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# From Thought to Therapy: Lessons from a Primate Laboratory

*How investigation of the learning capability of rhesus monkeys has led to the study of their behavioral abnormalities and rehabilitation*

A basic maxim of scientific investigation is that significant research directed toward providing an answer for a particular question will inevitably generate a host of new problems awaiting resolution. Rarely is a scientific inquiry germinated and subsequently resolved in a vacuum. The endless effort required to solve any major problem frequently leads to other channels of thought and the creation of new areas of interest—often by chance or almost chance associations.

*Harry F. Harlow joined the University of Wisconsin staff as an assistant professor of psychology in 1930, after receiving his Ph.D. at Stanford University. Almost immediately Dr. Harlow set out to create a primate research facility at Wisconsin, which has evolved into one of the most eminent facilities of its kind in the world. His primary research interests have focused on learning abilities of rhesus monkeys, effects of brain lesions on learning and social behavior, primate affection, effects of social isolation, and, most recently, induction of depression in monkeys. Dr. Harlow is currently Director of the Primate Laboratory and George Cary Comstock Research Professor of Psychology at the University of Wisconsin.*

*Margaret K. Harlow is Professor of Educational Psychology at the University of Wisconsin, as well as Research Associate at the Primate Laboratory. Before coming to Wisconsin in 1946 she had had extensive experience in research with human children, unlike the other authors, but had not worked with monkeys. Her principal current interest is the study of various aspects of monkey family life, utilizing the nuclear family experimental situation she designed.*

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Multiple illustrative cases substantiating this point have evolved from research carried out over the years at the University of Wisconsin Primate Laboratory. We have never completely forsaken any major research goal once we pursued it, and we are still searching for the end of each and every rainbow—even though we have already found our fair share of research gold.

During the Primate Laboratory's 40 years of existence we have maintained an ongoing research program investigating the learning capability of rhesus monkeys. Learning has been the key directing the creation, not the culmination, of many of our major research efforts. The first of a series of studies stemming from the earlier learning researches determined the effects of lesions in specific cortical regions, including unilateral and bilateral occipital (7), frontal (2), and temporal (3) lobes, on learning task performance. Just as the early lesion research developed from learning,

later learning research stemmed from the lesion research. To assess lesion effects we were forced to create more reliable and lucid learning tasks and to develop and standardize them into a battery of tests that covered varied abilities and cortical locations. A natural problem raised then concerned the ontogenetic development (4) of ability to perform these various tests, for we already knew that some tests were so difficult that they could not be solved by monkeys younger than three years, and some were so simple they could be solved by monkeys in the first weeks of life.

To study developing learning abilities in monkeys required a large number of subjects spanning the age range from birth through adolescence, and so we instituted a breeding program and devised means for rearing monkey subjects in the laboratory from birth onward. In order to reduce the incidence of both confounding variables and contagious disease, we separated the babies from their mothers a few hours after birth and raised them in individual cages where they were hand-fed and received human care (5). The infants were provided with cheesecloth diapers to serve as baby blankets, and we noticed that many of the neonates developed such strong attachments to the cheesecloth blanket that it was hard to tell where the diaper ended and the baby began (as shown in Fig. 1). Furthermore, the monkeys became greatly disturbed when the diapers were removed from their cages for essential sanitary services.

## The surrogate mothers

Dirty diapers and distressed infants were produced for some years—an adequate time for insightful learning to occur—before the true significance



Figure 1. Infant monkey clothed in cheesecloth.

of the diaper was duly recognized. It is a long way from brains to blankets, but this is the strange, mysterious way in which research programs develop. Many creative ideas have suddenly appeared in a flight of fancy, but the surrogate mother concept appeared during the course of a fancy flight. The cloth surrogate mother was literally born, or perhaps we should say baptized, in 1957 in the belly of a Boeing stratocruiser high over Detroit during a Northwest Airlines champagne flight. Whether or not this was an immaculate conception, it certainly was a virginal birth. The senior author turned to look out the window and saw the cloth surrogate mother sitting in the seat beside him with all her bold and barren charms. The author quickly outlined the researches and drafted part of the text and verses which would form the basis of his American Psychological Association presidential address (6) a year later. The research implications and possibilities seemed to be immediately obvious, and they were subsequently brought to full fruition by three wise men—one of whom was a woman.

The original theoretical problem to be solved by the surrogate mother researches was to measure the relative strength of bodily contact comfort as opposed to satisfaction of nutritional needs, or activities associated with the breast, as motivational forces eliciting love for mother in rhesus neonates. Actually the primary purpose was to continue to dismantle derived drive theory (7). The results of the now famous cloth-mother and wire-mother experiments provided total support for contact comfort as the superordinate variable or motive binding infant to mother. As pictures of baby monkeys clinging contentedly to soft surrogates (see Fig. 2) unfolded across tabloid pages throughout the world, the downfall of primary drive reduction as the predominant theory to account for the development of social attachment was assured. The cloth mother became the first female to attain fame so quickly while still retaining her virginal virtues. There is more than merely milk to human kindness.

On the basis of the diaper data it came as no great surprise to find that monkey infants overwhelmingly preferred nonlactating cloth mothers to lactating wire surrogates. However, during the course of testing infants in novel environments we discovered an unex-



Figure 2. Baby monkey clinging to cloth surrogate.

pected trait possessed by our cloth surrogates: the capacity to instill a sense of basic security and trust in their infants (8). This is the way creative research often arises—sometimes by insight and sometimes by accident. Baby monkeys placed in an unfamiliar playroom devoid of a cloth surrogate, or with a wire surrogate present, typically rolled into tight furry balls (as shown in Fig. 3), screeching in terror.

When the same infants were placed in the same environment in the presence of cloth surrogate mothers, they

initially scurried to the surrogates and clung for dear life. After their first fears abated, the monkeys would then venture away from the surrogates and explore the environment, as shown in Fig. 4, but often returned (Fig. 5) to their inanimate mothers for a reassuring clasp or a deep embrace to desensitize fear or alleviate insecurity. This response was predicated upon a psychiatric principle discovered by baby monkeys long before the advent of Watson (9), Wolpe (10), or any of the Skinnerians. Basic trust was the achievement of the first of Erikson's (11) eight human developmental crises, and although basic trust may not be fashioned out of whole cloth, for baby monkeys it apparently can be fashioned from cloth alone.

Subsequently we recognized the obvious truth that no major act of animal behavior is determined by a single variable. To illustrate this axiom we created surrogates of varying form and function, and they disclosed that many variables other than contact comfort possessed more than measurable effects on infant monkey maternal attachment (12). These findings led naturally to a series of studies designed to measure all possible variables, regardless of importance, relating to the maternal efficiency of our man-made mothers. The researches disclosed a number of variables secondary in importance to contact com-

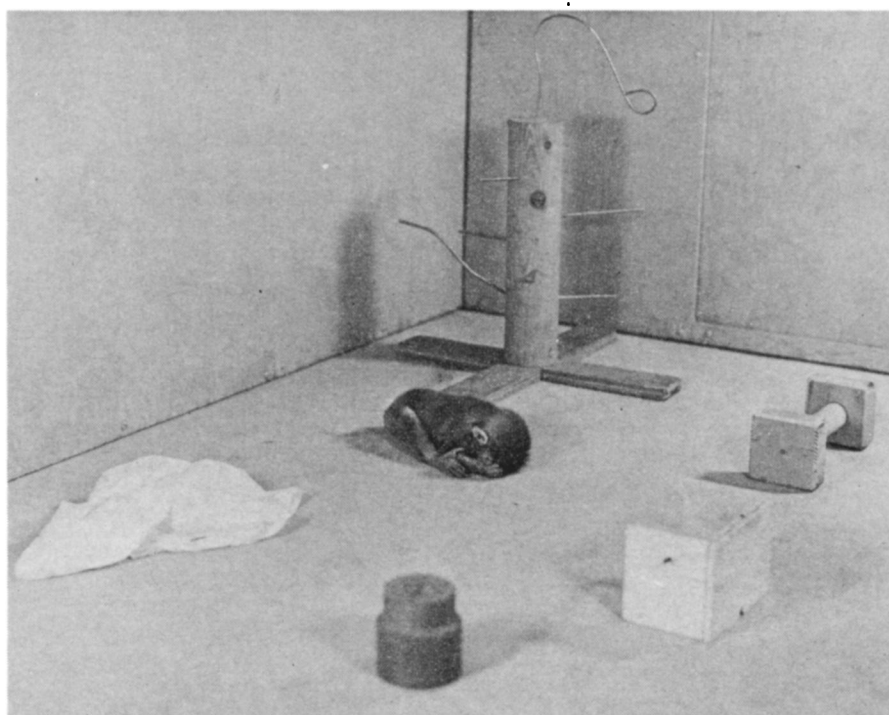


Figure 3. Infant terrified in absence of surrogate mother.



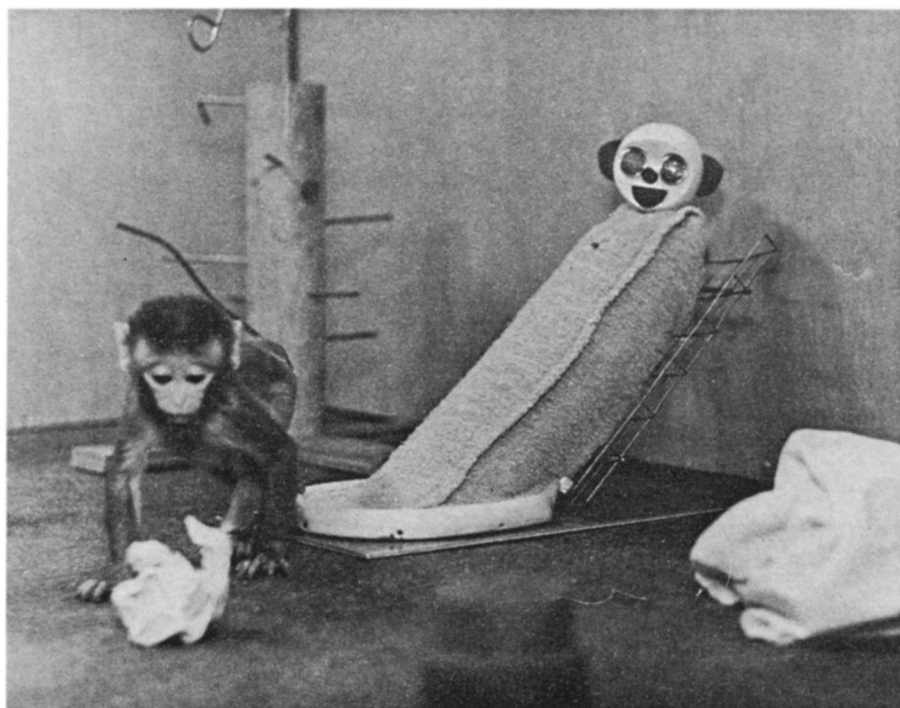


Figure 4. Infant security in presence of cloth surrogate.

fort. With contact comfort held constant by constructing lactating and nonlactating terry-cloth surrogates, it was possible to demonstrate that nursing, or activities associated with the breast, was a significant variable during the first 90 days of life. Thus, by this ingenious research we learned what had been totally obvious to everyone else, except psychologists, for centuries. Furthermore, rocking sur-

rogates and rocking cribs were preferred to nonrocking surrogates and cribs for about 160 days. Body surfaces other than wire or cloth were also investigated, with predictable results. Satins and silks might be adult symbols of prestige, but they do not warm the infant heart as does terry cloth.

Infant rhesus monkeys preferred a warm wire surrogate to a cool cloth

surrogate for the first 15 days of life, illustrating the limited temporal span of some variables and confirming the well-known "hot mama" or "warm woman" hypothesis. Warmth was the only variable to lend even transient preference to the wire surrogate. However, the most striking maternal temperature data were recently obtained by Suomi (13), who constructed a cold cloth surrogate with ice water in her veins. Neonatal monkeys tentatively attached to this cold cloth figure, but then retreated to a far corner of the cage, as shown in Figure 6, and remained aloof from mother forever. There is only one social affliction worse than an ice-cold wife, and that is an ice-cold mother.

Finally, we compared the efficiency of our man-made mothers with their natural counterparts, and we are convinced that real motherhood is superior and that it is here to stay. The cloth mother may serve milk, but not in the cozy continuous containers provided by the real mother. The real mother eliminates nonnutritional sucking by her infant, whereas no surrogate mother, regardless of Skinnerian schedule, can inhibit nonnutritional sucking. The real monkey mother trains her infant to be a placer, rather than a spreader, of feces (14). The real mother trains her infant to comprehend the gestural and vocal communications of other monkeys (15), while language learning is beyond surrogate love. The real mother is dynamic and responds to the infant's needs and behavior, but the surrogate can only passively accept. Subsequently the mother plays an active role in separating the infant from her body, which results, probably inadvertently, in the exploration of the surrounding animate and inanimate environment. Finally, and of most importance for future peer adjustment, the real mother is far more efficient than the cloth surrogate in the regulation of early infant play, the primary activity leading to effective age-mate love.

We might have remained imprinted on surrogate mothers forever had it not been for a comment made to the senior author independently by an eminent psychologist and an eminent psychiatrist within a single month. Both said, "You, know, Harry, you are going to go down in the history of psychology as the father of the cloth mother!" This was too much! In a desperate effort to escape this fate we



Figure 5. Infant monkey returning to surrogate mother for reassurance.

branched out into new areas of research, which were subsequently to fall into two broad, disparate areas: the nature of normal and natural love in rhesus monkeys, and the induction of psychopathology.

## The natural nature of love

I enlisted the aid of my wife, and we fell in love, or at least in love with love, in all its multifaceted forms. Normal and natural love in rhesus monkeys develops through the sequencing and interaction of five major love systems: maternal love; infant love, or love of the infant for the mother; peer love, which other psychologists and psychoanalysts will someday discover; heterosexual love; and paternal love.

Maternal love has always been obvious, and even Freud was fully aware of it. We have already described its social functions. An extremely important basic function is the management of infant play so that infant monkeys play together effectively instead of in a disorganized manner. Maternal love serves as an important antecedent to the development of peer or age-mate love.

The variables underlying the love of the infant for the mother have already been described in the surrogate researches. It is our opinion that a more important love system, in fact, the most important from the view of the whole life span, is age-mate love, which develops first through curiosity and exploration and later through multiple forms of play. Peer interactions enhance the formation of affection for associates, the development of basic social roles, the inhibition of aggression, and maturation of basic sexuality. We believe heterosexual behavior in primates is another love system, evolving from peer love very much as peer love evolves from maternal love.

Heterosexual love was not discovered by Freud. Freud became lost in the libido even before he experienced it, and he never fully learned about love. Heterosexual love differs in form and function in various animal families. Beach (16) eventually discovered love in beagles, but so had the beagles. Some female beagles have warm and wondrous love affairs despite the fact that they are basically bitches. Heterosexual love in rats and people is

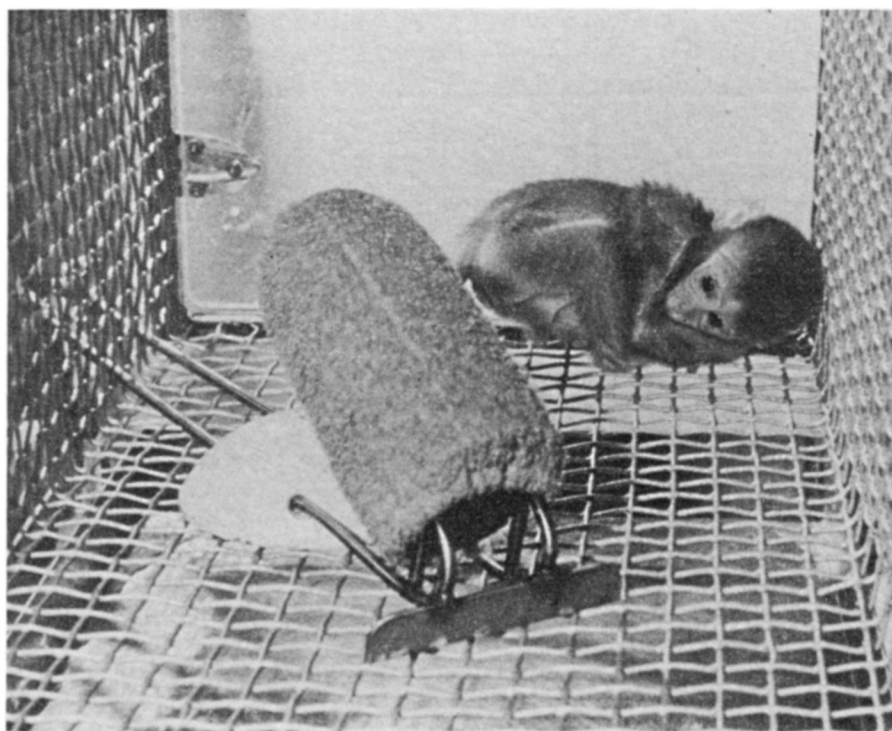


Figure 6. Infant rejecting cold mother surrogate.

planned in different fashions. If you are a rat, your sex life may be endocrinologically determined, and you will do very well. However, if you are a primate—monkey, ape, or man—and your heterosexual life is primarily gonadally determined, you face a grim and grave future, and the sooner the grave, the better. Sex without antecedent and concurrent love is disturbed and disordered (17).

After resolving the nurture and nature of maternal, infant, peer, and heterosexual love, the only thing that remained was paternal love. Having analyzed monkey love as far as we could with our existing facilities, I realized that we had no love with father, and I dejectedly proclaimed to my wife that, although paternal love in feral baboons and monkeys had been described, this love system could not be analyzed and resolved under laboratory restraints. A month later Margaret Harlow brought me the experimental design for paternal laboratory love and a plan for the necessary housing facilities. After the relatively simple task of rebuilding the attic over our laboratory had been achieved, the analysis of paternal love was on its way.

## The nuclear family

The nuclear family apparatus, shown in Figure 7, is a redesigned, redefined,

replanned, and magnified playpen apparatus where four pairs of male and female macaques live with their offspring in a condition of blissful monogamy. In the nuclear family apparatus each and every male has physical access to his own female and communicative access to all others. It is obvious from time to time that some males and females would like to have physical access to their neighbors' mates, but their courting must be limited to calls and lip-smacking and visual fixation. Fortunately, they accept their frustration with minimal effects on their mates.

Most important of all, each and every infant has access to every male, and, perhaps because of the cunning and curiosity of all the infants, most nuclear fathers responded socially to most infants. Finally, the apparatus provides unrivaled opportunities to study sibling interactions and friendship formation in infants of similar and disparate ages.

Creation of the nuclear family has provided us with a body of basic information concerning paternal love. The nuclear fathers do not allow mothers, their mates, and neighbors, to abuse or abandon infants, and the fathers serve as a cohesive force guarding the group against predators—primarily experimenters. In addition, the fathers, through some



developmental mechanism which we do not yet understand, show affection in varying degrees to all infants. Many fathers engage in reciprocal play with the infants at a level far surpassing that of the mothers, and the fathers ignore aggression from the infants and juveniles, including pinching, biting, and tail- and ear-pulling—behaviors the fathers would never accept from adolescents and adults of either sex.

Preadolescent monkey males, unlike females, exhibit limited interest in all new infants except their siblings until the babies can play. The males largely ignore them, while the female preadolescents continually struggle to make contact with the new babies. The precursors of paternal behavior are present, however, for the older male infants and juveniles cradle, carry, and protect young infants that venture in their path. The watchful eyes of the adults and their ready threats may abet the gentle behavior of the older infants and possibly begin the inculcation of protection of all young. We have still much more to learn about the variables in the development of paternal behavior.

The advent of the second and third infants in the families has disclosed interesting aspects of maternal love and sibling interaction. We had long presumed that the appearance of a second monkey gift from Heaven would exaggerate the mother-infant separative mechanisms long in progress, and that neonatal fairy fingers playing upon the maternal heart-strings would rapidly dissipate the love for the older infant. True to predic-

tion, the immediate reaction of the newly delivered mother to her older infant was negative. She threatened body contact, prevented nipple contact, and cradled the new infant continuously. But every mother eventually reversed this policy toward the older infant. The only individual difference was the interval between the new birth and contact with the older infant, which ranged from 8 hours to a matter of days. Most displaced infants or juveniles spent a night or two without maternal contact, often with their fathers, but one managed to achieve contact with mother the very first night and every night thereafter by persistent approach, cooing and squealing until her mother made room for her too. Although she had a good relationship with her father, she made no attempt to substitute him.

Much to our surprise, the displaced infants did not overtly exhibit punitive signs of jealousy toward the newcomers, probably because of fear of the mother, although one male juvenile did engage in teasing his little sister at every opportunity when mother was not looking. All displaced infants showed disturbance in this situation of denial and despair, of suspicion and separation, and the older infants would spend hours trying to achieve contact comfort, real or symbolic, from the body of the mother—both awake and asleep. Indeed, initial contact was usually made when the mother was sleepy and had reduced her vigilance. In desperation, when this failed, some would enter adjacent living chambers and make overtures to other mothers, who

generally accepted their presence but denied them bodily contact. Alternatively, proximity and contact with their fathers were sought when mothers were not available.

In spite of the fact that the nuclear families provided a wealth of new data on the affectional systems, the most striking psychological contribution of the nuclear family has not been to love but to learning.

## Lonely learning

For a number of years we had assiduously studied the effects of early environment upon later learning capability, and to achieve this we had always used groups of normal monkeys and groups of socially isolated monkeys. We knew that total social isolation damaged or destroyed the social-sexual capabilities of monkeys, as is described in detail in the subsequent section, but it did not depress learning ability. Our socially deprived monkeys were reared under conditions of 6, 9, or 12 months of total social isolation, a condition of deprivation or privation so severe that no one will ever impose it upon human children.

Our "normal" monkeys had been reared in partial social isolation. We had recognized the fact that partial social isolation would hardly qualify as a haven or Heaven, but because of limited facilities this is the manner in which we had always reared our normal monkeys. For decades our normal monkeys have achieved learning performances better than those achieved in any other laboratory, owing no doubt to the unusual care we took in adapting them to the test situation.

Finally, S. D. Singh (18), who had had extensive test experience on the Wisconsin General Test Apparatus (WGTA) in the United States and in India, reported that feral animals (reared in forests or in temples) were not intellectually different from each other and were not superior to our monkeys reared in partial social isolation. Furthermore, Singh's test battery was adapted from our own, utilizing discrimination problems which rhesus monkeys are able to solve at 6 months of age, delayed-response tests at 10 months of age, learning-set tasks mastered at 12 months of age, and, later, complex oddity-learning-set tasks which are

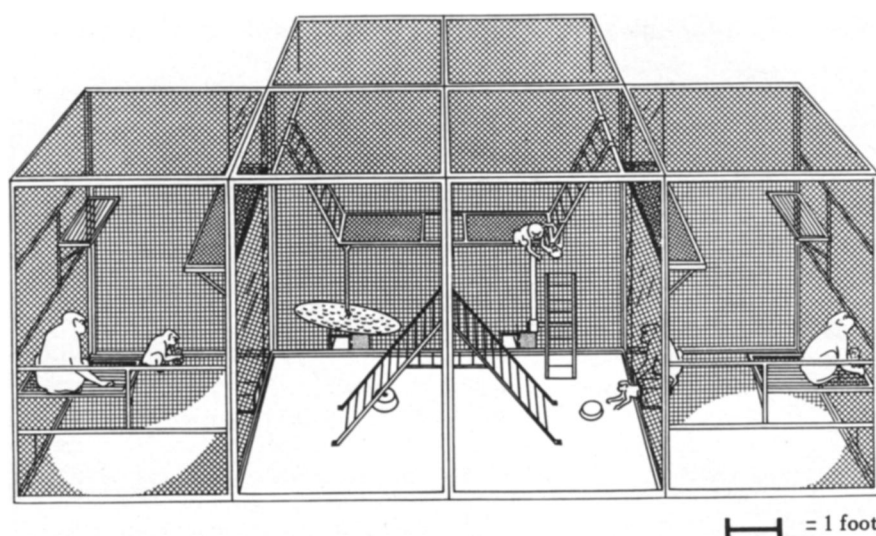


Figure 7. Nuclear family living apparatus.

not efficiently solved by monkeys until 36 months of age. Singh's data gave every indication that partial isolation cages were just as stimulating to intellectual development as were temples and forests.

We had assumed that "enriched" environments were in no way superior to the deprived environments in stimulation and development of the intellectual processes. To demonstrate this, we compared the performance of monkeys reared from birth in the nuclear family apparatus with that of totally socially isolated monkeys and our normal monkeys. Just as predicted, the enormously socially enriched monkeys reared in interacting family groups did no better than deprived monkeys or control monkeys on discrimination tasks, delayed-response tasks, and complex learning-set tasks. My world of happy intellectual isolation was jolted, however, when the socially enriched preadolescents and adolescents, as contrasted with the socially isolated adolescents and controls, proved to be superior at the .001 significance level on our most complex problem-oddity-learning set. Had there been a progressive separation in performance between enriched and deprived monkeys as they traversed through tests of increasing complexity, we would gladly have conceded a difference, but the difference appeared only when the most complicated learning test was administered.

One can only conclude that this enriched early environment, at least, enables monkeys adequately adapted and trained to reach more lofty intellectual performance levels than those attained by deprived monkeys. The basis for the performance difference, however, is by no means established. Superiority could stem from nonintellectual factors as readily as from intellectual differences. The nuclear family animals give every evidence of being the most self-confident, self-assured, fearless animals we have ever tested. They are more relaxed in the test situation than other subjects and could well be more persistent, thus persevering after "normal" subjects give up. This difference would not be apparent on unchallenging tasks, but when the problems become very difficult, the personality factors could operate to produce performance differences. Unfortunately, it is as difficult to test as is the hypothesis that middle-class children excel intellectually over



Figure 8. Catatonic posture of partial isolate.

lower-class children because of their environmental advantages.

## Induced psychopathology

For many years behavioral scientists attempted to produce psychopathological behavior syndromes in non-human subjects by experimental manipulation, but their successes were at best limited. H. F. Harlow (19) hypothesized that maternal rejection might provide the critical contribution to this area, and so a family of surrogate mothers was designed to impart fear and insecurity to infant monkeys. Four different forms of evil artificial mothers emerged, and although all were designed to repel clinging infants, each had its own unique means by which to achieve this end. One surrogate blasted its babies with compressed air, another tried to shake the infant off its chest, a third possessed an embedded catapult which periodically sent the infant flying, while the fourth carried concealed brass spikes beneath her ventral surface which would emerge upon schedule or demand.

These surrogates produced temporary emotional disturbance in the infants, but little else. When displaced from their artificial mothers, the infants would cry, but they would return to the mother as soon as she returned to normal. In retrospect, it should have been obvious—to what else can a frightened, contact-seeking infant cling? The only individuals to suffer prolonged distress from these experimental efforts were the experimenters.

Later we discovered the existence of far more sadistic monkey mothers—real ones.

In the midst of these ill-destined efforts, we discovered that we already had dozens of abnormal monkeys produced without any special effort. It became apparent to us that something was awry after the animals we tested in the study of the development of learning had completed their experimental chores and were physically mature enough to transfer to the breeding colony. We had every expectation that these healthy, well-developed animals would give us disease-free infants to supply our experimental needs. The animals were paired appropriately and placed in large cages. Weeks passed, then months passed, and we never saw any copulation, and there certainly were no offspring. When summer came, we hoped to change their behavior by assigning some of them to group living on an unoccupied monkey island in the Madison zoo.

The group psychotherapy had some effect. The aggression that erupted when the monkeys were initially transferred gradually disappeared. Animals began to form social groups and to groom each other. But no heterosexual behavior was observed and there were no pregnancies. In the belief that a highly experienced male from the breeding colony could conquer the females, we released onto the island one of our most capable males. He met all challengers with ease and immediately became leader of the island. But still no females became pregnant. We knew then that we had raised a colony of monkeys abnormal in their sex behavior. This was the beginning of a systematic effort to study sexual and social development of monkeys raised under varying environmental conditions.

One rearing condition we had already established—the raising of infants from birth onward in bare wire cages without companions. Subsequently, we termed this "partial social isolation." The subjects were not only devoid of heterosexual behavior at maturity but showed exaggerated oral activities, self-clutching, and rocking movements early in life, then apathy and indifference to external stimulation subsequently. Individualized stereotyped activities involving repetitive movements characterized many



subjects and extremely bizarre behavior appeared in some. An animal might sit in the front of its cage staring aimlessly into space. Occasionally one arm would slowly rise as if it were not connected to the body, and wrist and fingers would contract tightly (Fig. 8)—a pattern amazingly similar to the waxy flexibility characteristic of some human catatonic schizophrenics. The monkey would then look at the arm, jump away in fear, and subsequently attack the offending object. Unfortunately, we know nothing about the forces that cause one isolated monkey to drift into inactivity and another to demonstrate bizarre repetitive behavior patterns.

To understand why partial social isolation, which seems to be a relatively benign condition, is actually so devastating socially, one need merely consider the effect that rearing in partial or total social isolation from birth onward has upon the development of the five love systems (19). The monkey reared in partial social isolation knows no maternal love and therefore cannot love its mother. Furthermore, living alone in a cage it cannot develop age-mate or peer affection, which comes for the normal monkey through physical interaction with other young monkeys. Sex in a bare wire cage is either nonexistent or at best limited and lonely. Thus it is not surprising that partial social iso-

lation produces profound behavioral abnormalities in monkeys. By chance we had discovered what had been sought for years by design.

If denial of physical access to other monkeys produces such psychopathology, it would seem likely that denial of visual, as well as physical, access to other monkeys would produce even more serious deficiencies. Subsequent research found this to be the case. When William A. Mason came to Wisconsin in 1954, we designed total isolation chambers, and the first research describing the effects of long-term social isolation in these chambers was published by Mason and Sponholz in 1963 (20). Subsequently, an improved total social isolation apparatus was created with true cunning and connivance by Rowland (27), and this became and remains our standard total social isolation chamber. Rowland's apparatus was designed so that monkeys could be raised from birth onward without seeing any other animal or part of any other animal except the experimenter's hands and arms which assisted the neonate up a feeding ramp during the first 15 days of life. Subsequently, the experimenter could easily observe the infant through a one-way vision window, while the infant monkey saw no animal of any kind. Moreover, the apparatus was designed so that the learning ability of the isolate-reared monkey could be

measured by remote control, and this was successfully achieved in Rowland's original study.

The total social isolation apparatus enabled us to quantify the socially destructive effects of isolation from birth onward. Monkeys reared in total social isolation for 90 days were enormously disturbed when admitted to the great wide world of wonder, and two of them actually died of self-induced anorexia before we recognized the syndrome and instituted forced-feeding. However, all surviving monkeys rapidly made a complete social adjustment to age-mates, so that behavior from one postisolation month onward was normal for all measurable purposes.

In contrast, monkeys subjected to 6 months of total social isolation from birth and then allowed to interact with age-mates were very adversely affected for the rest of their lives. They spent their time primarily engrossed in autistic-like self-clasping, self-mouth-ing, and rocking and huddling. The isolates never interacted successfully with normal peers over an 8-month period, although pairs of isolate monkeys did show limited recovery in terms of exploration and even play with each other. These monkeys were then maintained in partial social isolation for approximately 3 years, and, when subsequently tested, their behavioral repertoire appeared to have deteriorated rather than improved. Their social efforts were plaintive and their sexual efforts pitiful. Practically the only social behaviors that seemed to have matured were fear and aggression, and the animals showed these inappropriately and often explosively. Six-month isolates aggressed against infants—an act no normal monkey would consider—but before, during, and after aggressive acts, they were frozen in fear even though the infants they faced were only half their size (Fig. 9). In addition, several isolate monkeys attempted a single suicidal sortie against very large adult males—an act no normally socialized animal would be foolish enough to try.

We also discovered that 12 months of total social isolation from birth had even more drastic effects than 6 months on behavior in the playroom. Exploration and even simple play were nonexistent. Torn by fear and anxiety, aggression was obliterated in these monkeys, and even the simple

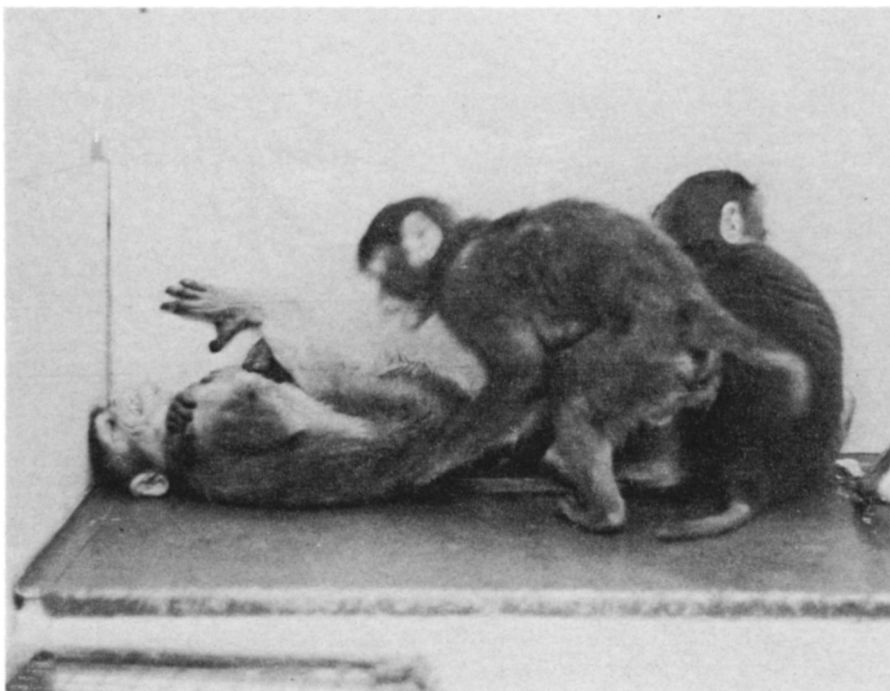


Figure 9. Isolate infant frozen in fear.

pleasure of onanism was curtailed. They sat huddled alone in the corners or against the walls of the room. The actual experiment was stopped after 10 weeks, since the control animals were literally tearing up the 12-month isolates, and the isolates made no effort to protect themselves. These animals were maintained for many years and never demonstrated any vestige of virginal social ability, even for a very long time afterward. They were tested by Robert E. Miller some three years later for their ability to receive and express social communication. They were a perfect control group, totally devoid of all social signaling.

A considerable number of our isolate-reared females were eventually impregnated by patient and competent feral males. When adequate animal assistance failed, we resorted to an apparatus affectionately termed the rape rack, which we leave to the reader's imagination. Very soon we discovered that we had created a new animal—the monkey motherless mother. These monkey mothers that had never experienced love of any kind were devoid of love for their infants, a lack of feeling unfortunately shared by all too many human counterparts (22). Most of the monkey motherless mothers ignored their infants, as shown in Figure 10, but other motherless mothers abused their babies by crushing the infant's face to the floor, chewing off the infant's feet and fingers, and in one case by putting the infant's head in her mouth and crushing it like an eggshell. Not even in our most devious dreams could we have designed a surrogate as evil as these real monkey mothers.

## Experimental study of depression

The door to discovery of behavioral deficits produced by isolation rearing was opened largely by chance. In contrast, the initial enlightenment of procedures which resulted in another form of monkey psychopathology, that of depressive behavior, was unlocked by love. During the course of study of mother and infant affection, two experiments (23, 24) were conducted in which infants were reared with mothers and peers, then separated from their mothers for a period of several weeks. It was found that the maternal separations precipitated severe reactions among the

infants. During the period of separation the young monkeys ceased their peer play activity and became withdrawn and inactive. When reunited with their mothers, they spent more time engaging in mother-directed activity than they had spent immediately prior to separation, amply demonstrating the overwhelming strength of the mother-infant attachment bond.

A closer examination of these data indicated that more than love had been disclosed by the experiments. During the maternal separation the infants had initially expressed protest, characterized by increased activity and vocalization, but soon withdrew and became inactive. Normal social interactions among the infants declined or disappeared, as was the case for play, the most complex social behavior the infants possessed. These behavioral abnormalities vanished when the infants were reunited with their mothers.

Several years earlier Spitz (25) and Bowlby (26) had witnessed surprisingly similar reactions among human infants who had been separated from their mothers via hospitalization. Spitz termed the reaction "anaclitic depression." Bowlby delineated two stages of the reaction during the period of separation, which ranged from a few days to a few months: initial pro-

test, characterized by agitation and crying, and despair, characterized by withdrawal from the world of both animate and inanimate objects. When Spitz's children were reunited with their mothers, recovery was immediate and spontaneous, but Bowlby observed a "detachment" among some of his infant patients upon maternal reunion, a phenomenon he now feels may not represent a universal aspect of reaction to maternal separation. At any rate, these data suggested a close parallel between human and monkey infants in terms of reaction to maternal separation: anaclitic depression resulted in both cases.

Mother-infant separation experiments were subsequently carried out at several other primate laboratories, and the findings from study to study were amazingly consistent (27, 28). Almost immediately following separation, infants exhibited initial protest, characterized by increasing activity and vocalization. Shortly thereafter most subjects entered into a depressive withdrawal, even though the form and duration of the despair stage varied among the monkeys in the various researches and differing experimental conditions. Upon reunion infant-mother interactions rapidly became essentially normal, and there was little evidence of maternal detachment.

Several years later, the accumulation



Figure 10. Motherless mother ignoring her infant.



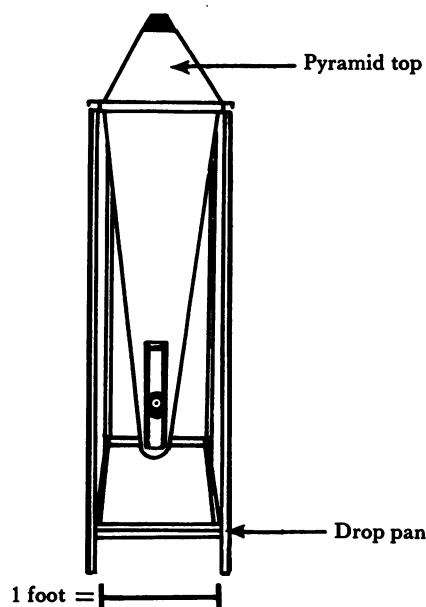


Figure 11. Vertical chamber apparatus.

of a vast body of normative information and a desire to investigate new and challenging problems led us to shift our major interests to the study of depression in monkeys. Leaving love in search for psychiatry is not that major a transition. The study of normal behavior furnishes all needs and norms necessary for the analysis of monkey madness and laboratory lunacy. At this time, a reconsideration of the mother-infant separation studies indicated a point of departure for the production of depression in nonhuman primates. Our earlier studies had duplicated, in laboratory monkeys, both the precipitating situation and the subsequent syndrome described as

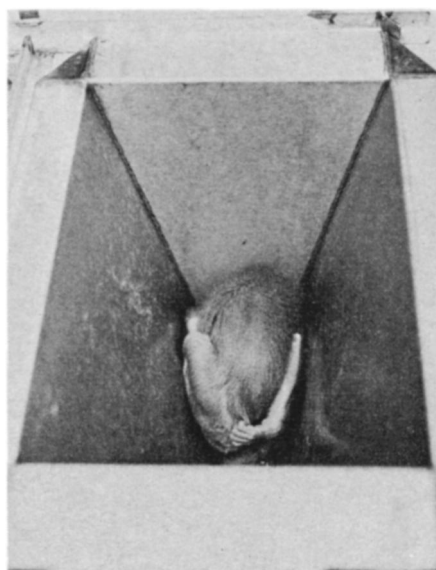


Figure 12. Immobilized posture.

anaclitic depression for human infants. However, it was obvious to us that mother-infant separation had both theoretical and practical limitations as a standard procedure for large-scale investigation of depression in monkeys, and to achieve significant advances in this area it would be necessary to transcend the mother-infant separation model.

Our first effort in this direction was initiated by Suomi (29), who reared infant monkeys with each other rather than with mothers. When these infants were separated from their playmates at 3 months of age, they exhibited a protest-despair reaction to separation virtually identical in form to that resulting from maternal denial in both human and monkey infants. Unlike the mother-infant separation studies, the infant-infant separation technique was expanded so that the young monkey peers were separated from each other not once but many times—4 days for each of 20 experimental weeks spread over a 6-month period. During every separation period the infants exhibited a severe protest-despair reaction, and each time they were reunited their activity primarily consisted of mutual clinging. This pattern did not change significantly from the beginning to the end of the multiple separation periods, even after 20 separations.

An unanticipated and fascinating discovery was the finding that the multiple separations produced a severe maturational arrest in the monkeys. Their behaviors following the separations were as infantile at age 9 months as they were prior to the first separation. Neonatal behaviors of nonnutritional orality and self-clasp persisted throughout the 6-month separation period, but the complex infant play activities which normally mature from 90 to 180 days had not appeared by the age of 9 months. This finding was in total contrast to the fascinating progression of social development traditionally reported in normal monkey infants. It was as if Suomi had stopped the monkeys' biological calendars.

The results of Suomi's study indicated that depressive reactions could be precipitated in monkey subjects by procedures other than that involving separation from the mother. No longer bound by the restraints of the mother-infant separation model, we could now seriously consider production and

study of depressions other than anaclitic in monkey subjects.

A radically different approach to the production of depressive behavior in monkeys, one that did not involve any social attachments, was made possible by a vertical chamber apparatus created by H. F. Harlow. This apparatus, illustrated in Fig. 11, is a stainless steel chamber with sides that slope downward to a wire-mesh platform above a rounded steel bottom. Depression in humans has been characterized as a state of "helplessness and hopelessness, sunken in a well of despair" (30), and the chambers were designed to reproduce such a well for monkey subjects. Although the confined monkeys are free to move about in three dimensions within the chamber, and although they eat and drink normally and maintain proper weight, within a few days they typically assume a huddled, immobilized posture in a corner of the apparatus (Fig. 12).

Suomi (31) then tested 90-day-old monkeys antecedently subjected to 45 days of chamber confinement and compared their subsequent activity in both social and nonsocial situations with two groups of equal-aged monkeys, one group peer-reared and the other reared as partial isolates. Extensive testing was conducted for 9 months, and throughout this period the chambered subjects consistently exhibited highly elevated levels of self-clasping and huddling, low levels of locomotion and exploration, and nonexistent social activity. These behaviors were in sharp contrast to those of both control groups (Fig. 13). Clearly, chamber confinement of relatively short duration was enormously effective for producing profound and prolonged depression in young monkey subjects.

Suomi then measured the effects of combined chamber confinement and peer separation in two studies utilizing monkey subjects under a year of age and found that chamber confinement intensified depressive separation-produced effects in monkeys with extensive prior social experience (37). We have long believed that a phenomenon as complex as depression cannot possibly be mediated by a single variable, and these researches indicated that the depths of our infants' depressions were dependent upon a number of factors, including duration of separation and/or confinement, age at

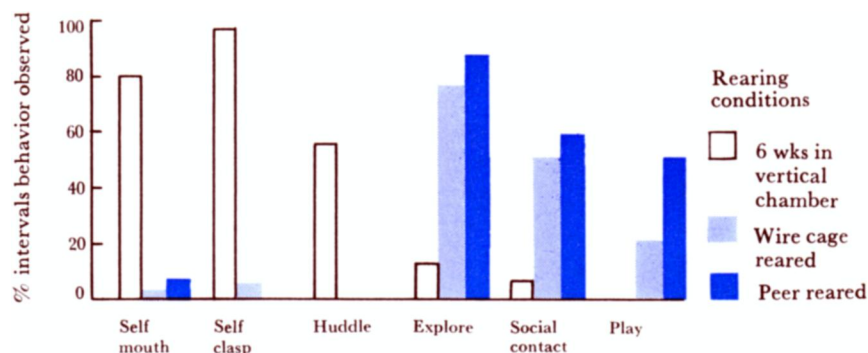
which depression was produced, and prior social history of the subjects.

The addition of a psychiatrist, Dr. William McKinney, to our depression project brought both clinical insight and psychiatric respectability to the research endeavors, and his presence has been welcome and fruitful. He has already taken a leading role in the experimental induction of depression in older-aged monkeys, whereby the diagnosis of anaclitic depression is excluded. In addition to investigating the behavioral aspects of depression, he has directed the initiation of researches involving analyses of biochemical variables, including the catecholamines (32). Three years ago the idea of using monkeys to unravel the behavioral and biochemical intricacies of an affliction suffered in some form, and at some time, by virtually every human being and fully understood by virtually no human mind, seemed to be little more than a desperate dream or humble hope. Today we are finally and firmly on the road to success.

## Monkey psychotherapy and rehabilitation

Our research endeavors in the field of depression have resulted in a sizable increase in our population of emotionally disturbed monkeys, and we are now initiating researches designed to rehabilitate our "patients" to a state of social normality. We plan long-term researches utilizing all possible types of therapeutic agents, including various antidepressant drugs and even such techniques as electroconvulsive therapy (ECT). Actually, our primary interest lies in the alleviation of depression by psychotherapeutic techniques since many of the monkey depressions were induced through social manipulations. Thus, social approaches to therapy have been our principal concern. Recently we have had several rewarding experiences which have provided valuable information relative to the stages of depression formation and alleviation.

While we were inducing depression in monkeys we were also attempting to rehabilitate several of our total social isolation-reared subjects, an effort previously initiated by many investigators with little or no success (33). As stated earlier, isolates exposed to



socially normal age-mates were the recipients of severe aggression with little therapy, and any subsequent social improvement was limited at best. However, we did discover that isolate-reared subjects showed some social improvement if they were able to achieve contact acceptability with various social agents. In particular, the motherless mothers whose infants survived in spite of evil maternal efforts eventually submitted to their babies' persistent attempts to achieve and maintain maternal contact, and to our great surprise these females usually exhibited adequate maternal behavior toward subsequent offspring. Also, isolates exposed to heated surrogates soon after emergence from confinement eventually learned to contact the nonthreatening surrogates,

leading to significant decreases in self-directed disturbance activity. When these animals were subsequently paired with each other they exhibited the rudiments of basic social-interaction patterns (34).

These findings convinced us that significant rehabilitation of isolate-reared subjects via social exposure was feasible and that the crucial variable lay in the nature of the social stimulation utilized. Each of the three authors is convinced that he (she) created the plan and procedure for monkey rehabilitation, and this is probably true since all were thoroughly familiar with the essential maturational data underlying a feasible therapy program. It seemed that an effective monkey "therapist" might be one who would in-

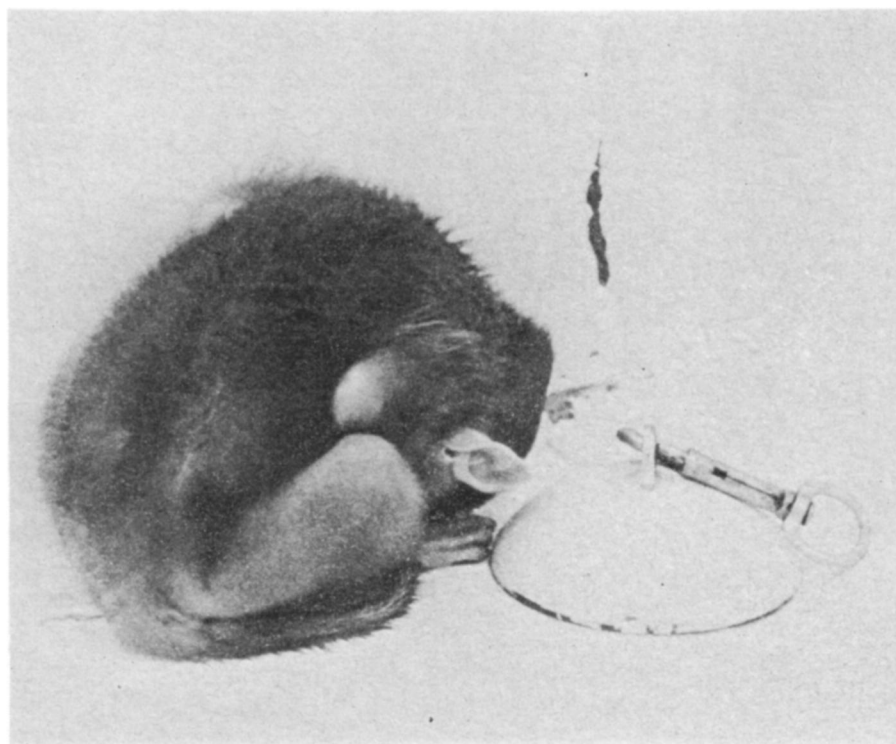


Figure 14. Isolate disturbance activity.



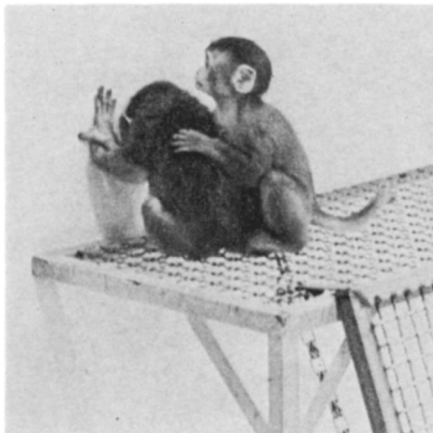


Figure 15. Therapist clinging to isolate.

still contact acceptability in the isolate monkeys without providing a threat of aggression and could subsequently or simultaneously provide an appropriate medium for the development of an increasingly sophisticated social repertoire. Our knowledge of monkey social development led us to select socially normal animals 3 to 4 months old as therapists for the isolates. At this age normal monkeys are too young to show aggression, they still provide stable contact clinging responses, and they are on the verge of gradually expanding their basic social interactions into fully developed play (35).

We therefore took 6-month-old animals who had been socially isolated from birth and housed them individ-

ually in compartments of a "quad cage" (36) adjacent to therapists 3 months their juniors. The quad cage, designed by Suomi, is an extremely versatile social testing unit which can simultaneously or successively serve as a living and testing area. Selection of interior panels dictates roommate assignment, while removal of the panels permits partner interaction in home territory. In this study (37) we permitted interactions between isolates and therapists 2 hours per day, both within the quad cages and in a social playroom. As therapy progressed interaction time in the quad cages was decreased and time in the playroom increased.

The isolates' initial response to their interaction opportunities was to retreat to a corner and rock and huddle (Fig. 14), and the therapists' initial response was to follow and cling to the isolates (Fig. 15). Soon the isolates were clinging back, and it became only a matter of weeks until isolates and therapists were playing enthusiastically with each other (Fig. 16). During this period most of the isolates' previously abnormal behaviors gradually disappeared, and after 6 months recovery was essentially complete.

An interesting sidelight or fringe benefit from the above findings concerned observed sex differences. Not entirely by design, all of the isolates in the

above experiment were males, while all of the therapists were female. We have long known that under normal rearing conditions males develop a rougher and more contact-oriented form of play behavior than females, and these differences are initially expressed prior to 6 months of age. Our rehabilitated males had spent their first 6 months of life in total social isolation and thereafter were exposed only to the female therapists and to each other. The psychotic monkeys had no social model for the development or creation of masculine play. Nevertheless, their play, when it emerged, was clearly masculine in form, adding to our data long cumulating that sex-typing of play in monkeys is governed not by imitation but by genetics (38). Culture makes clothes but God gives gonads.

## Conclusion

Thus we have traveled from thought to therapy by a route neither straight nor narrow. There have been obstacles and detours, but we have found throughout the years that these are to be cherished, not chastised, as blessings in disguise. We began with learning which led to lesions and later to love. Our first love was a soft and simple surrogate. Now it is a sophisticated simian society, whose study has led us back to learning. There have been other grand and great circles. In our study of psychopathology, we began as sadists trying to produce abnormality. Today we are psychiatrists trying to achieve normality and equanimity. Tomorrow there will be new problems, new hopes, and new horizons. Since knowledge is itself forever changing, the search for knowledge never ends.

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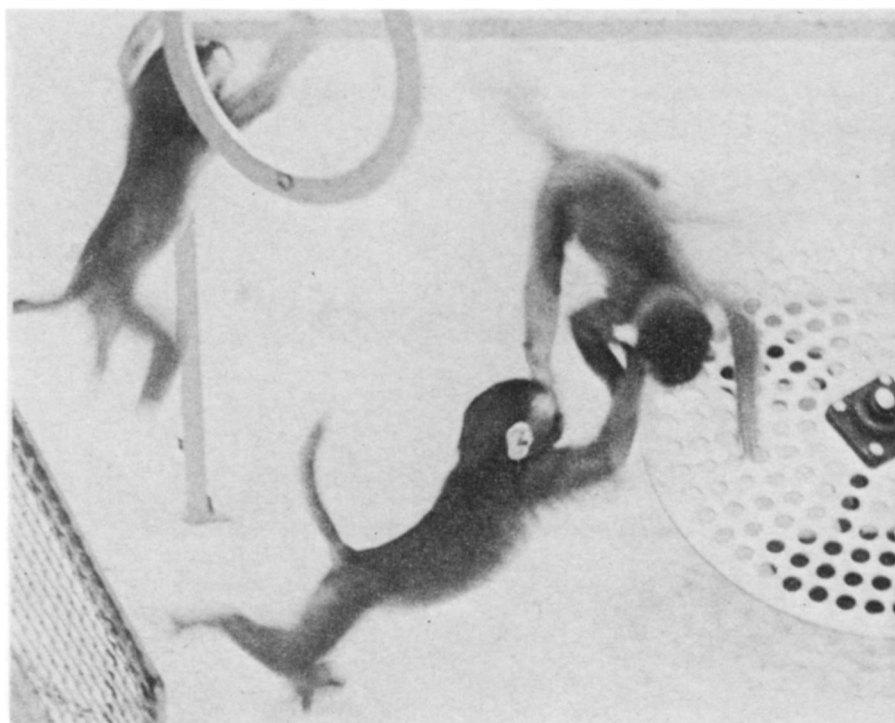


Figure 16. Isolates and therapists in vigorous play bout.

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"The devil with the food chain. I like mercury."