subjects to one of the rearing conditions, the reader is referred to VOCHTELOO et al. (1993).

OBSERVATIONS

Subjects were observed for half an hour once a week from 6 until 26 weeks of age and once a fortnight from 27 until 41 weeks of age. In the 50th week the subjects were observed for one hour and a half. Observation periods during which the activities of the animals were recorded by means of remote control video were scheduled randomly across the week between 09:00 and 17:00.

PARAMETERS

The parameters to assess the subject's range of action were: 1) distance between subject and mother; and 2) utilization of space.

Distance Between Subject and Mother

In order to assess the distance between subject and mother the subject's location was recorded, and in case of a MMR subject its mother's location was recorded as well.

Utilization of Space

After 22 weeks the mobility of the subjects was too high to make a reliable measurement of the distance between subject and mother. Therefore from the 22nd week only the location of the subjects was scored. The parameter "utilization of space" was used to assess at what pace subjects achieved visits to various parts of the cage while "off mother." Utilization of space was expressed as the number of zones of the cage utilized. In both cage compartments three zones were distinguished: front, central, and rear (see Fig. 1). The

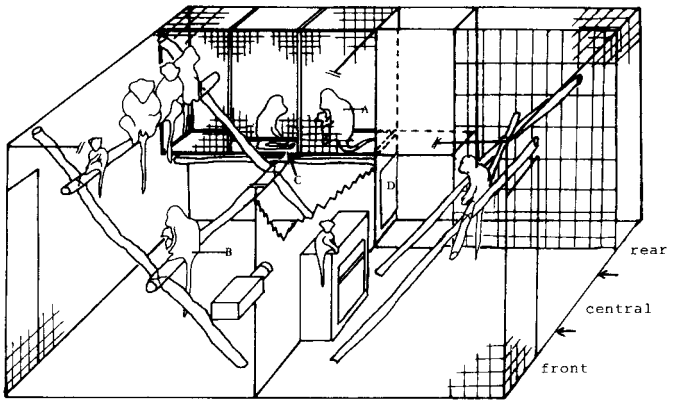

Fig. 1. Experimental setup for the MMR and IMR group. A: Restrained mother (IMR group); B: unrestrained mother (MMR group); C: slit in the netting of the separation cage; D: open passage between compartments.

criterion for utilization of a zone was that a subject spent at least 1% of its time "off mother" in that zone.

Statistics

The data were divided into age-blocks of 28 days and expressed in percentages of time "off mother." The means of the age-blocks were polynomially transformed and consecutively analyzed using a MANOVA trend analysis procedure with rearing condition and gender as between group factors. Additionally per age-block the factors group and gender and their interaction were analyzed. Further a Mann Whitney *U*-test was used to analyze differences between groups per age-block. In the relevant analyses the general differences in the mean are shown as "Fmed" and the linear trend effects as "Flin" (an upward/downward trend in the percentage duration of a parameter). In the figures presented a second order polynomial curve was fitted (Feldman et al., 1986). Changes in the number of zones utilized were analyzed by a Friedman two-way analysis of variance.

To analyze the differences between the groups in the distance of the subject from the mother the mean percentage of time "off mother" that a subject stayed at a certain distance from its mother was calculated. Between the MMR and IMR group the following comparisons were made: 1) within arm's reach of the mother (<0.7 m) in MMR subjects vs inside the separation cage in IMR subjects; 2) $0.7-2.0$ m from the mother in MMR subjects vs outside the separation cage to 1.5 m from the separation cage in IMR subjects; and 3) more than 2 m from the mother in MMR subjects vs more than 1.5 m from the separation cage in IMR subjects.

RESULTS

Effects of Gender

There were no main effects of sex on the development of range of action. Per age-block the analyses revealed that between 28 and 32 weeks males spent less time "off mother" than females [Fmed $(1,14)=10.3$, $p<0.01$].

EFFECTS OF REARING CONDITION

The groups did not differ in percentage of time "off mother" [Fmed (1,14)=2.19]. Both groups showed an increase in percentage of time "off mother" [Flin (1,14)=32.3, $p<0.01$].

Range of action

DISTANCE BETWEEN SUBJECT AND MOTHER

The subjects of the MMR group went farther away from their mothers than the IMR subjects did. During the whole period (6−22 weeks) as well as during each age-block of this period, the differences between the IMR and the MMR group were significant for each distance measured (<0.7 m, 0.7−2.0 m, and >2.0 m) [Fmed (1,14)>118; $U\leq 6$, $p<0.01$] (Fig. 2). In contrast with IMR subjects, MMR subjects after ten weeks showed no further increase in the distance from their mothers.

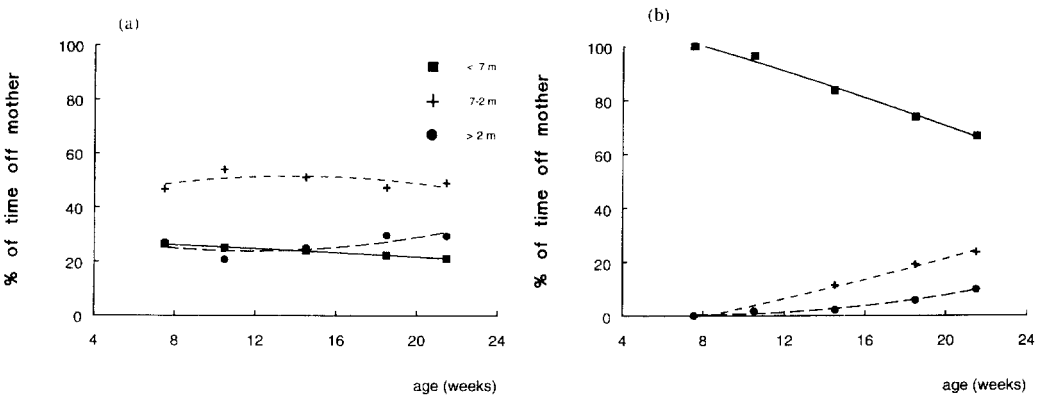

Fig. 2. Mean percentage of the time off mother (per period of 28 days and second order polynomials) that infants of (a) the MMR group and (b) the IMR group stayed at distances of less than 0.7 m (■), between 0.7−2.0 m (+), and more than 2 m (●) from their mothers.

UTILIZATION OF SPACE

It appeared that from 32 weeks on IMR subjects utilized as many zones as MMR subjects. Till the age of 32 weeks the IMR group utilized less zones (mean per subject=3.3) than the MMR group (mean per subject=5.6) did ($U\leq 15$, $p<0.05$; Fig. 3). In the IMR group there was an increase in the number of zones utilized (Friedman $\chi^2=45.2$, $p<0.01$), whereas in the MMR group this number did not change as they already utilized most zones after ten weeks.

DISCUSSION

It appeared that IMR young showed a temporary retardation in the development of their

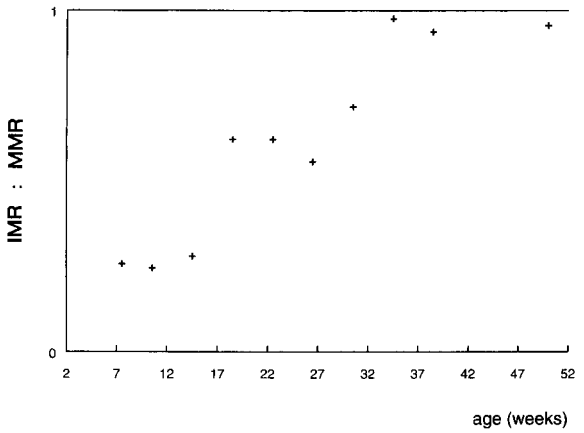

Fig. 3. The ratios [restrained mother group (IMR)]: [unrestrained mother group (MMR)] for the number of zones utilized (per period of 28 days). A zone was scored to have been utilized if a subject stayed in it longer than 1% of its time off mother.

radius of action. During the first 22 weeks IMR infants not only spent less time out of arm's reach than MMR infants, which we already assessed earlier (VOCHTELOO et al., 1993) but they also stayed closer to the mother when they went beyond arm's reach. Further, IMR subjects in comparison to MMR infants showed a temporary retardation in utilization of the living cage. Since during this period the MMR infants' distance from the mothers could not be scored (due to the mobility of their mothers and the high mobility of their young), we cannot exclude that the utilization score of MMR infants was affected by their mothers' favoured locations. What the comparison does show, anyhow, is that until the 32nd week the IMR subjects visited less zones than the MMR subjects but from the 32nd week onward IMR subjects visited an equal number of zones as MMR subjects. This development in the behaviour of IMR subjects cannot be ascribed to changes in their mothers' location.

In baboons, *Papio cynocephalus* (ALTMANN, 1980) and in rhesus monkeys, *Macaca mulatta* (HINDE & SPENCER-BOOTH, 1968; HINDE, 1983) it was found that the time the infant spent beyond arm's reach of the mother was affected by maternal behaviour like rejection and restriction, but as we already reported, restrained and unrestrained mothers did not differ in this respect (VOCHTELOO et al., 1993).

One might argue that the development of the range of action in IMR subjects was retarded because restraining the mother affected the behaviour of group members towards the mother and her infant. However, if this had been the case a difference between restrained and unrestrained mothers in maternal behaviour as well as a difference between their infants in the time they had contact with their mothers was to be expected. As we did not find any of such differences (see also VOCHTELOO et al., 1993), there are no reasons to assume that the behaviour of group members towards the restrained mother and her infant played a part.

Another item is that the difference between groups in the development of range of action could have been affected by the difference between groups in sex-ratios. However, we found no sex effects.

Our explanation of the retardation, as already brought forward in VOCHTELOO et al. (1993), is that without maternal support, as it was the case in IMR subjects, the space

outside the separation cage remained unfamiliar. This at first deterred the IMR subjects from entering it (see also KING, 1966; BRONSON, 1968 a, b; SIMONDS, 1974; BALDWIN & BALDWIN, 1977; BOWLBY, 1977; MILLER et al., 1986; DUIJGHUISEN et al., 1992). Probably for the same reason the IMR group attained a maximal utilization of living space much later than the MMR group.

Then there is the effect of the social context on the infant. ROSENBLUM (1971) hypothesized that for a young infant a complex environment at first is aversive, and the infant therefore needs the proximity of the mother. When the infant gets older a complex environment would become attractive. The first part of this hypothesis seems to apply to the retardation in IMR subjects concerning the development of the distance from their mother. The IMR subjects may have been avoiding the adult conspecifics outside the separation cage. The second part of ROSENBLUM's hypothesis seems to be confirmed when at a later age the IMR subjects expanded their radius of action without the company of their mother. The IMR subjects then may have been attracted by the presence of conspecifics outside. We have no quantitative data of the behaviour towards IMR subjects of group members apart from the mother, but we found no differences between MMR and IMR subjects in time spent on social interactions with these group members (VOCHTELOO et al., 1993). Therefore, we have no reasons to assume that specific behaviours of these group members played a part in the expansion of the radius of action of IMR subjects. A pilot study in a cage without group members, apart from restrained mothers, showed that young of restrained mothers rarely went farther away than 1.5 m from their mother's cage even at 52 weeks of age (VOCHTELOO, 1994). This finding suggest that the presence of group members outside the restrained mothers' separation compartments stimulates the infants to venture away from their mothers.

We conclude that being carried about by the mother during the first month of life facilitates the development of the infant's range of action. This most probably is a result of getting familiar with the environment with the mother nearby. On the other hand, being carried about by the mother appeared not to be necessary to become familiar with the environment, since IMR subjects finally began to move about independently. So the role of the mother in the development of self-reliant excursions by the young has to be considered as a catalyzing rather than as an indispensable one.

Acknowledgments. We thank J. C. M. KRIJNEN for taking care of the monkeys and the technicians of the Psychological Laboratory for instrumental support.

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—— Received: *August 1, 1993*; Accepted: *October 3, 1995*

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