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Reactions to conspecifics as novel stimuli in protein malnourished and socially isolated rhesus monkeys

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REACTIONS TO CONSPECIFICS AS NOVEL STIMULI IN PROTEIN MALNOURISHED AND SOCIALLY ISOLATED RHESUS MONKEYS

By

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B.A., San Diego State University, 1973

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ABSTRACT

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Reactions to Conspecifics as Novel Stimuli in Protein Malnourished and Socially Isolated Rhesus Monkeys (132 pp.)

Director: David A. Strobel DAS

An exploratory study of the effects of protein-calorie malnutrition and partial social isolation on various reactions to the novel presence of a conspecific was conducted with 16 juvenile rhesus monkeys. Diet and rearing condition were varied in a factorial design, with two levels of protein intake, two levels of social contact, and six repeated measures. The dietary manipulation involved the feeding of a low protein or a high protein diet from 120 days of age. Rearing condition was varied by housing subjects either individually or in groups of four. Testing took place in a specially designed operant chamber, separated by clear plexiglas from an adjoining compartment. Subjects were trained to press a bar for food reward on an FI-60 second schedule of reinforcement and then stimulus animals were unexpectedly introduced into the adjoining chamber. Measures of bar pressing suppression and five incidental behavior categories were taken.

The predictions of two principal, opposing hypotheses were tested. For the measure related to the suppression of bar pressing, a main effect for rearing condition and the suggestion of a diet x rearing condition interaction were found. Other main effects and interactions involving most of the incidental behavior categories were also found, such that a proposed increase in fearfulness of nutritionally or socially deprived subjects received more support than the suggestion of insensitivity to social cues on the part of these subjects. However, neither alternative hypothesis accounted for a preponderance of the observed reactions.

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CHAPTER I

INTRODUCTION

Early life experiences have long been recognized as powerful determinants of both childhood and adult behavior. Examples of this acknowledgment appear in the folklore and literature of many cultures and have received consensual validation through casual observation, the work of theorists such as Freud and his followers, and many relatively recent scientific investigations. Although the connections between childhood events and later behavior have been observed in many animal species, the major concern of researchers in this area has been the study of such effects on human activity. In many cases, attempts have been made to study the results of various environmental conditions directly with human subjects in natural situations. More often, however, researchers have chosen to study nonhuman subjects in a laboratory setting.

From the systematic study of the effects of early experience, two broad classes of variables, diet and rearing condition, have emerged as extremely interesting environmental influences on later behavior. With regard to diet and human research, the relevant studies have been reviewed and summarized in several previous reports (Strobel, 1972;

Holombo, 1975; Yeaton, 1975). Therefore a detailed discussion of these projects will not appear below. However, a general overview of this body of data will be included and should help introduce the current research.

Human Research

The physical consequences of a number of diseases collectively referred to as protein-calorie-malnutrition (PCM) have been well documented (WHO, 1962) and it has been reported, for example, that kwashiorkor, marasmus, and famine edema in human infants are all characterized by growth retardation, muscle wasting, and abnormal blood chemistry along with some loss of hair (Jelliffe and Welbourne, 1963; Pollitt, 1972). The behavioral consequences of these conditions, on the other hand, are much less clear. It should also be noted at this point that the diseases that comprise PCM are different from one another in some important ways. For example, marasmus usually appears earlier and the prognosis is poorer than is the case for kwashiorkor (Pollitt, 1972). Another important consideration concerning PCM is the severity of the condition. That is, the biological and social factors involved in milder forms of nutritional deficiency are so different from those associated with severe malnutrition that a one-dimensional continuum cannot adequately describe the relationship between the milder and the more severe forms (Pollitt, 1972).

In general, studies of the effects of severe malnutrition on children in many countries, under diverse conditions and with a variety of dependent measures have tended toward the conclusion that permanent psychological impairment does result from severe PCM. Differences between experimental PCM subjects and controls have been reported for measures of language development, intersensory functioning, intelligence, sorting tasks, memory and performance on various other psychological tests (Pollitt, 1972; Yeaton, 1975). Although many of the human field studies are subject to methodological criticism, the suggestion that physiological changes in the central nervous system are caused by nutritional deficiency has received wide support, especially from animal studies. The issue that remains in question is whether the reduction in number of brain cells and other physiological changes are causally related to behavioral abnormalities (Winick, 1972). This issue exists largely because of the problems inherent in adequately controlling the differing environments of human subjects. For example, mother-child relations, separation trauma, and infectious diseases are sources of between group variance which have usually not been taken into account.

As the preceding remarks indicate, malnutrition, because of its high frequency, has stimulated a considerable amount of research involving human subjects. The effects of various rearing conditions, on the other hand, have tended to prompt only animal studies. This state of affairs can perhaps be accounted for by the fact that the confounding of rearing conditions with environmental variables is even more pronounced in natural situations than are nutritional variables. Considering the interpretational difficulties associated with studies of malnutritional effects in humans, and the paucity of data on the consequences of human rearing conditions, it is to the animal literature that we must turn for more basic evidence concerning the dynamics of these important variables. A review of research contributions in the areas of animal diet effects and rearing conditions should also provide the necessary background to the present experimental concern. In order to impose some organizational framework on this literature, it will be useful first to discuss separately the research findings on diet and rearing conditions, and then to focus on the smaller body of data dealing with the interaction of the two variables.

Animal Research

Diet Studies.

Early studies of the behavioral effects of a protein deficient diet concentrated on the organism's capacity to learn (Yeaton, 1975). In general, the outcome of such studies supported the idea that early protein malnutrition results in impaired learning. However, the necessity to distinguish between learning capacity and learning performance has been clearly demonstrated. For example, Stoffer and Zimmermann (1973) minimized the motivational differences between high and low protein subjects by eliminating incentives which were known to differentially affect the performance of the two types of animal. Appetitive and strongly noxious stimuli, as well as incentives involving stimulus change were among those avoided in favor of pressurized air blasts. These constraints produced no significant differences between high and low protein subjects on a variety of learning tasks in the Wisconsin General Test Apparatus (WGTA).

The difficulty of demonstrating a causal link between PCM and learning capacity notwithstanding, there are several reported effects of protein deficiency which remains essentially unchallenged. For example, Levitsky and Barnes (1970) found that previously malnourished rats responded more strongly to an aversive noise than did control animals. The same study also showed rats deprived of protein early in life to make more bar pressing responses in a Sidman avoidance situation and to display more passive avoidance of an electrified grid floor. These results were interpreted as an indication that protein malnutrition during early development can produce a relatively stable lowering of the stress-response threshold. A related observation was made with primates by Zimmermann, Strobel, and Maguire (1970). Noting abnormally strong responses to new or novel stimuli on the part of malnourished infant rhesus monkeys, they quantified and experimentally verified this observation by exposing infant monkeys to sets of temporally distinct object-quality discrimination tests over a period of several months. When an additional trial was added for the presentation of a novel object, the low protein subjects, in contrast to their high protein counterparts, exhibited sharp decreases in number of responses. This demonstration of neophobic reactions in protein deprived subjects adds important detail to the behavioral syndrome associated with protein malnutrition and calls attention to the environmental deprivation that can accompany malnutrition.

Strobel (1972), in a series of experiments, demonstrated that protein deficient diets can affect perceptual and motivational factors governing stimulus control of specific behaviors. The first two of these studies dealt with the reactions of monkeys to novel stimuli. As predicted, it was found that the appetitive responding of malnourished subjects was disrupted by novelty in a free operant situation and facilitated (disinhibited) under an FI-1 schedule of reinforcement. These results are especially important because they show that the malnourished animal's reaction to novelty is not due merely to an overall reduction in responsiveness.

The measure used by Strobel in his second experiment as a determinant of sensitivity to novel stimuli is known as disinhibition of delay. This phenomenon is related to the classical conditioning demonstration in which Pavlov (1927) found that a novel stimulus presented during the early part of a long CS-UCS interval caused an interruption or disinhibition of the usual delayed response pattern. The result of this disinhibition was the onset of responding earlier in the CS-UCS interval. In operant conditioning, disinhibition had previously been shown to occur when novel stimuli were presented during fixed interval schedules of reinforcement (Hinrichs, 1968; Singh and Wickens, 1968). Strobel's operant procedure involved first the training of monkeys to bar press for food reward and then the presentation, on some trials, of novel stimuli. His results indicated a more pronounced disinhibition of delay response (i.e., increase in bar presssing) by protein malnourished subjects than by controls. Among the explanations offered for this outcome was the possibility that the animals used various collateral behaviors such as pacing, spinning, and flipping as aids in timing the reinforcement interval. The low protein subjects being more sensitive to the intrusion of novelty might have been more inclined to interrupt their timing activities and then, to avoid missing an opportunity for reinforcement, begin responding immediately.

In summary, the distinctive reactions of protein malnourished monkeys to novel stimuli become especially informative when one focuses on the contrast between such reactions and the typical behavior of normal monkeys. Not only are normal monkeys known to have an affinity for novel objects, but they have been shown experimentally to manipulate objects as a function of the objects' novelty (Carr and Brown, 1959a, 1959b).

In addition to their increased sensitivity to novel stimuli, low protein monkeys have demonstrated enhanced sensitivity to the presence of food reward (Peregoy, Zimmermann, and Strobel, 1972). In a situation where the opportunity to manipulate puzzles (intrinsic reward) was the only form of reinforcement, Aakre, Strobel, Zimmermann, and Geist (1973) found that high protein subjects manipulated at a significantly higher rate than did low protein monkeys. When food reward (extrinsic reward) was introduced, along with partial reinforcement, however, the low protein subjects manipulated as much or more than the other subjects. The low protein animals also stopped responding at a much more rapid rate than did the high protein subjects when food reward was withdrawn.

Protein deprivation has also been conclusively linked to deficiencies in animal social behavior. For example, Zimmermann, Steere, Strobel, and Hom (1972) observed significant differences between monkeys raised on low and high protein diets on three dependent measures of social behavior. To be more specific, this study found protein malnourished monkeys to be less responsive to social interactions, more aggressive and fearful, and more likely to engage in non-social (undirected) behavior than were the adequately nourished subjects. Three hypothetical explanations were offered to account for the inhibited socialization processes in the protein deprived subjects. First, it was suggested that protein malnutrition might induce a condition functionally similar to social isolation. This condition, which will be discussed in more detail later, has been linked to abnormal reactions quite similar to those recorded by Zimmermann and his associates (e.g., Zimmermann, Strobel, and Maguire, 1970; Zimmermann and Strobel, 1970; Strobel and Zimmermann, 1971). The second interpretation of these data proposed that the protein malnourished animals could be so predisposed toward food acquisition that opportunities for development of normal social behavior would be lost. Finally, it was noted that protein deprived monkeys typically exhibit behaviors characteristic of immature animals. The suggestion was then made that such infantile responding may not be compatible with normal socialization. Such interpretations also suggest that the _de facto_ social isolation, preoccupation with food and infantile response patterns of the deprived subjects may interact in some way to produce the observed abnormalities.

Comparable findings have been reported by Frankova (1973), who studied the effect of early protein-calorie-malnutrition on the postnatal social development of rats.

The results of this experiment show the malnourished subjects to be below normal in number of social contacts and social grooming, but above normal in aggression. Similar outcomes in experiments with pigs as subjects have also been reported (Barnes, Reid, and Pond, 1970).

Rearing condition studies. Evidence of causal relationships between various rearing conditions and subsequent behavior has come from a broad range of sources. Some of these findings suggest that the decremental effects of rearing deprivation may be more persistent in organisms capable of more complex behavior. For example, Sackett (1968) indicates that while simpler species may suffer only transient effects of rearing deprivation, monkeys have shown an array of permanent abnormalities from such manipulations. This suggestion is consistent with Sackett's previous work (Sackett, 1967) in which he reported reversible effects of rearing deprivation in rats. In another study of rodents, however, Latene, Nesbitt, Eckman, and Rodin (1972) found that long-term social isolation was associated with significant increases in social attraction. At the primate level, the literature is less ambivalent. With a few qualifications, reports consistently depict enduring negative consequences for early social deprivation. An example is reported by Harlow and Harlow (1962) who, summarizing the results of their research program, proposed a critical period between the third and sixth months of life during which deprivation of physical contact with age mates produces a permanent detriment to normal social behavior. Peer experience was identified by both Sackett (1968) and Harlow (1962) as the critical element in early social relations--more important even than the mother-infant relationship.

Just as most diet research with animals has involved the assignment of various levels of protein consumption, rearing condition experiments generally have involved various degrees of social isolation. That is, in most cases experimental subjects were removed from their mothers at an early age and housed in a wire cage from which other animals could be seen but not touched. In general, results obtained on a variety of dependent measures for subjects deprived in this way have delineated a syndrome of abnormal behaviors quite similar to those associated with protein malnutrition. This syndrome has been outlined by Mason (1968) as including the following elements: 1) abnormal postures and movements, 2) motivational disturbance, 3) poor integration of patterns, and 4) deficiencies in social communication. Empirical support for this conception comes, in part, from a study by Menzel, Davenport, and Rogers (1963) which was concerned with the relationship of rearing conditions to the way in which a variety of behaviors are organized into more general response patterns. As compared to control subjects, restricted chimpanzees displayed "gross and generalized differences in the postural, spatial, and temporal organization of behavior."

Similarity of effect between socially isolated rearing and protein malnutrition is particularly noticeable when one considers some of Mason's earlier results. In one such study (Mason, 1960), he observed that restricted monkeys fought more frequently than feral animals, spent less time grooming, had less frequent, more poorly integrated sexual contacts, and in general, showed poorly established responses to social cues. Another study (Mason and Green, 1962) involving the reactions of restricted and feral monkeys to an albino rat yielded further similarities. Especially noteworthy was the observation that restricted monkeys tended to exhibit various stereotyped, repetitive, self-directed behaviors. The authors concluded that these responses were essentially infantile in nature and ordinarily made with reference to the mother. Further concurrence with the deprivational rearing syndrome is reported by Elias and Samonds (1973, 1974) who replicated with cebus monkeys many of the abnormal response tendencies that have been observed in rhesus macaques. In summary, the typical effects of rearing deprivation are dramatically negative, or as Mason so aptly stated it, "Isolation reared primates change as they mature from rocking, digit sucking, grimacing, self-clutching recluses to pacing, socially aggressive, self-threatening, masturbating, self-mutilating menaces who often make bizarre movements."

Diet x rearing condition studies. The similarity of effects in protein malnutrition and social isolation has stimulated several attempts to assess the interactional potential of these conditions and to determine whether a single mechanism mediates the common effects. Beginning with Frankova's (1968) study of spontaneous behavior in the rat, evidence has accumulated which consistently indicates a nutritional and environmental interaction in behavioral development.

After observing that for a variety of responses in rats, the behavioral effects of early malnutrition were exaggerated by environmental isolation, Levitsky and Barnes (1972) offered two theoretical explanations. First, it was proposed that certain "physiological mechanisms which may be responsible for the long term effects of early stimulation may not be operative because of a concurrent state of malnutrition during a critical period of development." The other explanation suggested that the behavior produced by malnutrition may be incompatible with the proper processing of environmental information for cognitive growth. That is, preoccupation with food acquisition may contribute to the insensitivity displayed toward environmental cues. A similar type of explanation derived from a factorial study of problem solving ability in rats (Wells, Geist, and Zimmermann, 1972). Performances in the Hebb-Williams maze provided the dependent measure and it was observed that protein malnourished subjects reared under conditions of environmental deprivation made the greatest number of errors, remained longest in the maze, and were slowest to leave the start box. Converse results were obtained for animals reared under enriched dietary and environmental conditions. These findings were interpreted as evidence that the restricted environment produced more exploration which inhibited problem solving ability, especially in the low protein animals. These studies of rat behavior represent only the beginning of an experimental assault on the problem of interactive effects between dietary and rearing variables. Additional progress toward less speculative extrapolation from animal research to the human condition will come as studies of more complex animals are carried out. Some work in this direction has involved the factorial study of diet and rearing condition and their effects on the learning of delayed alternation tasks (Yeaton, 1975). Although no interactions between diet and rearing were found in this study, significant main effects for each variable were obtained. In explaining the lack of support for an interaction hypothesis, Yeaton invoked the distinction made by Harlow, Schiltz, and Mohr (1971) between emotional stability and learning ability as dependent measures of social deprivation effects. Furthermore, she pointed out that all of the studies in which a diet-rearing interaction had been found involved exploitation of the neophobic and excessively emotional reactions of low protein and socially isolated animals. Thus emotionality rather than learning ability had been the dependent measure in the previous diet by rearing condition studies. Yeaton therefore concluded that there may be separate mechanisms associated with each of these deprivational states, at least with regard to learning deficits.

Another factorial study involved the effects of diet and rearing condition on the social behavior of young rhesus monkeys (Holombo, 1975). In this two-part investigation a previous finding of abnormal social development among protein malnourished animals (Zimmermann, Steere, Strobel, and Hom, 1972) was replicated and was found in some cases to be exacerbated by restriction of social contact. Although the question of whether abnormal behaviors serve as stress reduction mechanisms was also addressed by these experiments, no conclusive answer was produced.

Brief Recapitulation

In the foregoing introductory remarks, evidence was cited for the existence of abnormal behavioral syndromes associated with both protein malnutrition and socially isolated rearing conditions. It was also pointed out that the elements of these syndromes are often similar to one another. For example, it was reported that abnormal postures and movements, infant-like response patterns, insensitivity to social cues, aggressive responses, and poorly integrated sexual behavior are all typical of animals exposed to early protein malnutrition or rearing deprivation. These similarities, along with the fact that the two conditions often occur together in human societies, lead to the need for additional exploratory consideration of their combined and possibly interactive effects. The limited extent to which these combined effects have been examined was reported in the immediately preceding section.

Present Research

A number of studies have involved reactions to novelty as a dependent measure of the effects of various deprivational states (e.g., Menzel, Richards, Davenport, and Rogers, 1962; Sackett, 1967; Zimmermann, Strobel, and Maguire, 1970; Strobel, 1972). This practice stems, in part, from the observation that most socially or nutritionally restricted animals seem to be subject to an abnormally low stress-response threshold or perhaps an increase in general drive, and are consequently more sensitive to potentially aversive elements of new or unusual stimuli. Also, in contrast, it has been shown that most non-deprived animals exhibit an affinity for novelty (Carr and Brown, 1959; Brown, 1961). In many cases, the neophobic tendency of the restricted animals has served to clearly distinguish not only between experimental and control animals, but also between various levels of deprivation within factorial designs.

Some early studies dealing with fear as an acquired source of drive (Brown, Kalish and Farber, 1951; Merryman, 1952) provide evidence for the utility of unexpected stimuli in eliciting responses which distinguish between more and less fearful animals. These experiments, drawing on the clinical observation of exaggerated startle responses among anxious persons, used the sound made by a toy pistol to elicit startle responses in rats (Brown, 1961). As predicted, animals that had undergone previous conditioning designed to maximize fear displayed startle responses of significantly greater magnitude than did control animals. In addition, the Merryman (1952) study found that fear conditioned subjects that were also food deprived showed greater startle responses than nondeprived fearful rats or nonfearful rats, whether or not the nonfearful animals had been deprived of food. Although the mechanisms underlying the interaction of fear and food deprivation were not specified, it was suggested that the combination could have acted to augment the general drive level, thereby increasing the startle response.

Results such as those cited above contribute to the impression that a general class of stimuli including the designations new, novel, unusual, or unexpected have been quite useful in the assessment of the effects of some deprivational or motivational states. However, the utility of such stimuli remains unclear because of the inferential leap required to generalize from the necessarily contrived laboratory situation to naturally occurring behavior. Although the introduction of loud noises, light patterns, strange objects and the like may qualify as novel stimuli, they often have little in common with situations actually encountered by people and non-laboratory animals. That is, the truly novel stimulus may not be particularly relevant to the natural setting. Thus, to the extent that a stimulus falls within the class of laboratory producible novelty and simultaneously contains elements of naturally occurring novelty, it should fulfill an important research need.

These criteria are met by a type of stimulus, namely the conspecific, that has not been entirely overlooked as a potential form of novelty. For example, Miller, Banks, and Ogawa (1963) established that monkeys could be conditioned to prevent shock to another monkey in situations where only the facial expression of the animal to be shocked was communicated via television to the responding animal. In a subsequent experiment, Miller, Caul, and Mirsky (1967), using the same cooperative avoidance paradigm, found that monkeys reared for the first year of life in isolation were unable to use the facial expressions of other monkeys as the basis for performance of appropriate avoidance responses. Same-species animals have also been used as stimuli in several other experiments (e.g., Butler, 1953; Butler and

Harlow, 1954) but again without exploiting their potential as novel stimuli.

An important implication of the introductory material presented to this point is that in synthesis it could lead to interesting and useful exploratory research. That is, the previous findings from studies involving diet and rearing manipulations when combined with a dependent measure of the response to a "novel" conspecific and with the available information on communication of affect provides a unique research opportunity.

The present experiment was primarily concerned with the task of further verifying main effects and identifying possible interactional relationships between protein malnutrition and socially isolated rearing. To accomplish this goal, the reactions of monkeys reared and presently living under four different conditions were compared. The four cells in the design represent the logical combinations of the following conditions: socially isolated or socially enriched rearing and low or high protein diet. One behavior dependent upon these manipulations, and which was a basis for between groups comparisons, involved suppression of appetitive responding as a function of exposure to a novel stimulus in the form of a conspecific. Another animal and its behavior thus functioned as stimuli for each subject. In addition, the nonappetitive, incidental responses of subjects and stimulus animals were recorded.

Hypotheses

Predictions of the differential bar pressing response tendencies among groups of subjects arise principally from two alternative theoretical foundations (see appendix A for summary). The first hypothesis (A) is based, in part, on the idea that protein malnutrition and socially isolated rearing are both conditions which tend to lower the stress or fear reaction threshold of animals exposed to them from an early age (Levitsky and Barnes, 1970; Menzel, Davenport, and Rogers, 1963). The other basis for the first hypothesis comes from the finding that novel objects or situations can be aversive and behaviorally disruptive to both malnourished and socially deprived animals (Levitsky and Barnes, 1970; Mason and Green, 1972; Menzel, Davenport, and Rogers, 1963). From this foundation comes the prediction that animals exposed to either or both of these conditions will show a greater reduction in instrumental (bar pressing) behavior than animals not so exposed, when confronted with a novel conspecific. To be more specific, it was expected that of the four groups the low protein-social isolation reared (LPI) subjects would suppress appetitive responding to the greatest extent, and that the high protein-socially reared (HPS) subjects would show the lowest degree of suppression. Tentative predictions were made with regard to the order in which the remaining two groups (HPI and LPS) would suppress their bar pressing activity, based on the assumption that rearing condition is the more powerful variable. This assumption is supported by the findings of Yeaton (1975) and Holombo (1975), but was further tested by this research.

The other, and to some extent, opposing hypothesis (B) was derived, in part, from what Miller, Caul, and Mirsky (1967) refer to as "communication of affect." Research on the subject of social behavior in primates and particularly in the area of social communication (Zimmermann, et al., 1972; Miller, Caul, and Mirsky, 1967) leads to the conclusion that low protein animals and animals reared in social isolation are much less sensitive to social cues or communications than are their high protein, socially reared counterparts. Therefore, to the extent that the latter animals are sensitive and attend to the inevitable social cues emanating from an adjoining cell, they should be less likely to maintain their previous level of appetitive responding. Furthermore, if the stimulus animal should engage in distress behavior, evidence exists which suggests that subjects most sensitive to communication of affect would have a stronger tendency to suppress their instrumental behavior than would other subjects (Wechlin, Masserman, and Terris, 1964). Likewise, it seems that the infantile response patterns common to malnourished and socially deprived subjects and the overriding preoccupation with food acquisition among low protein animals would interfere with any tendency to respond in a prosocial or sympathetic manner. It should be noted here that although measures were taken to equate motivational levels (see method section), it is considered unlikely that the effects of long term protein malnutrition can be completely controlled for with regard to food acquisition drive. Hence the expectation that this source of motivation may be differentially operative. In connection with the LPS and HPI groups, the same situation existed here as was the case for the first hypothesis. That is, there was a somewhat more tenuous basis available for systematic prediction of their reactions in relation to the two extreme groups. In general, however, the HPI group should fall between the LPI and the LPS groups.

The remaining hypotheses concern the incidental (non-bar pressing) responses of subjects. Although these predictions derive from the same two theoretical frameworks discussed above, the categories into which these behaviors were recorded are presented below in the method section. Hence these hypotheses will be dealt with more coherently later in the discussion. It should also be noted here that the two major hypotheses (A and B) will henceforth be referred to as the "fear hypothesis" and the "communication of affect hypothesis" respectively.

CHAPTER II

METHOD

Subjects

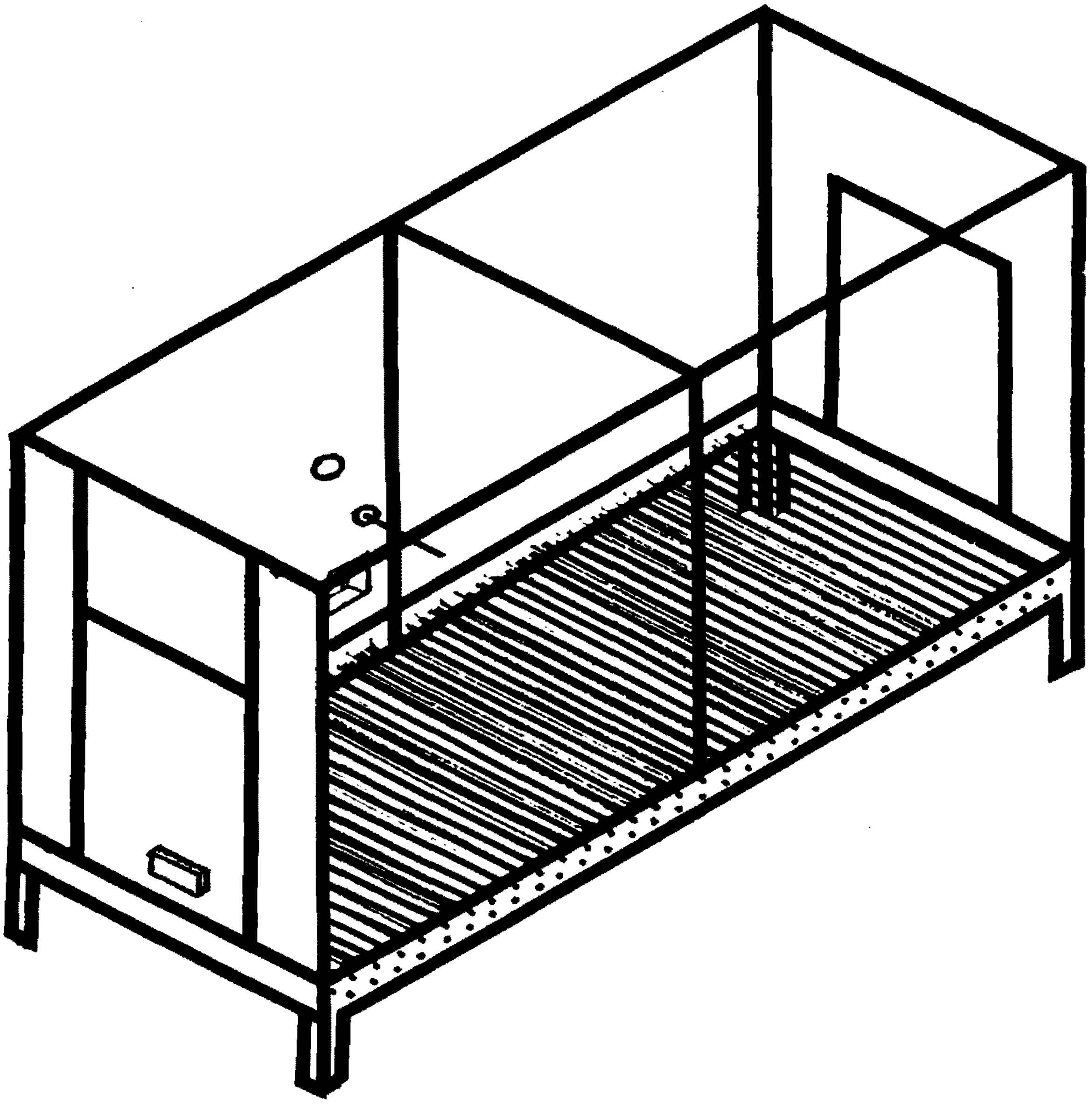
Subjects were 16 prepubescent, laboratory-born rhesus monkeys (macaca mulatta), representing four equally sized groups. These groups differed from one another on two factorial dimensions corresponding to the two independent variables, i.e., diet and rearing condition. More specifically, there were two four-animal groups designated as high protein subjects and two groups designated as low protein subjects. The high protein groups were so named because these animals received a special diet containing 25% protein by weight, commencing 120 days after birth (Geist, Zimmermann, and Strobel, 1972). In addition, one of the high protein groups was reared under a condition of social isolation from other animals as of the beginning of weaning (90 days of age) while the other high protein group shared a common pen. Social isolation, within the context of this experiment, means simply that the animals reared under this condition were housed separately in wire cages from which other animals could be seen and heard, but not touched. The rearing conditions of the two low protein groups were also manipulated as has just been described. The distinguishing feature of the low protein groups is their special diet which contained only 3.5% protein by weight but was calorically identical to the high protein diet.

Two additional laboratory-born rhesus macaques, one infant and one adult male, were used as the stimulus animals for all groups. These animals, which were not previously exposed to the subjects, presumably occupied extreme positions on a monkey-as-stimulus continuum. Consequently, they represent an attempt to neutralize certain prepotent response tendencies that may be unequally distributed among groups.

Apparatus

A special experimental apparatus was designed, which allowed the presentation of stimulus animals to responding subjects. This apparatus was a rectangular box 123 centimeters long, 52 centimeters wide, and 60 centimeters high (figure 1). The end panels and back were constructed of .5 cm masonite material and the front wall and ceiling panels were constructed of .5 cm clear plexiglas. Each end panel contained a 23 x 36 cm sliding door for placement and removal of the animals. The apparatus was divided into two equally sized compartments, separated by a 1/4-inch clear plexiglas partition. The floor of both compartments consisted of two offset rows of 1/4-inch round steel rods running from front to rear of the apparatus at 2.5 cm intervals.

Figure 1. Experimental apparatus



The experimental chamber contained a 10 cm long flexible bar which protruded through a hole in the masonite rear wall and was connected to a microswitch. Directly above the bar was a round opaque white light 3 cm in diameter which was mounted on the same surface and activated by responses to the bar. Banana flavored 190 mg, 6.4 mm round pellets (P. J. Noyes Company, Lancaster, New Hampshire) were automatically dispensed by a modified Scientific Prototype model D700 feeder into a steel food cup located below and slightly to the left of the flexible bar. The reinforcement contingencies were programmed by BRS electronics model 2901 logic and responses counted by 10 Sodeco 12 volt counters.

A white noise-masking stimulus was presented continuously through a 16 cm round speaker mounted on the laboratory wall. Illumination of the apparatus during pre- and posttrial periods was provided by three 100-watt incandescent light bulbs. During trials the only light source was a shaded 50-watt incandescent bulb mounted between and above the chambers. All behavior of subjects and stimulus animals was monitored by an Akai closed circuit television camera equipped with a 10-40 mm zoom lens and mounted directly above the apparatus. In addition, the behavior was recorded with an Akai videotape recorder and another closed circuit television camera. Both cameras were connected to a 17 inch General Electric video receiver. The non-instrumental recorded behaviors of both subject and stimulus animals were registered with a hand-held box containing five typewriter keys connected to microswitches. The microswitches automatically activated five counters and five timers which displayed the frequency and duration of each behavior category. The power sources for this equipment were two Electro model EF filtered DC power supplies and a BRS model PS-12. All monitoring, recording, and programming equipment was located in a room adjacent to the 8 ft. x 12 ft. 8 in. laboratory room.

Procedure

Training phase. Each of the 16 experimental subjects was trained in the apparatus to bar press for the food reward which was ultimately delivered on a fixed interval (FI) 60-second schedule. Both high protein groups were deprived, to varying degrees, of their normal food ration in order to insure an adequate response base rate, but no subject was allowed to fall below 90 percent of its normal, pre-experimental body weight. The low protein animals, because of the protein deficiency inherent in their diet, and their consequent high motivational level with regard to any type of food, were allowed access to their usual full ration.

All of the subjects were fed on a variable schedule, within one hour after completing the daily (six days per week) 30 cycle training trial. Each animal was fed separately and given one hour access to food, after which time the subjects were returned to their home cage. On weekends, the subjects were also fed by the above described procedure, except on Saturday when each deprived (high protein) subject was given access to a full normal diet ration. This procedure was intended as a means of preventing these animals from properly adapting to the decreased amount of food provided on other days. The training phase of the experiment was considered complete when each subject attained a stable rate of bar pressing within each 60 second FI cycle. In order to determine when this criterion had been met, stable bar pressing behavior was defined as not more than 25% of the responses emitted during the first 50% of the FI cycle (Strobel, 1972).

Experimental phase. After completion of the training phase, each of the 16 experimental subjects was paired in the apparatus with a stimulus animal for six separate 15-cycle trials. That is, after 15 one-minute cycles alone in the apparatus (comparable to the first 15 cycles of the training trials) a stimulus animal was introduced for the remaining 15 cycles of each 30-cycle trial. These pairings were conducted once each day for each subject, over a period of six consecutive days. For the first subject (chosen randomly) of each group, the order in which the two stimulus animals were presented was randomly determined and then reversed for each subsequent subject. For example, if the first HPS subject was presented with the infant stimulus animal for the first three test days and the adult stimulus animal for the remaining three test days, the second HPS subject (also randomly selected) was exposed to the adult stimulus animal during the first three test days and to the infant stimulus animal on the remaining trials.

The subject/stimulus animal pairings began when the stimulus animal was placed into the apparatus which was already partially occupied by a subject. The stimulus animal, in each case, occupied the chamber immediately adjacent to the response chamber and was separated from the subject by a clear plexiglas partition. In order to minimize the effect of the process of introducing the stimulus animal, the experimenter entered the laboratory room after the first 15 cycles of the last six daily training trials. During this short (approximately 20 seconds) interruption, all elements of the stimulus animal introduction process were simulated, except those involving the stimulus animal. That is, the experimenter entered the room with an empty transport cage, simulated the release of a stimulus animal into the adjacent chamber, and then left the laboratory room during the remaining 15 training cycles.

As indicated earlier, the principal dependent measure in this study involved appetitive bar pressing which was recorded from an array of counters. However, other types of behavior were also recorded with the aid of videotape equipment and additional counters and timers. The procedure for coding these other activities involved the following five behavioral categories:

1. Fear--obvious signs of agitation, vocalizations, grimacing, huddling, defecation, attempts to escape.
2. Object oriented--picking at or biting of objects; licking; bar pressing.
3. Self-directed--clutching, self-biting, eye-poking.
4. Repetitive--spinning, flipping, bouncing, pacing.
5. Threat--lunging at other animal, pounding on partition; threat vocalization, posture.

The frequency and duration of the coded behaviors were recorded on data sheets, from the videotapes, for both the subjects and stimulus animals. Because the experimenter was the sole coder of these behaviors, it was not possible to obtain interrater reliability data for this operation. However, the experimenter had previously participated in similar coding operations where the interrater reliability coefficients between more than a dozen different observers was at least .95. In view of the similarity of categories and recording procedures between the current project and these prior efforts (Holombo, 1975), it is likely that the previous reliability statistics would generalize, to an acceptable extent, to this research.

CHAPTER III

RESULTS

Overview

To circumvent the potentially confusing nature of the data, a few introductory remarks are necessary. These remarks are intended only to convey the general nature of the analyses and the order in which they will be discussed. For a very brief summary of results for the principal dependent variables, see table 1.

The bar pressing data were subjected to two alternative forms of analysis (A/A+B, where A = responses during second half of 30-minute trial, and B = responses during first half of trial), wherein the suppression ratio functioned as the basic unit (Annau and Kamin, 1961). The first of these two analyses called for a split-plot factorial analysis of variance on the raw data and each of five transformations. These data transformations represented attempts to normalize the distribution of the data in consideration of the assumptions underlying analysis of variance. However, since an analysis of the suppression ratio for the six test days alone does not make use of the baseline data collected during the days immediately preceding introduction of the stimulus

TABLE 1

BRIEF SUMMARY OF RESULTS FOR PRINCIPAL DEPENDENT VARIABLES

	Predictions (Order of Magnitude)				
Dependent Variable	Effect	Fear Hypothesis (A)	Communication of Affect (B)	Outcome	Prob.
Change in bar pressing suppression	D	HP < LP	LP < HP	HP < LP	$p < .16$
	R	S < I	I < S	S < I	$p < .08$
	DxR	HPS<LPS<HPI<LPI	LPI<HPI<LPS<HPS	HPS<LPS<LPI<HPI	$p < .10$
Incidental Behaviors					
1. Fear	D	HP < LP	LP < HP	HP < LP	$p < .21$
	R	S < I	I < S	S < I (rate)	$p < .06$
	DxR	HPS<LPS<HPI<LPI	LPI<HPI<LPS<HPS	HPS<LPS<HPI<LPI	$p < .35$
2. Object oriented	D	LP < HP	HP < LP	HP < LP	$p < .15$
	R	I < S	S < I	S < I	$p < .19$
	DxR	LPI<HPI<LPS<HPS	HPS<LPS<HPI<LPI	HPS<HPI<LPS<LPI	$p < .56$
3. Self-directed	D	HP < LP	HP < LP	HP < LP	$p < .20$
	R	S < I	S < I	S < I	$p < .39$
	DxR	HPS<LPS<HPI<LPI	HPS<LPS<HPI<LPI	LPS<HPS<LPI<HPI	$p < .89$
4. Repetitive	D	LP < HP	HP < LP	LP<HP (duration)	$p < .08$
	R	I < S	S < I	I<S (duration)	$p < .02$
	DxR	LPI<HPI<LPS<HPS	HPS<LPS<HPI<LPI	HPS<LPS<HPI<LPI	$p < .27$
5. Threat	D	LP < HP	LP < HP	HP < LP	$p < .16$
	R	I < S	I < S	S < I (duration)	$p < .009$
				S < I (rate)	$p < .07$
	DxR	LPI<HPI<LPS<HPS	LPI<HPI<LPS<HPS	HPS<LPS<HPI<LPI	$p < .78$

D = Diet
R = Rearing condition
DxR = Diet x rearing condition

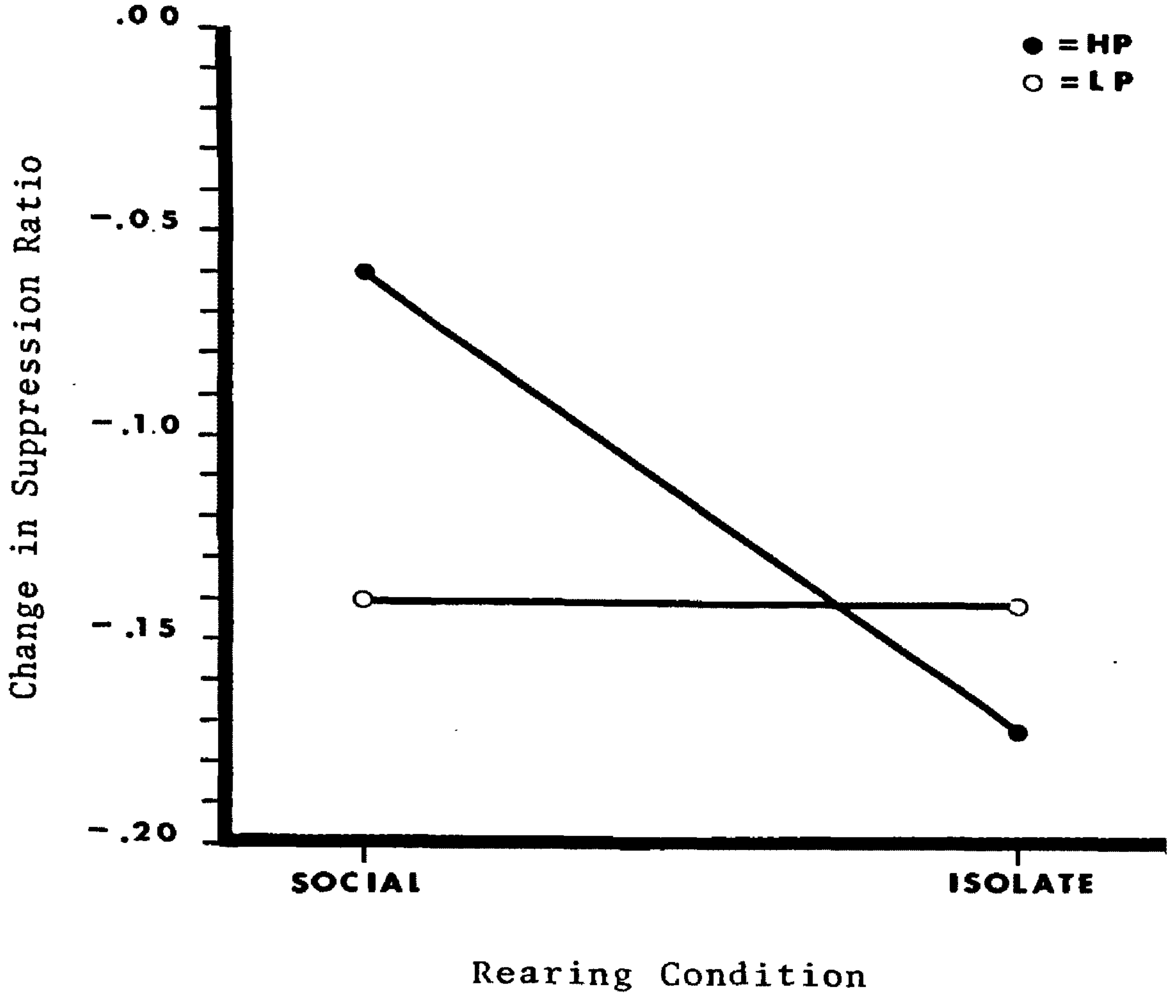
HP = High protein diet
LP = Low protein diet
S = Socially reared
I = Partial isolation

animals, a more appropriate analysis was chosen. For this reason, the first bar pressing analysis (suppression ratio: test days only) will be included only as an appendix in tabular form (appendix B). The second analysis of the bar pressing data was based on the change in suppression ratio from baseline to test (stimulus animal present) trials, and is expressed as the difference (A/A+B[b]-A/A+B[t]) between these two ratios. This analysis is included in the results section and discussed below.

Two additional types of analysis were performed on data representing the incidental behaviors (five categories) of either the subjects or stimulus animals. Within each of the two incidental behavior analyses, the frequency, duration, and rate of each behavior category was subjected to a separate analysis of variance. The first of these two analyses to be presented involves only the behavior of subjects, while the subsequent analysis is based on the correlation of selected pairs of subject and stimulus animal behaviors. Although the frequency data for the incidental behavior analyses was thought to be potentially the least reliable of the three forms of data available, no such qualitative distinction could easily be made between the duration and rate data. Thus, the analyses based on both of the latter forms are included in the results section, while the frequency data appear only as an appendix (appendix C). A final note of orientation relates to the matter of support for various hypotheses. Because this research involves more than the testing of a single alternative against the null hypothesis, the decision as to which, if either alternative hypothesis has anticipated a given result will be expressed in the discussion section.

Considering suppression of bar pressing as the principal dependent variable, the contrast between control and test trials was used as the unit of analysis. Analyses of variance were performed on the raw data and two transformations of the raw data. The former ANOVA yielded significant differences only with regard to the effect of the two stimulus animals ($p < .0006$). Across groups it was found that the change in suppression ratio from control to test trials was much greater on those test trials during which the adult stimulus animal was present. This finding is not surprising and was encountered in most of the other analyses. When the data were subjected to the log $(X+1.0)$ transformation, a marginally significant main effect for rearing condition emerged which suggests that subjects in the partial isolation conditions were affected to a greater degree by the introduction of stimulus animals than were socially reared subjects ($p < .08$). In addition to a main effect for stimulus animal, this transformation yielded a marginally significant ($p < .10$) diet x rearing condition interaction. As indicated in figure 2, for high protein subjects rearing conditions seems to be an important factor with regard to the change in

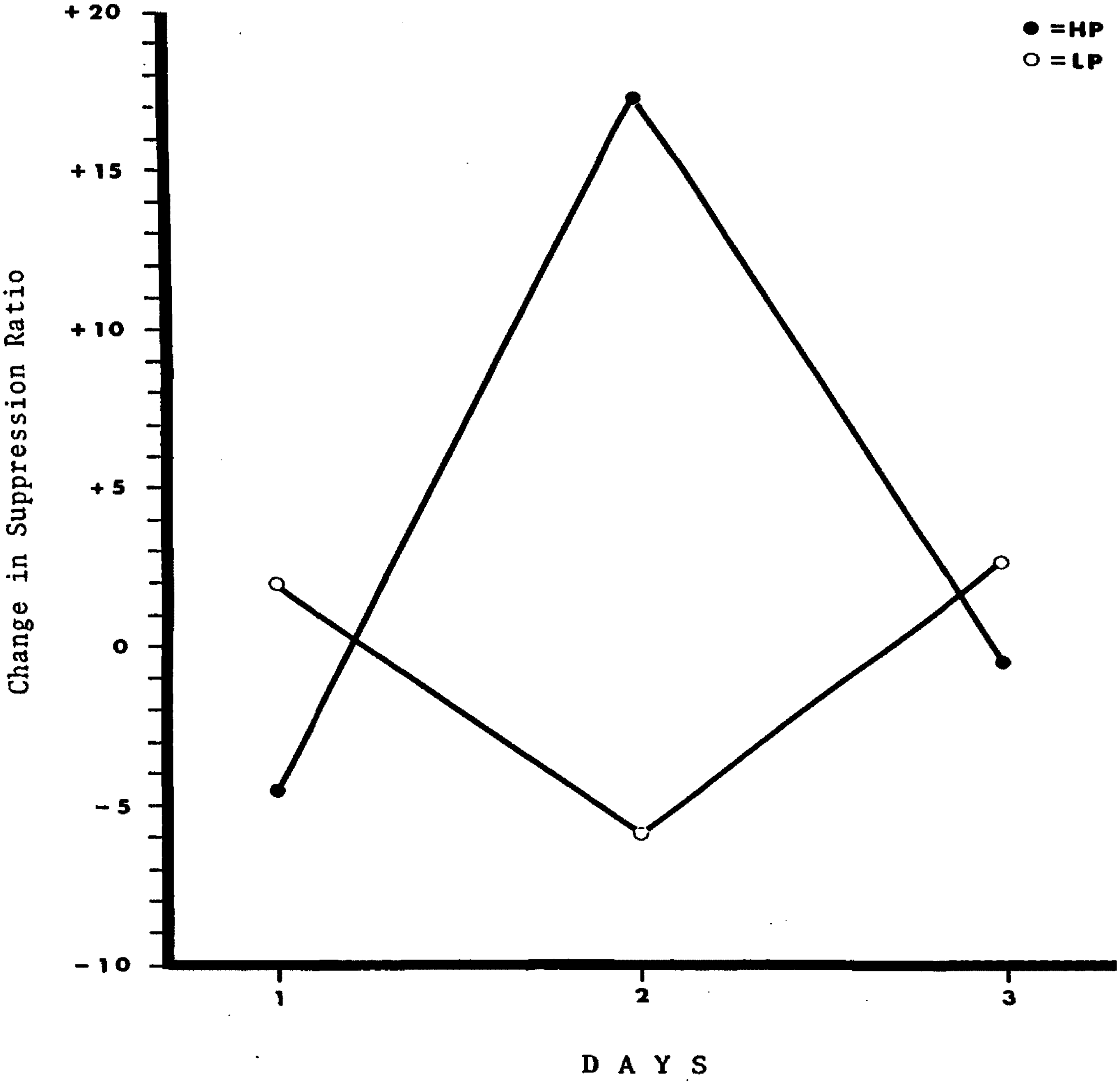
Figure 2. Net change in bar pressing suppression ratio (log transformation) Diet x Rearing interaction*



*HSD = .31

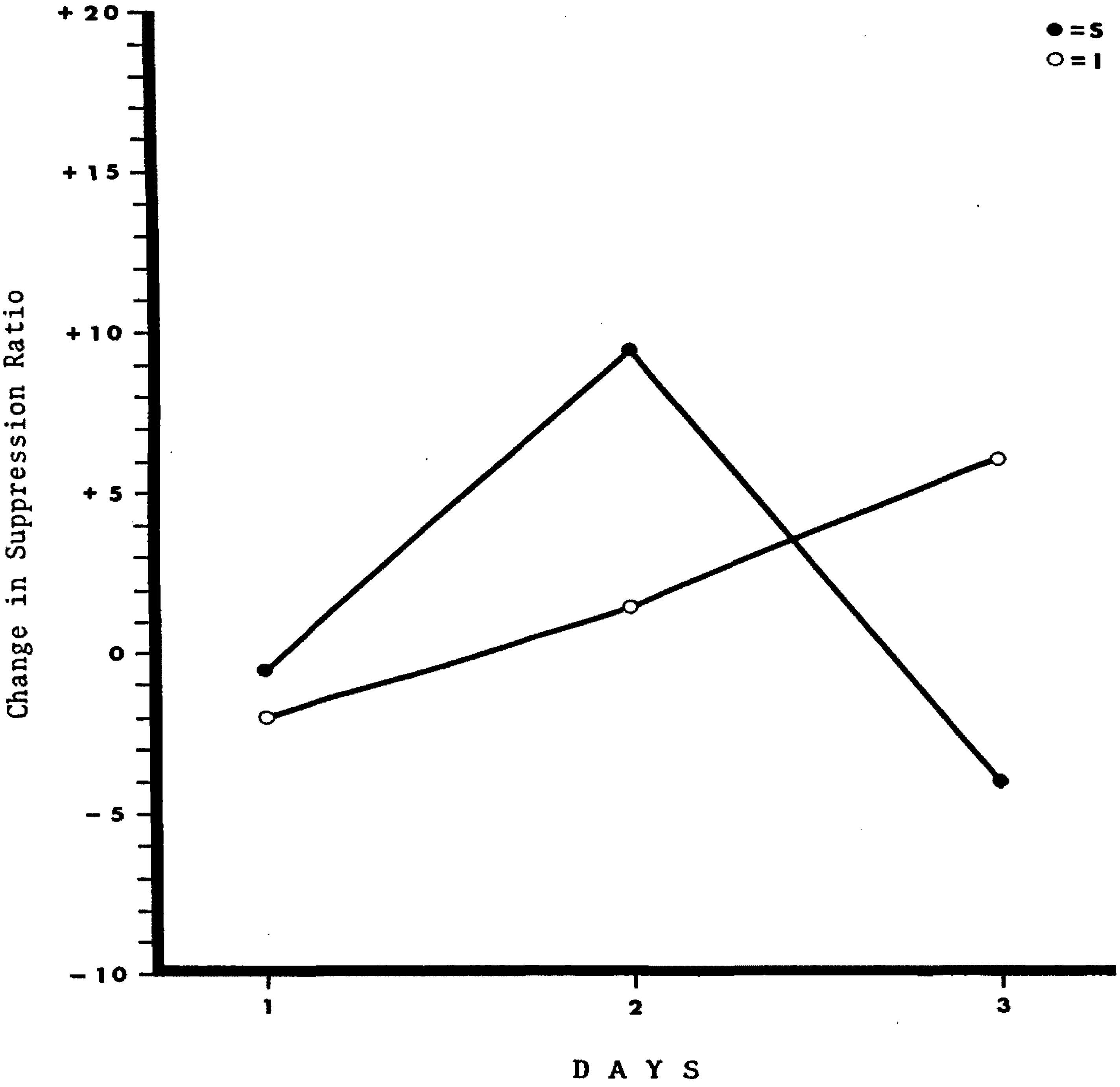
suppression ratio, while for low protein subjects rearing condition made little difference. A multiple comparison test (Tukey's HSD) however, failed to indicate that any of the four means involved in this interaction were significantly different from one another. Several additional interactions were suggested when another ANOVA was performed using the inverse (1.0/X) transformation. A significant ($p < .001$) diet x days interaction indicates that while high and low protein groups were relatively similar on the first and last days of their encounters with the two stimulus animals, their change in suppression ratio was markedly different ($p < .05$; figure 3) on the second day. In particular, the high protein animals appear to have changed their suppression ratio in the direction of increased suppression, while the low protein animals changed in the opposite direction. The nearly significant ($p < .06$) rearing x days interaction (figure 4) also involved similar trends for two of the three encounters across both stimulus animals. However, in this case, the isolate subjects continued a positive linear change in suppression ratio and the socially reared subjects reversed a similar trend on the third day. In connection with the diet x rearing x days interaction ($p < .10$; figure 5), it appears that the LPI group, in contrast to the other three groups, displayed a change in suppression ratio which was decisively in the direction of greater suppression. Also, the HPS group on day 2 was significantly different ($p < .05$)

Figure 3. Diet x Days interaction:* Change in bar pressing suppression ratio across stimulus animals (inverse transformation)



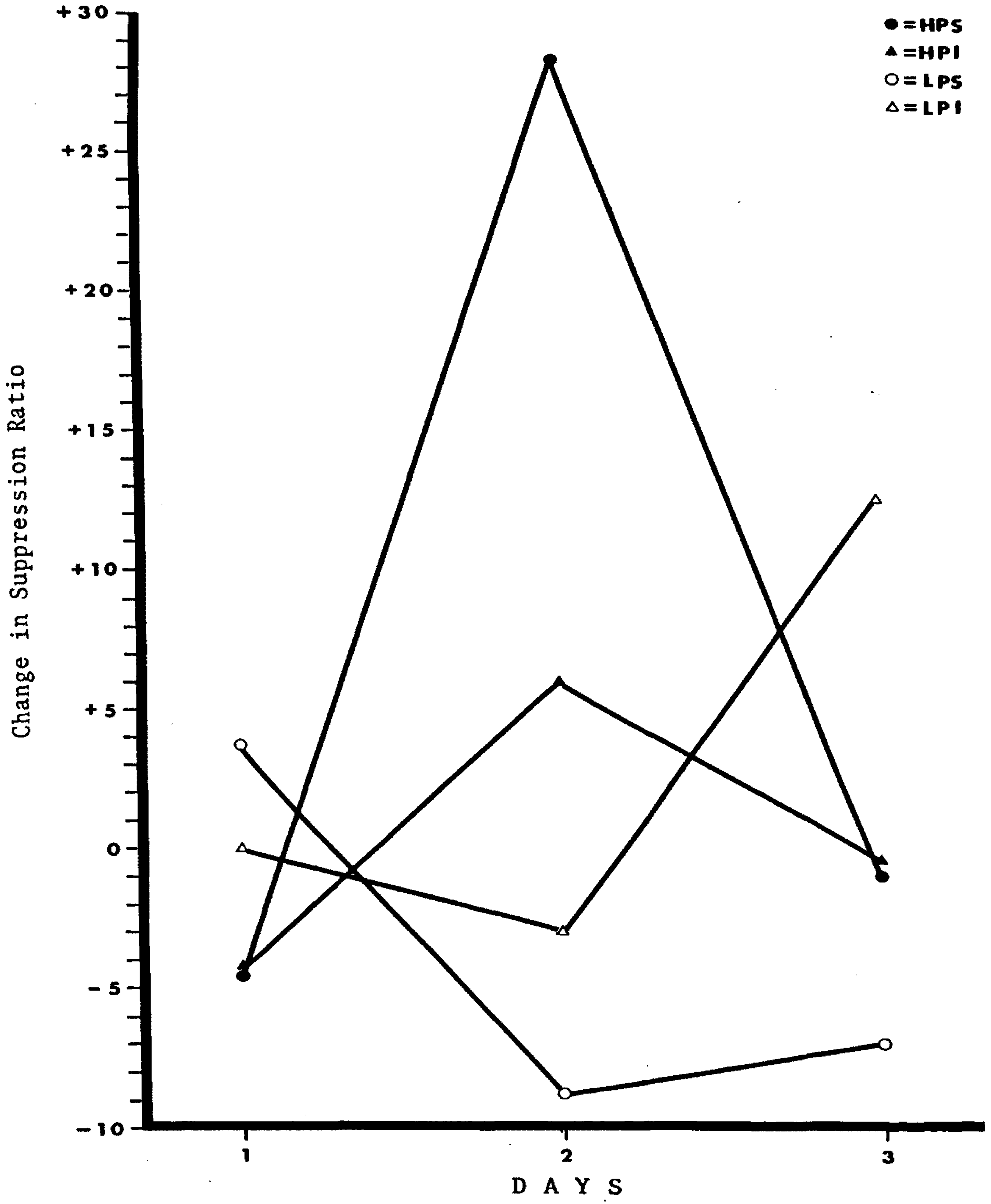
*HSD = 22.96

Figure 4. Rearing x Days interaction:* Change in bar pressing suppression ratio across stimulus animals (inverse transformation)



*HSD = 22.96

Figure 5. Diet x rearing x days interaction:* Change in bar pressing suppression across stimulus animals (inverse transformation)

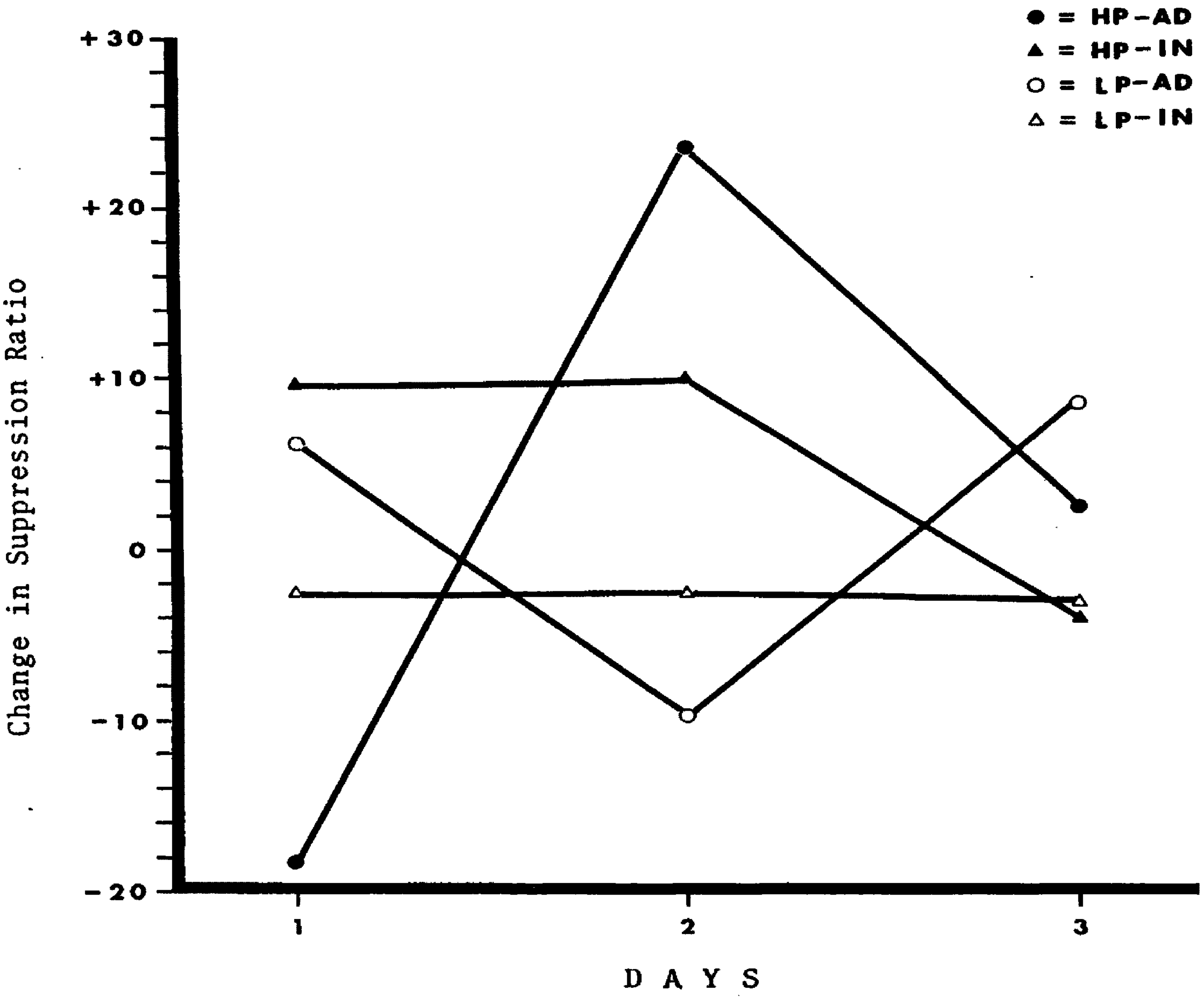


*HSD = 34.40

from the LPS group, but not from the other groups. Although the ANOVA indicated that the diet x stimulus animal x days interaction was significant ($p < .04$; figure 6), a multiple comparison test failed to affirm differences between specific means. In any case, it does appear that the high protein animals exposed to the adult stimulus animal may have reacted in a fashion different from the other three groups on days 1 and 2. Finally, the 4-way diet x rearing x stimulus animal x days interaction was nearly significant ($p < .06$), but again a multiple comparison test did not show specifically where these differences occurred. It is interesting to note, however, that the HPS group exposed to the adult stimulus animal, reacted across days in much the same pattern as did the HP/AD subjects mentioned in the previous diet x stimulus animal x days interaction (figure 6).

In summary, when change in suppression ratio was the dependent variable, only the ANOVAs based on transformations of the data yielded significant or marginally significant effects. That is, for the log transformation, a main effect for rearing condition was suggested ($p < .08$) along with a possible diet x rearing condition interaction ($p < .10$; figure 2). When the inverse transformation was employed, several other interactive effects were suggested, all of which included subordinate variables, i.e., diet x days (figure 3), rearing x days (figure 4), diet x rearing x days (figure 5), diet x stimulus animal x days (figure 6),

Figure 6. Diet x Stimulus animal x days interaction:* Change in bar pressing suppression (inverse transformation)



*HSD = 55.08

and diet x rearing x stimulus animal x days.

Subjects' Incidental Behaviors

Fear. Analysis of the duration of subjects' fear responses during encounters with stimulus animals yielded significant differences of interest only for the diet x days x stimulus animal ($p < .01$, figure 7) and the rearing x days x stimulus animal ($p < .06$, figure 8) interactions. The precise nature of these differences is shown in tables 2 and 3, where all cells sharing a common symbol represent values that are not significantly different from one another according to Tukey's HSD (honestly significant difference) multiple comparison test. Thus it appears that the bulk of the between groups variance for the diet x days x stimulus animal interaction is accounted for by initially high (days 1 and 2) levels of fear when the low protein subjects were paired with the adult stimulus animal. Similarly, for the rearing x days x stimulus animal interaction, it appears that the adult stimulus animal, when paired with either socially reared or isolated subjects on days 1 and 2, elicited fear responses of longer duration ($p < .05$, Tukey's HSD) than did any of the other rearing x days x stimulus animal possibilities.

A main effect for rearing was the only significant difference between the four groups with regard to rate (duration/frequency) of fear responses. Subjects reared

Figure 7. Diet x Days x Stimulus animal interaction: Duration of fear responses (in seconds)

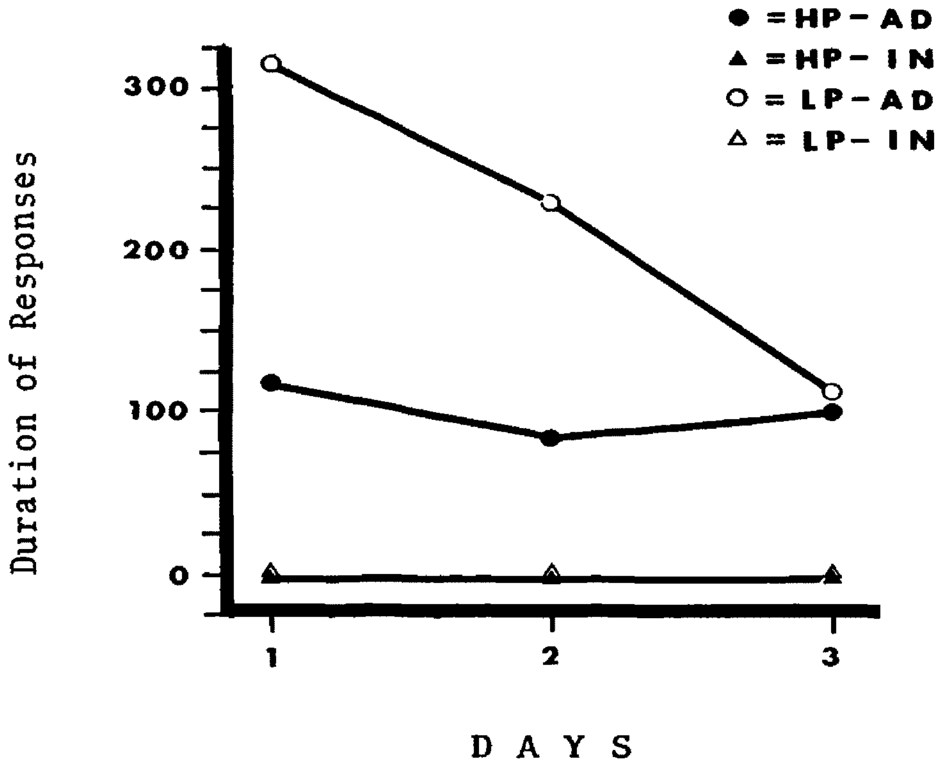


Figure 8. Rearing x Days x Stimulus animal interaction: Duration of fear responses (in seconds)

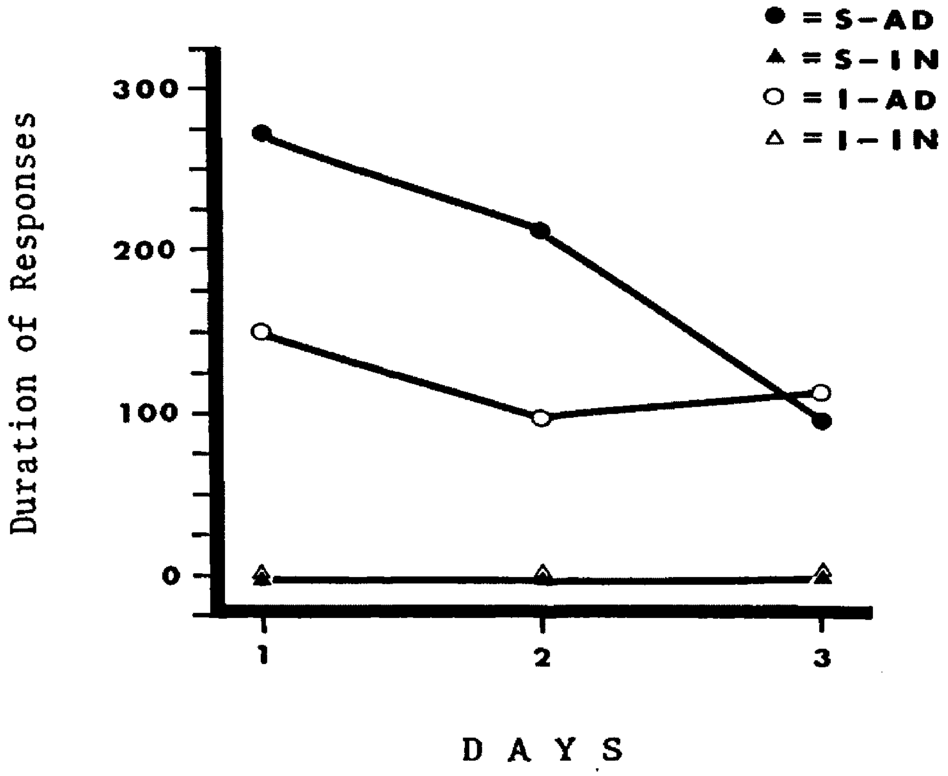


TABLE 2

DIET X DAYS X STIMULUS ANIMAL INTERACTION: DURATION OF FEAR RESPONSES (IN SECONDS) (HSD = 183.90)

	HP/IN	HP/AD	LP/IN	LP/AD
Day 1	§.0	§†114.1	§.0	β309.4
Day 2	§.0	§† 80.0	§.2	†β229.0
Day 3	§.2	§†102.9	§.0	§110.8

TABLE 3

REARING X DAYS X STIMULUS ANIMAL INTERACTION: DURATION OF FEAR RESPONSES (IN SECONDS) (HSD = 166.95; p .10)

	S/IN	S/AD	I/IN	I/AD
Day 1	§.0	β273.9	§.0	§†149.5
Day 2	§.0	β†211.7	§.2	§† 97.3
Day 3	§.0	§† 96.6	§.2	§†117.1

in partial isolation displayed a higher (p .06) rate of fear responding than did socially reared subjects.

Object oriented. There were no significant differences in the duration or rate of subjects' object oriented behavior with the exception in both analyses (duration and rate) of the expected main effect for stimulus animal. In these two cases, as in all other instances, the effect of the stimulus animal was in the direction which would have been predicted had the stimulus animal been a variable of central interest. As an example, more time was spent in object oriented behaviors, across subjects, in the presence of the infant stimulus animal than when the adult stimulus animal was encountered. This is in contrast to the comparable finding for fear responses, wherein more time was spent in fear responding when the adult stimulus animal was present than when the infant stimulus animal was present.

Self-directed. None of the differences between groups with regard to self-directed behaviors was significant.

Repetitive. A significant (p .02) main effect for rearing condition was found in the analysis of variance for duration of repetitive behaviors. Socially reared subjects spent more time engaged in repetitive behaviors than did subjects reared in partial isolation. The same analysis also yielded a significant (p .05) diet x rearing condition interaction. As can be seen in figure 9 and table 4, for socially

Figure 9. Diet x Rearing interaction: Duration of repetitive responses

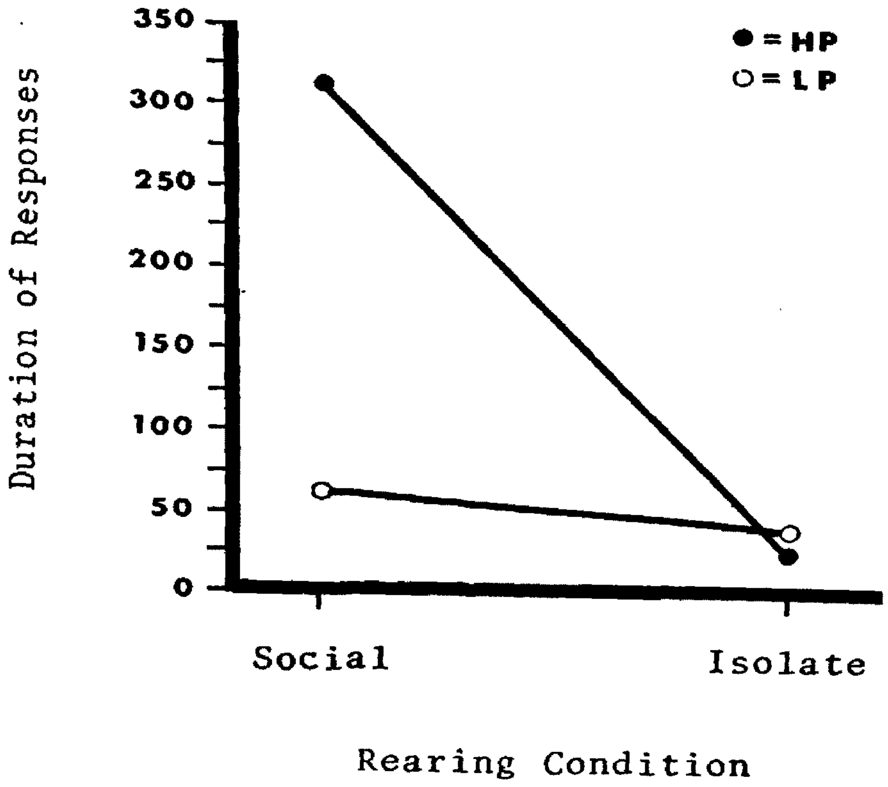


TABLE 4

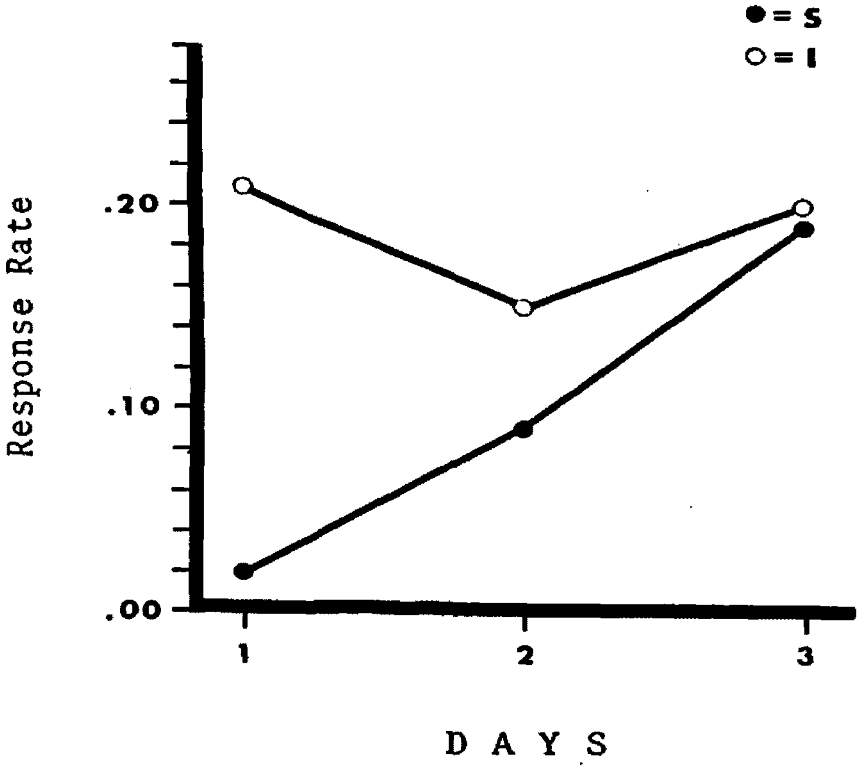
DIET X REARING INTERACTION: DURATION OF REPETITIVE RESPONSES (HSD = 432.28)

	HP	LP
S	§308.04	§68.57
I	§ 25.31	§39.98

reared animals diet is apparently a more important determinant of time spent in repetitive behaviors than it is for partially isolated subjects. Unfortunately, however, this difference did not achieve significance when subjected to Tukey's HSD multiple comparison test. Finally, the ANOVA for rate of repetitive responses showed no significant differences between groups.

Threat. The results of the ANOVA for duration of threat responses show a significant (p .009) main effect for rearing, with partially isolated animals engaging in more threat than their socially reared counterparts. The same type of main effect was shown (p .07) when the ratio of duration to frequency (i.e., rate of threat was the dependent variable. In addition, the analysis of rate for this category yielded three significant interactions of some interest. First, a rearing x days interaction (p .04, figure 10) indicated

Figure 10. Rearing x Days interaction: Rate of threat response



more threat by isolates on the first day of their encounters with the stimulus animals (i.e., across stimulus animals) than by socially reared subjects. Over time this difference was seen to diminish, and at day 3, across stimulus animals, the time spent in threat by each group was nearly identical. Even the initial (day 1) difference between the two conditions, however, was not shown to be significant when tested by multiple comparison procedure (table 5).

TABLE 5

REARING X DAYS INTERACTION: RATE OF THREAT RESPONSES (HSD = .22)

	S	I
Day 1	§ .02	§ .21
Day 2	§ .09	§ .15
Day 3	§ .19	§ .20

Although the diet x rearing x days (figure 11) and the 4-way diet x rearing x stimulus animal x days interactions were also shown to be significant with regard to rate of threat behavior ($p < .009$ and $p < .02$ respectively), the Tukey's HSD test again failed to provide more precise information on just where the significant differences occurred (tables 6 and 7).

Summary. In order to give a clearer picture of the subjects' non-bar pressing behavior, the mean duration and rate of each behavior for each of the four groups is shown in tables 8 and 9. As previously indicated, the only significant 2-way interaction revealed by either of these analyses involved the duration of repetitive behavior (figure 9). Although the large difference between the HPS group and each of the other three groups, on this particular measure, was not found to be significant (HSD = 347.37), the group means do provide some descriptive information. Likewise, the group means for the other behaviors from both analyses, although not significantly different within behavior categories, are informative with regard to possible directional trends. Also, these means, when averaged across either diet or rearing condition, illustrate the effect of each of these two principal variables alone. Accordingly, it will be recalled that duration of repetitive and threat behaviors were significantly different for the two rearing conditions, as was the rate of fear responding.

Figure 11. Diet x Rearing x Days interaction: Rate of threat responses

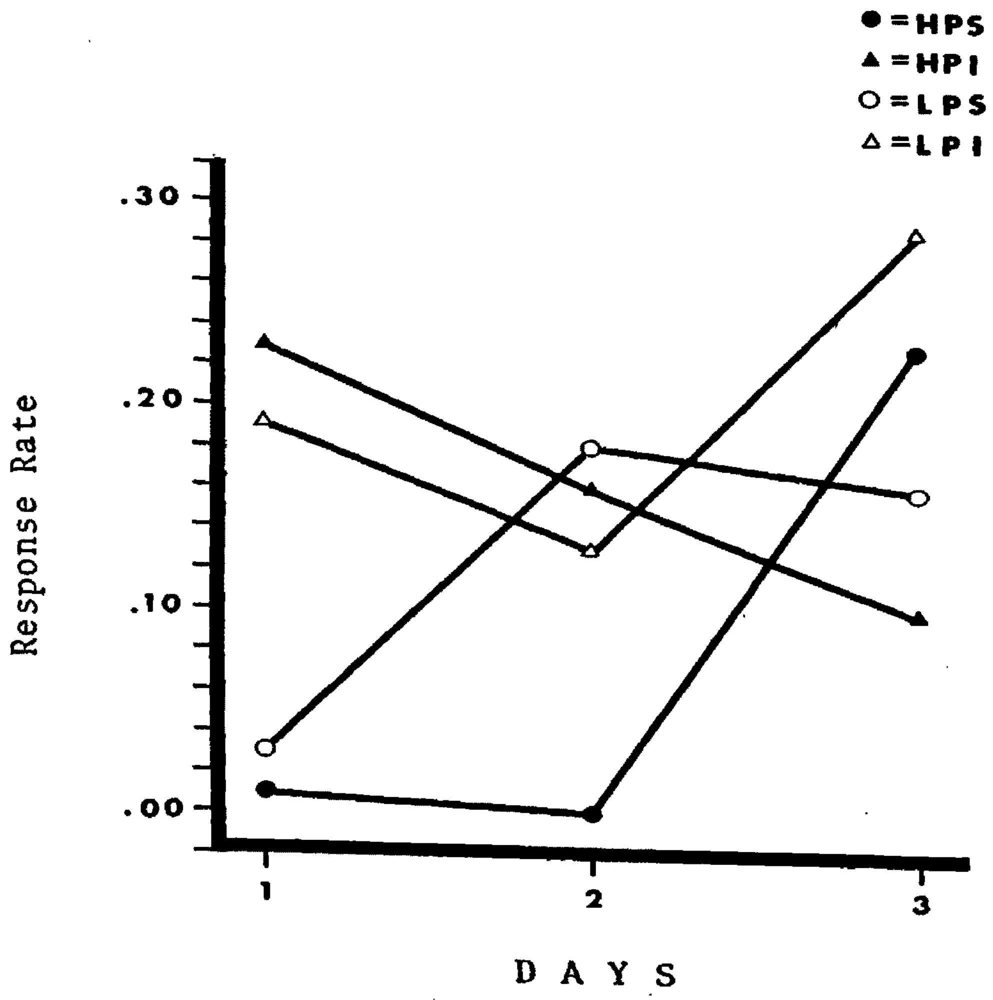


TABLE 6

DIET X REARING X DAYS INTERACTION: RATE OF THREAT RESPONSES (HSD = .36)

	HPS	HPI	LPS	LPI
Day 1	§ .01	§ .23	§ .03	§ .19
Day 2	§ .00	§ .16	§ .18	§ .13
Day 3	§ .23	§ .10	§ .16	§ .29

TABLE 7

DIET X REARING X STIMULUS ANIMAL X DAYS INTERACTION: RATE OF THREAT RESPONSES (HSD = .64)

	HPS AD	HPS IN	HPI AD	HPI IN	LPS AD	LPS IN	LPI AD	LPI IN
Day 1	§ .00	§ .00	§ .36	§ .09	§ .05	§ .00	§ .35	§ .03
Day 2	§ .01	§ .00	§ .33	§ .00	§ .36	§ .00	§ .19	§ .06
Day 3	§ .45	§ .00	§ .20	§ .00	§ .32	§ .00	§ .54	§ .04

TABLE 8

MEAN DURATION OF INCIDENTAL BEHAVIORS (IN SECONDS)

Behavior	HPS	HPI	LPS	LPI
Fear	30.95	68.08	162.09	53.37
Object oriented	103.08	71.34	155.71	102.93
Self-directed	.68	4.63	7.03	30.03
Repetitive	308.04	25.31	68.57	39.98
Threat	1.50	15.54	55.25	26.58

TABLE 9

MEAN RATE OF INCIDENTAL BEHAVIORS

Behavior	HPS	HPI	LPS	LPI
Fear	.08	.09	.03	.13
Object oriented	.27	.21	.17	.19
Self-directed	.17	.24	.06	.20
Repetitive	.18	.21	.25	.27
Threat	.08	.16	.12	.20

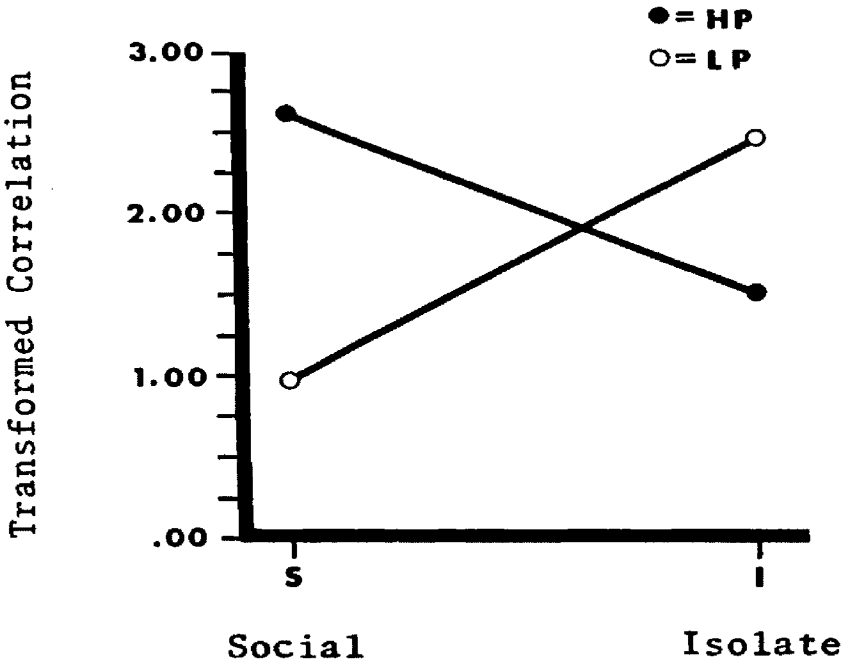
Subjects' Incidental Behaviors Correlated With Stimulus Animals' Incidental Behaviors

Duration. Using the transformed (Fisher's Z) correlation coefficient for the association between the duration of various incidental behaviors of subjects and stimulus animals as a basis, another ANOVA was performed on selected pairs of these behaviors. For example, the correlation between subjects' fear and adult stimulus animals' self-directed behavior was used as the basis for an ANOVA, and a significant main effect for both diet ($p < .02$) and rearing ($p < .06$) emerged. For the diet effect, it was found that high protein subjects tended to become less fearful as the adult stimulus animal engaged in more self-directed behaviors, while under similar circumstances the low protein subjects became more fearful. Likewise, the rearing condition effects showed that the socially reared animals exhibited fear responses of shorter duration as the adult stimulus animals' self-directed behavior increased, whereas the partial isolates responded more fearfully in similar situations. Also, when the subjects' object oriented behavior was correlated with the same category for the adult stimulus animal, a main effect for rearing condition was shown. Between these two variables, the association was much stronger for partially isolated than for socially reared subjects ($p < .02$). It should be noted, however, that these results relate only to the difference between groups in the association of a subject behavior and a stimulus animal behavior, and are not based on the finding or assumption of significant correlation coefficients. This qualification also applies to the remaining comparisons within the current section.

For the correlation between subjects' fear responses and the adult stimulus animal's threat behavior, a significant diet x rearing condition interaction ($p < .04$) was found. Although figure 12 suggests that the association between the duration of subjects' fear and the duration of threat by the adult stimulus animal is more positive for high protein, socially reared than for low protein, socially reared subjects, and that this situation is reversed for partially isolated subjects, a multiple comparison test (table 10) did not provide conclusive support for this notion.

Another diet x rearing condition interaction ($p < .06$), this one for the correlation between the object oriented behavior of the subject and the infant stimulus animal's repetitive behavior, was found. Here again, a multiple comparison test (table 11) did not verify what appears to be the case according to figure 13. That is, for socially reared subjects, the high protein diet seems to be associated with a positive correlation between duration of both subjects' object oriented behavior and the infant stimulus animal's repetitive behavior, whereas the low protein diet

Figure 12. Diet x Rearing interaction: Correlation of subject fear and stimulus animal threat (duration) in seconds



Rearing Condition

Figure 13. Diet x Rearing interaction: Correlation of subject object oriented responses and stimulus animal repetitive behavior (duration) in seconds

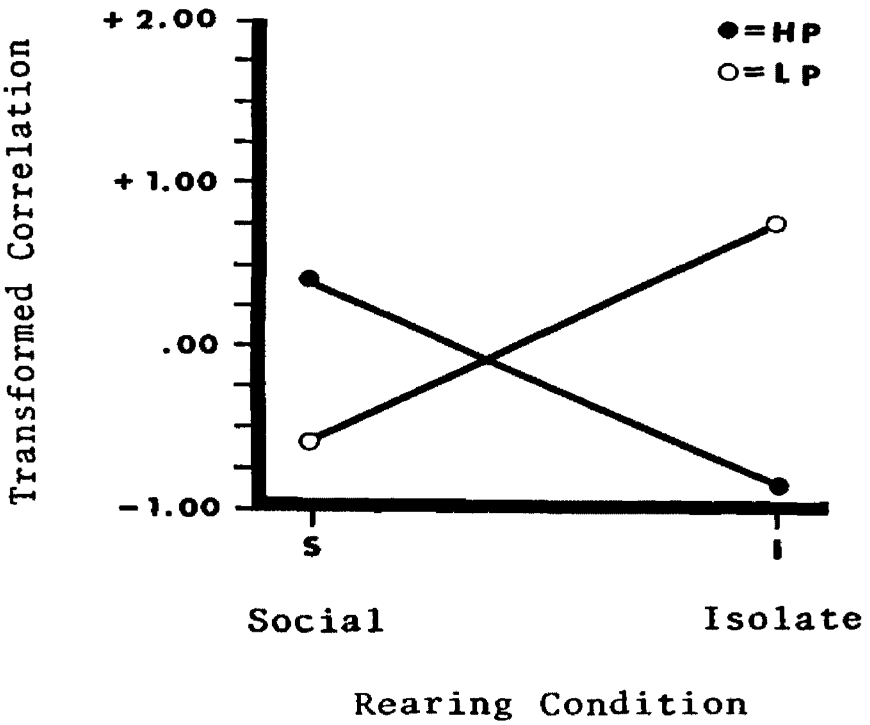


TABLE 10

DIET X REARING INTERACTION: CORRELATION OF SUBJECT FEAR AND STIMULUS ANIMAL THREAT (DURATION: [IN SECONDS] HSD = 2.10, p .10)

	HP	LP
S	† 2.68	§ .96
I	†§ 1.52	†§ 2.44

TABLE 11

DIET X REARING INTERACTION: CORRELATION OF SUBJECT OBJECT ORIENTED RESPONSES AND STIMULUS ANIMAL REPETITIVE BEHAVIOR (DURATION [IN SECONDS]: HSD = 2.84)

	HP	LP
S	§ .44	§ -.58
I	§ -.94	§ .76

seems to be negatively related to these behaviors. Moreover, for subjects reared in partial isolation, it appears that these relationships may be reversed.

Rate. The only selected comparison involving the correlation subject and stimulus animal rate of behavior for which a significant between groups difference resulted was subject fear and adult stimulus animal self-directed behavior. Here, a main effect for rearing condition ($p < .04$) was found with socially reared animals appearing to become more fearful as the adult stimulus animal engaged in more self-directed behavior, and partial isolates becoming less fearful as the stimulus animal's self-directed behavior increased. This effect appears to be in conflict with the analysis of the same comparison where duration served as the dependent variable. As in the duration analysis, the correlation of object oriented behavior between subject and stimulus animal suggested a main effect, in the rate analysis as well. However, the effect was for diet ($p < .09$) in this instance with the association somewhat stronger for low protein than for high protein subjects.

Of the six planned comparisons between the various subject and stimulus animal behaviors, only two failed to yield main effects or interactions for either diet or rearing condition. These two comparisons involved subject fear correlated with adult stimulus animal object oriented behavior, and subject fear correlated with infant stimulus animal threat.

CHAPTER IV

DISCUSSION

The material to be discussed in this section is divided primarily into categories relating to the effects presented in the results section. Within each of the headed categories, the discussion also follows the same order in which the various analyses were previously mentioned.

The Diet Effect

Contrary to the predictions of both the fear hypothesis (A) and the communication of affect hypothesis (B), the principal dependent measure (change in bar pressing suppression ratio) failed to show significant differences between groups of animals as a function of the subject's diet. Although this outcome could be interpreted as a testimony to the stability of rhesus monkey behavior, it also seems possible that this particular dependent variable was too gross a measure and that real differences were consequently masked. Some slight support for this notion, in the form of more diet and rearing condition effects, will appear as the two secondary measures are discussed. In any case, these secondary measures may be seen to involve rather specific activities which are perhaps more representative of the animals' behavioral repertoire than is the suppression of bar pressing. Furthermore, one of the two secondary measures includes a factor other than the subject's "target" behavior, i.e., a behavior of the stimulus animal.

The only other dependent measures which dealt exclusively with one subject behavior at a time were analyzed under the rubric "subjects' incidental behaviors." For the five categories of behavior analyzed, only the duration of repetitive behavior approached significance with regard to differences due to diet. In this instance, the repetitive behavior of low protein subjects was of shorter duration than that displayed by high protein animals. Although this difference was not significant ($p < .08$) it was in the direction predicted by the fear hypothesis. That is, according to this hypothesis, a more fearful animal would tend to cease the presumably adaptive repetitious responding which may aid the animal in timing fixed reinforcement intervals. The communication of affect model, on the other hand, would have predicted opposite results because of presumed tendencies of high protein animals to attend to the stimulus animal and the low protein subjects to ignore such environmental cues.

In the last measure of diet effects, two of the six selected comparisons yielded significant or nearly significant group differences, and in one case it was the fear hypothesis which anticipated the direction of the differences, while the communication of affect hypothesis predicted the other result. To be more specific, when the duration of subject fear was correlated with the adult stimulus animal's self-directed behavior, the association was found to be significantly ($p < .02$) stronger (positively) for LP animals than for their HP counterparts. Also, when the rate of subjects' object oriented behavior was correlated with the rate of the adult stimulus animal's object oriented responses, the association was found to be stronger (positively) for LP than for HP subjects ($p < .09$). In the former case, the fear hypothesis correctly predicted that the LP subjects' fear responses would fluctuate more closely with activity, even self-directed, on the part of the adult stimulus animal than would the same type of responses by HP subjects. The latter case, however, was more accurately predicted by the communication of affect hypothesis which is based, in part, on the high protein animal's greater cognizance of the stimulus animal's activity. Hence the stronger association between the behavior of the adult stimulus animal and HP subjects for this type of activity (object oriented).

Considering the number of tests performed on the data, the variety of dependent variables, and the relatively small number of significant differences attributable to diet, it seems that diet manipulations such as those included in this study simply do not independently cause wideranging changes in the behaviors observed. However, to the extent that meaningful differences between groups were seen, the fear hypothesis (A) as engendered by Levitsky and Barnes (1970), Menzel, Davenport, and Rogers (1963), and others, seems to account for these results somewhat more adequately than the alternative communication of affect hypothesis.

The Rearing Condition Effect

The effect of rearing condition on changes in bar pressing suppression ratio was expressed in a significant difference ($p < .02$) between socially reared and partially isolated subjects. As the fear hypothesis predicted, the suppression ratio of partial isolates increased more with the appearance of the stimulus animal than did the suppression ratio of socially reared subjects.

When the subjects' incidental behaviors during test trials were considered, several additional rearing effects were noted. For example, the rate of fear responding for socially reared subjects was considerably less than that of partial isolates ($p < .06$). Needless to say, this difference was consistent with the predictions of the fear hypothesis. Also, the repetitive behaviors of partially isolated subjects was of shorter duration than that displayed by socially reared animals ($p < .02$). Because of the presumed behavioral similarity of socially isolated and nutritionally deprived animals, this result can be interpreted as support for the fear hypothesis, as was the analogous diet result. That is, fearfulness probably prevents the deprived subject from engaging in some forms of adaptive behavior, such as employing repetitious collateral behaviors during fixed intervals of reinforcement.

According to the same hypothesis (A), the duration and rate of threat responses should have been less for partial isolates than for socially reared subjects. However, both of these measures yielded differences in the opposite direction. That is, the duration ($p < .009$) and rate ($p < .07$) of threat behavior was greater for the partially isolated animals. Although this finding cannot be clearly interpreted as support for the communication of affect hypothesis because of the difficulty of generating predictions for this category from it, the result is consistent with the observations of other researchers in this area. For example, Holombo (1975) "found that partial isolation resulted in an animal who was more aggressive and who engaged in less social contact and play behavior than the group living animals."

For the last measure of rearing condition effects, the outcome paralleled the comparable diet effects rather closely. In particular, the predictions of the two alternative hypotheses found support in the same two selected comparisons. When the duration of the subject's fear responses was correlated with the duration of the adult stimulus animal's self-directed behavior, the association was found to be stronger

($p < .06$) for partial isolates than for socially reared subjects. Also, when the duration of the subject's object oriented behavior was correlated with the duration of the adult stimulus animal's object oriented behavior, the association was found to be stronger ($p < .02$) for partial isolates than for socially reared subjects. Mitigating the support for the fear hypothesis, however, was a difference between groups ($p < .04$) for rate of subjects' fear responses correlated with rate of adult stimulus animal's self-directed behavior, which was in the opposite direction (i.e., supporting hypothesis B) from the duration result. Such a dramatic reversal of results defies interpretation, and leaves in its wake the suggestion that no reliable differences due to rearing condition can be assumed for this particular measure.

Although most of the possible between group comparisons based on rearing condition supported the null hypothesis, as was the case for the diet manipulation, the proportion of meaningful differences to total number of tests was much larger (8/23 vs. 3/23) for the rearing condition variable. To the extent that this state of affairs is typical of research in which these variables have been manipulated, it seems reasonable to conclude that rearing conditions may be a more powerful determinant of certain behaviors than is protein intake. Of course, this conclusion is contingent upon the failure to find that diet in combination with some other variable or variables accounts for a disproportionately large amount of the variance. In any case, the fear hypothesis appears to have been a somewhat better predictor of the direction of differences observed, due to rearing condition, than was the communication of affect hypothesis.

The Diet X Rearing Condition Effect

Changes in bar pressing suppression revealed a suggestive, if nonsignificant, interaction ($p < .10$) between diet and rearing condition (figure 2). However, this interaction, as well as all other diet x rearing condition interactions for which analysis of variance suggested intra-group differences, involved means which were subsequently judged by multiple comparison test not to differ significantly from one another. Nonetheless, since the negative results of the multiple comparison tests may be attributable as much to small group size as to the magnitude of differences between means, it would seem reasonable to discuss the significant diet x rearing condition interactions as though the means of at least the two extreme groups were indeed different. According to this concession then, a given hypothesis would find support whenever the predicted groups' means appeared in the proper directional relationship to one another and at the quantitative extremes with regard to the dependent measure. For example, had the changes in bar pressing suppression ratio been reflected in either of the following orders (from low change to high change): HPS-LPS-HPI-LPI or HPS-HPI-LPS-LPI, the fear hypothesis would have received some support. In fact, however, the actual outcome (HPS-LPS-LPI-HPI) failed to directly support either of the two main alternative hypotheses. Furthermore, the order of groups for the other three significant diet x rearing interactions (figures 9, 12, and 13) also failed to support either the fear or the communication of affect hypothesis. The first of these three additional interactions involved the duration of the subjects' repetitive behavior which was suggested by the ANOVA to vary significantly ($p < .05$) across groups in the following order: HPI-LPI-LPS-HPS (from shorter to longer duration). Next, an ANOVA suggested that when the duration of subjects' fear responses was correlated with the duration of the adult stimulus animal's threat behavior, a significant ($p < .04$) difference in the strength of the association became evident (i.e., LPS-HPI-LPI-HPS; from lower to higher correlation). Finally, when the duration of subjects' object oriented behavior was correlated with the duration of the infant stimulus animal's repetitive behavior, a nearly significant ($p < .06$) difference became apparent (i.e., HPI-LPS-HPS-LPI).

Disregarding the two non-extreme groups, it should be possible to suggest tentative alternative explanations for these diet x rearing condition interactions. For example, the result described above which involved changes in the subjects' bar pressing suppression ratio (figure 2) showed that this ratio changed more, and in the direction of greater suppression, for the HPI group than for the HPS group. In a very general sense, this outcome is consistent with the fear hypothesis and also lends some support to the idea that rearing condition is a somewhat more powerful determinant of behavior than is diet. The first of the three additional interactions mentioned above (duration of subjects' repetitive behavior, figure 9) also is consistent with this explanation. In this case, again the high protein groups appeared at the extremes with the social animals (HPS) exhibiting longer repetitive responses than did the isolates (HPI). If the previously mentioned interpretation of this type of behavior as an adaptive timing mechanism is correct, one would expect more fearful animals to spend less time engaged in such activity.

This line of interpretation is clouded, however, by consideration of the other two interactions discussed above. In the interaction involving subjects' fear responses and adult stimulus animal threat (figure 12) the association was much stronger for HPS than for LPS subjects. This outcome is consistent with the communication of affect hypothesis, whereby high protein subjects were predicted to be more sensitive to the affective states of the stimulus animal than were the low protein monkeys. It is also obvious that for this interaction the diet manipulation was apparently more powerful than was the rearing condition variable.

In the last diet x rearing condition interaction to be discussed (duration of subject object oriented behavior and infant stimulus animal repetitive behavior, figure 13), the diet variable also appears to have been the principal determinant of the two extreme groups. However, since the association between these two variables was stronger for LPI than for HPI subjects, the communication of affect hypothesis is clearly not supported. On the other hand, for this result to be interpreted as support for the fear hypothesis it would be necessary to consider object oriented behavior to be a manifestation of high fear which it probably is not. Therefore, this particular combination of behaviors seems to provide somewhat less information than the other selected pairs.

In summary, the diet x rearing condition interactions discussed above appear to be somewhat more supportive of the fear than of the communication of affect predictions, as was the case for both principal main effects. However, the rather clear dominance of the rearing condition variable in determining main effects was considerably diminished for these interactions.

Interactions Including Subordinate Variables

Of the three main dependent measures employed, only two (changes in subjects' bar pressing suppression ratio and subjects' incidental behaviors) involved time (days) and stimulus animal as independent variables. In total, there were ten significant or nearly significant interactions involving these factors. In terms of any pertinent hypotheses, interpretation of most of these interactions, because of a lack of consistent systematic group differences, would be extremely tenuous, if not impossible (see e.g., figures 3, 4, 5, 6, and 11). For three of the ten interactions, however, some further discussion is warranted. First, it should be noted that all three of the following interactions involve the dependent measure of "subjects' incidental behavior."

For the category of subject fear, the significant ($p < .01$) diet x days x stimulus animal interaction (figure 7) suggests that the adult stimulus animal accounted for much of the large variance observed on the first day it was introduced. Although these differences diminished almost entirely over three days of exposure, the first day, when considered alone, allows a choice to be made between the two opposing explanations being tested. That is, low protein animals clearly displayed more fear when first confronted with the novel presence of an adult male monkey than did their high protein counterparts. This result is perhaps more meaningful than it would at first appear, because in the feral state the first such encounter may well be the last or only confrontation between the two animals, all future interaction having been affected by the initial, unexpected meeting. Thus, this particular interaction can be interpreted as support for the fear hypothesis.

The rearing x days x stimulus animal interaction which also approached significance ($p < .06$, figure 8), in contrast to the situation just discussed, seems to be more appropriately interpreted in terms of the communication of affect hypothesis. Here, again, the adult stimulus animal's ability to arouse fear, especially when first encountered, is in evidence. However, it was the socially reared subjects who seemed to be most affected by the initial encounter, as predicted by the communication of affect hypothesis. In sum, the two foregoing interactions appear to contradict one another and to render hypothetical explanations impotent. A final note regarding the apparent dimunition of fear response to the adult stimulus animal is in order. Aside from the obvious potential effects of time and non-disastrous exposure, the subjects may have been aware, as was the experimenter, of some rather eccentric behavior on the part of the adult stimulus animal. Although such behavior (e.g., eye-poking and self-biting) was not preponderant, it may have mitigated the ferocity of the adult animal.

Having now interpreted the two above interactions as consistent with two different hypotheses, it only remains to be shown that a final interaction supports neither explanation. In this case, it is the subjects' threat behavior which functions as dependent variable and the rearing condition x days interaction ($p < .04$) which is of interest. Similar to the preceding situations, only the first test trial (across stimulus animals) shows differences large enough to allow relatively unhindered speculation. According to the fear hypothesis, partially isolated subjects should, of course, engage in less threat behavior than should the socially reared subjects. As figure 10 indicates, this prediction found no support on Day 1. In this instance, the communication of affect hypothesis would also have predicted more threat by socially reared animals, because of their greater sensitivity to situations in which threat is either appropriate or would be tolerated. Again, figure 10 reveals no evidence for this explanation. A third possibility is suggested by the experimenter's recollections of previous experimental and casual observations. According to these recollections, the partial isolates would be expected to exhibit sufficient threat in the presence of the infant stimulus animal to outweigh a total lack of such behavior in the presence of the adult, as well as any threat behavior on the part of socially reared subjects. Unfortunately, such an explanation would require a significant rearing x stimulus animal interaction as a foundation, and this did not occur.

The present research represented an attempt to assess the effects on response to a novel stimulus of what were thought to be two very powerful independent variables. The particular way in which these variables were manipulated was intended, in part, to counteract the restricted generality of some of the past laboratory studies, and to allow for the clarification or extension of previous results through exploratory probing. To the extent that these objectives were not reached, it can be assumed that either stability of the animals' behavior across conditions, methodological weaknesses, explanatory oversights, or some combination of these factors was responsible.

For example, the last of these three factors could well have resulted from the somewhat artificial restriction imposed on the design by the pitting of two alternative hypotheses against one another. However, the previous literature appeared to offer two answers to the same question, thereby setting the stage for the present confrontation. Although neither of the two principal alternatives correctly anticipated all of the results, the idea that protein malnutrition and social isolation both contribute to more fearful rather than less sensitive behavior did find considerable support.

Methodological weaknesses, like explanatory oversights, tend to emerge as subsequent experiments are conceived. However, one design consideration wihch undoubtedly dampened the effects of both independent variables was the small size of the groups. An n of four for each group allowed within group variance to play perhaps a greater role in the outcome than would reasonably be expected. The comparative magnitude of between groups variance may then have been unduly diminished.

Finally, the behavioral stability factor in these results should be given its due. That is, rather than considering failures to find significant differences as "non events," the remarkable stability of behavior across conditions involving what are among the most powerful variables at our command, should be noted (Bowers, 1973). In the present research, for example, no main effect for diet or rearing condition was found for the subject's object oriented or self-directed behavior, nor for two of the six correlations between subject and stimulus animal behavior. Furthermore, no interaction of the two independent variables occurred for these measures.

CHAPTER V

SUMMARY

An exploratory study of the effects of protein-calorie malnutrition and partial social isolation on various reactions to the novel presence of a conspecific were conducted with 16 juvenile rhesus monkeys. Diet and rearing condition were varied in a factorial design, with two levels of protein intake, two levels of social contact, and six repeated measures. The dietary manipulation involved the feeding of a low protein (3.5% casein by weight) or a high protein (25% casein by weight) diet from 120 days of age. Rearing condition was varied by housing subjects either individually or in groups of four. Testing took place in a specially designed operant chamber, separated by clear plexiglas from an adjoining compartment. Subjects were trained to press a bar for food reward on an FI-60 second schedule of reinforcement and then stimulus animals were unexpectedly introduced into the adjoining chamber. Measures were taken of bar pressing suppression as well as five incidental behavior categories including fear, object oriented, self-directed, repetitive, and threat behaviors.

The predictions of two principal, opposing hypotheses were tested. On one hand, the "fear hypothesis" was based on the idea that protein malnutrition and socially isolated rearing are both conditions which tend to lower the stress or fear reaction threshold of animals exposed to them from an early age, and the finding that novel objects or situations can be aversive and behaviorally disruptive to both malnourished and socially deprived animals. Following from this hypothesis was the prediction that animals exposed to either or both of these conditions would show a greater reduction in bar pressing behavior than control animals when confronted with the unexpected presence of an unknown conspecific. The opposing "communication of affect" hypothesis was based on primate social communication research which supports the conclusion that low protein animals and animals reared in social isolation are much less sensitive to social cues than are their high protein, socially reared counterparts. Accordingly, this hypothesis anticipated that the more deprived animals would be less likely to suppress their instrumental behavior in the experimental situation. In addition, both of these hypotheses were used as the basis for predictions regarding the five incidental behavior categories.

For the measure related to the suppression of bar pressing, a main effect for rearing condition and the suggestion of a diet x rearing condition interaction were found. Other main effects and interactions involving most of the incidental behavior categories were also found, such that a proposed increase in fearfulness of nutritionally or socially deprived subjects received more support than the suggestion of insensitivity to social cues on the part of these subjects. However, neither alternative hypothesis accounted for a preponderance of the observed reactions. Also noted was the tendency of the rearing condition variable to be a somewhat more powerful determinant of behavior than was the diet variable.

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APPENDIX A

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SUMMARY OF HYPOTHESES

TABLE 12

EXPERIMENTAL MATRIX

	HP	LP
S	HPS	LPS
I	HPI	LPI

I. Fear hypothesis

A. Changes in bar pressing suppression ratio.
Magnitude of change (low to high): HPS-LPS-HPI-LPI

B. Incidental behaviors (duration, rate)

1. Fear: HPS-LPS-HPI-LPI
2. Object oriented: LPI-HPI-LPS-HPS
3. Self-directed: HPS-LPS-HPI-LPI
4. Repetitive: LPI-HPI-LPS-HPS
5. Threat: LPI-HPI-LPS-HPS

II. Communication of affect hypothesis

A. Changes in bar pressing suppression ratio.
Magnitude of change (low to high): LPI-HPI-LPS-HPS

B. Incidental behaviors

1. Fear: LPI-HPI-LPS-HPS
2. Object oriented: HPS-LPS-HPI-LPI
3. Self-directed: HPS-LPS-HPI-LPI
4. Repetitive: HPS-LPS-HPI-LPI
5. Threat: LPI-HPI-LPS-HPS

APPENDIX B

TABLE 13

SUMMARY OF THE ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY UNTRANSFORMED DATA

Source	SS	df	MS	F
D	.615	12	.615	2.154
R	.260	12	.260	0.001
DR	.555	12	.555	0.194
A	4.695	12	4.695	118.125***
DA	.114	12	.114	2.871
RA	.124	12	.124	0.311
DRA	.376	12	.376	0.009
T	.589	24	.295	3.324
DT	.582	24	.291	0.328
RT	.483	24	.241	0.272
DRT	.156	24	.781	0.882
AT	.643	24	.321	2.819
DAT	.890	24	.445	0.039
RAT	.108	24	.539	0.473
DRAT	.171	24	.857	0.751

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 14

SUMMARY OF THE ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY SQUARE ROOT TRANSFORMATION

Source	SS	df	MS	F
D	.373	12	.373	1.521
R	.121	12	.121	0.494
DR	.131	12	.131	0.533
A	8.937	12	8.937	159.982***
DA	.158	12	.158	2.836
RA	.333	12	.333	0.595
DRA	.115	12	.115	0.206
T	.568	24	.284	2.338
DT	.821	24	.411	0.338
RT	.383	24	.192	0.158
DRT	.231	24	.116	0.952
AT	.766	24	.383	2.923
DAT	.997	24	.498	0.381
RAT	.817	24	.408	0.312
DRAT	.383	24	.192	0.146

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 15

SUMMARY OF THE ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY SQUARE ROOT +.5 TRANSFORMATION

Source	SS	df	MS	F
D	.175	12	.175	2.139
R	.124	12	.124	0.015
DR	.184	12	.184	0.224
A	1.585	12	1.585	129.665***
DA	.360	12	.360	2.945
RA	.331	12	.331	0.271
DRA	.299	12	.299	0.024
T	.179	24	.897	3.417 *
DT	.186	24	.930	0.354
RT	.140	24	.699	0.266
DRT	.411	24	.205	0.782
AT	.199	24	.994	2.857
DAT	.585	24	.293	0.084
RAT	.332	24	.166	0.477
DRAT	.447	24	.223	0.643

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 16

SUMMARY OF THE ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY SQUARE ROOT +1.0 TRANSFORMATION

Source	SS	df	MS	F
D	.892	12	.892	1.759
R	.132	12	.132	0.260
DR	.217	12	.217	0.428
A	15.665	12	15.665	152.554***
DA	.298	12	.298	2.902
RA	.521	12	.521	0.507
DRA	.141	12	.141	0.138
T	.118	24	.590	2.712
DT	.145	24	.723	0.332
RT	.807	24	.403	0.185
DRT	.415	24	.207	0.953
AT	.149	24	.747	2.954
DAT	.135	24	.676	0.267
RAT	.176	24	.881	0.348
DRAT	.135	24	.673	0.266

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 17

SUMMARY OF THE ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY LOG (X) TRANSFORMATION

Source	SS	df	MS	F
D	.709	12	.709	0.500
R	.709	12	.709	0.500
DR	.142	12	.142	1.000
A	.709	12	.709	0.500
DA	.142	12	.142	1.000
RA	.142	12	.142	1.000
DRA	.496	12	.496	3.500
T	.160	24	.798	1.125
DT	.408	24	.204	2.875
RT	.408	24	.204	2.875
DRT	.129	24	.647	9.125**
AT	.408	24	.204	2.875
DAT	.129	24	.647	9.125**
RAT	.129	24	.647	9.125**
DRAT	.170	24	.851	12.000***

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 18

SUMMARY OF ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY LOG (X+1.0) TRANSFORMATION

Source	SS	df	MS	F
D	.609	12	.609	2.136
R	.748	12	.748	0.026
DR	.654	12	.654	0.229
A	.570	12	.270	132.122***
DA	.128	12	.128	2.957
RA	.111	12	.111	0.256
DRA	.123	12	.123	0.029
T	.633	24	.316	3.438*
DT	.670	24	.335	0.364
RT	.487	24	.244	0.265
DRT	.139	24	.695	0.755
AT	.702	24	.351	2.860
DAT	.242	24	.121	0.099
RAT	.118	24	.589	0.480
DRAT	.152	24	.760	0.619

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 19

SUMMARY OF ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY INVERSE TRANSFORMATION

Source	SS	df	MS	F
D	.709	12	.709	0.500
R	.709	12	.709	0.500
DR	.142	12	.142	1.000
A	.709	12	.709	0.500
DA	.142	12	.142	1.000
RA	.142	12	.142	1.000
DRA	.496	12	.496	3.500
T	.160	24	.798	1.125
DT	.408	24	.204	2.875
RT	.408	24	.204	2.875
DRT	.129	24	.647	9.125**
AT	.408	24	.204	2.875
DAT	.129	24	.647	9.125**
RAT	.129	24	.647	9.125**
DRAT	.170	24	851	12.000***

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 20

SUMMARY OF ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY 1/0/X+1.0 TRANSFORMATION

Source	SS	df	MS	F
D	.174	12	.174	2.073
R	.105	12	.105	0.125
DR	.232	12	.232	0.276
A	2.015	12	2.015	145.229***
DA	.418	12	.418	3.009
RA	.313	12	.313	0.226
DRA	.803	12	.803	0.058
T	.197	24	.985	3.415*
DT	.246	24	.123	0.426
RT	.144	24	.721	0.250
DRT	.361	24	.180	0.625
AT	.223	24	.112	2.845
DAT	.155	24	.775	0.198
RAT	.368	24	.184	0.469
DRAT	.386	24	.193	0.492

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

TABLE 21

SUMMARY OF ANALYSIS OF VARIANCE: SUPPRESSION RATIO: TEST DAYS ONLY ASIN SQUARE ROOT TRANSFORMATION

Source	SS	df	MS	F
D	.644	12	.644	1.716
R	.639	12	.639	0.170
DR	.170	12	.170	0.453
A	11.267	12	11.267	148.650 ***
DA	.218	12	.218	2.875
RA	.490	12	.490	0.646
DRA	.996	12	.996	0.131
T	.842	24	.421	2.607
DT	.893	24	.447	0.277
RT	.606	24	.303	0.188
DRT	.359	24	.179	1.111
AT	.109	24	.543	2.972
DAT	.838	24	.419	0.229
RAT	.113	24	.565	0.309
DRAT	.101	24	.504	0.276

*p less than .05
**p less than .01
***p less than .001

D = diet
R = rearing
A = stimulus animal
T = days

APPENDIX C

TABLE 22

SUMMARY OF THE ANALYSIS OF VARIANCE: FREQUENCY OF FEAR RESPONSES

Source	SS	df	MS	F
P	54.000	12	54.000	0.879
R	192.667	12	192.667	3.136
PR	54.000	12	54.000	0.879
D	1151.270	24	575.635	16.567***
PD	50.688	24	25.343	0.729
RD	199.771	24	99.8854	2.875
PRD	188.688	24	94.344	2.715
A	661.500	12	661.500	19.895**
PA	16.667	12	16.667	0.501
RA	28.167	12	28.167	0.847
PRA	24.000	12	24.000	0.722
DA	929.313	24	464.656	11.417***
PDA	10.896	24	5.448	0.134
RDA	12.646	24	6.323	0.155
PRDA	116.063	24	58.031	1.426

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 23

SUMMARY OF THE ANALYSIS OF VARIANCE: FREQUENCY OF OBJECT ORIENTED RESPONSES

Source	SS	df	MS	F
D	22.042	12	22.042	0.047
R	541.500	12	541.500	1.152
DR	234.375	12	234.375	0.499
A	44290.000	12	44290.000	90.108***
DA	170.667	12	170.667	0.347
RA	1.042	12	1.042	0.002
DRA	32.667	12	32.667	0.066
T	897.250	24	448.625	3.888*
DT	360.583	24	180.292	1.562
RT	286.750	24	143.375	1.242
DRT	91.000	24	45.500	0.394
AT	1160.580	24	580.292	4.583*
DAT	255.083	24	127.542	1.007
RAT	567.583	24	283.792	2.241
DRAT	82.333	24	41.167	0.325

D = diet
R = rearing
T = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 24

SUMMARY OF THE ANALYSIS OF VARIANCE: FREQUENCY OF SELF-DIRECTED RESPONSES

Source	SS	df	MS	F
P	108.375	12	108.375	1.231
R	140.167	12	140.167	1.592
PR	84.375	12	84.375	0.959
D	19.771	24	9.885	1.063
PD	16.938	24	8.469	0.910
RD	50.521	24	25.260	2.716
PRD	25.188	24	12.594	1.354
A	16.667	12	16.667	5.868*
PA	.417	12	.417	0.015
RA	4.167	12	4.167	1.467
PRA	.375	12	.375	0.132
DA	3.146	24	1.573	0.273
PDA	23.896	24	11.948	2.072
RDA	15.896	24	7.948	1.378
PRDA	26.313	24	13.156	2.281

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 25

SUMMARY OF THE ANALYSIS OF VARIANCE: FREQUENCY OF REPETITIVE RESPONSES

Source	SS	df	MS	F
P	3650.670	12	3650.670	7.759*
R	7420.170	12	7420.170	15.770**
PR	5017.040	12	5017.040	10.662**
D	7395.400	24	3697.700	41.352***
PD	885.646	24	442.823	4.952*
RD	2875.150	24	1437.570	16.077***
PRD	1195.400	24	597.698	6.684**
A	759.375	12	759.375	22.203***
PA	73.500	12	73.500	2.149
RA	522.667	12	522.667	15.282**
PRA	234.375	12	234.375	6.853*
DA	2583.060	24	1291.530	33.580***
PDA	390.812	24	195.406	5.081*
RDA	995.646	24	497.823	12.943***
PRDA	591.063	24	295.531	7.684**

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 26

SUMMARY OF THE ANALYSIS OF VARIANCE: FREQUENCY OF THREAT RESPONSES

Source	SS	df	MS	F
P	102.094	12	102.094	3.056
R	372.094	12	372.094	11.138**
PR	21.094	12	21.094	0.631
D	204.646	24	152.323	4.060*
PD	22.563	24	11.281	0.301
RD	148.187	24	74.094	1.975
PRD	.437	24	.219	0.006
A	33.844	12	33.844	2.677
PA	3.010	12	3.010	0.238
RA	1.260	12	1.260	0.100
PRA	.104	12	.104	0.001
DA	34.938	24	17.469	0.987
PDA	28.521	24	14.260	0.806
RDA	2.646	24	1.323	0.075
PRDA	10.896	24	5.448	0.308

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

APPENDIX D

TABLE 27

DURATION OF FEAR RESPONSES

Source	SS	df	MS	F
P	82731.80	12	82731.80	1.969
R	31610.00	12	31610.00	0.752
PR	129404.00	12	129404.00	3.080
D	307953.00	24	153977.00	8.492**
PD	42658.90	24	21329.50	1.176
RD	16827.50	24	8413.73	0.464
PRD	91549.90	24	45774.90	2.525
A	71788.30	12	71788.30	14.844**
PA	1996.55	12	1996.55	0.413
RA	74.20	12	74.20	0.015
PRA	17072.00	12	17072.00	3.530
DA	304620.00	24	152310.00	14.643***
PDA	114179.00	24	57089.70	5.489*
RDA	67275.20	24	33637.60	3.234
PRDA	22216.50	24	11108.30	1.068

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 28

DURATION OF OBJECT ORIENTED RESPONSES

Source	SS	df	MS	F
D	42554.700	12	42554.700	2.045
R	42866.900	12	42866.900	2.060
DR	2656.520	12	2656.520	0.128
A	779293.000	12	779293.000	69.597***
DA	26500.300	12	26500.300	2.367
RA	2083.230	12	2083.230	0.186
DRA	225.699	12	225.699	0.020
T	13494.000	24	6746.980	2.141
DT	620.568	24	310.284	0.098
RT	3923.710	24	1961.860	0.622
DRT	3237.580	24	1618.790	0.514
AT	26554.400	24	13277.200	4.851*
DAT	1589.630	24	794.816	0.290
RAT	990.109	24	495.055	0.181
DRAT	1465.020	24	732.510	0.268

D = diet
R = rearing
A = stimulus animals
T = days

*p less than .05
**p less than .01
***p less than .001

TABLE 29

DURATION OF SELF-DIRECTED RESPONSES

Source	SS	df	MS	F
P	6053.140	12	6053.140	1.484
R	4359.160	12	4359.160	1.069
PR	2178.370	12	2178.370	0.534
A	1070.000	12	1070.000	1.109
PA	163.543	12	163.543	0.169
RA	3205.130	12	3205.130	3.321
PRA	1047.420	12	1047.420	1.085
D	303.831	24	151.915	0.265
PD	2037.790	24	1018.890	1.777
RD	400.509	24	200.254	0.349
PRD	1435.500	24	717.751	1.252
AD	621.015	24	310.508	2.076
PAD	337.790	24	168.895	1.129
RAD	633.129	24	316.565	2.117
PRAD	666.694	24	333.347	2.229

P = diet
R = rearing
D = days
A = stimulus animals

TABLE 30

DURATION OF REPETITIVE RESPONSES

Source	SS	df	MS	F
P	303199.00	12	303199.00	3.578
R	581524.00	12	581524.00	6.862*
PR	387515.00	12	387515.00	4.573
A	346212.00	12	346212.00	11.445**
PA	7460.65	12	7460.65	0.247
RA	111691.00	12	111691.00	3.692
PRA	30079.40	12	30079.40	0.994
D	9797.40	24	4898.70	1.156
PD	2143.76	24	1071.88	0.253
RD	7104.60	24	3552.30	0.838
PRD	5422.13	24	2711.06	0.640
AD	4895.37	24	2447.69	0.587
PAD	4044.50	24	2022.25	0.485
RAD	11275.80	24	5637.92	1.352
PRAD	8535.89	24	4267.95	1.023

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 31

DURATION OF THREAT RESPONSES

Source	SS	df	MS	F
P	1313.500	12	1313.500	1.715
R	7506.580	12	7506.580	9.799**
PR	318.646	12	318.646	0.416
A	3607.630	12	3607.630	2.220
PA	93.813	12	93.813	0.058
RA	729.856	12	729.856	0.449
PRA	75.792	12	75.792	0.047
D	1533.390	24	766.693	2.857
PD	286.120	24	143.060	0.533
RD	858.110	24	429.055	1.599
PRD	272.539	24	136.270	0.508
AD	80.002	24	40.001	0.178
PAD	254.039	24	127.019	0.565
RAD	613.901	24	306.951	1.366
PRAD	331.697	24	165.848	0.738

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

APPENDIX E

TABLE 32

RATE OF FEAR RESPONSES

Source	SS	df	MS	F
P	.193	12	.193	0.011
R	.747	12	.747	4.235
PR	.393	12	.393	2.227
D	.220	24	.110	2.813
PD	.206	24	.103	0.264
RD	.102	24	.511	1.307
PRD	.197	24	.984	0.025
A	.156	12	.156	6.984*
PA	.728	12	.728	3.256
RA	.103	12	.103	0.460
PRA	.885	12	.885	3.955
DA	.527	24	.263	0.848
PDA	.127	24	.636	0.205
RDA	.284	24	.142	0.458
PRDA	.829	24	.414	1.334

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

TABLE 33

RATE OF OBJECT ORIENTED RESPONSES

Source	SS	df	MS	F
D	.684	12	.684	1.285
R	.816	12	.816	0.153
DR	.415	12	.415	0.779
A	.523	12	.523	17.754**
DA	.469	12	.469	0.159
RA	.489	12	.489	1.659
DRA	.174	12	.174	0.591
T	.118	24	.590	0.275
DT	.550	24	.275	0.128
RT	.564	24	.282	1.316
DRT	.670	24	.350	0.163
AT	.838	24	.419	2.359
DAT	.368	24	.184	1.035
RAT	.101	24	.504	2.838
DRAT	.384	24	.192	1.080

D = diet
R = rearing
A = stimulus animals
T = days

*p less than .05
**p less than .01
***p less than .001

TABLE 34

RATE OF SELF-DIRECTED RESPONSES

Source	SS	df	MS	F
P	.123	12	.123	0.862
R	.274	12	.274	11.914
PR	.335	12	.335	0.234
A	.225	12	.225	0.926
PA	.124	12	.124	0.511
RA	.719	12	.719	0.030
PRA	.660	12	.660	0.272
D	.389	24	.195	1.058
PD	.116	24	.579	0.315
RD	.191	24	.955	0.519
PRD	.409	24	.205	0.111
AD	.297	24	.149	0.075
PAD	.797	24	.398	2.019
RAD	.265	24	.132	0.671
PRAD	.258	24	.129	0.654

P = diet
R = rearing
D = days
A = stimulus animals

TABLE 35

RATE OF REPETITIVE RESPONSES

Source	SS	df	MS	F
P	.105	12	.105	0.845
R	.146	12	.146	0.117
PR	.988	12	.988	0.008
A	.421	12	.421	0.050
PA	.300	12	.300	0.358
RA	.632	12	.632	0.753
PRA	.211	12	.211	2.510
D	.270	24	.135	1.787
PD	.218	24	.109	1.441
RD	.103	24	.514	0.679
PRD	.258	24	.129	0.170
AD	.157	24	.785	1.039
PAD	.118	24	.588	0.778
RAD	.116	24	.578	0.077
PRAD	.443	24	.222	0.293

P = diet
R = rearing
D = days
A = stimulus animals

TABLE 36

RATE OF THREAT RESPONSES

Source	SS	df	MS	F
P	.442	12	.442	1.046
R	.166	12	.166	3.935
PR	.753	12	.753	0.002
A	1.453	12	1.453	75.226***
PA	.312	12	.312	1.616
RA	.519	12	.519	2.690
PRA	.178	12	.178	0.092
D	.138	24	.790	3.392*
PD	.310	24	.155	0.761
RD	.156	24	.779	3.831*
PRD	.233	24	.117	5.734**
AD	.187	24	.937	3.735*
PAD	.183	24	.914	0.036
RAD	.101	24	.505	2.013
PRAD	.247	24	.124	4.930*

P = diet
R = rearing
D = days
A = stimulus animals

*p less than .05
**p less than .01
***p less than .001

APPENDIX F

TABLE 37

SUMMARY OF THE ANALYSIS OF VARIANCE: CHANGE IN BAR PRESSING SUPPRESSION RATIO UNTRANSFORMED DATA

Source	SS	df	MS	F
D	.504	12	.504	0.749
R	.137	12	.137	2.027
DR	.172	12	.172	2.549
A	4.420	12	4.420	51.208***
DA	.864	12	.864	1.001
RA	.350	12	.350	0.041
DRA	.700	12	.700	0.081
T	.121	24	.604	0.265
DT	.124	24	.618	0.271
RT	.413	24	.206	0.091
DRT	.969	24	.485	2.128
AT	.527	24	.264	1.042
DAT	.827	24	.413	0.164
RAT	.351	24	.175	0.693
DRAT	.168	24	.838	0.332

D = diet
R = rearing
A = stimulus animals
T = days

*p less than .05
**p less than .01
***p less than .001

TABLE 38

SUMMARY OF THE ANALYSIS OF VARIANCE: CHANGE IN BAR PRESSING SUPPRESSION RATIO LOG X +1.0 TRANSFORMATION

Source	SS	df	MS	F
D	.121	12	.121	0.553
R	.759	12	.759	3.469
DR	.687	12	.687	3.137
A	1.355	12	1.355	34.358***
DA	.680	12	.680	1.724
RA	.935	12	.935	0.024
DRA	.257	12	.257	0.065
T	.199	24	.995	0.750
DT	.197	24	.987	0.744
RT	.159	24	.795	0.060
DRT	.480	24	.240	1.810
AT	.308	24	.154	1.310
DAT	.303	24	.151	0.001
RAT	.208	24	.104	0.884
DRAT	.885	24	.443	0.038

D = diet
R = rearing
A = stimulus animals
T = days

*p less than .05
**p less than .01
***p less than .001

TABLE 39

SUMMARY OF THE ANALYSIS OF VARIANCE: CHANGE IN BAR PRESSING SUPPRESSION RATIO INVERSE TRANSFORMATION

Source	SS	df	MS	F
D	482.336	12	482.336	1.084
R	0.588	12	0.588	0.001
DR	1185.070	12	1185.070	2.664
A	16.966	12	16.966	0.012
DA	282.314	12	282.314	0.204
RA	1582.870	12	1582.870	1.141
DRA	24.531	12	24.531	0.018
T	771.768	24	385.884	1.747
DT	4199.550	24	2099.770	9.506**
RT	1369.970	24	684.985	3.101
DRT	1104.900	24	552.449	2.501
AT	1479.29	24	739.645	1.585
DAT	3372.860	24	1686.430	3.614*
RAT	210.518	24	105.259	0.226
DRAT	2855.230	24	1427.620	3.059

D = diet
R = rearing
A = stimulus animals
T = days

*p less than .05
**p less than .01
***p less than .001

APPENDIX G

TABLE 40

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT FEAR AND ADULT STIMULUS ANIMAL SELF-DIRECTED BEHAVIOR (FREQUENCY)

Source	SS	df	MS	F
D	3.391	12	3.391	0.847
R	3.879	12	3.879	0.969
DR	1.249	12	1.249	0.59225

D = diet

R = rearing

TABLE 41

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED RESPONSES AND ADULT STIMULUS ANIMAL OBJECT ORIENTED RESPONSES (FREQUENCY)

Source	SS	df	MS	F
D	.227	12	.227	0.070
R	10.285	12	10.285	3.167
DR	.534	12	.534	0.164

D = diet

R = rearing

TABLE 42

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT FEAR AND ADULT STIMULUS ANIMAL THREAT (FREQUENCY)

Source	SS	df	MS	F
D	1.437	12	1.437	1.234
R	.280	12	.280	0.241
DR	1.248	12	1.248	1.072

D = diet

R = rearing

TABLE 43

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED BEHAVIOR AND INFANT STIMULUS ANIMAL REPETITIVE BEHAVIOR (FREQUENCY)

Source	SS	df	MS	F
D	2.480	12	2.480	2.501
R	1.205	12	1.205	1.215
DR	.240	12	.240	0.242

D = diet

R = rearing

APPENDIX H

TABLE 44

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED BEHAVIOR AND INFANT STIMULUS ANIMAL REPETITIVE BEHAVIOR (DURATION)

Source	SS	df	MS	F
D	.469	12	.469	0.256
R	.160	12	.160	0.001
DR	7.456	12	7.456	4.072

D = diet

R = rearing

TABLE 45

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED BEHAVIOR AND ADULT STIMULUS ANIMAL OBJECT ORIENTED BEHAVIOR (DURATION)

Source	SS	df	MS	F
D	1.202	12	1.202	0.354
R	23.380	12	23.380	6.893*
DR	.300	12	.300	0.001

D = diet

R = rearing

*p less than .05
**p less than .01
***p less than .001

TABLE 46

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT FEAR AND ADULT STIMULUS ANIMAL THREAT (DURATION)

Source	SS	df	MS	F
D	.632	12	.632	0.471
R	.108	12	.108	0.081
DR	6.939	12	6.939	5.179*

D = diet

R = rearing

*p less than .05
**p less than .01
***p less than .001

TABLE 47

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT FEAR AND ADULT STIMULUS ANIMAL SELF-DIRECTED BEHAVIOR (DURATION)

Source	SS	df	MS	F
D	10.108	12	10.108	7.889*
R	5.402	12	5.402	4.216
DR	.175	12	.175	0.000

D = diet

R = rearing

*p less than .05
**p less than .01
***p less than .001

APPENDIX I

TABLE 48

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED BEHAVIOR AND INFANT STIMULUS ANIMAL REPETITIVE BEHAVIOR (RATE)

Source	SS	df	MS	F
R	.766	12	.766	0.003
P	1.776	12	1.776	0.596
RP	1.507	12	1.507	0.506

TABLE 49

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT OBJECT ORIENTED BEHAVIOR AND ADULT STIMULUS ANIMAL OBJECT ORIENTED BEHAVIOR (RATE)

Source	SS	df	MS	F
R	16.974	12	16.974	3.335
P	.235	12	.235	0.046
RP	.870	12	.870	0.017

TABLE 50

SUMMARY OF THE ANALYSIS OF VARIANCE: TRANSFORMED CORRELATION OF SUBJECT FEAR AND ADULT STIMULUS ANIMAL SELF-DIRECTED BEHAVIOR (RATE)

Source	SS	df	MS	F
R	.792	12	.792	0.381
P	11.089	12	11.089	5.333*
RP	.292	12	.292	0.140

*p less than .05
**p less than .01
***p less than .001