Manipulatory responsiveness in protein-malnourished monkeys*

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Two groups of rhesus monkeys were placed on diets containing either 3% or 25% protein at 210 days of age and tested consecutively on two puzzle manipulation tasks varying in difficulty. Malnourished Ss were able to learn to solve the puzzles in the absence of food rewards but showed significantly lower final performance levels on the easier puzzles than did controls. The more complex puzzles were learned with equal difficulty by the high- and low-protein groups. Manipulatory responsiveness in this study was interpreted to be partially influenced by secondary diseases associated with protein-calorie malnutrition.

Children suffering varying degrees of protein-calorie malnutrition (PCM) have long been observed to exhibit abnormally low levels of curiosity, and apathy has often been used in the clinical diagnosis of PCM (Jelliffe & Welbourn, 1963). This condition has been found even for malnourished, but relatively healthy, Ss (Trowell, Davies, & Dean, 1954). The use of animals, however, to study manipulatory responsiveness has advantages not found by observing the human condition. These include greater control of the dietary composition and administration, the degree and kind of socialization, and the extent of environmental interactions.

Harlow, Harlow, & Meyer (1950) first demonstrated that normal rhesus monkeys would readily manipulate and solve a mechanical puzzle in the absence of any apparent intrinsic reward. Performance on more complex puzzles appeared persistent (Harlow, 1950), and manipulatory responsiveness could be found within the first month of life for an infant monkey (Harlow, Blazek, & McClearn, 1956).

The present study follows the report by Zimmermann & Strobel (1969), that protein-malnourished monkeys show reduced levels of visual exploration and chain-pulling behavior. A new measure consisting of puzzle problems was used to test manipulatory responsiveness in protein-deprived Ss.

EXPERIMENT 1

Method

The Ss were 10 infant rhesus monkeys born in the laboratory and separated from their mothers 90 days after birth. At 210 days of age, 6 Ss (low-protein group) were placed on purified diets, previously described by Zimmermann & Strobel (1969), containing 3% protein by weight. The

remaining 4 Ss (high-protein group) were given a diet containing 25% protein, but isocaloric with respect to the 3% diet. At approximately 244 days of age, the Ss were presented the first manipulation task.

The apparatus consisted of a modification of a device described by Harlow, Blazek, & McClearn (1956). Twelve individual puzzle units were mounted on a Masonite panel, replacing a wall of a 24 x 18 in. cage. Each puzzle unit consisted of a screen-door hook and hasp, in combination such that the hasp could not be opened without the removal of the hook. A contact circuit connected each puzzle unit with a cumulative counter. The counters were activated whenever a S touched a puzzle piece. The number of solutions (sum of the hooks and hasps displaced) and accumulated contacts were recorded following each 1-h session. The Ss were tested in the apparatus for 125 sessions, with the order and time of day randomized.

Results

Analyses of variance using unweighted-means solutions for repeated measures were completed, using 25-day block totals from solutions and contacts. The high-protein Ss showed a significant increase in puzzle solutions over the experimental Ss ($F = 18.24$, $df = 1/8$, $p < .01$). These data are presented in Fig. 1. In addition to solving fewer puzzles, the low-protein Ss made significantly fewer contacts with the puzzle units ($F = 14.83$, $df = 1/8$, $p < .01$). Significant differences were found between sessions for solutions ($F = 8.15$, $df = 4/32$, $p < .01$).

EXPERIMENT 2

Method

The Ss were the same as those in Experiment 1. At approximately 422 days of age, or 212 days on the diet, the two-part puzzle units were replaced by three-part puzzle devices. These puzzles were identical to the two-part puzzles, except for an additional pin assembly that had to be

Fig. 1. Mean number of solutions of two-part puzzle by high- and low-protein-raised infant monkeys.

removed before the hook and hasp combination could be solved.

Results

Performance by the high- and low-protein Ss on the three-part puzzles are presented in Fig. 2. Significant increases were found between blocks for solutions ($F = 14.41$, $df = 3/24$, $p < .01$) and for contacts ($F = 10.01$, $df = 3/24$, $p < .01$). No group differences were found to be significant.

DISCUSSIONS

The study has indicated that protein-malnourished monkeys are capable of learning to solve simple and even more complex puzzles in the

Fig. 2. Mean number of solutions of three-part puzzle by high- and low-protein-raised infant monkeys.

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absence of any obvious intrinsic rewards. In the case of the two-part puzzles, these Ss showed lower final asymptotic performance than did controls, indicating the apparent loss of interest in the testing device. In contrast, the malnourished Ss showed only a slight, but not significant, reduction in performance when compared with normals in the three-part puzzles. There is no way to determine from this data if the differences between the results of these two experiments were due to the complexity of the task, early effects of the diet, or repeated testing.

The major change appears to be the decrease in performance of the high-protein Ss in the three-part puzzle. The low-protein Ss continued to respond at a frequency that was consistent with their performance on the first puzzle. The high-protein Ss may have shown increased satiation to the situation, or the low-protein Ss may have had abnormally low scores on the first test due to some other variable. It is likely that the latter situation was the case. During the testing of the first experiment, most of the malnourished Ss showed signs of infective diarrhea, a disease that typically accompanies the PCM syndrome. By the time the Ss were on the diet for over 200 days, the diarrhea symptoms had disappeared and these malnourished monkeys were beginning to show a modest weight gain. Thus, they may have been adapted to the diet at the time they were exposed to the three-unit puzzle.

This interpretation is supported by other observations at our laboratory that indicate that early in the diet, low-protein Ss also showed loss in learning set and object discrimination that was associated with secondary infection.

It is clear that in animal research, as well as in human studies of PCM, the possible influence of 'satellite' diseases and systemic malfunctions associated with the protein deficiency must be taken into account. These secondary factors may be responsible for, or contribute to, the observation of reduced manipulatory responsiveness in malnourished children.

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CRF pretraining and differential magnitude discrimination*

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Rats were given CRF pretraining in a black alley, which became either the positive or the negative stimulus in a subsequent discrimination based on differential magnitudes of reward. Discrimination developed more rapidly when the black alley became the negative stimulus.

Amsel & Ward (1965) have presented a series of experiments concerning the effects of prediscrimination treatments on vigor discriminations where continuous reinforcement was associated with a runway of one brightness (S^+) and nonreward was associated with a runway of another brightness (S^-). Discrimination developed faster when Ss had CRF prediscrimination training to S^- than when pretraining was to S^+ . That is, if CRF training was given in, say, a black alley (S_B), discrimination developed more rapidly when S_B became S^- and a novel white alley was S^+ than when the reverse was

true, i.e., $S_B + S_W^-$. The present experiment was an attempt to extend these findings to the case where S^- was some smaller reward than S^+ , i.e., the case where discrimination is based on differential magnitudes of reward.

METHOD

The Ss, which were approximately 90 days old on arrival in the laboratory, were 14 male albino rats obtained from Holtzman Farms, Madison, Wisconsin. They were fed Wayne lab chow ad lib for 1 week after arrival and then were fed 14 g of chow each day for 2 weeks, after which the experiment was begun. The feeding regimen was continued throughout the experiment. During the period of deprivation, the Ss were occasionally handled by being removed from their home cages, gently jostled, and returned.

The apparatus was two 3-ft

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