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LA THÈSE A ÉTÉ MICROFILMÉE TELLE QUE NOUS L'AVONS REÇUE

THE PHARMACOLOGICAL MODIFICATION OF AN EXPERIMENTALLY - INDUCED DEPRESSION IN THE INFANT CYNOMOLOGUS MONKEY, (MACACA FASCICULARIS)

by

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A Thesis
presented to the University of Ottawa
in partial fulfillment of the
requirements for the degree of
MASTER OF ARTS
in
Psychology

Ottawa, Ontario, 1980

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CURRICULUM STUDIORUM

Paul-Helmuth von Kulmiz was born in Düsseldorf, West Germany in 1948. He received his primary education in Canada and his secondary education in both Canada and Switzerland. He attended the University of Ottawa where he received a Bachelor of Arts degree (cum laude) with concentration in psychology in 1972.

ACKNOWLEDGEMENTS

This study was conducted at the University of Ottawa under the scholarly supervision of Professor Roger Stretch, Ph.D of the Departments of Psychology and Pharmacology. The daily operation of the research was patiently guided by Professor Pavel D. Hrdina M.D. of the Department of Pharmacology.

My sincerest thanks are extended to Miss Adrienne Stevenson, Mrs. Judith Ryde and Mr. Paul Gallagher for their indispencable work in observation. None of this research would have been possible without their conscientious and patiently sustained effort. I am especially grateful for the personal friendship and moral support shown by Mrs. Ryde and Mr. Gallagher during difficult periods in the work. I am also indebted to Mr. Robert Schiemann for providing computer software and Mr. Herman Van Den Bergen for the construction of the electronic apparatus and invaluable technical assistance and interest.

Financial support was provided by Professor Hrdina's grant MTM-1PO-ROD from the Ontario Mental Health Foundation. Supplies of the antidepressant desmethylimipramine were generously provided by CIBA-GEIGY (CANADA) LIMITED.

ABSTRACT

The procedure of separating infant macaques from their mothers or social peers is believed to produce a stressful behavioural syndrome that is similar to anaclitic depression in man. A set of two longitudinal observational experiments was begun in order to address two experimental concerns. In the first experiment, four young macaques were separated two times from their mothers, without any further intervention, in order to verify the exact nature of the separation reaction. This experiment also served to establish the optimal procedures and parameters for later experimentation. The second experiment was run under similar conditions with the exceptions that there were two groups and a pharmacological intervention at the second separation. The drug used was a tricyclic antidepressant compound, desmethylimipramine, known to be efficacious in some human depressions. The drug treatment allowed an assessment of the second major concern, i.e., does desipramine alleviate the separation-induced behavioural disturbance? A positive result would be taken as further validation of the separation model of depression.

LIST OF ABREVIATIONS

AMPT--------------Alpha-Methyl-Para-Tyrosine

MHPG--------------3-Methoxy-4-Hydroxy-Phenylglycol

DA----------------Dopamine

DMI---------------Desmethylimipramine

CPZ---------------Chlorpromazine

5-HT--------------5-Hydroxytryptamine

VMA---------------Vanymandelic Acid

NE----------------Norepinephrine

dB----------------deciBells

DIV---------------Division

CONT--------------Control

CON---------------Condition

FR----------------Fixed Ratio

FI----------------Fixed Interval

HR----------------Heart Rate

VTR---------------Video tape recording

REM---------------Rapid eye movement

EEG --------------Electroencephalogram

EMG---------------Electromyogram

EOG---------------Electroocculogram

MMPI--------------Minnesota Multiphasic
Personality Inventory

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION AND REVIEW OF LITERATURE

The research of clinically important problems with primate models of psychopathology raises a number of unavoidable problems and touches upon an extensive field of scientific concerns. These concerns may be posed in the form of the following questions;

1. What is the nature of depression?
2. Is anaclitic depression similar to adult depression?
3. What are the forms of treatment of depression?
4. Does the primate separation model have any relevance to human depression?
5. What is the nature of the experimental subjects?
6. What kind of research has been done in the area and what are its limitations?

Such broad questions are very important and difficult to answer satisfactorily. Their very lack of specificity is a direct reflection of the problems and limitations of research in primate models of the human condition. The introduction and review of the literature is intended to provide some insight into these methodological and philosophical problems in roughly the same order as they are stated. It is recoginized that answeres to these questions are, to some extent, speculative. The following poem by Hopkins carries greater insight into the nature of depression than the usual metaphore.

Human Depression

no worst, there is none. pitched past pitch of
grief, more pangs will, schooled at forepangs,
wilder wring. comforter, where, where is your
comforting? mary, mother of us, where is your
relief? my cries heave, herds-long; huddle in a
main, a chief woe, world sorrow; on an age-
old anvil wince and sing then lull, then leave
off. fury had shrieked "no ling- ering! let
me be fell: force i must be brief.

o the mind, mind has mountains; cliffs of fall
frightful, sheer, no-man-fathomed. hold them
cheap may who ne'er hung there. nor does long
our small durance deal with that steep or
deep. here! creep, wretch, under a comfort
serves in a whirlwind: all life death does
end and each day dies with sleep.

from "spelt from sibyl's leaves." where,
selfwrung, selfstrung, sheath-and-Shelterless,
thoughts against thoughts in groans grind.

Gerald Manley Hopkins, 1844-1889.

In cognitive formulations of depression, such as those of Aaron Beck (1967,1976, Kovacs and Beck, 1978), depressive mood and behavior are seen as resulting from consistently construing ordinary experience in negative non-logical ways, including selective abstractions, over-generalizations, magnifications and arbitrary inferences. Input information is screened in such a way that the patient consistently: 1) construes ordinary experience in a negative way. Interactions and objects become burdensome obstacles and represent defeat and disparagement. Neutral remarks are taken as criticism; 2) The patient views himself in a negative way; inadequate, unworthy, sinful etc. These labels are inferred to represent stable traits within himself to which he may attribute all his failings; 3) the patient views the future in a negative way. The future, if it is conceived at all, becomes a mere extension of his present misery with little prospect for relief. Foresight is filled with the expectation of failure and that undertakings will not be rewarded. Consequently there is very little motivation to do anything but avoid activity, often leading to dependency on family and friends for the accomplishment of elementary tasks. If goals have been set, they are often unrealistically high, filled with 'shoulds' and 'either-or' premises. Subsequent failures are then taken as further evidence of inadequacy.

The person who has developed this nucleus of negative cognitive patterns has the necessary vulnerability to environmental and social stresses to become depressed. The 'triggers' may be situations reminiscent of early trauma, illness or physical incapactiy, frustration and thwarting of goal attainment, lowering of self-esteem, isolation or sudden loss. The effect of the reaction is a constriction of the cognitive field and a selective inattention to many other areas of interest, making them unavailable to the patient. The patient is literally incapable of assimilating positive environmental feedback. The following quotation illustrating the personal and cognitive effects of depression, is from an actual case.

> "There was a real world all around, but I seldom saw it. I walked familiar streets, but saw no friendly houses, there was only the echo of my footsteps in an empty gloom."
>
> Knauth, 1976

The agency responsible for the maintenance of depressive cognitions is thought to be cognitive structures or schemata, a concept borrowed from the structuralist theories of Piaget. Structures in the theoretical sense have the characteristic of being a unity which is 'structured' by a specific set of lawful transformations whose activity produces no effects outside itself and which is self-regulating (Piaget, 1970). Self-regulation, in terms of psychological structures (as opposed to logical or mathematical) refers to transformations which unfold in time and are subject to correction or feedback, that is, learning and memory depend on antecedent structures which may accomodate modifications due to contact with the environment. At equilibrium, an entirely new or recast structure will result.

Cognitive Theories

In Beck's (1967,1978) theory of depression, cognitive structures are relatively enduring and organized representations of prior experience, which condition and codify the full range of internal and external stimulation. Through repetition, depressogenic structures replace more advantageous ways of evaluating experience. Recall is not only negative but also acquires the characteristic of rigidity and absoluteness seen in the early moral values of children. This has led Beck to speculate that depressive schemata are very durable and developmentally early structures stemming from the patient's childhood years.

The tacit assumption often has been that behavioural disorders in depressed persons are due to a distortion in the information stream (feedback) to the person or at least in its utilization, that is the person's behaviour is incongruent with the environment. Coyne (1976) presents the view that both the individual and his environment conspire actively together in mutual manipulation to maintain a depressive spiral ie. a "mutually causative deviation-amplification process." The same dynamic is true in other psychopathology as well; for instance one may be quite paranoid but chances are that the perceived antagonism and conspiratorial behaviour is often quite genuine. As Liberman and Raskin (1971) have pointed out, depressed persons often elicit avoidance, guilt and hostility from those around them. The essential point is that there are still active but negative processes that maintain pathological behaviour and which cannot be explained entirely by isolation alone. Depressive feedback persists and this, at some level, makes the depressed person's behaviour congruent with his environment.

Behavioural Theories

There are several behavioural formulations of depression, including Ferster (1973,1977), Moss and Boren (1972), Liberman and Raskin (1971), Burgess (1969), Lewinsohn (1974), Kanfer and Saslow (1965), Costello (1972), Wolpe (1971), Lazarus (1968) and Peter Mclean's concept of communication deficits (1973,1975). Two excellent reviews are given in Akiskal and Mckinney

(1975) and Eastman (1976). Only a couple will be mentioned here.

Functional analyses of depressed behaviour were conducted by Ferster (1966,1973) and Moss and Boren (1972). These formulations emphasize loss of reinforcible behaviour, ie. a decreased frequency of behaviour that is intrinsically reinforcing and capable of eliciting reinforcement as the common denominator of all depressions. Other factors such as those that determine thoughts and feelings (cognitive factors) are viewed as consequent upon the primary datum, low frequency of behaviour. It is claimed that a purely topographical or content analysis, emphasizing thoughts and feelings, does not discriminate between controlling and dependent variables. Thus one dependent variable may be attributed to another while nothing is said about controlling factors. It may not be clear that behaviours of similar appearance may fall into different functional classes, while behaviours of different appearance may be in the same functional class. Crying, for example, may be associated with grief or with physical trauma, whereas crying and insomnia may both be related to persistent low social reinforcement.

Moss and Boren (1972) define two environmental conditions that may result in depression, namely 1) insufficient positive reinforcement and 2) aversive control. Insufficient reinforcement has been described along parameters of frequency, magnitude, duration and the amount of behaviour necessary to obtain reinforcement (response cost). As the frequency and magnitude of reinforcement decrease and the amount of behaviour required to obtain it increases, normal behaviour may fall out of reinforcer control. Depressive and idiosyncratic behaviour may then appear by default of the remaining repertoire.

Aversive control occurs usually through conditioned rather than primary aversive stimuli. They are associated with a reduction of positive reinforcement and pain so that the tendency is to avoid or escape them. For instance a man may do housework frequently simply to avoid his wife's nagging. In depression, where aversive control may be quite high, this often results in a passive rather than active repertoire whose net effect is to limit positively reinforcible behaviour. In a dyadic interaction, for example, the depressed person is likely to be negatively reinforced; he emits very little behaviour except to avoid an aversive situation such as having to speak up or total silence. Therefore, he passively prompts the other and complies and otherwise positively reinforces listener while he himself is under negative control and cannot come up with any positively reinforcible behaviour or initiatives.

The active aspect of the depressive repertoire has been mentioned by Lewinsohn (1969), Ferster (1973), Burgess (1969), and Freud (1917). In the first place, avoidance and escape may actually remove an aversive or dangerous stimulus, but again, with repetition prepotent avoidance behaviours eliminate positively reinforcible actions. Equally important, however, may be the conditioned acquisition of depressive behaviours concurrent with the extinction of normal behaviours. The very absence of the normal performing behaviours becomes the occassion for the reinforcement of depressive ones.

Lewinsohn reasons that lack of social skill, as a deficit in instrumental response capacity, is the necessary antecedent condition for depression; that is, a low frequency of response-contingent positive social reinforcement, due to poor social skills, may result in depression. Social skill is defined as the ability to emit behaviours followed by social reinforcement and not by punishment. The amount of reinforcement anyone gets depends on his skill in emitting reinforcible behaviour and the current availability of the reinforcers.

Lewinsohn has derived five operational measures which, conceptually, are very similar to measures used in some primate experiments. These help define therapeutic goals and discriminate between depressives and non-depressives: 1) The total number of emitted actions (usually quite low). 2) Interpersonal efficiency; a ratio of the amount of behaviour put out to the amount returned. 3) Interpersonal range; the range (number) of people he deals with. 4) Use of positive reactions; skill in reinforcing actions emitted towards himself. 5) Action latency; the appropriateness of timing in the use of social action and reinforcement. Data for these measures are derived partly from inventories such the MMPI but mainly from on-going interpersonal behaviour which is quantified and coded according to a schedule that yields categories of 1) Type of interaction eg information request v.s. criticism. 2) Content of interaction, 3) Negative v.s. positive interaction. 4) Source of action and object. These coded data constitute his five operational measures, which then become the object of explicit behavioural training.

There are many other significant and very interesting contributions to this field. To cite a number of examples there is Wolpe (1971) whose theory concerns 'neurotic depression' due to exaggerated reaction to loss, exposure to prolonged anxiety or failure to control interpersonal situations. A. Lazarus (1968) believes that depression is due to prolonged anxiety or insufficient reinforcement. Hiroto and Seligman (1975) have extended a cognitive form of learned helplessness to man. There is also Costello's theoretical reinforcer effectiveness and Peter Mclean's (1975) concept of inadequate communication skills. Restrictions of scope preclude an integration of all these factors.

The Pharmacology of Depression

The Biogenic Amine Hypothesis

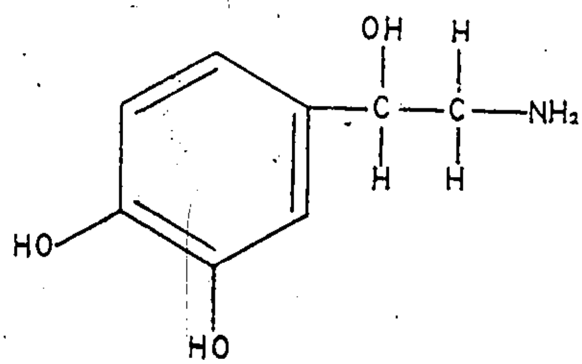
Early interest in the pharmacological aspects of depression was stimulated by the observation of behavioural side effects of such drugs as reserpine and iproniazid. Reserpine had been used as a tranquillizer and antihypertensive but it was noted that a small percentage of patients seemed to become depressed shortly after receiving the drug. Conversely, other patients receiving iproniazid for the treatment of tuberculosis seemed to experience an elevation of mood and behavioural activation. It is believed that the two drugs affected the availibility of neurotransmitter substances in an opposite way; that is, reserpine caused a depletion and inactivation while iproniazid prevented enzymatic degradation by monoamine oxidase and elevated the mood of the patient. This led to the formulation of the 'biogenic amine hypothesis' of affective disorders by Schildkraut (1965) and others. It says simply that depression is associated with a relative deficiency of monoamine neurotransmitters at functionally important receptor cites in the brain while mania is associated with an excess of the amines.

Regrettably, much of the accumulated evidence is not compatible with this simple hypothesis and problems associated with the indirect nature of the evidence and multiple drug effects have so far hindered efforts at a more definitive restatement. Comprehensive reviews of these topics may be found in Mendels (1975) and in Gallant and Simpson (1976) who conclude that a simple excess - depletion mechanism is not a sufficient cause for the development of clinical depression and that the exact role of monoamine metabolism is unclear at this time. Nevertheles, there remains the important clinical observation that patients given drugs that increase the availability of NE and 5-HT at central synapses often do get better, and it is the dibenzazepines or tricyclic antidepressants that usually fill this therapeutic need.

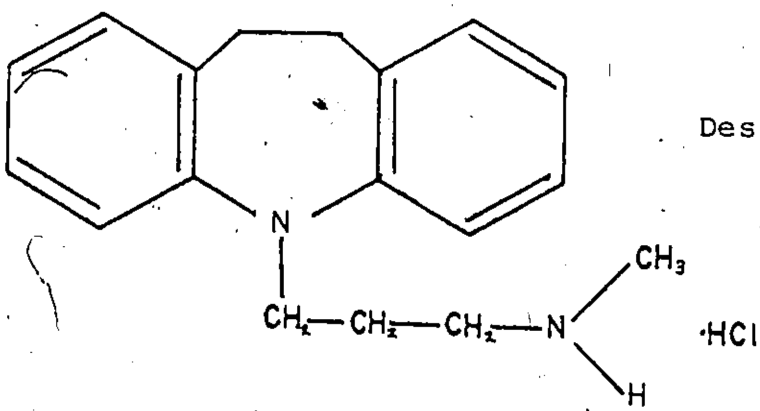
Tricyclic Antidepressants

the tricyclic antidepressants are a group of related compounds that have structure-activity characteristics similar to the phenothiazine antipsychotics such as chlorpromazine. The tricyclics receive their name from the characteristic three ring molecular structure, which with minor substitutions, is also shared by the antipsychotics. However few structural similarites between these drugs and the neurohumours have been determined (Goodman and Gillman, 1970). as may be surmised by comparing the structural formulae given in Figure 1

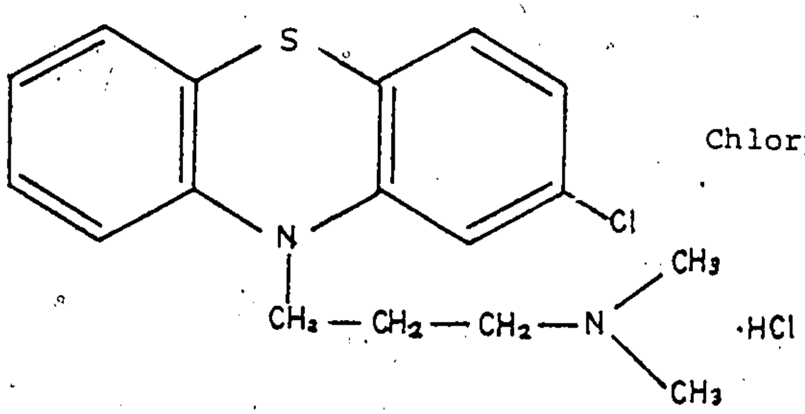
Figure 1: Comparison of structural formulae



Norepinephrine



Desipramine



Chlorpromazine

Desipramine (DMI or desmethylimipramine) is the desmethyl, or demethylated, derivative of imipramine and is its active metabolite, as nortriptyline is the desmethyl derivative of amitriptyline. When imipramine is administered, the drug is metabolized by demethylation to form DMI, which is then either taken up by the central nervous system or rapidly excreted. It is the active metabolite that has been suggested as the agent responsible for the antidepressant effects. The parent compounds and their congeners share a common mode of action; both inhibit the reuptake of released neurotransmitters thereby increasing their availability at receptor sites. Such inhibition further constitutes an interference in the normal feedback control of monoamine synthesis and results in an overall increased rate of turnover of the transmitter.

In this respect however, not all tricyclics are the same. The desmethyl derivatives, especially DMI, are more potent (ie. require a lower concentration) in blocking the reuptake of NE by the presynaptic membrane than the parent compounds. On the other hand, imipramine is more potent in blocking the reuptake of 5-HT. Neither drug has a strong effect on DA which is more strongly affected by chlorpromazine. The exact significance of this differential effect on the biogenic amines to the clinical problem of depression is not known at this time, but standard clinical wisdom says that patients who respond well to a brief pretreatment with d-amphetamine and/or who show low levels of urinary MHPG (a metabolite of NE) are more likely to improve with IMI and DMI rather than amitriptyline (Maas, 1975).

From the point of view of behavioural pharmacology, the phenothiazines and the tricyclics have been difficult to distinguish as both tend to suppress conditioned avoidance responding . (Iversen and Iversen, 1975). With food reinforced behaviour, both types of drug produce dose-dependent decrements in responding on FR schedules and tend to flatten the scalloped pattern seen on FI schedules. By more indirect means however, it has been shown that the tricyclics and not chlorpromazine antagonize the depressant effects due to chronic reserpine treatment, and potentiate the stimulant effects of amphetamine. From the clinical perspective, an important distinction may be that while DMI and other tricyclics are ineffective in quieting and calming agitated patients, they do bestow a lightened affect on non-anxious depressed patients after about two weeks of pre-treatment. The effect has been described as a "dulling" of the depressive affect rather than directly mood elevating or euphoriant.

Early Psychoanalytic Theories

Hospitalism

R.A. Spitz was not the first to investigate and speculate about the relationship between separation, anxiety and depression, but in 1945 he shocked the psychiatric world with his two now-classical papers on Hospitalism (1945) and Anaclitic depression (1946). By the first term, "hospitalism", is meant a vitiated condition of the body due to long confinement in a hospital, or the morbid condition of the hospital atmosphere. "Anaclitic depression" is a syndrome that results from the loss of the mother figure and which is characterized by weepiness, withdrawal,rejection of the environment and contact. His work took place in a foundling home and a womens' jail (called nursery) where inmates kept and cared for their infants. Both of these were in an unnamed Latin American country. He emphasized at the outset that hygienic and nutritional standards in both places were not only adequate but impeccable; a somewhat surprising conclusion since he himself pointed out that "foundling home" was grossly underfinanced and understaffed. The infant population he observed in both institutions ranged in age from 3 to 18 months.

The main difference between the groups, according to Spitz, is that the infants of "nursery" had a mother that was constantly available to provide nourishment, stimulation, communication, security and love. There was an unbroken bond of "attachment." The poor infants of "foundling home" had little of that; their mothers came to nurse them for a period of about 3 or 4 months , after which they were left in the care of one nurse who had 7 other babies and many duties to look after.

After the mothers left , the infants regressed to the level of "imbeciles" as Spitz puts it. They were constantly subject to multiple infective illnesses, gastric disturb- ances and sleep disturbances. They became withdrawn and fearful; most could neither walk nor talk and many simply wasted and died. His graphic descriptions leave a strong impression on the reader. In contrast to these "lostlings" stood the active babies sequestered in nursery with their mothers. While their development was not brilliant (they were also a strongly disadvantaged group) they nevertheless progressed satisfactorily considering their humble origins, comparable in fact, to village children in normal impoverished families.

One of the most glaring differences, which was noted (but subsequently forgotten) was that foundling home children were a physically ill lot. Healthy minds do not arise out of unhealthy bodies, as the ancient Greek ideal says. Another is that nursery babies enjoyed plenty of sensory stimulation from the mother but also from the sight of other babies and activity in the room and from numerous toys and objects of manipulation. Foundling home babies had few toys, no mothers and could not see outside their cribs. Lastly, but not least, nursery babies were picked up, played with, helped to walk and allowed a good measure of free movement. Many foundling home babies, by sharp contrast, could not even move to turn over. Hollows worn in their mattresses effectively prevented all but the oldest babies from moving to any significant degree. They were virtually social isolates with nothing to do but stare at the ceiling and play with their hands, feet, genitals and feces. Spitz described the numerous bizarre stereotypies as catatonic motility.

It was in _Anaclitic Depression_ (1946) that Spitz formalized the clinical syndrome and completed some theoretical speculations (which will not be reviewed here). Anaclitic depression was defined as such mainly for reasons of psychoanalytic theory current in 1945. It was termed anaclitic because the entire sensory and motor aspects of the ID drive are geared to receive gratification passively by an adult's intervention, not through the infant's own activity. That is gratification of basic id drives, bodily needs and narcissistic needs are accomplished through anaclitic social relations. Anaclitic depression is thus triggered by the lack of the mother and may be corrected by her return. In this way it differs from many adult depressions.

The formal syndrome is based on three cases from 123 maternal separation events in the nursery group. The symptoms of anaclitic depression fall into 6 classes.

1. Apprehension
2. Lack of contact
3. Retardation of development
4. Loss of appetite
5. Insomnia
6. Depressive physiognomic expression.

The time-course of the reaction to separation observed by Spitz is given in broad terms and is rather variable, depending on age etc. Following the removal of the mother, the child's previously happy mien would be replaced by crying and implaccability. For two weeks or so, the babies were difficult to approach. Sleep would be excessive or missing. In the weeks following this, the reaction deepened to one of apparent despair. Indifferent to the external world and people , a separated infant would weep quietly, sobbing with an expression of profound suffering. By the third month the reaction would deepen even further, the child might cease to show apprehension, become blank with an immobile rigid expression on the face,often lying motionless ,refusing to sit up. Many of the characteristics described earlier under "hospitalism" would appear in extended separations. A timely restitution of the mother, especially when this final sequence has not yet evolved, usually brought a quick recovery in the infant, although probably with some lasting trauma. Goldfarb (1945, 1947) later tested a group of children who underwent previous separation and was able to show that they indeed did suffer lasting deficits on tests such as the Bender Gestalt and Stanford-Binet.

Spitz admits that he saw the full syndrome in only 15% of the children he observed, and another 21% showed it to a lesser extent. He therefore concludes that separation from the mother is a necessary but not sufficient condition for the development of anaclitic depression. The effects of race, sex and intelligence were deemed unimportant in the syndrome. Curiously, Spitz also dismissed the effect of age; a conclusion most later writers would dispute. For Spitz, the mother or anaclitic aspect in the ontogeny of the reaction was paramount. Other factors such as perceptual-motor deprivation were also dismissed; his own words say it best. At the early age of 6 months, a baby cannot appreciate the real purpose of an object but is only able to use it in a manner adequate to his functional needs.

> "our thesis is that perception is a function of libidinal cathexis and therefore is the result of the intervention of an emotion of one kind or another. (sic) Emotions are provided for the child through the intervention of a human partner i.e. by the mother or her substitute."
>
> Spitz (1945) p67

One significant aspect of this position is its great emotional appeal (in the rhetorical sense) and motivationg force. Mother-love came to be viewed almost as a unitary, undefinable essence of the caring person, a construct sufficient in itself to explain the events of separation. This somewhat anecdotal approach was eventually supplanted by Bowlby's more experimental line of thought. However, in order to properly understand Bowlby's theory of anaclitic depression, attachment and separation anxiety, anxiety, I shall briefly present the more general psychoanalytic model stemming from Freud, from which Bowlby borrows heavily.

Freudian Theory

Freudian theory dealing with the relation of melancholia, anxiety and defense is given mainly in two of Sigmund Freud's later writings, Mourning and Melancholia (1917) and Inhibitions, Symptoms and Anxiety, (1926). Very briefly, Freud[1] reasoned that the loss of the loved object

---

[1] Neo-freudian psychoanalysis has produced several variant attempts to explain separation anxiety eg. Melanie Klein

resulted in anxiety and hostility, and that hostility directed at the self brought on feelings of guilt, worthlessness, mourning and melancholia. Anxiety was seen to result in the operations of defense.[2] Freud thus affirms that missing someone who is loved and longed for is the key to understanding anxiety and depression.

The following quotation from Bowlby is his attempt to paraphrase psychoanalytic thought on the topic of separation.

> "anxiety is a reaction to the danger of losing the object, the pain of mourning to the retreat from the lost object, defense a mode of dealing with the anxiety and pain."
>
> Bowlby (1960) p92.

The high impact, emotionally charged writings of R.A.Spitz provided much of the impetus and background for later separation experiments with monkeys. It remained for John Bowlby however, to provide a comprehensive, psychoanalytic theory with ethological leanings to tie all observations together in a form acceptable to primatologists in the 1960's.

----

and the theory of oral aggression or the Rank theory of birth trauma.

[2]It is the characteristic of self-abasement that distinguishes melancholia from mourning.

<u>Attachment Theory and Separation Anxiety</u>

Bowlby's attachment theory rests on a deduced behavioral base that is supposedly common to both man and animals and is almost an integration of psychoanalysis and ethology. Theoretical changes derive from the observations that some animal behaviour is instinctive or innate. Bowlby replaces the id and the instinctive libidinal system with an instinctive system of attachment behaviours. Bowlby reasoned that all animals possess instinctive behavioural systems leading to attachment to adults because this has a very high survival value for the young. It is noted that animals in a pressing situation tend to do two things (1) They escape <u>from</u> a specific situation or object and (2) They flee <u>to</u> a specific situation or object i.e. to a specific tree, burrow or house and to a specific care giver. These behaviours demonstrate attachment. The work of Lorenz (1950, 1970) demonstrates the cross-species validity of this position. This theory understands the separation reactions seen in monkeys , ape and man as homologies of each other.

Now, the model proposes an instinctive behavioral attachment system with two characteristics

1. An activating system biologically attuned to situations dangerous to the species and the individual.

2. A termination system biologically attuned to the mother.

In this theory, the reaction of anaclitic depression is likely to occur whenever an instinctive behaviour-attachment system is activated and fails to be terminated, as for instance when a child is lost and the mother is not there. Initially there will be a period of frantic and fearful hyperactivity labelled 'protest' followed by, as if exhausted, a period called 'despair'. This is the period that looks most obviously like a depression; positive behaviors are diminished overall along with a rise in sullen resistance. If the parents are returned during the course of these reactions the child may refuse to accept them immediately. This is called 'detachment.'

Bowlby was aware of the maturational effect implied in his observations. Being sympathetic to Piaget, Bowlby expects the human infant to arrive at full insight into the mother's leaving at about 9 months. Separation anxiety however is still possible before 9 months because it has two components as well: (1) Separation anxiety is initially always a form of unconditioned "primary anxiety", a biological datum ; (2) A learning component called "expectant anxiety" which matures at 9 months and which is superimposed on the first.

The numerous behavioural events (crying, sucking, following, clinging, running away/to) comprising the instinctive system, interact in complex ways in the dynamics of a social situation. When the system is active and free to flow and reach termination, what is experienced is an urge to action accompanied by an emotional state peculiar to each behavioural response. When the system fails to terminate, tension and anxiety or incongruity are experienced. Thus grief and mourning are the psychological processes that occur when attachment behaviors are activated but the object is known or believed to be permanently unavailable. In the infant the experience of separation anxiety will be a more generalized and undifferentiated mass response.

In the final analysis, separation anxiety is a special case of primary anxiety. The impact of anxiety resulting from a separation from the mother or peers is an age-related function. The period in life of greatest vulnerability is whilst the system mediating the activation of attachment and escape is easily activated to a high intensity and when the system mediating termination is narrowly focussed on one or a few figures. Thus young children under 6 years and pairs in old, established relationships are most vulnerable. The inordinately heavy investiture of energy in one or a few inportant people (pivotal reinforcers) prevents a quick and easy redirection or restitution, which is possible only by a heavy cost in the labour of mourning. At a critically young age the incipient ego would be stripped of its security and attachment. Lacking coping skills to deal with the hyper-arousal and exhaustion, it would be exposed to the full impact of separation anxiety and necessarily fall back on defense mechanisms.

In human experience, the trauma of previous separations is supposed to sensitize the individual to a similar experience in the future. Conversely several traumatic separations are expected to blunt the individual to emotional involvement and attachment at later times. Often such people turn to the neurotic self reliance of the "burnt child" syndrome. Several common child rearing practices are likely to lead to separation anxiety in the child. For instance, banishment to a room or the threat of withdrawal of love, which are commonly used to enforce obedient behaviour, may be perceived as separations. Thus a child may become extremely sensitive to conscious or unconscious separations or threats of separation. Bowlby speculates that children who have an ambivalent relationship with their parents or those who experience ambivalence or hostility from their parents are more likely to become depressed. Children who are spoiled with attention by their parents are also thought to be more liable because spoiling is often a displaced form of hostility or a reaction formation. Of course any actual separations like extended hospital stays or overt rejections from significant others will have a powerful potentiating effect on subsequent psychic trauma.

In terms of mother-infant relations in macaques, several interesting parallels can be drawn between the predictions presented above and observable maternal behaviours. Suspected candidates for depression might be those infants who have had nipple or ventral contact refused often or those who have had to be most active in maintaining contact with the mother (Hinde, 1972). A monkey mother who monopolizes her infant to herself to a great extent might be expected to have a very depressed infant on separation. It has indeed been found, that in m. Nemestrina, a species which shows these traits more than most, the reaction to separation is quite pronounced. (Kaufman and Rosenblum 1967).

In the end Bowlby is not able to accurately say who will be depressed and who will not. He admits that individual differences are great and that some 'unattached' people are in all other ways not unusual. He drew an analogy of smokers i.e. some people smoke all their lives and do not get cancer (Bowlby 1978, presentation at the Ottawa General Hospital) Nevertheless, for Bowlby, instinctive behavioural attachments and their internal psychic significance are at the root of the organism's capacity for deep feeling and emotion. The monotropism of instinctive drives makes all attached individuals liable to some extent to depression. This last simple notion is the apparent theoretical base of Bowlby's work. Many primate experiments have proceeded in an equally simple-minded way. If the mother were removed, this would result in anaclitic depression in most of the infants; and in some it did, in others it apparently did not.

Challenges to the Separation Anxiety Theory

The presence of a 'true depression' in young children, even the possibility of it, is by no means a universally accepted truth in psychiatric circles. H. Rie (1966) notes the rarity of even the mention of depression in children. A review of several rather confusing psychoanalytic arguments, which assert the virtual impossibility of the phenomenon, is presented. The psychic structure of the young child is immature, undeveloped and hence cannot operate the complex psychodynamics found in the adult. The incipient superego, with its incomplete introjection of parental figures, is not capable of self-directed aggression and other hallmarks of adult depression. It is forced by virtue of its incomplete development, to continue to search for external objects of attachment rather than internalized ones. Prompt defense against loss of object cathexis is therefore of prime importance to the survival of the immature ego. This last conclusion at least retains a notion of the importance of object loss.

Stott (1962) however, argues that even separation may be a trivial event of only actuarial relevance to childhood psychopathology. He provides evidence that children seen in foundling homes are often that sample placed and pre- selected on the unexpressed basis of worst prognosis. Such children would have been placed because they had the poorest chance of survival at home. Frequently these children suffered from multiple concurrent infantile diseases and were intellectually and socially retarded. Based on such evidence, the thrust of his argument outlines factors of prenatal stress and congenital stress-related abnormalities as the basis of individual vulnerability to anaclitic depression.

Other Observations of Human Children

During World War two, Burlingham and Freud (1944) studied British children separated from mothers who were involved in the war effort. The children initially protested and cried loudly at the loss of the parents and then entered a period of apathy involving increasing loss of newly acquired controls of bladder and bowels. New attachments were made to a favored adult but behaviour towards her was often ambivalent; that is jealous attention seeking yet hostile. When the mother finally did return the children often refused to recognise her and remained detached. This reaction was not as prevalent with the fathers.

Much more systematic observations of separated children were made by several clinicians including Robertson, Bowlby, Heinicke and Westheimer. In the 1950's it was well known that maternal separation could have grave effects on future development, but individual differences seemed so diverse that little could be said with certainty. Thus Bowlby, Heinicke and Westheimer undertook more or less controlled observational studies of groups of briefly separated children (Bowlby, 1969; Heinicke and Westheimer, 1965) Their sample consisted of two groups of ten children two to three years old. Length of separation varied from 3 to more than 7 weeks. The separated group was observed before separation at home, during separation at the nursery and after reunion at home. The controls were seen at home only.

At the moment of separation, behavior changed dramaticaly from nervousness or quiescence to desperate screaming and sobbing. Crying and calling for the parents began to subside after three days but never disappeared. All the children had trouble sleeping during the first nights. In the first 5 days, there was a general resistance to the routine of the nursery. This declined thereafter but continued in specific forms. While resistance was the dominant response, attempts to seek a positive relationship with adults in the nursery steadily increased in the first 12 days. At the same time, the incidence of hostile behavior also increased and reached its peak on the days 10 to 12. Finally a subtle regression took place. The children spoke fewer different kinds of words during the first 12 days and all showed a significant loss of sphincter control.

The implications of and discussion on this study are very broad ranging. Some of the most important variables that were identified are; (1) age at separation (2) length of separation and (3) the presence of siblings. The age of greatest sensitivity to effects of this type of separation seems to be between one year and four. Generally the longer the separation the worse were the effects and the presence of a sibling tended to diminish the effects.

It must be remembered that the children in the above study went into a new environment where they received a great deal of kind attention and care. This is in stark contrast to some of the conditions written about a few years earlier by Spitz. Furthermore most of the children seen by Bowlby et al were at the preoperational stage and therefor had a broad repertoire of behaviours with which to try various coping strategies. They were old enough to initiate new contacts on their own. Although the condition of the children never became as severe as that seen by Spitz, the similarities are clear enough.

Physiologically Based Theories

Kaufman and Rosenblum (1967) have attempted a synthetic reformulation in the terms of better-described neural mechanisms. Basing themselves on constructs taken from many other sources, these writers tried to account for neural mechanisms, developmental state and psychological constructs such as social bonds in their eclectic theory.

Separated infants go through the three stages oft described by Bowlby on which there is general agreement. The initial "protest" stage is mediated by excitatory neural processes and functions through the sympathetic nervous system and its diencephalic counterpart, the ergotropic system as proposed by Hess (1954). This is a highly agitated state with a very limited and time-dependent survival value because of the extreme output of energy. For the separated infant, this state of "facilitated distress" normally assures a quick reunion with the mother. However when the mother is not able to return to the infant, continuing extreme excitement would be very dangerous. A rebound of the vegetative functions subsequently ensures that a second state of "suppression-distress" takes control. Now inhibitory neural processes mediated by the parasympathetic and trophotropic systems allow psychobiological resources to be conserved, even though the internal milieu of acute distress continues. This is the "despair" stage of separation. Conservation is achieved through marked inactivity and huddling together as previously described and protects the infant from exhaustion and a quick death.

What the infant is likely experiencing in more psychological terms is the unfulfilled expectation of the percept of the parent; that is, "biotaxic" stimuli, (such as warmth, softness, rhythm, odor, touch etc.) important in organizing the percept of the parent, are anticipated but no longer available. In other words, the organized gestalt of the parent has aquired a psychological and functional meaning (social bond) in the context of mother-infant interaction, in addition to its purely physical importance.

The state of suppressed distress, after several days of separation, becomes counter-productive as well in that it prevents effective group participation and endangers survival unless social relations are resumed. The data presented here as elsewhere, indicate a recovery at some point in the second week of separation, especially in more dominant infants. The missing parent represents an incongruity in the cognized environment of the infant. Redress of the incongruous input can be achieved in several different ways. "Defense mechanisms" may come to bear on the incongruous input and simply gate it out, in effect preserving old, centrally-mediated congruities without reference to external evidence. On the other hand new learning may take place as the infant learns to cope and regains social contact. New congruities in the cognized environment are formed, presumably relieving the infant of any attendant anxiety.

Primate Patterns and Sociobiology

Many genera are potentially vulnerable to separation anxiety and depression. The main requirement is only that they show strong attachment behaviors. Thus Senay (1966) proposed the use of dogs in separation experiments in order to study depression. Geese have also been noted to display acute separation reactions (Lorenz, 1970). Higher anthropoid primates have been the most thoroughly studied subjects. The varieties studied have included both new world and old world, including saimiri sciureus, several species of macaca, erythrocebus patas, pan troglodytes and of course homo.

The reason for this is clear i.e. higher simians and apes have often outstanding cognitive abilities, the young are dependent for a long time and form deep "attachments."

Their societies are complex and remarkably adaptive structures that include mechanisms of communication, regulation of conflict, social mobility and status. These and numerous other attributes bring them quite close to man. The following descriptions will outline some of the general characteristics of macaques that make them excellent subjects in the study of separation effects. They are also necessary for the full appreciation of these very complex animals and to avoid over-simplification of the experimental analogy.

Communication Patterns

Communication patterns in macaques are mediated by vocalizations, body language and touch. Communication in monkeys must be considered as expressive mainly of emotional states, (Dolhinow and Sarich, 1972). Monkeys do not seem to send specific intentional messages such as "get out of my way". Rather , what is felt as the emotional concomitant of a desired or felt effect is expressed, it seems, somewhat automatically. Such expressions may be conceived as releasing mechanisms that result in one or more specific responses from the group. A mild threat, issued as a stare and expressing felt dominance in alpha, will result universally in looking away or retreat by every other monkey. A sharp bark from a frightened troop member will instantly release flight by the whole troop, "women and children " first. Similarly, when a separated monkey "coos" or "whoos", one may be quite sure that it is feeling very bad.

Other forms of communication common to both monkey and man, in the wild and out , are expressed as body language and touch. A threat is likely to be composed of many postural and facial effects depending on the social context. A serious threat, for example, is accompanied by intense stares, a rigid posture, and an open mouth, sometimes with bared teeth. Humans and monkeys both are acutely conscious of the social stare. Ellefson (in Dolhinow and Sarich, 1972) gives an excellent account of how attuned to social situations monkeys are and the context specificity of their communication. Behaviour patterns are appropriate to dominance, status , oestrous, kinship, age, sex, the proximity of a particular individual. For instance a favoured female may be able to threaten a more dominant animal when in the company of her even more dominant protector. When not in his company such manipulation would not succeed. These patterns are in constant flux with the flow of social dynamics. Figure 2 is an adaptation of a diagram used by Ellefson (1972) in discussing the species of interest in this study, namely macaca Fascicularis.

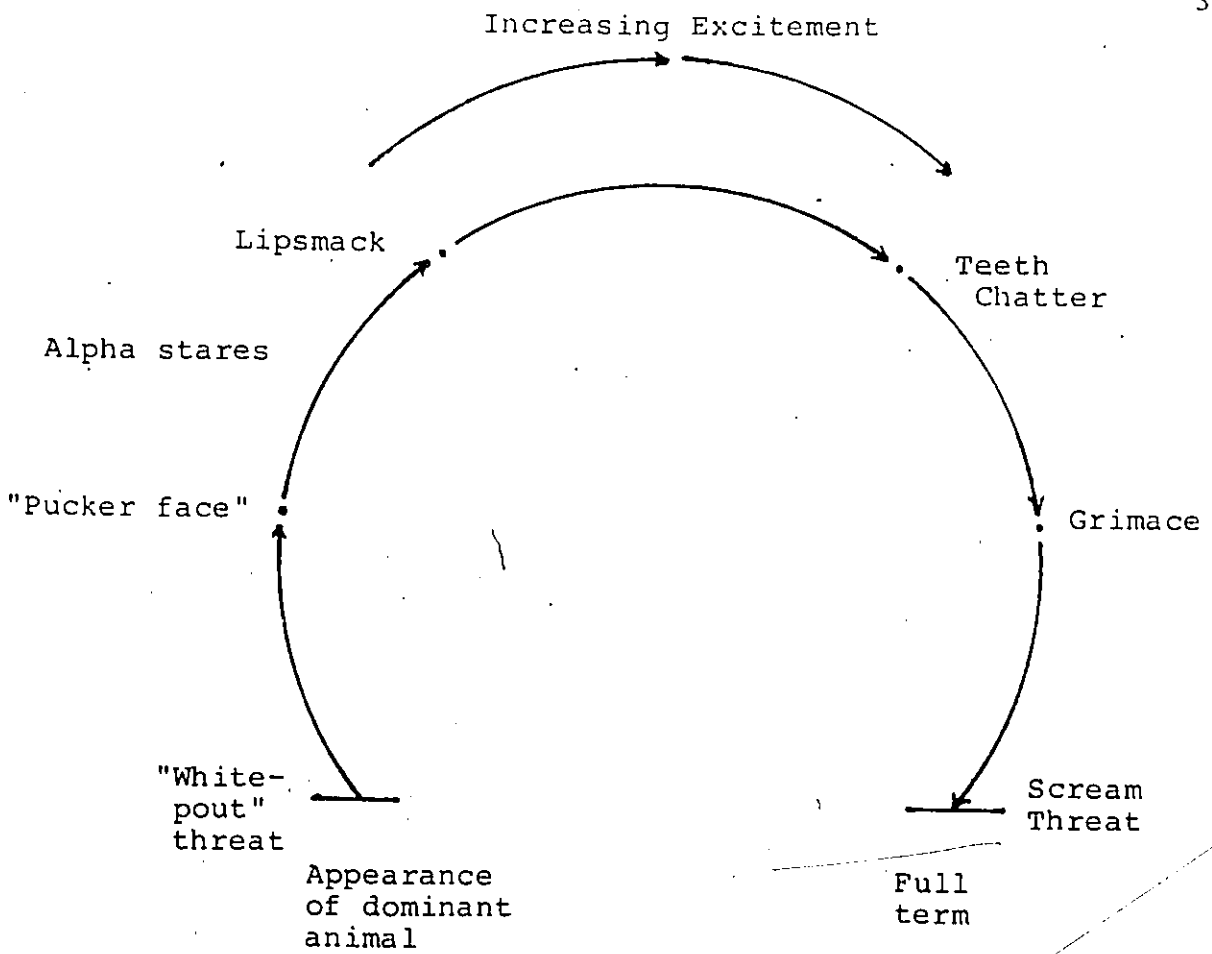


Figure 2: Adapted from Ellefson (1972)

The morphological continuum of facial expressions in a hypothetical social encounter with a human or dominant animal. Arousal increases clockwise.

This feature of context-specific, dynamic variability permits a very large and flexible matrix of communications exchanges. Signals may be fleeting and variable; eyes, ears, eyelids, teeth, hair, lips, limbs etc. may all be incorporated and graded according to intensity. Ambiguity is minimized when all concerned are mindful of the context. For the human observer, this is much more of a problem. An animal that is lipsmacking is neither being very submissive nor dominant, but may be at a point where an uncertain social/power encounter is imminent or where actions must be conciliatory. Should the animal's fear increase the lipsmack may merge into teeth chattering, with still more fear this will perhaps become a grimace or scream. In the laboratory, it was often observed that when an infant found the nerve to approach another adult female, it would approach hesitantly, lipsmacking or "grinning". Should the adult return what must surely be a baleful glance, the infant instantly scampers away in great haste.

Social Structure and Dependence

The most frequently seen social structure, at least on the ground, has been described as a series of concentric courts (Eaton 1976). The most dominant males are in the center, around them are their favourites and the dominant females. Around this court is the majority of the troop, mostly females and the young. At the perimeter are the "cadet" males, the group of lowest status. Such a general structure may not however be the rule. It has been suggested that this commonly observed structure is limited to terrestrial troops in situations where food is concentrated in one area such as when they are fed. In a predominantly arborial setting, the distribution of food and pressure from predators may result in quite a different adaptation of social structure. Clear dominance hierarchies mainly among males seem to be a universal feature of macaque society.

There is a considerable amount of sexual dimorphism in the genus. They are medium to large monkeys. Only males have imposing canines. Females average between 60 and 70% of the male weight. The range of weight in the female Java monkey is about 3 to 16 kg. (Jolly 1972). In most macaque species, the mother is the exclusive care-giver for the infant although other females may express interest or even steal the infant. Males play mainly an indirect protective role although an adult male may "adopt" an older infant or juvenile.

Infants are generally very dependent on the mother for about one month, however this dependency decreases rapidly until at the end of the third month the infant spends a large amount of time at a distance from the mother (Hansen 1966). At first the mother tends to restrict her infant's excursions. Later she is much more active in promoting the independence of the infant by increasing punishments, rejections, refusals of contact; behaviors which serve to commence weaning as well. Such maternal behaviours are moderated by the dominance status and parity of the mother and the sex of the infant. Fearful mothers are more restrictive than dominant ones and all generally are more rejecting of males in promoting indepencence.

Weaning is a gradual process that ends after one year or at the arrival of the next infant (Hafez, 1971). Infants nurse almost immediately after birth and are quite capable of clinging. Because the change from milk to solids is very gradual it is difficult to determine exactly when lactation ceases. Infants only one month old may be seen to mouth solid food but rarely eat more than a nibble before two or three months. At some time between six and twelve months the production of milk will have ceased. Then solids become more important but suckling continues, probably for non-nutritive reasons. A mother may continue to show maternal concern and protection for older infants years after they have become independent. Such maternal behavior establishes kinship systems along matrilines often spanning many generations. If the mother is very dominant this may become a virtual dynasty. The dominance status of the mother will be instrumental in the rise to social power of her sons, and to a lesser extent, her daughters. Such a male is more likey to remain in the center of the troop, be obviously self-confident and secure. The son of a very subordinate female will have quite a different learning history. He will be subordinate himself most likely, lack security and confidence, will tend to be excitable and aggressive and will generally have a much harder time at the periphery of the troop.

Natural Habitat and Behaviour

In the wild, macaques are distributed over a considerable area, always in tropical climates except in Japan. Sociobiological variables differ considerably in the forest macaque from the common city or temple variety. Urban rhesus in India show a much higher level of aggression, xenophobia and territorial monopolizing. On the other hand they seem much more "sophisticated" and crafty than their country cousins. By contrast, rhesus living at the forest edge are more relaxed, have a home range that may overlap considerably with other troops and are generally healthier. (Bourne, 1974)

The macaques are semi arborial; they move well in trees. While on the ground, the preferred mode of locomotion is quadrupedal but bipedalism is freqently seen when they are carrying something off. The Java monkey (macaca Fascicularis), the subject species of this study, is a close cousin of the rhesus, but is generally somewhat smaller. Like the other macaques, it is an old world monkey belonging to the family cercopithecoidea. It is variously called m. Irus, crab-eating monkey and cynomologus monkey as well. Its natural habitat is formed by coastal areas of mangrove swamps and rubber forest or mountain forest along rivers (Furuya 1961). Troop sizes vary from 30 or so to 70 or more. The sex ratio varies from 2 to 5 females per male. In many respects, descriptions applicable to the rhesus are also applicable to this species.

When discussing the natural behaviour of wild monkeys, the question naturally arises as to differences between free-ranging behaviour and laboratory behaviour. Can one generalize from behaviour and an environment that is not "natural" ? To some extent this is a false issue, at least to the extent that there is no ultimately natural behaviour. All primate behaviour is an impressive and complex adaptation to its setting. Note for instance the difference between city and country rhesus. No cultural pattern is immutable. Thelma Rowell (1962) describes second generation male hamadryas baboons in captivity who have largely ceased their typical "species- specific" herding of females.

In practice the essential thing to be aware of is the characteristics of the group under study and the characteristics of those to whom the generalization may eventually be applied. It is necessary to understand the functional relationships of the behaviour of each group with its particular environment. This is important in order not to mistake an artifact of behaviour due to some environmental factor for an effect due to the treatment. An intriguiging example of such discrepancies is the finding by G.Meier (1965), that in his laboratory colony, socially isolated monkeys displayed adequate social, sexual and maternal behaviour after receiving ostensibly the same form of isolation used by Harlow.

Animal behaviour in cages or a colony is known to vary in certain general ways from wild behaviour. Experiments have shown that a physical environment in which macaques are forced to constantly face each other induces greater aggression, often severe fighting leading to death (Erwin, 1977). The addition of some simple forms of cover and diversion can prevent this.

Each animal has an individual distance which it would prefer to maintain around itself in the presence of its group and conspecifics. Similarly, animals will maintain a "flight distance" or the minimum distance between itself and a potential enemy. This distance can be modified by learning, but many species will be disturbed by the presence of observers. Housing that violates these social dynamics may cause serious problems.

Monkey mothers are also known to behave somewhat differently towards their infants when confined in a small cage rather than a large cage or a gang room. In the small cage they will tend to be more irritable and punishing to their infants. Newly formed groups as well tend to undergo a great deal of tension and fighting until the social heirarchy is stabilized. Cage environments may be generally regarded as being more stressful but simple-minded comparisions are not always possible.

After these caveats, it is encouraging to realize that what one sees in the field one can generally see in the colony or laboratory as well. The difference is that some types of behaviours may simply not have the chance to occur, as a result of design. Forms of communication are among those behaviours more resistant to change.

The type of questions one wishes to ask must determine the kind of environment in which one studies the subjects. For the purposes of the present experiments, the mother-infant relationship remains intact except of course at the time of separation. It is also expected that the typical forms of interaction within the mother-infant dyad will not change. Normal infant social learning should proceed adequately because contact is permitted with social peers and other mothers.

Research in Maternal Separation

Conceptual Approaches

The basic approaches to the problem of depression in primates may be divided into 2 strategies, one simple and the other more complex. The first more common strategy may be compared to the shot-gun approach; that is, infants are separated and scored on as many relevant behaviours as can be identified, or scored on as many behaviours as possible, from which a smaller more managable number of groupings is isolated. This is the approach that characterizes most of the separation studies published (Seay and Harlow, 1965; Kaufman and Rosenblum, 1967; Erwin, Brandt, Mitchell, 1973; Hinde, 1966). This approach is useful because one can identify many relevant behavioural items through it and possibly even a "depression profile" based on the range of items under study. There are, however, many obvious limitations to this plan since all specificity for the particular separation conditions is lost. Colony social dynamics and artifacts specific to the laboratory and its procedures are lost sight of and only add to the unexplained variability. In this approach, variability can only be dealt with by nonspecific experimental contols and design factors.

The other more difficult strategy involves the identification and monitoring of behaviours in their interactive relation to other behaviours and their functional relation to ongoing social and laboratory events. Only this approach can hope to arrive at some explanation of why some animals get depressed and others do not in apparently the same situation.

The papers by Gewirtz (1972), Cairns (1972), Ferster (1966), Chappell (1972), Chappell and Meier (1975), Spencer-Booth and Hinde (1971), Hofer (1977) and Reite (1977) offer some clues, if not a methodology, on behavioural and physiological relations and their quantification. Chappell exemplifies the most qualitative approach to behaviour relations. She paraphrases her data as a record of "who does what to whom, where and in whose company." Work at their laboratory has accounted for the dynamic mutual stimulus-responding of the mother-infant dyad. Hinde's work exemplifies an approach of using complex measures derived from quantification of simpler observational data. These two approaches are similar to the methods of Lewinsohn (1974) and Mclean (1975) in human behaviour therapy for the treatment of depression. Lewinsohn relies heavily on quantified observations of a patient's interpersonal behaviour and its consequences in order to provide the client with therapeutic feedback information. The quantified measures he derives are similar to those of Hinde's in concept and may be of heuristic value in future experiments with monkeys. Greater developments in the functional approach await a study in which the experimenter can demonstrate a functional point of intervention, other than the separation, which shows stimulus control over behaviours being studied.

Primate Separation Experiments

Systematic and controlled experiments with macaque monkeys began in the 1950's when such men as H.F. Harlow started to investigate the nature of the mother -infant bond. This was the famous series of experiments using wire and cloth mother surrogates (Harlow, 1958, 1959). Separation of pairs began in 1962 and was replicated a number of times thereafter (Seay, Hansen and Harlow, 1962, Jensen and Tolman,1962); Seay and Harlow, 1965; Hinde, Spencer-Booth and Bruce,1966; Kaufman and Rosenblum 1967; Mitchell, Harlow, Griffin and Moller, 1967) Reaction to separation in monkeys, as in humans, proved to be quite predictable in gross terms. Immediately after separation the infants screeched and cooed incessantly. They were agitated and obviously very frightened. Pacing and searching head movements were very frequent. Kaufman and Rosenblum report a lack of sleep throughout the first day. From about the second to the ninth days, the pattern changed to one of despair and dejection. There is little locomotor activity and a virtual cessation of play. The qualitative impression is one of sadness and grief. Thereafter play behaviour and social contact increased as a gradual process of recovery occurred. Upon reunion there was an intensification of mother-infant behaviours; some have mentioned the possibility of "detachment" episodes (Abrams 1969), that is, non-acceptance of the mother. Although this has been observed by Bowlby and others in humans, its occurrence has not been generally reported in monkeys. A more complete description of the reaction is given below and may be found in any of the studies referenced.

In the mid 1960's, there was a gradual shift of inquiry away from emphasis on the nature of the mother-infant bond per se to investigating the relation of the bond to experimental depression. The work of Spitz and Bowlby had gained wide acceptance and early work of Harlow and others provided the experimental methodology of separation. Early calls for an animal model of depression along separation lines came from Senay (1966) who proposed the model in dogs. The following year, Kaufman and Rosenblum published their experiment and interpreted it in the light of an eclectic theory of depression of their own based largely on the psychoanalytic conservation-withdrawal theory of Englel (1962). By 1969 the consensus was that maternal separation in primates approximates very well the anaclitic depression syndrome described by Spitz and Bowlby. The investigation of the primate model had begun. Mckinney and Bunney (1969) published a work specifically titled "Animal Model of Depression" in which they discuss the reaction to loss in various species and the importance of this to drug research in particular.

The basic strategy of simple separation and observation has been used by most studies published in the area (McKinney et all 1971,1973,1976;Suomi et al 1973,1976; Laurens 1973, Preston 1970,Schlottman 1972; Kaufman 1968,1978, Hinde 1977 and the present study) however the terms of investigation and discussion have been broad. Thus we find a generally high level of consistency from most early and later reports concerning the depressive effects of maternal separation. Most monkey infants, except bonnets and patas it seems, follow the classical protest-despair pattern. However, inconsistencies in the model were apparent; some infants became very depressed, others a little and still others hardly at all. Timely and well argued criticism of the field came from Chappell and Meier (1975) who stated that variations in design, testing procedures, species and a lack of base data made comparisons difficult not only across studies but within studies as well. They called for greater standardization of procedures.

Moderating Variables

Reports on various factors influencing the mother-infant relationship and the outcome of separation are somewhat equivocal, perhaps for the reasons given by Chappell and Meier (1975). Several studies, still within the same basic separation paradigm, have attempted to identify variables affecting the infants' response to separation,(McKinney, 1973,1977; Chappell and Meier, 1975; Suomi et al, 1976,1970; Hinde, 1977; Jensen, 1968; Mason, 1974).

Age is an important variable in monkeys as it is in humans. The development of the "fear response" (Sackett, 1966, 1970) has already been described. Infants only 2 months old do react with the typical separation pattern but infants 3 months old apparently react more severly than either younger ones or older ones, (Suomi, 1973; Mitchel, 1970) Generally, the effect between 3 and 7 months will go to full term. In older infants the effect becomes more variable while in juveniles it may be distinctly different.

The effects of the sex variable has received contradictory reviews. McKinney (1977) concluded that there is little evidence that either males or females are a priori more prone to depression following separation from the mother.

Genus, species and race have been examined as relevant variables. There is no primate form that has been studied that is inherently immune to depression following separation. However, some species such as m. Radiata and erythrocebus Patas have developed social patterns that might provide a measure of restitution in appropriate situations. With proper design and controls however, these species will react in a way similar to the others (Kaufman, 1978).

The object of attachment-separation has been considered as an important variable. Theory would lead one to expect that separation from any object that is imprinted upon the infant will lead to the typical protest-despair reaction. Infants raised without mothers, for example, but with peers do show the reaction when separated from them. On the other hand, separations of older peers had been rather unsuccessful until recently. Usually such pairs have been together for experimental purposes for a relatively short time and were raised by natural mothers besides. Very old, established, especially heterosexual or consort, pairs may react more severely. Tinkelpaugh (1928) reports self-mutilation in a male rhesus when separated from his mate of long standing. Harlow has reported that infants raised on cloth surrogates react with fear and immobility when separated from them.

One naturally expects the length of separation to have important consequences. Infants have been separated for a few minutes or hours (Jensen and Tolman, 1962), to several days (Hinde, 1966) to several weeks (McKinney et al, 1973) to permament separation (Suomi, 1973). In general one can safely say that the longer the separation the more traumatic it is for the infant, assuming that other factors are constant. The important issue here is the time course of the reaction. A very short separation may not be long enough for the despair phase to become manifest.

The degree of attachment and degree of separation -isolation are two obviously important variables, and will be extensively discussed below under the next section.

Physical and Social Environments

The discussion of the physical and social environment must be considered under the conditions of separation and non-separation in order to fully account for their important effects. The two factors are, to some extent, co-determinant of each other as well as the degree of separation. The type physical environment used to house the monkeys must, of course, affect their social dynamics. Covarying with these general aspects are the more specific stimulus properties of the environment. There are physical and social enrichment / impoverishment parameters and emotional variables relating to the social environment.

Gang Environments in Separation

One of two major types of social and physical environments has been used in most studies. One type is the "gang cage" as was used by Kaufman and Rosenblum (1967), Suomi et all (1973) and others. In this situation there are usually several adult monkeys living as a group. Normally there will be one adult male and two or more females and young. This might be considered a somewhat more "natural" social situation. Certainly the possible social experiences to which the infant is exposed, in this environment, is much more varied and enriched. A greater social repertoire is therefore expected in these infants.

At the same time, it is known that monkey groups in a gang situation experience more social encounters and must tolerate closer individual distance. For this reason the level of tension will generally rise (Erwin, 1978) and the dominance hierarchy will generally become more rigid. The net effect is likely to be a polarization, with dominant females in control and submissive females becoming even more fearful and submissive. Evidence for this may be seen in the higher levels of plasma cortisol in submissive females (Erwin, 1977). The learning histories of the infants will be conditioned by the social responses of the mother and her place in the power structure. Submissive mothers are more fearful, will tend to restrain their infants more and monopolize the infant. Usually she will allow fewer other females (aunts) to approach the infant, especially not the dominant ones or the male. The infants of dominant females in any environment will have a more relaxed mother and learning history. Their mothers tend to restrain them less and are much less worried by interest expressed by other females. As a result there will be infants with widely divergent social experience and competence.

The experiments of Kaufman and Rosenblum (1967) illustrate these effects . Three of their four pigtail infants become depressed in the classical pattern, sitting in a slumped posture and disengaged from each other and the physical environment. A fourth infant, who belonged to the dominant female, did not become depressed. This was probably because that particular infant was known and accepted by the other adults of the group and was able to spend much time with them and thereby achieve some degree of restitutuion. The other infants of the non-dominant females also made attempts to approach adults but were rejected. This example can also serve to illustrate another important aspect, that is the physical/social environment during separation. In this case the infant remained in the same complex social environment while the mother was removed. Everything remained the same except the absence of the mother. What changed was the universal social rejection.

Experiments by Chappell and Meier (1975) found that infants separated for six days and left in the familiar environment showed the typical signs of despair whereas those infants that were removed to a different cage while the mother stayed behind became more agitated than despairing. Hinde (1972), using a much longer separation period, found much the same result. Infants removed and separated were agitated for several days but did also eventually show despair.

Mothers returned to the group must contend with the re-establishment of their social position in the heirarchy as well as resumption of the mother-infant bond. Some mothers have more trouble than others and even lose their former position of status. These mothers have less time to devote to their infants and so the mother-infant relationship is further disrupted. The infants of these mothers were observed to be in a continued state of disturbance some time into the reunion.

The problem of state regulation or control of high arousal for an already agitated infant, reunited with a mother who is also over-aroused is considerably more difficult than that experienced by a depressed infant reunited with a mother in relative peace who is able to give proper care. Separations of the type where the mother is removed and reunited after 3 or 4 days may have overall more deleterious effects for the pair, depending on the state of arousal of the mother and the quality of care she is able to provide. On the other hand, if the infant only is removed while the mother stays behind, the mother's social relatiohships are not disrupted. These infants were seen to recover more quickly on reunion.

The quality of the mother infant relationship during different phases of the experiment and the quality of care received by the infant during these phases can now be identified as one of the the most crucial psychological variables in determining the response of the infant to maternal separation (albeit these are still on the level of hypothetical constructs rather than parameterized variables).

Cage Environments in Separation

Other ways of manipulating the mother-infant bond and the quality of care giving, are by the use of the second major kind of spacial-social environment and by the type of separation used. The homecage/playpen apparatus used by Seay, Hansen and Harlow (1962) is the prototype of this kind of environment. It consists of 2 to 4 home cages attached to a common playpen. Small doors bar the mother's entrance into the playpen but allow the infants free access. (see Figure 3) Under baseline conditions this allows an infant a range of social interactions almost as wide as that in the gang cage while holding the variables of maternal status and its social consequences relatively constant. Thus a particularly fearful mother will not need to contend with constant harassment from other adults or the male and may allow the infant greater freedom of movement. Hopefully this will result in a freer kind of social play on the part of all infants.

It is diffcult to say exactly what impact this environment will have on the mother. While it provides an opportunity for freedom, it may actually happen that a mother who is used to restraining her infant a great deal may be afraid to lose control over it when it is outside in the playpen. If a mother doesn't want to let her infant go, nothing short of draconian measures is going to get it out.

During separation, one is capable of several manipulations not possible in the gang situation. Obviously the separation procedure itself is greatly simplified. If all the mothers are removed at the same time the social environment will be radically different from the situation where a number of sequential separations are performed. In the first place the psychologically aversive effects of constant rejection from other mothers will not occur. Secondly it is possible that a group of separated infants will derive some measure of contact comfort from each other and form new attachments. Whether or not they will form new attachments quickly enough to avoid depression is an empirical question that has not yet received much systematic attention, and existing data are difficult to interpret. Suomi et al (1976) report an experiment in which infants with unlimited peer contact were apparently able to compensate for an incomplete separation from the mother; that is separation by a mesh pannel that allowed hand contact through the aperatures. However, when all tactile contact was removed, the peers were insuffi..ient enough and a clearer protest-despair reaction ensued. It is possible that had the development of new attachments been given additional time to develop (by force of the new indepedence thrust upon them) adequate restitution may have been achieved. Another study by Suomi et al (1973) found that infants showed the protest-despair reaction whether housed as pairs or alone but those that were housed and separated alone showed a more severe reaction. An uncritical interpretation is always dangerous however, partly because of weakness in the published reports and because behavioural outcomes are seldom "cut and dried."

In the cage environment it is also possible to maintain each of the separated subjects alone and isolated in his own cage, except for specified daily periods of social intercourse. Of course one is no longer dealing with the "single" factor of maternal separation but with peer deprivation and social isolation as well. Studies by Chappell and Meier (1975) and Suomi et al (1973,1976) have found that single housing or isolation is an effective method of inducing behavioural disturbance and that this disturbance takes on a more agitated form than separation while remaining in the old familiar environment.

A few other more specialized environments have been reported but are not in general use. McKinney, Suomi and Harlow (1973), Suomi (1973), for example, report the use of such devilish devices as vertical pits to induce severe behavioural abnormalities. The exact nature of the abnormal behaviour is not clear, nor is its direct relation to the problem of anaclitic depression.

Status of the Primate Model

The consensus concerning the maternal separation model of depression, after more than 15 years of experimental work is that it provides an appropriate and probably excellent model of maternal separation in humans (Lewis et al, 1976). Within the animal model, as in the human situation there is a great deal of variation and individual difference that may cloud interpretation. Numerous experiments have shown that not all infants get obviously depressed when separated from their mothers and thereby indirectly reaffirm Spitz's

(1945) conclusion that separation from the mother may be a necessary but not sufficient condition affecting depression. Unresolved doubts include the relevance of anaclitic depression in infancy to depression in adults. Paykel (1973) has shown that separation or exit type events do indeed occur significantly more frequently in hospitalized patients prior to a depressive episode.

The present model of anaclitic depression has several general guidelines or criteria to ensure its validity. Most of the following points have been proposed by McKinney and others at various times.

1. Conditions inducing such behaviours in animals should be similar to those inducing parallel behaviours in man.

2. The behavioural/affective states produced should be similar in man and monkey.

3. The behaviours produced should persist beyond the time of induction.

4. Treatment methods effective in alleviating depression in man should reverse experimental depressive changes in animals.

5. There should be similar underlying neurobiological mechanisms.

In addition to these, one would also tentatively consider two more.....

6. The experimentally produced behaviours should be self-limiting when normal conditions are returned.

7. The experimentally produced behaviours should be functionally related to specific stimulus conditions in the same way for both man and animal.

A corollary of the last two would be that the pattern is partially independent of environmental conditions of perceptual enrichment since this has effects outside the attachment bonds. Of course, for any of this to take place the subjects must be susceptible to separation stress in the first place i.e. they should be capable of strong and stable bonds of attachment.

Lewis et al (1976) and McKinney (1977) suggest that the large amount of variability of the maternal separation procedure may compromise its usefulness for prediction and control in experimentation. In its place they offer the peer-peer separation procedure as being more practical. The change of emphasis in this proposal is to a different object of attachment i.e. to infants reared together without mothers. The specific advantages of this method are that the group is more likely to be homogeneous since numerous "mother " variables will not be active. Such subjects will be returned to a peer-relationship that is less likely to wax and wane according to age and the social preoccupations of the object. Furthermore this paradigm is more convenient and amenable to the experimenter's will for reasons of technique, simplicity and availability of sujects. It is possible that it will prove easier to get more consistent results from peers raised together.

To what extent are the the above mentioned criteria being fulfilled by present standards and experimentation? Since the earliest experiments, most of these criteria have been satisfied quite well, at least in those monkeys that did get depressed. (For amplification see Discussion of Theoretical Context) The focus of attention of current work in the field is primarilly concerned with the criteria of treatment methods and neurobiological parameters. In so far as treatment methods are concerned, Suomi, Delizio and Harlow (1976) have shown that behavioural therapy by younger infant "therapists" is effective in alleviating depressive behaviours in subjects who have undergone repeated separations and isolation. Pharmacological treatment strategies, to be presented below, are somewhat more difficult to evaluate, but have also been partially successful in alleviating some signs of separation-induced changes.

Psychophysiological Parameters

M.A. Hofer, (1970, 1971, 1972) has investigated the nutritional and physiological "anlagen" of the attachment processes in infant rats. When separated from their mothers the pups become hypothermic and begin to "lose behaviour" as well as show a decline in heart rate (HR). The addition of heat will precipitate a dramatic increase in behaviour rates to hyper aroused levels, analogous to that seen in monkeys. The separation induced bradycardia however was not the reflex bradycardia often seen in animals in stressful situations, rather it was related to a nutritional factor in the mothers milk. Return of the mother in a non-lactating state reduced the hyperaroused behaviours but did not change the lowered HR. A dose-dependent relationship between milk delivery and HR recovery was seen when milk was fed by gastric cannulation. Further experiments with a sympathetic blocking agent, propranolal, demonstrated that milk is responsible for maintaining sympathetic tone and that its loss will slow the heart by a decrease in b-adrenergic stimulation from the gut. Hofer also succeeded in identifying the olfactory pathway as the most important neural route, in the rat at least, for the regulation of highly aroused behaviour states. Groups of anosmic pups with their mothers, anosmic pups without their mothers and separated but intact pups did not differ significantly on behavioural measures. All groups however, were more active than intact pups remaining with their mothers.

How much weight to give to these data is a problem. Rat pups do not "have" much behaviour in comparison to monkeys. In addition, rats are very olfactory animals whereas monkeys, except for some prosimians, generally are not. The more important sensory pathways in monkeys seem to involve contact, clinging, visual and auditory stimuli. The nutritional factor is an unknown variable in relation to separation in monkeys. Hofer evaluates the role of the rat mother in these processes as an exogenous zeitgeber to an immature physiological and neuroanatomical system known to be deficient in cholinergic, presumably inhibitory systems. The disruption of attachment can now also be seen to involve specific and discrete effects as well as the global or mass effects often attributed to infants.

A series of investigations by M. Reite and others was aimed at identifying various physiological correlates of separation in young monkeys. (Reite et al. 1974, 1977a, 1977b, 1978). Reite was able to measure HR, body temperature, EEG,EMG, and EOG in freely moving infants by a radio biotelemetry system. Reite was reporting on pigtail infants in a group living situation from which the mother has been removed. Some of the data are quite different from those presented by Hofer and are subject to a large amount of variability both between and within subjects.

Reite confirms that sleep patterns in monkeys are generally similar to those seen in man. Separation results in changes in primarily paradoxical or REM sleep and arousal; arousals are more frequent and longer, and sleep onset is prolonged. There is a marked decrease in both the frequency and duration of REM sleep. Slow wave sleep on the other hand remains relatively unchanged. It was found that those infants with the most severe alterations in sleep patterns were the ones to become most depressed according to behavioural measures. Heart rate was found to be a highly variable function and not obviously related to nutrition. The immediate reaction following separation is an increase in both HR and body temperature. Subsequently infants exhibited decreases in heart rate and body temperature both during days and during nights. Both of these parameters were characterized by an increasing amount of variability during the experiments. Along with the separation-induced bradycardias was a significant negative relation with cardiac arrhythmias such that the slowest heart rates predicted the greater arrythmias.

Electroencephalographic analyses during the separation - depression reaction showed a general shift to slower frequencies. It is thought that this shift, primarily in the central-temporal lead, is due to an increased central inhibitory effect, possibly related to depletion of central norepinephrine. The alpha rhythm normally recorded from the occipital lead during darkness, showed no changes during separation. It is intriguing that many of the variables measured by Reite tended towards baseline values in a few days, while behavioural indicies, continued to reflect depression for several days. There is a lag between systems, perhaps conforming to the independence found by Hofer. In some infants the separation - induced changes in heart rate and body temperature tended to persist well into reunion.

These findings appear to be somewhat at odds with what is known of human depressions. In humans one often finds an increase in EEG frequency and a shorter REM latency and increased REM activity. Only a subset of the depressed population shows reduced REM activity (Kupfer, 1976).

The relationship of abnormal spike actvity to various limbic and cortical sites was investigated in isolation-reared monkeys (Heath, 1972). Results consistent with findings in human psychosis were established. Spike activity was seen in the septal and hippocampal regions as well as thalamic relay and deep cerebellar nuclei. These subcortical areas have long been associated with awareness of emotions and somatic sensations. While it does appear that isolation-induced behaviours are different and more severe than the behavioural syndrome of separation, they nevertheless serve to establish a clear effect of socially and perceptually induced abnormallity on subcortical structures associated with emotional expression.

The dramatic rise in 17-OH-Steroids and VMA in the urine and blood of the chimpanzee (Abbott et al, 1972) and squirrel monkey (Coe et al, 1978, Mendoza et al, 1978) and rhesus monkey (Meyer et al, 1978) support the fact that social isolation and separation are a powerful stressor with systemic and hormonal effects. Continuing high levels of corticosteroids and VMA in the chimpanzee during isolation have been interpreted as an adaptation response to stress leading to a stage of resistance and possibly exhaustion. In both the squirrel monkey and the rhesus monkey, greatly increased levels of plasma cortisol have been seen in response to separation. These hormonal effects have been identified as an effect of removal of some factor inherent in mother-infant interaction. High levels of the steroid were not found to be dimished by adoption of the infant by an aunt. In both species, infants that were normally mothered and those that were surrogate reared could not be differentiated on the basis of plasma cortisol levels. In the rhesus however only infants that were mother reared showed raised steroid levels after witnessing the blood sampling procedure in their peers, indicating perhaps a form of empathy not found in surrogate-reared infants.

Breese et al (1973) separated infant monkeys for 6 days in order to study the effect of the protest stage of separation on the activity of adrenal catecholamine synthesizing enzymes, choline acetylase and central catecholamines. The only change in central biogenic amines they found was increased concentrations of serotonin (5-hydroxytryptamine) in the hypothalamus; NE, DA and tyrosine hydroxylase showed no change. The activity of adrenal enzymes however was markedly elevated. Adrenal tyrosine hydroxlase, choline acetylase as well as other synthesizing enzymes all showed greatly increased activity that was apparently under sympathetic neural mediation.

The catecholamine hypotheses of affective disorders suggests that the depressive syndrome seen in man is associated with a functional deficit of central biogenic amines, norepinephrine and dopamine. When the synthesizing enzymes of these amines, specifically tyrosine hydroxylase, was inhibited in rhesus monkeys, the resulting amine depletion produced a depressive behaviour syndrome similar to that following depletion by reserpine and superficially similar to the despair stage of maternal separation. Redmond et al (1971) used alpha-methyl-paratyrosine (AMPT) to selectively deplete NE and DA stores without affecting serotonin. The monkeys showed retarded motor activity and withdrawn postures and initiated fewer social exchanges. Social responding however remained unchanged.

The treatment of alleged depressive states in monkeys and man with antidepressant agents is predicated on the theory that these will increase the functional availability of neurotransmitters. The effect of drugs on isolation-induced behaviour disorders in primates has been previously reported. Whereas trifluoperazine (Stelazine), dextroamphetamine sulphate and oxazepam were found to be singularly ineffective in modifying the behavioural deficits in isolation-reared chimpanzees (Menzel et al 1963, Turner et al 1969) the administration of CPZ to rhesus monkeys subject to partial social chlorpromazine (CPZ) isolation resulted in a significant decrease in their self-disturbance behaviours (McKinney et al 1973). However, in this latter study, CPZ failed to increase the frequency of active social encounters in most subjects.

The demonstration that a clinically effective antidepressant drug, imipramine hydrochloride, has altered some behavioural parameters in infant monkeys during separation (Suomi et al 1978) lends new support to the separation paradigm as a model of depression. These investigators chose the peer-separation paradigm with 3 consecutive separations. By the third separation, infants receiving imipramine showed lower levels of self-clasping and somewhat greater interest in the environment. During the last reunion, the differences between groups became more pronounced, the imipramine group being the more normally oriented.

Statement of Problem and Hypotheses

This project centered on two separate but related experiments and their associated problems and hypotheses. Because there were two experiments separated by about one year, some diversity of problems under investigation must be reported. The first experiment served as a pilot project to test the feasibility of different aspects of the experimental model and laboratory procedures. Simply stated, the problem to be investigated by the first experiment was the feasibility, reliablity and validity of the maternal separation procedure as an experimental model of depression in young monkeys. The attainment of this goal was, however, contingent upon the successful development of several systems and procedures, which may be summarized as the development of an operational primate laboratory in the animal house of the medical building.

The hypotheses concerning specific behavioural events were stated primarily in qualitative terms. The frequency and duration of behavioural items defined as active and peer-directed were expected to decrease as a function of separation; the incidence of environment and self-directed activity was expected to increase; the incidence of distress behaviours was expected to rise; the frequency of all forms of play was expected to decrease almost completely; and the intensity of mother-directed behaviours was expected to rise dramatically upon reunion. The qualitative impression expected from the scene as a whole, was set by descriptions of previous experiments, namely a striking picture of 'despair'.

The goals of the second experiment may be summarized as the further development of the primate model of depression by the experimental use of a clinically effective antidepressant drug. Completion of this work depended to a large extent on experience gained from the first experiment. Procedures had to be adapted to a larger group of subjects and behavioural items were revised and extended. The hypothesis to be tested was that specific and systematic changes in the behavioural parameters, frequency and duration, resulting from the separation procedures, were expected to be reversed by treatment with the antidepressant drug .

MATERIALS AND METHODS

Subjects

Pregnant cynomologus monkeys (m. Fascicularis), were acquired from Connaught Laboratories of Toronto where they were screened for common primate diseases and were kept for breeding purposes. In total, thirteen pregnant females were obtained. They were feral born but all had a history of successful births at Connaught, although there were several still-births. The females arrived at the University of Ottawa approximately a month before parturition and were kept in an isolation room from their time of arrival until the infants were two or three weeks old. All females except one gave birth to normal infants. The births occurred alone and unattended at night within 42 days of each other. The infant of one female died shortly after birth from a respiratory infection and had to be replaced. This infant was 3.5 months younger than the others.

The composition of the group for the first experiment was three males and one female. The female, Maxie, is the oldest while Curious George is the youngest. Napoleon and Ullysses fall in between, close to the female.

The group for the second experiment consisted originally of three males and five females. The range of their ages placed them within 28 days of each other. This group went through essentially the same adaptation period as the first group. However, unexpectedly aggressive behaviour on the part of one female resulted in three infants being bitten during periods of free peer contact. In the case of one infant, whose forearm was broken, this amounted to a mauling. This unprecedented aggression finally resulted in osteomyelitis of the ulna and radius, a condition not likely to heal. On the advice of the veterinary surgeon the infant was euthanized. This left seven infants for the experiment, two males and five females .

Experimental Environment

Physical Location

The primate facility is located on the sixth floor of the medical building in the animal house. This actually consists of a long tiled corridor with animal quarters on both sides, most of which was occupied by dogs and a few cats. Two of the rooms are primate holding rooms; between them is the cage washing and cleaning area. Directly across the hall is a small laboratory and surgery where the separated mothers were kept. The primate laboratory itself is three doors down the hall. The laboratory and holding rooms measured 20 feet by 12 feet. They are finished in red floor tiles and white tiles on the walls. At the far end of the room is a window which cannot be opened. The rooms are well ventilated and lighted by an array of four fluorescent tubes.

The full assembly of cages and playpen occupied an area measuring approximately 12 feet by 5 feet in the center of the room. This left roughly 3.5 feet on either side and 4 feet at the ends in which the observers could move and work. If an observer were sitting directly beside the home cage of one of the pairs, he would be only 3.5 feet from the center of the cage. The maximum possible distance between and observer and a subject was about 8 feet, the distance between himself and the diagonally opposite cage. In practice, an observer was always stationed beside the home cage of the infant, where it joined the playpen. Depending on which pair of subjects was being observed, the two raters would be either on the opposite sides or on the same side of the assembly. Reference to Figure 4 will show all the pertinant spatial relationshops.

Lighting

A precisely controlled light-dark schedule was deemed unnecessary. First light entered the laboratory and holding rooms at dawn, which of course, varied over the course of the experiments. Overhead lights were fixed about 4 feet above the top of the cages and playpen. They were centered above the first set of cages, the other set received light more indirectly. Incident light levels were measured with a Sekonic studio 128c light meter reading in foot candles. At 11:20 hr. on a sunny day there were 120 foot candles, measured at the top of the cages. This is enough light to obviate the necessity of overhead lighting. Measurements were also taken from the bottom of each cage and the "playpen in the evening. Because of the positioning of the overhead tubes, light levels varied somewhat over the two halves of the assembly. Incident light in the center of the playpen was measured at 32 foot candles; enough light to read without difficulty.

Acoustic Phenomena

Acoustic phenomena in the animal house were also measured. The hard reflective surfaces allowed very little attenuation of noise. A clanging shovel which might produce a peak of over 115 dBC, measures practically the same 115 feet away at the other end of the corridor. A Bruel & Kjaer model 2205 was used to measure noise outside and inside the laboratory. Outside sound pressure levels were read on the 'c' network with fast damping. Slow damping was used inside when all peaks above the arbitrary cut off of 75 dBC (the preset level of white masking noise) were being recorded.

Outside, the most disturbing noises come from the loudest and largest dogs, which were capable of barking at over 120 dBC at the worst time of day. Inside such sounds were attenuated by about 25 or 30 dB. When the corridor was quiet at night, the ventilation maintained a steady background of 55 dBC. Results show that most of the noises measured inside the laboratory were created by activity of the monkeys in the metal cages and their vocalizations. These noises were measured in a range from about 55 dBC to over 90 dBC, depending on the time of day and the activity level.

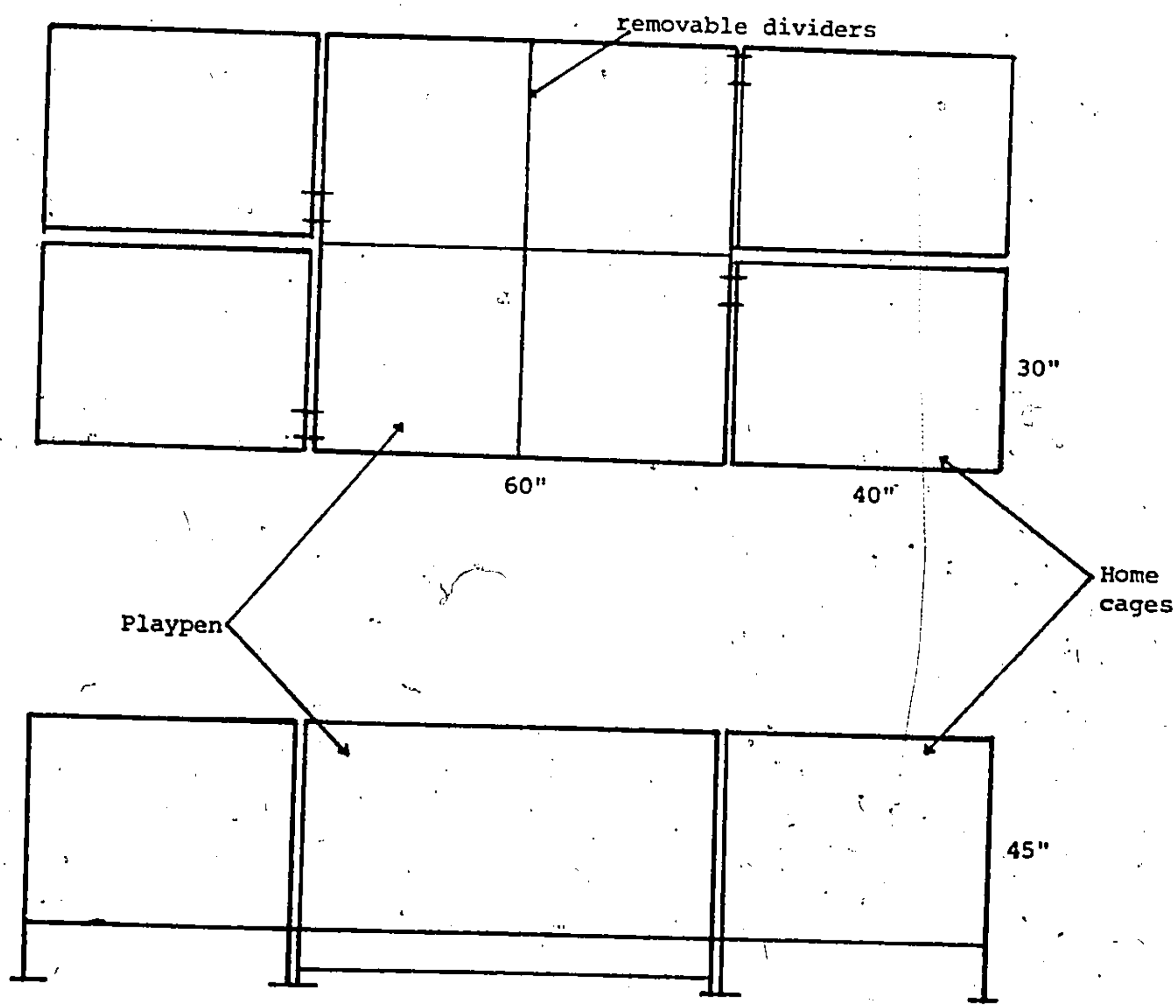
White noise was used during recording sessions (only) in the second experiment. At 75 dBC (at the source) this rendered much of the less intense nuisance inaudible. The actual intensity of the white noise, at some distance from the source, strongly depended on the orientation of the microphone.

Apparatus

Cage Housing

The primary apparatus was the home cage and playpen assembly, the design of which is almost identical to that used by Seay and Harlow (1962 and later). It consists of a central playpen and two sets of home cages facing each other from opposite sides (see Figure 3 The playpen is set 15 inches above the floor and is constructed completely out of stainless steel 1" mesh and stainless angle iron except for the toys inside. It can be subdivided into four individual playcells by the insertion of mesh pannels; each playcell corresponds to one home cage. Each quadrant also has its own small 3" by 5" door for the infants' exclusive use. The playpen measures 60" by 60" by 30", easily accomodating 4 infants and their energetic play.

Fig. 3. Living Cages Attached to Playpen



Scale 1mm = 1 inch

Figure 4; the laboratory

The home cages, fitted and locked in apposition to the playpen, also have a small door to match the one on the playpen. The two of these are actuated together by means of a long handle. The home cages are basically standard Hoeltge primate cages measuring 40" by 30" by 30". They are fitted with wheels and are also constructed of stainless steel. All have been modified to meet the requirements of the observers. The outside wall of each cage was cut out and replaced by a 1/4 " sheet of 'armour glass' measuring 38" x 21". Similarly, a large section of the ceiling was replaced by a 1/8" sheet of polycarbonate (lexan) measuring 24" x 24" so that light could enter from the top.

Recording System

The data encoders were designed and built in the Department of Pharmacology. One of the units is shown in Figure 5 . The encoders consist of an electronic keyboard device constructed of plastic, micro switches and common integrated circuitry available before the recent appearance of inexpensive microprocessors on the market. The front of the device consists of a bank of 12 large, spring-returned keys for easy manipulation, and an array of 3 toggle switches. The function of all the keys and switches is to provide one binary digit each in an array of 16 data points which are registered together and shifted out serially onto magnetic tape at a variable rate convenient to the user. In other words, an array of 16 data points is scanned, registered, shifted out and recorded as a group once every designated time interval.

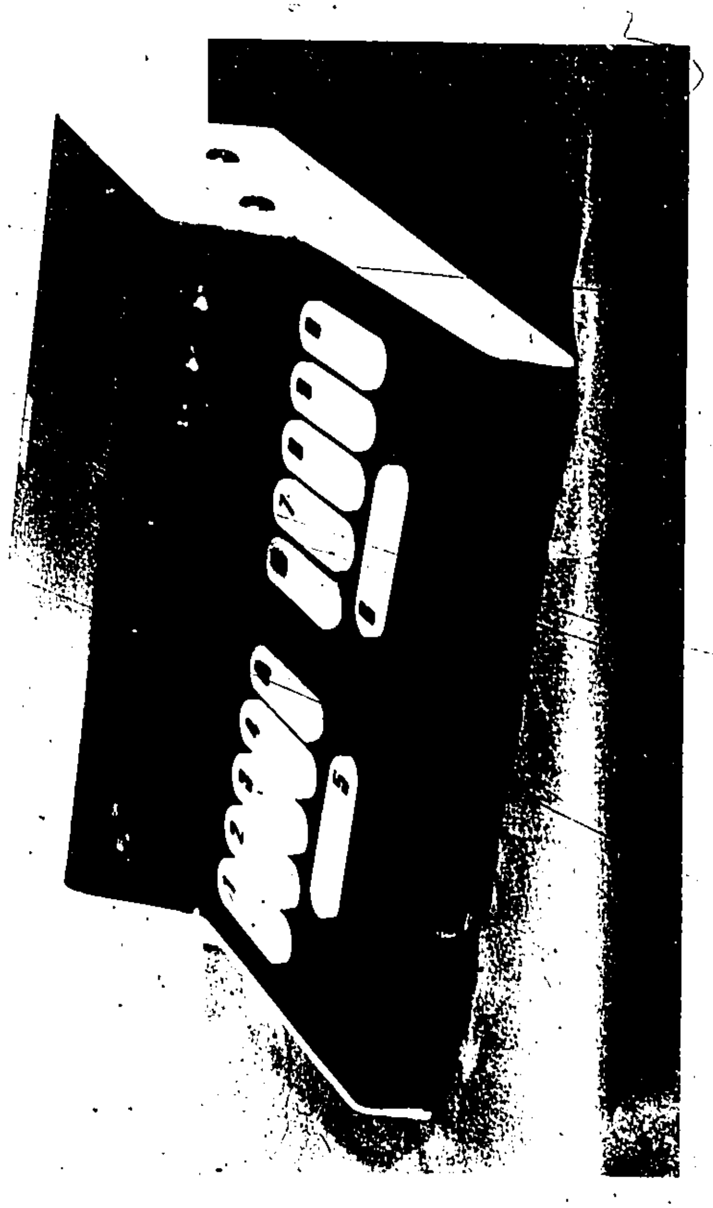


Figure 5; the encoder

These binary digits or bits are produced by means of the 15 keys and switches, for example when a key is depressed an event is registered, while in the up position nothing is registered. In this way a total of 15 events may be encoded. However, the modification of two keys (category or range delimiters) allowed a maximum instrument encoding capacity of 42 behaviours with the same 15 keys and switches. A pdp-8e assembly language was required program to descriminate the key functions. This provided by the Department of Psychology. The 42 behaviours must be recorded in 4 mutually exclusive ranges or categories and cannot be recorded simultaneously.

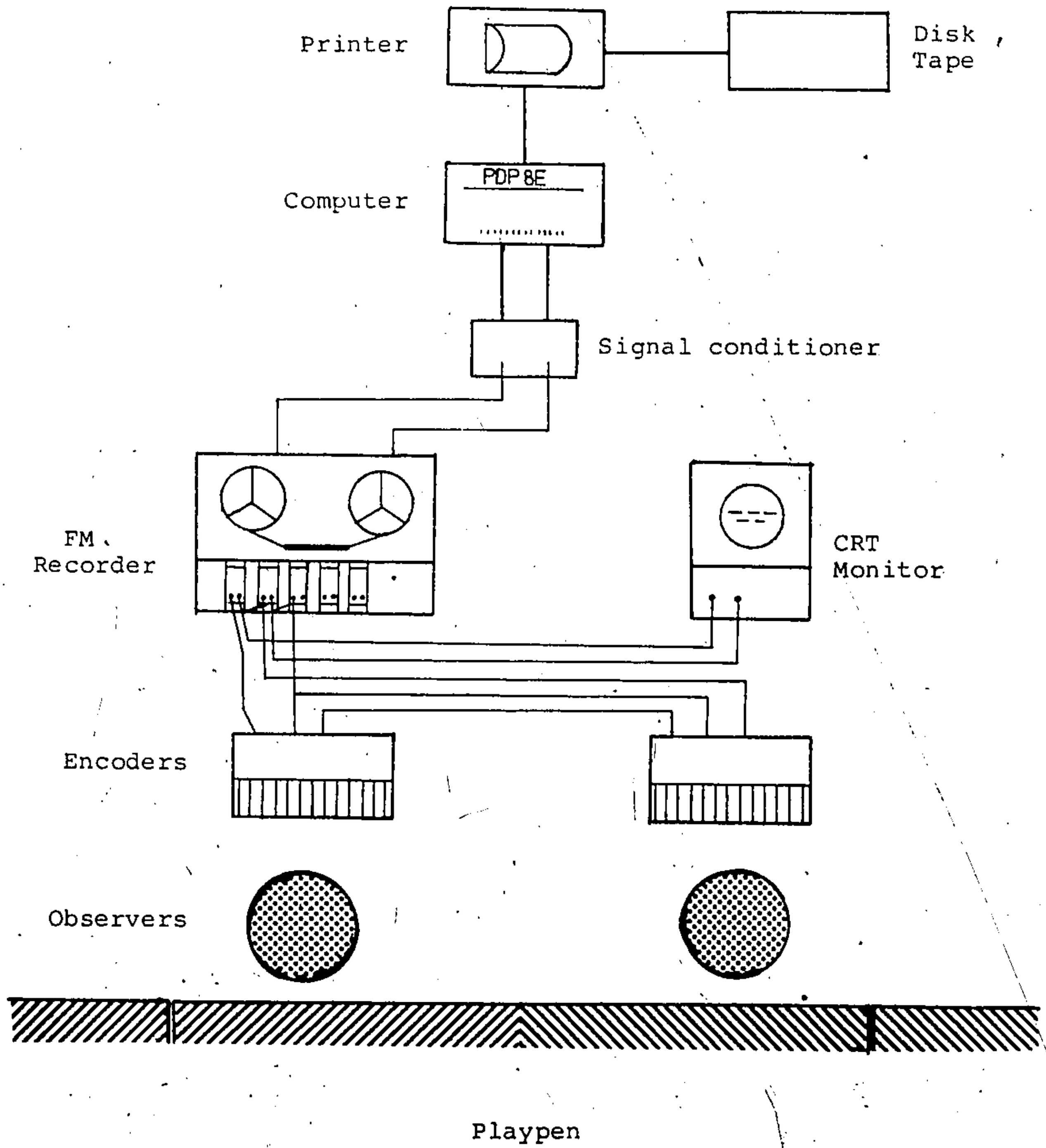
The actual behaviours assigned to any key is entirely at the discretion of the experimenter except for the value of the last or 15th key (a toggle switch) and the synchronization bit which is not represented by a switch. The 15th bit was used as a flag for the assembler program to begin compilation and the 16th bit or 'sync' bit was used as an electronic pacer and error check. Some idea of the design and operation of the units and the data stream may be gleaned from Figure 23 in appendix d.

These devices provide an easy way to key in and record behaviours without attention having to be often diverted to the hands. Behaviours could be recorded at a rate fast enough to considered true frequencies and true duration. Whenever a subject performs a relevant behaviour, the observer presses the corresponding key and holds it untill the behaviour has terminated. Little encumberment arises for the user as the unit is quite light and may be held in the lap during observations.

The encoder output was recorded on BASF magnetic tape of .5 mil thickness. The recorder consisted of a Crown series 700 tape transport and heads in conjunction with 4 Vetter FM plug-in amplifiers as well as an audio amplifier used for voice-over commentary during observation. The tape contents were played back through a signal conditioner to a pdp-8e computer for compilation. The computer itself is a vintage machine with a rather restricted core memory (4k), a fact of significance in the computation of results and observer concordance.

Other ancillary equipment used during the project was a Philips PM 3230 oscilloscope to monitor the recorded contents of the tape and to check for eventual equipment failures such keys gone out of adjustement or contact breaks, which occurred from time to time. Sony portable VTR equipment was used for a video recording of all phases of the first experiment while a Braun-Nizo model 800 super-8 cine camera was used for a visual record of the second. A Grason-Stadler model 901b white noise generator produced white masking noise and a Bruel & Kjaer model 2205 sound level meter was used to record sound pressure levels during the second experiment. A Sekonic studio studio 128c photographic light meter gave light levels in foot candels. A 'systems' diagram of the essential equipment is shown in Figure 6 .

Figure 6: Recording System



Software

Conditions during the two experiments were not identical, for instance during the first experiment only one observer and encoder were used while during the second, two observers and encoders worked simultaneously. Consequently the pdp-8 programming was also not the same. The assembler programme was rewritten entirely for the second experiment and became ready for use by the beginning of the final reunion. The relatively high rate of data input from two encoders rapidly filled the 4k core memory of the computer. For this reason the output was restricted to a within-sessions summary table of summated frequencies and durations as well as a serial dump of the input stream, minus the time base. If space ran out before the input stream had terminated, a summary table was produced of the data up to the limit of the core space. Input was then picked up again where it left off and a summary was then produced for the remaining data in the session. The two summaries together constitute the data for that session.

Summary tables for the entire experiment were then further collated from all the within-session's tables produced by the PDP-8. The data were then transferred to IBM computer card and finally to disk and tape files for more elaborate evaluation.

Development of Behavioural Items

The first task was the acquisition of an intimate knowledge of the monkeys, their behaviours in captivity and their peculiarities. It was necessary to simply spend many hours observing the interactions of the mothers and infants. In addition, 16 mm movies were borrowed from the Oregon Regional Primate Center in the hope that some dramatically relevant behaviours would be graphically displayed. Out of this basic knowledge and the experience of others in the area, we developed a range of 30 behavioural items thought relevant to the area of separation and depression.

Behavioural items were chosen for the first experiment on the basis of our preliminary observations mentioned above and on the basis of an extensive review of behavioural categories and items used by other workers in the field (Seay and Harlow, 1962,1965; Kaufman and Rosenblum, 1966,1967; Bowden and McKinney, 1971; Harlow et al, 1972,1973). A certain amount of intuition was also used in the selection of some behaviours that had the appeal of similarity to behaviours seen in depressed humans. A further rationale used was to include common behaviours that occurred very frequently to see how separation effected their base rates. In this way a preliminary list was drawn up which was revised several times before a final version was decided upon. The final lists of behavioural items, with definitions, groupings and explanatory rationale is given in Appendix (A). During the second experiment, the list again underwent extensive revision and discussion. Experience with the first experiment brought to light several behaviours and social dynamics of possible importance. Among these were the common behaviours of sitting, being still and foraging for food. A further distinction made was the differentiation of some behaviours into active and passive components. According to this scheme , the item labelled 'gross body contact' by Seay and Harlow (1965) was divided into 'passive contact' and 'active contact'. Similarly, play behaviours were divided into 'accepts play' and 'initiates play'. In the event that no difference appeared, the category could be regrouped. This notion was borrowed from the theory and practice of behaviour therapy where a passive or reactive repertoire is distinguished from an active one in which the depressed patient initiates social intercourse, (Lewinsohn, 1974, Ferster, 1973).

Grouping Schemes

There are several grouping schemes that could possibly descriminate different factors in the data. The most important one is the scheme based on the object attention. It was decided that 3 ranges of 10 behaviours could be developed which are mutually exclusive and which are distinguished on the basis of interest in the mother, the peer and 'aloneness'. These are the maternal behaviours, the social behaviours and the individual behaviours. In practice there was a small degree of overlap as when an infant was on the mother but playing with a peer at the same time. However, this did not occur very frequently. Activity was conceived of as constantly changing and shifting in nature; there is a constant irregular movement in and out of the 3 categories. An infant could not be in the individual mode and the social mode at the same time and the functional operation of the encoders required that a new range selection be made when a shift occurred. Another possible division lies along the sociopetal and sociofugal dimensions. Some infants spend more time engaging the environmental artefacts while others pursue their peers. There is also the possiblity of grouping based on intercorrelation matrices.

Methods

Lead-in period

Upon their arrival, the monkeys were set on a feeding schedule of two feedings per day, one at 08:30 and again at 16:00 hr. Their food consisted of Purina monkey chow, without izoniazid, and raw fruit and vegetables three times per week. This schedule remained unaltered during the experiments.

The monkeys were transfered from the isolation room to the laboratory 2 weeks after the birth of the first three infants. They were allowed to habituate to this room for the next four months while they remained in their home cages. During this time the early infantile behaviours were rapidly falling away with a concommitant rise in rejection behaviours on the part of the mothers and independence in the infants as described by Hansen (1966).

The fourth, replacement infant was born in the laboratory room two months and 24 days after the transfer of the others. At that time the first three already had an average age of 3 months and 16 days. It was immediately apparent that the fourth infant could not be included with the first three.

The other three infants, Maxie, Ullysses and Napoleon, received their first exposure to the playpen simultaneously but with the dividers in place. Their mean age at this point was four months. They were allowed to interact with each other for one week through the mesh before the barriers were cautiously lifted. The infant doors were left open continuously to allow the infants freedom of movement and to encourage independence and interaction as far as the mothers would allow. Only at night were the infants forced to return to the mother.

The policy of free access to playmates and the mothers of playmates was continued without serious incident for the rest of experiment 1. The only real surprise came when two mothers were found together in the same cage, grooming peacefully. All the mothers readily accepted other infants although it was noticed that Liza, Napoleon's mother, was more popular than all the others.

Observer Training

Observer training continued throughout this pre-baseline period. The method of Bijou (1969) was used to evaluate the level of concordance between observers. Appendix (B) contains a discussion of the Bijou method. A variety of 5 minute video-tape recordings were made using Sony portable VTR equipment. In this way the observers practiced and were evaluated on the 3 categories of behaviour viz. maternal, social and individual. If there was disagreement on any point, the sequence was played back and discussed until all could agree.

Experimental Protocol

Experiment I

The experiments were divided into 5 phases or conditions, namely (1) Baseline, or pre-separation (2) Separation I (3) Reunion I (4) Separation II (5) Reunion II. During the baseline period the infants lived with their mothers and had free access to their peers as described. Formal observation began when the infants had attained a mean age of 5 months and had been habituated to peer contact in the apparatus for one month. Observations proceeded according to a schedule of rotations which ensured that an infant did not have the same partner on successive observation periods. The observation schedule designated four observation periods per day, two in the morning at 10:00 hr and 11:00 hr and two in the afternoon at 14:00 hr and 15:00 hr. Each was 30 minutes in length. Observations were not made on Thursdays when the animal care staff completely disassembled the cages and playpen for washing.

The schedules of two observers, who worked alternately, were also rotated so that they did not observe the same monkey twice in succession. When the observer entered, he or she would check the schedule and select the subject and peer for that observation period. The third infant had to be trapped or otherwise manoevered back into his home cage for the period. This was not always easy to accomplish during separation when the infants tended to follow each other closely.

Observations continued uninterrupted, except for 'teething problems' with the equipment, until December 23 , when personnel left for the Christmas break. During the holiday the monkeys were looked after by a skeleton animal care staff and by the experimenter who ran spot checks on their behaviour.

All personnel returned on the first of January when the mothers were separated from the infants and removed to the veterinary laboratory a few doors down the hall. Thus separated, the mothers and infants could occasionally hear each other. Separation was accomplished quite simply and without incident by closing the door behind the infants when they were all together in the playpen. At that time the infants had attained a mean age of 5 months and 19 days. They continued to be observed according to the same schedule for the next 25 days, when the mothers were returned.

The period of reunion with the mothers lasted for the next 23 days. At reunion, the infants were confined to their own playcell while the mothers were transferred to their home cages one by one. Thus each reunion was observed separately.

The first period of reunion also served as the baseline period for the fourth infant, George, who was now three months and 17 days old. Up to that time he had been able to interact with his peers through the mesh of the playcell. This constraint was then removed; after a brief period of amiable investigations George was integrated into the schedule and we proceeded as usual.

At the time of the second separation, which lasted 22 days, George had attained 4 months, and 9 days and the others averaged 7 months and 24 days. The reactions of the 3 infants in the first separation prompted us to increase the severity of restrictions imposed on George relative to the others. Treatment for Maxie, Ullysses and Napoleon was identical to that received in separation I. George, however was confined to his cage during the whole of the separation period except for observations. In this way it was intended to compound the effects of separation by social isolation. The procedure of the final reunion was the same as for the first.

Experiment II

The protocol of second experiment was quite similar to that of the first. The induction and habituation periods for this group of monkeys was virtually the same as that for the previous experiment. Procedures had to be adapted to suit two groups and two observers working concurrently with separate encoders. Since there were two groups of monkeys, drug and control, one group had to remain in the colony room while the other went to the laboratory and playpen. Those in the laboratory remained there until noon when they were transferred back to the holding room and the other group replaced them. This schedule ensures that if a group were in the laboratory in the morning on one day, it would be there in the afternoon on the following day. This was done to control for possible effects associated with the time of day.

The major changes in procedure were (1) the revocation of free access to peers and other mothers. (2) augmentation of maternal separation by social isolation, the procedure used for George in experiment I (3) the administration of desmethylimipramine to the drug group during separation II and physiological saline to the control group. (4) the use of white noise to mask external disturbances.

Some of the minor changes include the use of a black curtain to separate the door and desk area from the cages and the introduction of a greater variety of toys in the playpen.

The lead-in period for this group again revealed seven unique approaches to life and seven different mothering styles. All the infants were given simultaneous exposure to the playpen with dividers in place. Most of the infants dealt adequately with the new situation and eventually explored it with a minimum of fear. The mothers of three of them, however, were extremely possesive and restrictive of their infants and for several days would not allow the infants to explore outside the home cage. These infants, as well, had the most difficulty in adapting to the new environment.

A schedule of observations of observer and subject was again devised using the same principles as before. In addition, an attempt was made to control for an 'order of observation effect' by ensuring that if an infant was in the first pair to be observed on one day, it would be in the second pair, for that group, on the next. The infants were restricted to their home cage during most of the day. Before a session started the two observers would pick the scheduled pair and allow them supervised interaction for 10 or 15 minutes while the system was turned on and inspected. The length of the observation sessions was reduced from 30 to 20 minutes to reduce observer fatigue. When the session ended the two other infants were released from their home cages and allowed to interact with the first two as a group of four for approximately 20 -30 minutes. The first pair was then enticed back to their mothers, with whom they remained for the rest of the day while the others were observed. Access to an 'aunt' was permitted and risked during observation sessions because supervision was close.

The two groups of monkeys received the same treatment throughout the baseline, separation I and the first 13 days of reunion I. All subjects went through two separations lasting 21 and 15 days respectively. Drug and saline administration began on reunion day 14 and continued until day 12 of separation II. The drug treated group (four subjects), received desmethylimipramine (DMI) in a single daily dose of 5 mg/kg i.m. while the control group received an equal volume of physiological saline. The injections were administered immediately after a recording session in order to minimize interference due to the stress of injection and the squeeze mechanism of the cage. The drug phase employed a double-blind procedure. An independent, outside technician delivered the injections but neither the observers nor the experimenter knew which subject received the drug and which received saline. The drug lead-in period was necessary to allow plasma and brain concentrations of the drug to rise and to allow for the latency of clinical effect (usually one or two weeks) typically seen in humans under tricyclic antidepressant therapy. The plasma concentrations of DMI were determined by means of a gas chromatograph according to the method described by Hammer and Brodie, (1967). Because the anaestesia and blood sampling procedure (femoral arteriopuncture) was very disturbing, a further series of injections was undertaken after the experiment to make these determinations. Three subjects from Experiment I were used. The general design of Experiment II is epitomized in Figure 7 .

DESIGN OF EXPERIMENT II

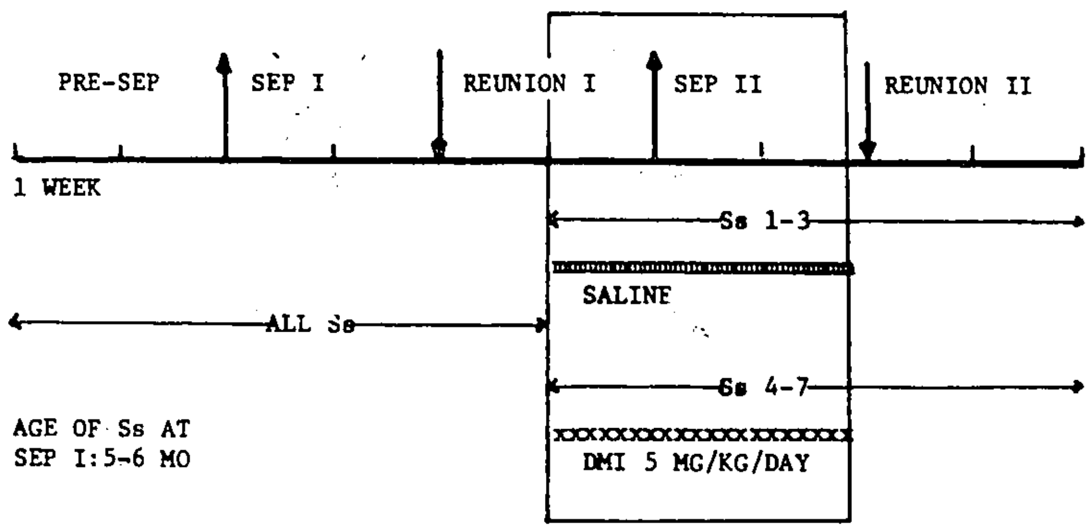


Figure 7

The drug testing phase is within the box, shown by xxx

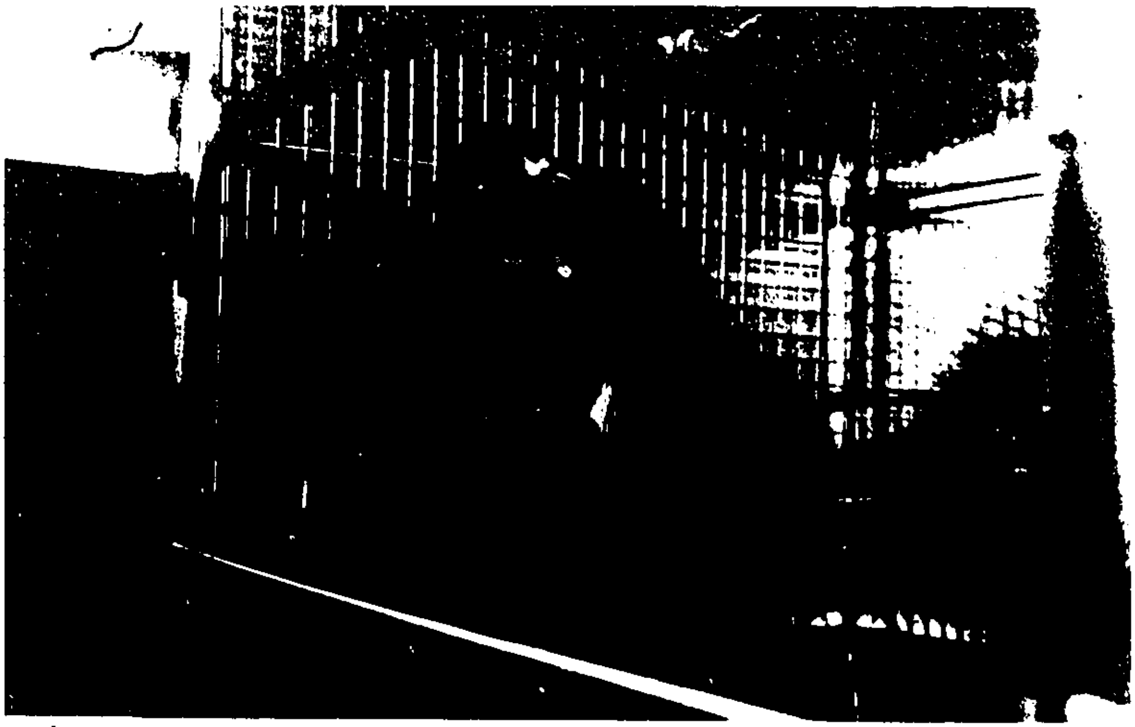
The mechanics of the separations were the same as previously described. During separation II. However, two infants, aroused by the reaction of the others, refused to leave their mothers and be separated. These mothers had to be sedated with a light dose of ketamine hydrochloride so that the infants could be 'peeled' off. The reunion procedure differed somewhat in that each reunion was recorded on super-8 film. Some very interesting footage was obtained of clear 'detachment' behaviour in 3 infants, a phenomenon reported only once before by Abrams (1969). Only after all the mother-infant pairs had been reunited were peer pairs selected for observation.

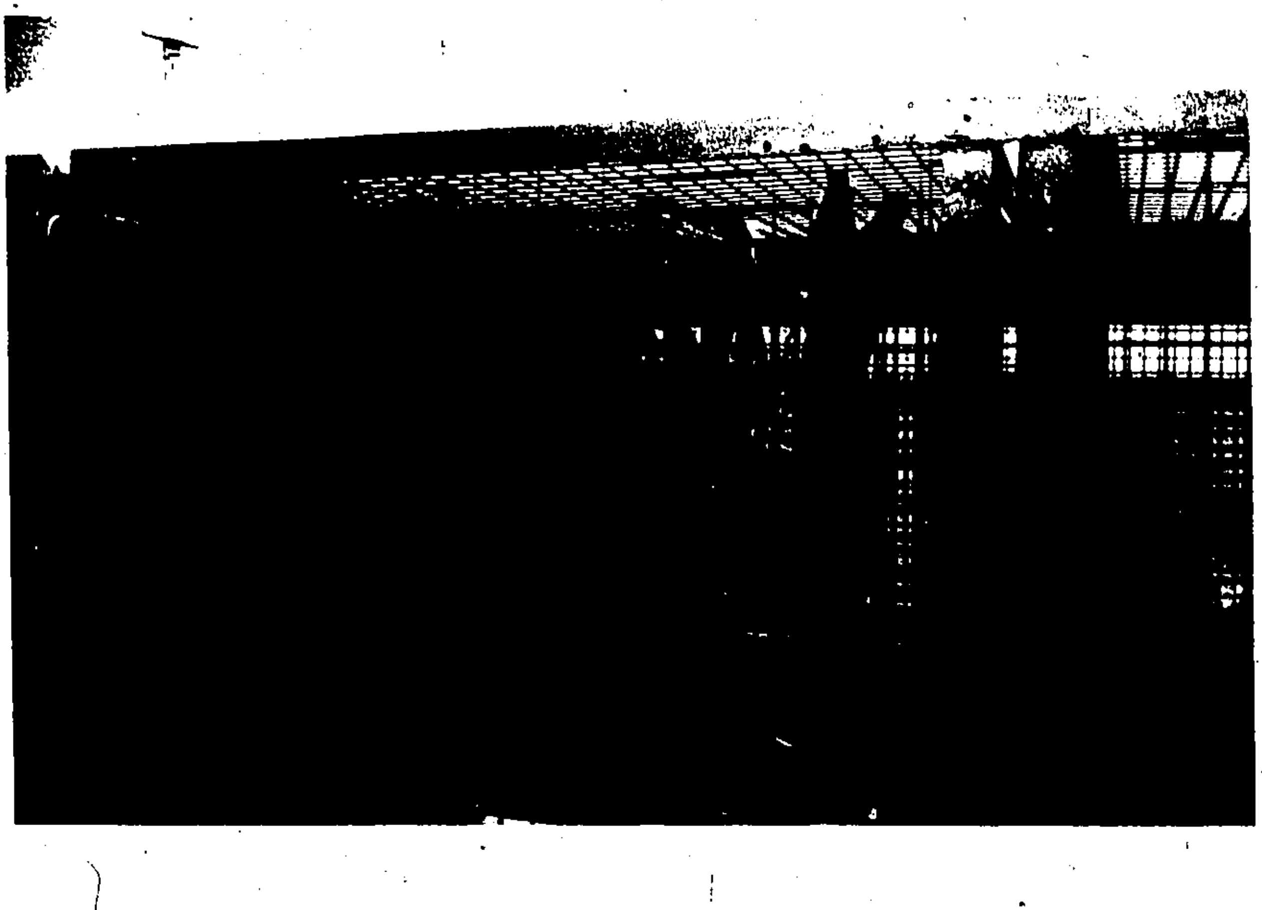
RESULTS

Phenomenological Description

Separation I

The first experiment was essentially a pilot study for the development of procedures and routines as already explained. Considering the different treatment of subject #4 from the others, it may be considered an experiment with two groups of n=3 and n=1. It would therefore seem more practical to report descriptive data for the experiment and a phenomenological account relying on the operant strengths of the design to determine the efficacy of the treatment, (Hersen and Barlow, 1976). To recapitulate briefly, this refers to the reversal or withdrawal design (ABAB and variants) which demonstrates effects by the initiation, withdrawal and reinstatement of treatments successively during the experiment. Here, A1 is the baseline period, B1 is separation I, A2 is reunion I, B2 is separation II, and AIII is the final reunion. A phenomenological description of the events of separation may help to increase the reader's appreciation of the significance of the figures in the context of the experiment. Figure 8 and Figure 9 show two scenes typical of baseline behaviour before separation. The former simply illustrates normal maternal behaviour. The latter shows an infant (Maxie) swinging from the ceiling while mouthing a ring. This provides an excellent example of "exercise play", one of the behaviours most strongly affected by separation. IT also provides a fine example of the simultaneous (in this case) behaviour "manual-oral-explore" or "MOE". (From this photograph the reader may appreciate that the observer's task was often to register several behaviours simultaneously.)





The very first reaction was one of alerting and mild fear as the infants watched their mothers being wheeled out. There were frequent, searching head movements and running from place to place to search and call; the well-known 'coo', 'hoo' or 'woo' calls. This initial reaction lasted for several minutes and was common to to all infants, Maxie, Napleon and Ullysses. As they saw that the mother was not about to return, the reaction took a dramatic turn in intensity and began to show individual differences. The most intense reaction came from the female Maxie, whose behaviour attained disorganized, panic proportions. Coos and schreeches were emitted every few seconds, often in bursts of three to eight. (Maxie was the only one to actually schreech, but all ran about in a repeated pattern of "in-look/call-leave". As the disorganized behaviour gained intensity, numerous small behaviours were repeated in a stereotypical way, indicating a state of extreme energy expenditure and disorganization. The two males, Napoleon and Ullysses displayed similar reactions but less intensely. In the case of Napoleon, the reaction was clearly less intense than Ullysses'.

This high intensity output was maintained for a few hours before it began to subside a little. The general form of this reaction continued for approximately 24 hours and was replaced by a pattern of time-dependent decreasing intensity, which consisted of continuing high levels of locomotion and cooing along with a general disappearance or loss of many normal behaviours. Notable for its absence at this time was play behaviour, especially rough-and -tumble, which did not occur at all. This was accompanied by the appearance of social disengagement or loss of interest. Figure 10 and Figure 11 Occasional attempts at play were made by the males during these days but they were short lived, consisting of a brief contact initiation, break-off and the resumption of dominant apathetic pattern. Individual play behaviours were also lost during the first days of separation although manipulation of the body was seen to increase, especially in Maxie.

We found no good way to record animation but it was clear that the former 'elan' and persistence were missing. The female, never attempted to engage in any play initiations and always withdrew when approached; however this was often her pattern before separation as well.

The pattern of these behaviours seems to have been a gradual decline, as it were, into a state of great apathy and perhaps depression. The nadir seems to be reached between the fourth and seventh days depending on the subject and probably lasts about 36 to 48 hours. Movement during this time had slowed down considerably in speed and social contact was at its lowest. Following this, we saw a gradual adaptation to living without the mother and the re-emergence of more normal behaviour patterns including some play. However, it is noteworthy that, at least on the level of impressions, a qualitative difference from baseline patterns seems to remain. Two weeks after separation, the infants are alert and active and increasingly playful but the previous characteristic of continuous rough-and-tumble play did not fully recover at any time after separation. It seems to have been replaced by less active forms of contact and individual and manipulative play.

It was noticed that, especially during the early and middle periods of separation (days 3 to 10), the infants tended to follow each other about and seek each others company, even though attempts at play were significantsly fewer. They tended to huddle together on the perch frequently; alert but non-playful. If one departed, the others tended to follow. Periods of sitting together passively or wandering aimlessly increased. Occassionally, contact took the form of grooming or ventral-ventral clinging. When one of triad was restricted to a cage during observations, that individual showed an immediate increase in agitation and looking towards his peers. In Maxie, this again reached extreme proportions and stopped as soon as she was reunited with the others. The impression was strongly reminiscent of the expression 'misery loves company'. Apparently some form of restitution is obtained through peer contact. In the cited literature, the description most similar to these infants was given by Preston et al. (1970) who used an entirely different species, erythrocebus Patas.

Separation II

Events during the second separation were quite similar to those of the first except that the infants appeared to adapt more quickly. Individual and manipulative play following the slow recovery seemed even more complex and varied than before. The infants were possibly habituated to the stress of separation or had adapted by new learning.

The pattern followed by George, the fourth infant, was similar to that shown by the others. While alone and segregated from the others, he appeared very nervous, dropping bits of food when startled. Occassionally he would threaten observers in a defensive way.. George was the only infant to clearly show the extreme form of these depressions i.e., the sagged facial features, the slumped posture and the "expression of despair". It must be made clear however that this form of behaviour was not maintained for any great length of time. It was short and phasic, and easily interrupted by on-going events, as if he were startled out of drowsiness. The full impact of his state is made clear in Figure 11 .

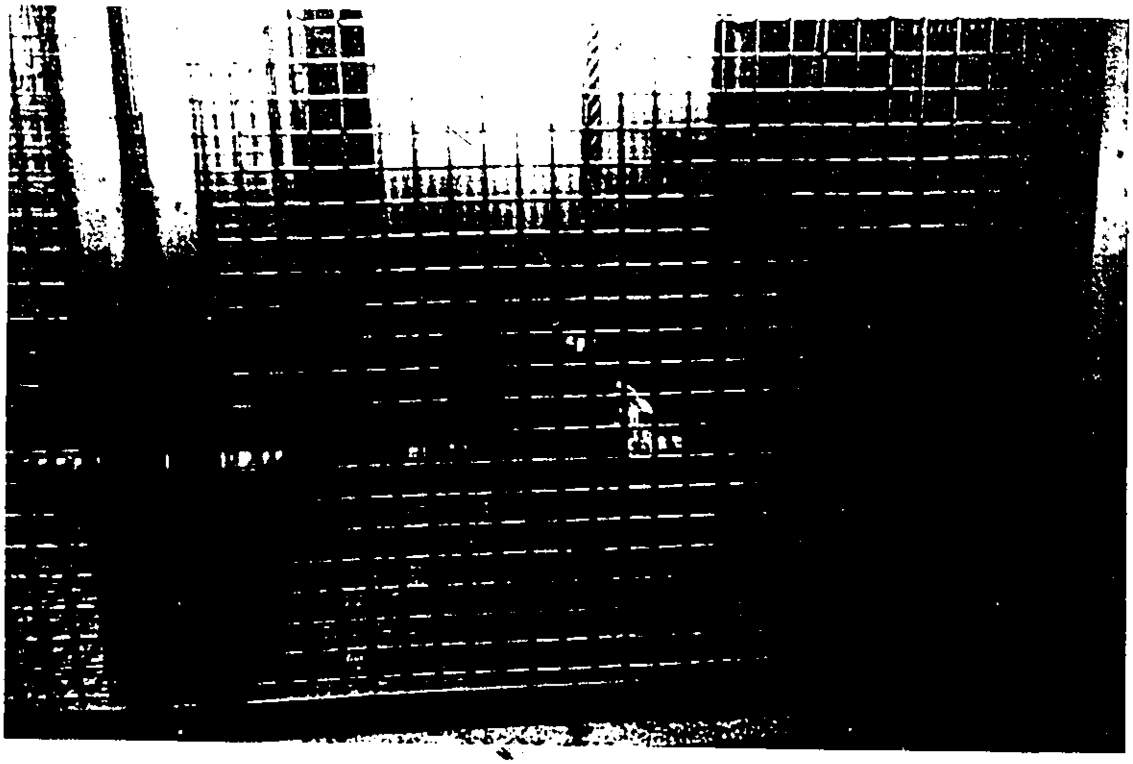


Figure 10 above;   Figure 11 below.

Events during reunion also held a few surprises. The initial reaction of all the infants to the mothers' return was a tremendous upsurge in excitement. all the infants ran to cling the mothers. Soon however, bedlam broke out. A few lines from the log may clarify the situation.

> "after a short period of ventral-ventral contact, the general commotion and agitation increased in pitch, somewhat out of control. Infants got off their mothers and ran outside and schreeched and cooed; all together but divided by the pannels. It's as if they feared losing their peers more than they wanted their mothers."

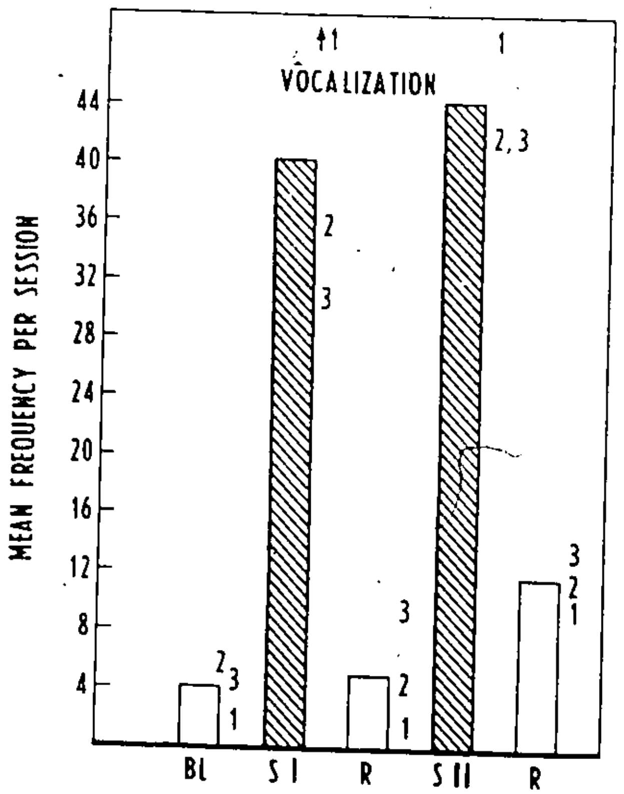
Strong new attachments had been made. By the second day, the mother-infant relationships had stabilized and re-established a more familiar routine.

Qualitative Results

The results for the first experiment are virtually the same as those reported by several other investigators; therefore only the most important items will be mentioned. Only those items showing marked changes in at least 3 out of 4 infants are reported. these are the items relating to to vocalization, locomotion, social play, individual play and non-specific gross body contact. Figure 12 shows the frequency of cooing and schreeches throughout the entire experiment. It is clear that during both separations this behaviour occurred at a very high rate indeed, while during periods of reunion and baseline the frequency was quite low. This behaviour never quite returned to preseparation levels as can be seen especially in the final reunion. This indicates that the infants never completely recovered from the effects of separation during the reunions. Mean values represent the mean frequency per recording session for 3 infants. The small numbers represent the relative position of the mean value for each infant; #1 being Maxie, #2 Ullysses, and #3 Napoleon. the mean values rose to over 10 times their baseline values; separation values were about the same in both separations. This item has proved to be the single strongest indicator of acute distress.

Results for the item 'touch infant', Figure 13 , which relates to an increase of gross physical contact, showed that each time the mother was removed the infants tended to huddle together and increase contact and proximity. This need disappeared as the mothers were returned. 'Social play' was the second most powerful indicator of distress. A strong suppression of play with immediate onset and long duration was seen in all subjects and is illustrated Figure 13 .

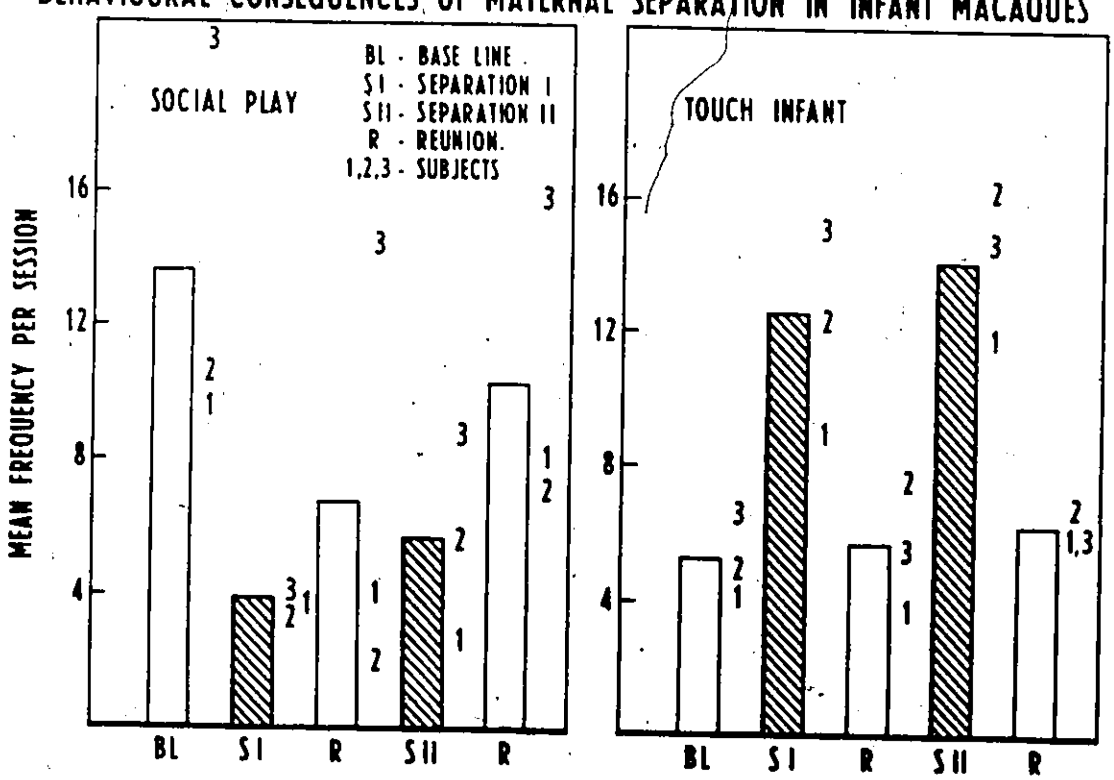
All forms of play behaviour were markedly suppressed by separation and did not fully recover during reunion. This again indicates that the disturbing effect of the first separation was carried across later conditions. The increase in agitation is shown in the results for "locomotion" given in Figure 14 . Results for George are summarized in Figure 15 .

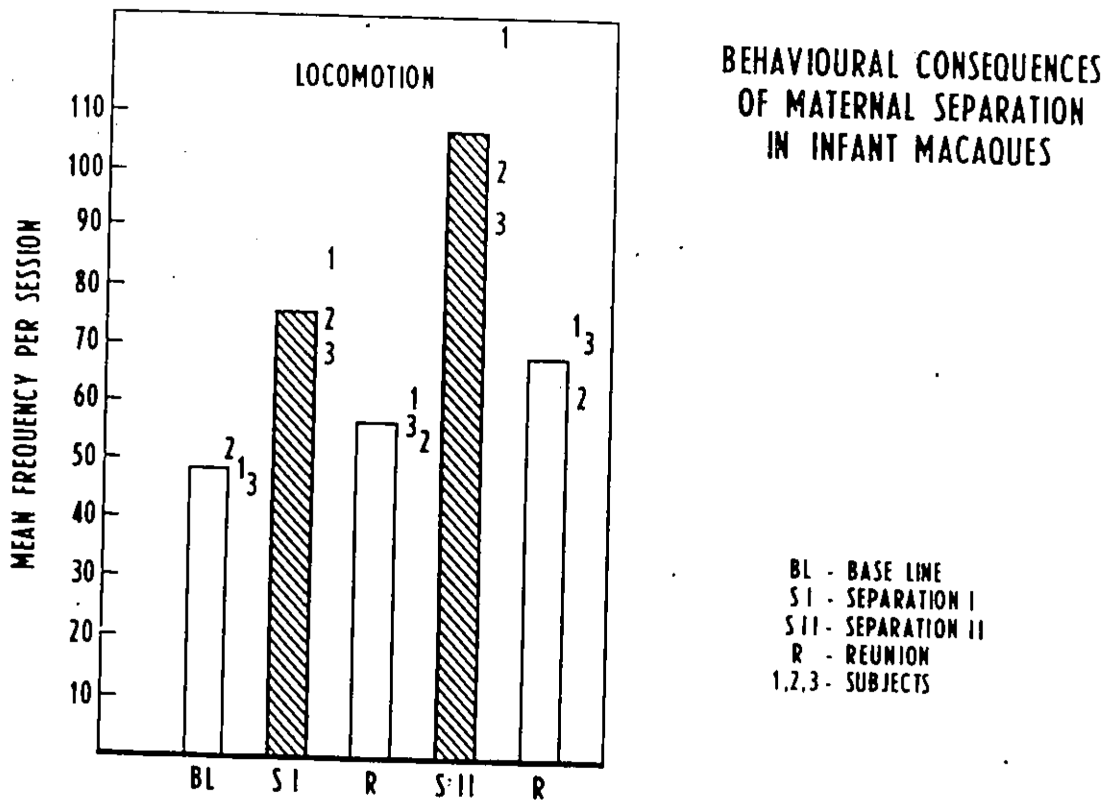


BEHAVIOURAL CONSEQUENCES OF MATERNAL SEPARATION IN INFANT MACAQUES

BL - BASE LINE
S I - SEPARATION I
S II - SEPARATION II
R - REUNION
1,2,3 - SUBJECTS

BEHAVIOURAL CONSEQUENCES OF MATERNAL SEPARATION IN INFANT MACAQUES




LOCOMOTION
MEAN FREQUENCY PER SESSION
110
100
90
80
70
60
50
40
30
20
10
BL
S I
R
S II
R
BEHAVIOURAL CONSEQUENCES
OF MATERNAL SEPARATION
IN INFANT MACAQUES
BL - BASE LINE
S I - SEPARATION I
S II - SEPARATION II
R - REUNION
1,2,3 - SUBJECTS

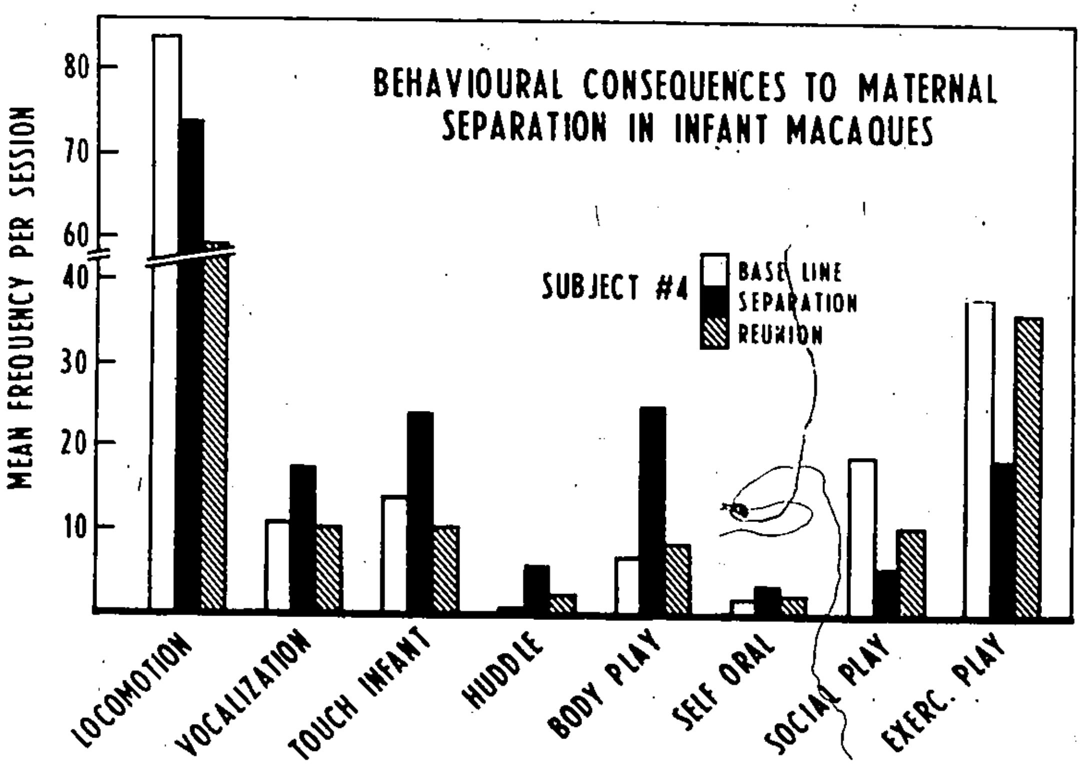

BEHAVIOURAL CONSEQUENCES TO MATERNAL
SEPARATION IN INFANT MACAQUES
MEAN FREQUENCY PER SESSION
80
70
60
40
30
20
10
SUBJECT #4
BASE LINE
SEPARATION
REUNION
LOCOMOTION
VOCALIZATION
TOUCH INFANT
HUDDLE
BODY PLAY
SELF ORAL
SOCIAL PLAY
EXERC. PLAY

Table 1 recapitulates the results represented in the previous bar graphs. It can be seen that those behaviours reflecting a normal playful interaction with the environment and with peers, (exercise play and social play) fall in response to separation. In contrast, those behaviours showing distress and agitation (locomotion, touch infant, vocalization) rise, at times dramatically. A glance at the accompanying standard deviations will reveal that the variation found in these monkeys is considerable in some items; however, referring to the bar graphs, the position of the individual subject's means shows that the values group sufficientsly to allow good separation between conditions. The graphs also seem to indicate that the first separation had the single most powerful effect in all three subjects. It is interesting to note that the subject #3 (Napoleon) who showed the least disturbance also showed the highest degree of affilation on the play item, as well as highest degree of contact seeking on the 'touch infant' item and generally the least amount of agitation and distress in locomation and vocalization. An approximately inverse relationship is indicated for subject #1 who showed the lowest degree of affiliation on social play. It may be that performance on this item predicts the subject's performance during separation.

	A1		B1		A2		B2	
Label	mean	sd	mean	sd	mean	sd	mean	sd
E P	23.6,	15.8	10.8,	8.7	16.1,	5.0	18.9,	11.2
S P	13.5,	12.4	3.9,	6.3	6.8,	5.7	10.4,	16.2
Lo	48.5,	21.8	75.5,	23.5	56.9,	19.1	106.9,	34.6
To	5.2,	4.4	12.4,	5.2	5.5,	5.6	14.0,	8.2
Vo	3.9,	4.4	40.0,	45.2	4.8,	6.8	43.6,	34.5

Mean values and standard deviations of five behavioural items averaged across the first three subjects in baseline to separation II The labels refer to exercise play, social play, locomotion, non-specific touch and vocalization respectively.

TABLE 1

MEAN VALUES AND STANDARD DEVIATIONS

Quantitative Results

The determinations of the plasma DMI concentrations will be presented here before the behavioural data. As can be seen in Table 2, the plasma[3] levels of DMI, measured at intervals of 4 and 22 hours after the last injection, vary considerably among the 3 tested subjects. However, the points fall within the range normally found in a human wash-out curve. (P.D. Hrdina, personal communication, Jan. 1980). The results are expressed in units of nanograms per millilitre.

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[3]CNS tissue concentrations (cortex and hypothalamus) in rats after a similar period are approximately 20 times greater than plasma concentration (Hrdina, Dubas and Riva, 1978).

PLASMA LEVELS OF DMI IN INFANT MACAQUES AFTER DAILY ADMINISTRATION OF 5mg/kg FOR 5 DAYS

Subjects	Plasma Levels (ng/ml) After Last Injection	
	4 hr	22 hr
No. 1	145	39
No. 2	219	68
No. 3	84	34
	$\overline{X} = 149 \pm 39$	$\overline{X} = 47 \pm 10$

Table 2.

In the analysis of data for experiment II, several passes through the data were made with BMDP using the bmdpp2v programme for repeated measures. Before the programme was run the data base was reorganized to reflect mean frequency values for blocks of three days. The first 12 days of each condition were designated as the repeated trial factor "condition" ie. baseline, separation etc. Within conditions, blocks of three days represent the second repeated trial factor "division". There are four divisions in each of four conditions considered. A third factor "group" represents the experimental DMI group and the control group. Three passes were made through each file to keep the jobs within a manageable computer size. The analysis of variance compared baseline-separation I, baseline-separation II, and reunion I-separation II. the results yielded ten analyses per comparison; one for each behavioural item.

Analysis of Individual Behaviours

Baseline and Separation I

The analysis of variance revealed many differences due to the conditions and divisions, see Tables 3 to 7 . Tables for the analysis of variance of the following items and the transformed raw data files are given in Appendix C.

The comparison of individual behaviours during baseline and separation I shows that the group factor differed only in "exercise play", ($f=9.2$, $df=1/5$, $p=.02$), indicating that the experimental group differed from the controls on this dimension both before and after separation. The remaining differences in variance were due primarily to the separation as it affected both groups equally. Differences in the trial factor "condition" were found in "sit" ($p=.003$), "eat and chew" ($p=.008$), "body play" ($p=.01$), "exercise play" ($p=.001$), and "vocalization" ($p=.02$) where f is greater than 6.0 and $df=1/5$. For 'sit' referr to Figure 16 .

All these changes represent, as hypothesized, increases in the corresponding behaviours except "exercise play" which decreased. Differences due to the trial factor Divisions appeared in five behavioural items, "sit", "eat and chew", "locomotion", "exercise play", and "vocalization" where $f \geq 3.2$, $df=3/15$, $p \leq .05$. This indicates that rates during blocks of 3 days vary; for instance the frequency of "sit" was much greater in the last three days of separation. The incidence of locomotion was also increased in both groups but the effect was especially noticeable in the control group. Control group values were lower (p=.07) at baseline but rose to match those of the DMI group at separation. The decrease seen in exercise play was especially low during Div1 and 2 for the control group and Div 2 for the DMI group. By Div 4 of separation, the drug group effected a substantial recovery not seen in the control infants. A second important difference at this point in the experiment, is an interaction of group by condition in the vocalization item. This behaviour, consisting of "woo" calls mainly, was initially quite low in both groups. At separation it rose sharply in the controls and remained high. Significantly elevated levels were attained by the DMI group only during days 4 to 6 of separation and then recovered. Since it is generally agreed that this index is a reliable indicator of distress, we may accept it as an indication of greater disturbance in the control infants during separation I. This difference did not hold in separation II.

TABLES OF INDIVIDUAL BEHAVIOURS IN BASELINE-SEPARATION I

In the tables that follow, the reference labels 'CONT' and 'DMI' refer to the two groups, while 'CON' refers to 'condition' and 'DIV' to 'divisions'. This structure remains unchanged in the respective figures. Groups are referred to by their initials under the bars.

CON	DIV	CONT	DMI
1	1	14.3	19.5
1	2	26.6	20.3
1	3	10.3	19.0
1	4	18.6	33.3
2	1	40.0	40.8
2	2	43.0	44.0
2	3	34.7	41.8
2	4	55.7	58.5
MARGINAL		30.4	34.6

Table 3

'CELL MEANS FOR "SIT"

CON	DIV	CONT	DMI
1	1	21.0	59.5
1	2	28.3	80.3
1	3	27.7	70.8
1	4	69.3	83.0
2	1	99.7	91.3
2	2	81.0	42.8
2	3	40.3	56.3
2	4	70.0	87.8
MARGINAL		54.7	71.4

TABLE 4

CELL MEANS FOR "LOCOMOTION"

CON	DIV	CONT	DMI
1	1	2.3	3.0
1	2	0.0	0.0
1	3	0.0	1.0
1	4	7.7	3.0
2	1	55.0	7.3
2	2	35.0	14.5
2	3	11.7	9.3
2	4	16.0	2.0
MARGINAL		15.9	5.0

Table 5

'CELL MEANS FOR "VOCALIZATION"

CON	DIV	CONT	DMI
1	1	9.7	32.5
1	2	14.7	39.8
1	3	9.7	29.3
1	4	23.7	35.8
2	1	4.7	13.3
2	2	9.0	6.5
2	3	5.0	8.0
2	4	7.6	25.3
MARGINAL		10.5	23.8

TABLE 6

CELL MEANS FOR 'EXERCISE PLAY'

CON	DIV	CONT	DMI
1	1	3.7	6.0
1	2	4.0	3.5
1	3	2.3	3.5
1	4	8.3	7.8
2	1	7.3	4.5
2	2	8.0	7.0
2	3	17.7	21.8
2	4	7.3	12.3
MARGINAL		7.3	8.3

TABLE 7

CELL MEANS FOR "FORAGE"

Baseline and Separation II

Results for the comparison of baseline and separation II are given in table 8 to table 12 and reveal a similar pattern of behaviour. In this comparison there were again no differences due to the group factor except in "exercise play" (f=13.3, df=1/5,p=.01). See Figure 17. As in separation I the DMI group showed and overall higher rate of play, both during baseline and separation. Both groups showed an immediate significant decrease at separation; the DMI group appeared less affected but the effect was not significant. Significant effects of separation are seen, however, in the condition factor, in seven items. In the cases of "body play" and "vocalization" (see Figure 18) the probability level remained at only .08 and .06 respectively. In the remaining items, "sit", "eat and chew", "locomotion", "exercise play" and "forage", f≥ 7.8 and p ≤ .03 with 1/5 degrees of freedom. These results reflect the fact that the mean frequencies for these self directed behaviours rose in response to separation; the exception is again "exercise play" which decreased from a baseline mean of 25.7 per session to 12.9 per session in separation.

In the results for the division factor, it was found that locomotion was especially high during the first two divisions (days 1-6) of the second separation. Figure 21 shows the relatively greater effect in the control group. During division 4, the rate of locomotion increased substantially in the control group over the drug group (f=3.9, df=3/15, p=.03). An interaction in the item 'forage' shows that the control group engaged in a relatively greater amount of this solitary activity during separation II (F=4.84, df=3/15, p=.01), which was not seen in the previous separation. Vocalizations also, while not showing a consistently high level across the whole separation, did show a sharply accelerated rate in the first three days of separation, (f=3.8, df=3/15, p=.03).

TABLES AND FIGURES OF INDIVIDUAL BEHAVIOURS IN BASELINE-SEPARATION II

CON	DIV	CONT	DMI
1	1	14.3	19.5
1	2	26.7	20.3
1	3	10.3	19.0
1	4	18.7	33.3
4	1	52.6	42.3
4	2	53.0	45.3
4	3	54.0	45.8
4	4	54.7	49.8
MARGINAL		35.5	34.4

Table 8

"CELL MEANS FOR 'SIT'"

CON	DIV	CONT	DMI
1	1	21.0	59.5
1	2	28.3	80.3
1	3	27.7	70.8
1	4	69.3	83.0
4	1	104.7	111.5
4	2	107.3	100.5
4	3	89.0	91.8
4	4	137.0	88.0
MARGINAL		73.0	85.7

TABLE 9

CELL MEANS FOR 'LOCOMOTION'

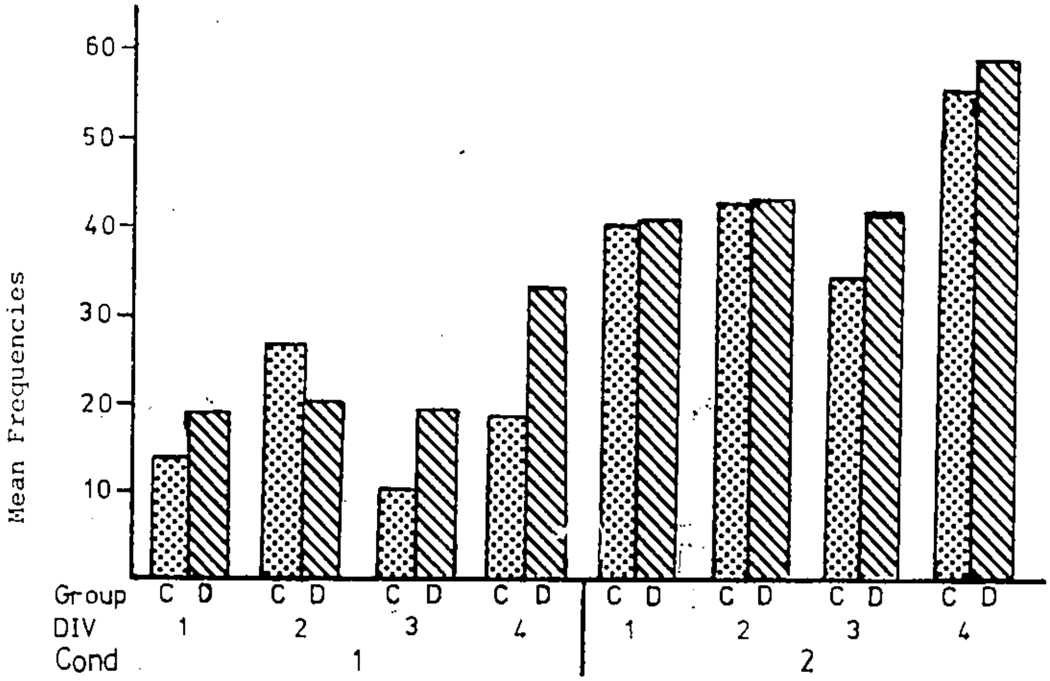

Fig. 16 Cell means of "Sit"
Baseline vs. Sep. 1

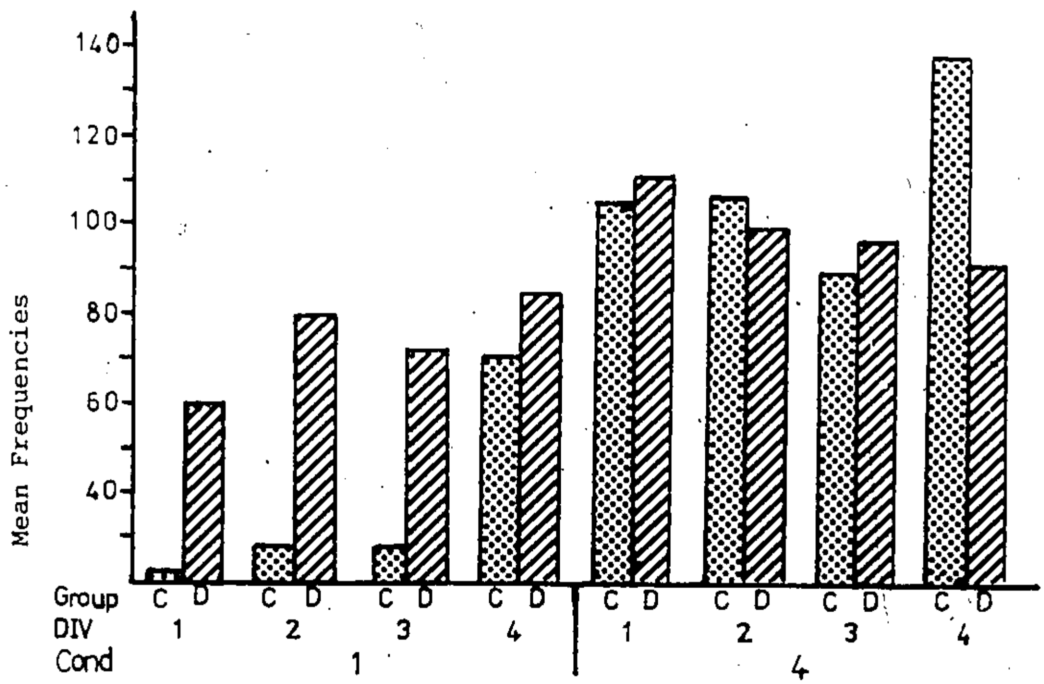

Fig. 17 Cell means of "Locomotion"
Baseline vs. Sep. 11

CON	DIV	CONT	DMI
1	1	9.7	32.5
1	2	14.7	39.8
1	3	9.7	29.3
1	4	23.7	35.8
4	1	6.0	16.0
4	2	4.6	19.0
4	3	7.3	16.0
4	4	13.3	16.3
MARGINAL		11.1	25.6

Table 10

CELL MEANS FOR 'EXERCISE PLAY'

CON	DIV	CONT	DMI
1	1	2.3	3.0
1	2	0.0	0.0
1	3	0.0	1.0
1	4	7.7	3.0
4	1	23.7	23.5
4	2	9.3	8.0
4	3	16.3	10.0
4	4	4.3	4.3
MARGINAL		7.9	6.6

TABLE 11

CELL MEANS FOR "VOCALIZATION"

CON	DIV	CONT	DMI
1	1	3.7	6.0
1	2	4.0	3.5
1	3	2.3	3.5
1	4	8.3	7.8
4	1	18.3	10.0
4	2	13.3	9.5
4	3	15.0	13.3
4	4	13.0	11.8
MARGINAL		9.8	8.2

TABLE 12

CELL MEANS FOR "FORAGE"

Reunion I and Separation II

The comparison of reunion I with separation II reveals several differences. Results in the group factor concerning "exercise play" are virtually repeated. Differences due to the conditions factor were found in four items; that is significant increases resulted in rates for 'body play", "eat and chew", "locomotion", and "MOE", where $f \geq 26.3$, $df=1/5$ and $p \leq .008$. It is interesting that "exercise play" is not in this set. The DMI group was more active on this dimension before separation and continued to be afterwards. The decrease experienced by both groups at separation was modest and did not reach significance, (p=.07). A phasic and non-significant decrease in this behaviour is seen in the first division of reunion, likely indicating a preoccupation with the mother. The same supression effect in the first division is also found in "sit", "eat and chew", "moe", and "forage". In the case of "sit" and "exercise play" the probability reaches only 0.07 and 0.06. Results for locomotion further show that while the control group showed initially lower rates early in the reunion, their rates equalled those of the drug group at the start of separation and finished much higher in Div 4. The experimental group apparently recovered more quickly on this item. The F for these interactions are greater than 4.5, df=3/15 and p is less than or equal to .02. Vocalization in both groups rose at separation but is not significant in this comparison. Rates returned to preseparation values by Div 4.

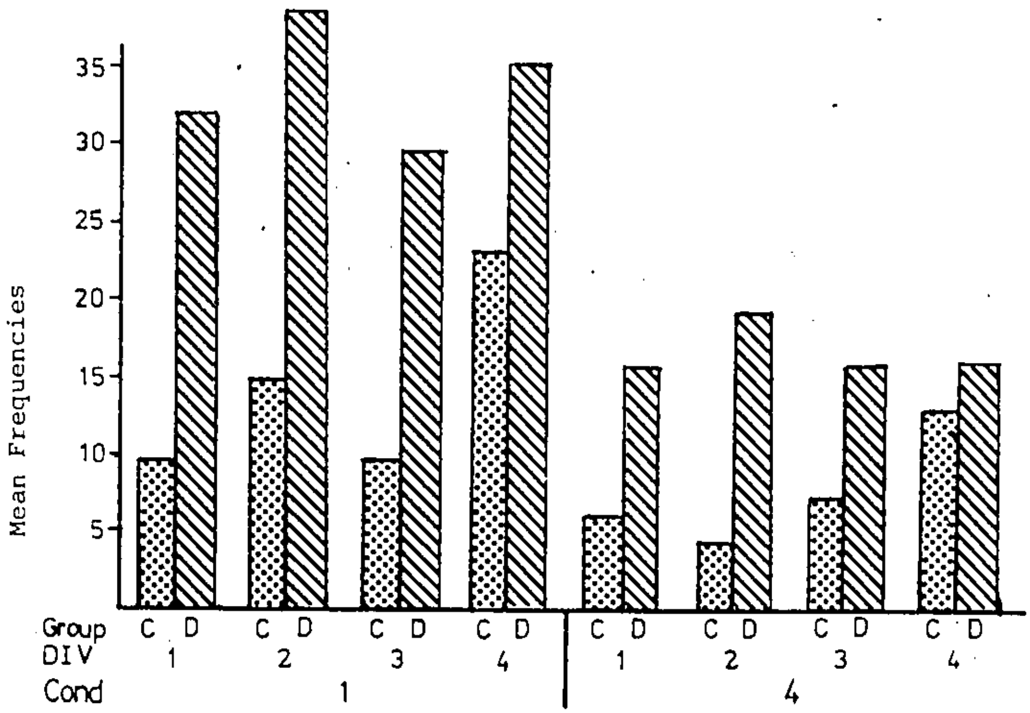

Fig. 18 Cell means of "Exercise Play"
Baseline vs. Sep. II

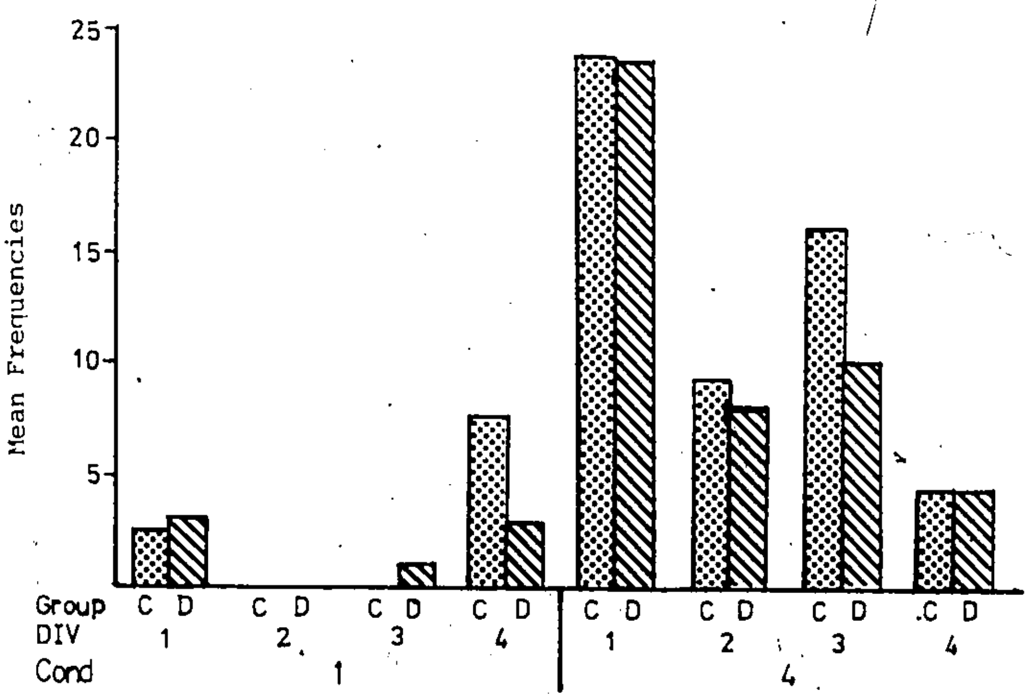

Fig. 19 Cell means of "Vocalization"
Baseline vs. Sep.II

Analysis of Social Behaviours

Baseline and Separation I

A similar set of comparisons was carried out for the social behaviours. In general these comparisons revealed fewer differences.

That this separation did have a profound effect on these infants is seen in Tables 13 and 14 The results for a special analysis done on a sample of six social behaviours. Since no drug was given at this time the data were pooled for all seven subjects. In this analysis the mean duration per event-behaviour was tested. The data were first transformed by the following operation, sum duration/sum frequency. It was found that the mean duration/event for all items decreased during separation. Not all the results were statistically significant, for example in "active contact", $p=.08$; "moe", $p=.06$; "accepts play", $p=.08$. However for "passive contact", "initiates play" and "mutual object interest" $f \geq 6.3$, $df=1/6$, and $p \leq .04$. It is noteworthy that all of these, including "passive contact", in which the frequency rose significantly, represent decreases. This indicates that when behaviours were started, they were quickly abandoned. The infants tended not to persevere in these behaviours.

CON	DIV	GROUP
1	1	2.0
1	2	1.9
1	3	1.9
1	4	1.9
2	1	0.3
2	2	0.3
2	3	0.6
2	4	0.5

Table 13

CELL MEANS FOR MAS "PASSIVE CONTACT"

CON	DIV	GROUP
1	1	3.8
1	2	4.2
1	3	4.2
1	4	2.7
2	1	0.5
2	2	0.1
2	3	0.0
2	4	0.3

TABLE 14

CELL MEANS FOR MAS "INITIATES PLAY"

Baseline and Separation I

Frequency changes for social behaviours during separation I are given in Tables 15 to 18 In the comparison of the baseline frequency values with those of separation I, one difference due to group and condition interaction was found. Results for the item "accepts play" shows that both groups had initially low but stable rates except during Div 2 of baseline, where rates for the DMI group were much higher. The behaviour virtually disappeared in both groups during separation and recovered again to preseparation levels in DIV 4 of separation (f=5.2, df=3/15, p=.01).

Significant main effects due to conditions were found in "passive contact". The mean frequency of this behaviour doubled in both groups in separation, from 16.4 to 36.4 (f=9.5, df=1/5 , p=.02). Other main effects (not significant) were seen as a decrease in "active contact" and as an increase in vocalization, (.08<p<.09). The item "initiates play" decreased significantly in the division factor. The control group showed a significantly higher rate immediately before separation in Div 4 of reunion and tended to remain higher during separation. This behaviour decreased in both groups but in the control group there was a significant supression only in the first division following separation. An interaction in 'approach' shows that the DMI group was somewhat more socially inclined in this item before separation. The distinction does not hold however, during separation II.

CON	DIV	CONT	DMI
1	2	3.0	4.0
1	2	2.3	6.8
1	3	1.3	5.5
1	4	4.3	4.2
2	1	8.3	11.8
2	2	8.0	14.0
2	3	3.0	7.8
2	4	10.3	8.0
MARGINAL		5.1	7.8

Table 15

CELL MEANS FOR "PASSIVE CONTACT"

CON	DIV	CONT	DMI
1	1	1.3	3.0
1	2	3.3	19.5
1	3	0.7	6.3
1	4	2.3	2.3
2	1	0.0	0.5
2	2	0.6	0.5
2	3	0.0	0.5
2	4	2.0	3.5
MARGINAL		1.3	4.5

TABLE 16

CELL MEANS FOR "ACCEPTS PLAY"

CON	DIV	CONT	DMI
1	1	4.0	4.8
1	2	4.6	15.0
1	3	5.6	6.5
1	4	10.7	2.3
2	1	0.0	2.5
2	2	3.0	0.8
2	3	2.0	0.3
2	4	8.7	7.8
MARGINAL		4.8	4.9

Table 17

CELL MEANS FOR "INITIATES PLAY"

CON	DIV	CONT	DMI
1	1	13.3	11.0
1	2	12.0	30.8
1	3	35.0	20.3
1	4	20.3	16.3
2	1	4.0	9.8
2	2	9.3	7.5
2	3	13.3	10.8
2	4	7.0	7.5
MARGINAL		14.3	14.2

TABLE 18

CELL MEANS FOR "ACTIVE CONTACT"

Baseline and Separation II

The comparison of baseline and separation II again reveals few differences overall. It is characteristic that "accepts play" is the item most strongly affected and mirrors the effect reported for separation I, ($f=3.5$, $df=3/15$, $p=.04$). See Figure 19, Figure 20 and Figure 21 as well as the tables presented in the section below. The frequency of "passive contact" again rose in both groups ($f=9.5$, $df=1/5$, $p=.02$) This time the frequency of "initiates play" clearly reflects the effect seen in "accepts play"; there is a significant decrease in Div 1 and 2 and a recovery in the final days of separation, ($f=3.8$, $df=3/15$, $p=.03$). The control group was no longer more active in this item. A non-significant interaction in "approach" shows that the drug treated infants approached their social peers somewhat more consistently during the first 3 divisions of separation II.

TABLES AND FIGURES FOR SOCIAL BEHAVIOURS IN BASELINE-SEPARATION II

CON	DIV	CONT	DMI
1	1	7.3	11.8
1	2	6.0	29.3
1	3	15.3	16.7
1	4	11.0	8.3
4	1	7.6	11.0
4	2	7.3	9.5
4	3	5.6	10.0
4	4	16.3	15.5
MARGINAL		9.8	14.0

Table 19

CELL MEANS FOR "APPROACH"

CON	DIV	CONT	DMI
1	1	3.0	4.0
1	2	2.3	6.7
1	3	1.3	5.5
1	4	4.3	4.3
4	1	8.0	10.3
4	2	9.3	8.8
4	3	9.3	8.8
4	4	9.0	13.0
MARGINAL		5.8	7.6

TABLE 20

CELL MEANS FOR "PASSIVE CONTACT"

CON	DIV	CONT	DMI
1	1	1.3	3.0
1	2	3.3	19.5
1	3	0.7	6.3
1	4	2.3	2.3
4	1	0.0	0.7
4	2	0.0	1.5
4	3	1.0	1.3
4	4	4.7	3.8
MARGINAL		1.7	4.7

Table 21

CELL MEANS FOR "ACCEPTS PLAY"

CON	DIV	CONT	DMI
1	1	4.0	4.8
1	2	4.7	15.0
1	3	5.7	6.5
1	4	10.7	2.3
4	1	1.0	0.5
4	2	1.6	1.5
4	3	2.3	3.8
4	4	7.0	10.0
MARGINAL		4.6	5.5

TABLE 22

CELL MEANS FOR "INITIATES PLAY"

CON	DIV	CONT	DMI
1	1	13.3	11.0
1	2	12.0	30.7
1	3	35.0	20.3
1	4	20.3	16.3
4	1	9.3	10.8
4	2	2.6	16.0
4	3	8.0	12.0
4	4	8.3	12.0
MARGINAL		13.6	16.1

TABLE 23

CELL MEANS FOR "ACTIVE CONTACT"

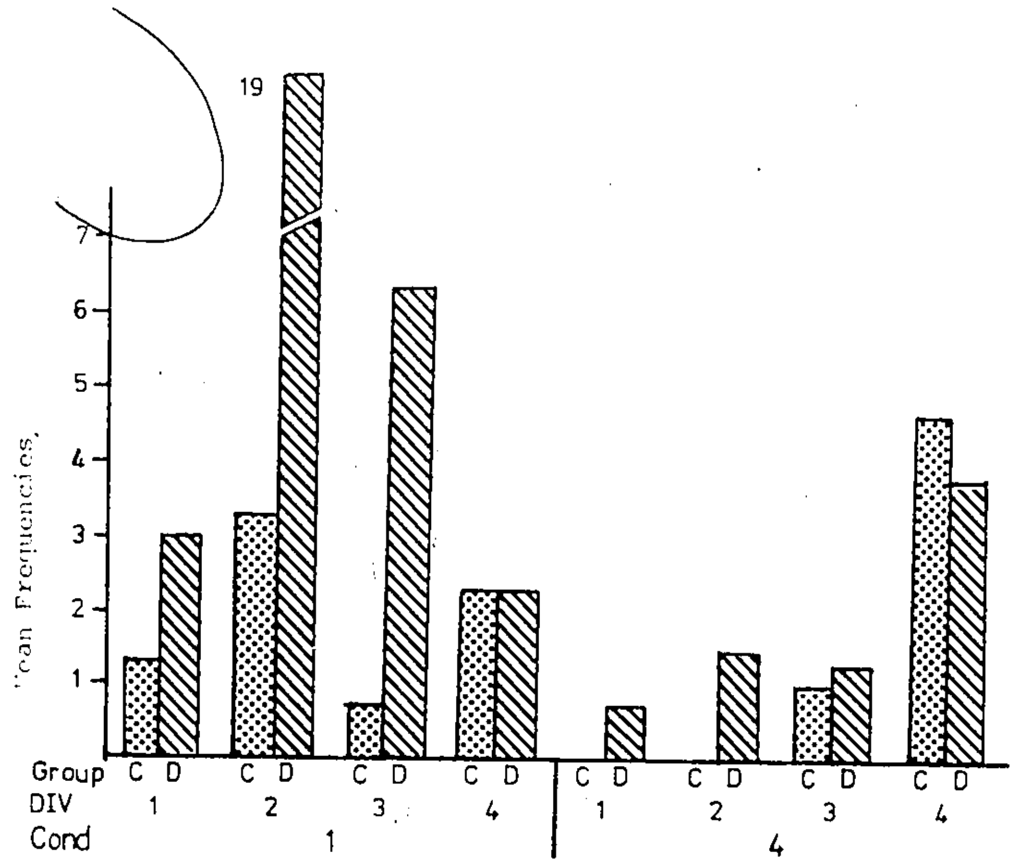

Fig. 20 Cell means of "Accepts Play"
Baseline vs. Sep. II

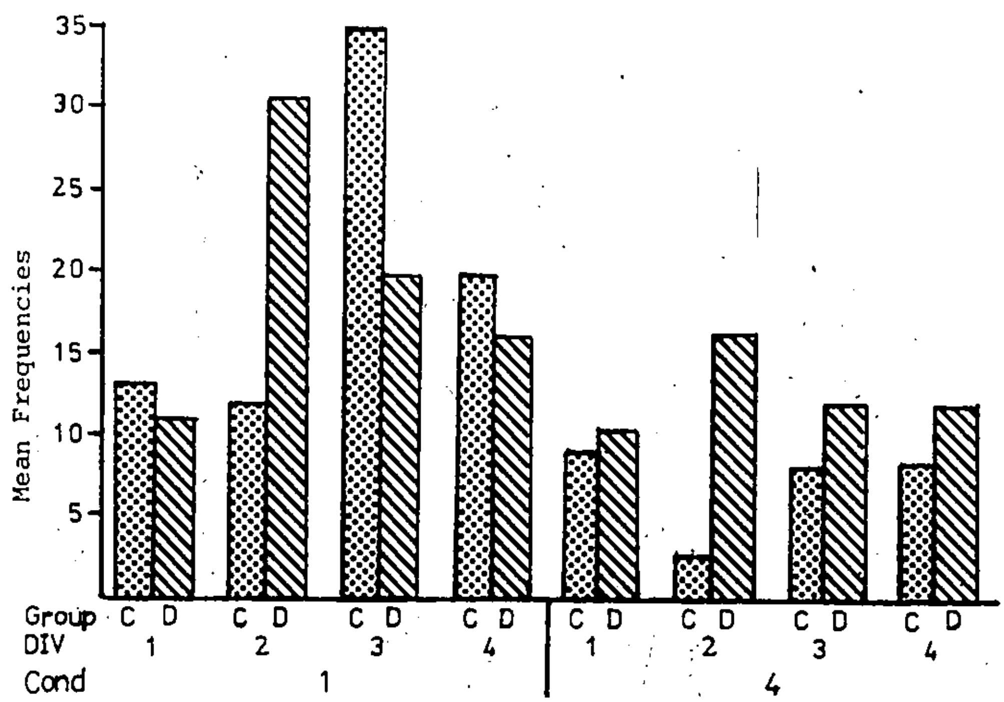

Fig. 21 Cell means of "Active Contact"
Baseline vs. Sep. II

Reunion I and separation II

In the comparison of reunion I with separation II, main effects due to conditions were found in "mutual object interest" and "passive contact" where $f \geq 18.9$, $df = 1/5$, and $p \leq .007$. For the former, these figures represent a strong supression, while the latter is greatly increased. Significant effects due to the divisions factor are seen in six behaviours i.e., for "reach", "approach", "accepts play", "initiates play", "moe", and "withdraw" ($f \geq 4.3$, $df = 3/15$, and $p \leq .02$). The figures represent significant decreases in most the corresponding behaviours. For items "approach" and "withdraw" this does not reflect a suppressive effect of separation, rather an initially low rate due to reunion with the mother. In fact at Div 4, the end of separation II, both groups greatly increased this behaviour.

One of the notable features of these results is the low or often non-existent frequencies of many behaviours in Div 1 of reunion. This is naturally accounted for by the resumption of the maternal relationship after a period of traumatic separation. The phenomenon is seen in both groups. Rates of behaviour usually returned to normal levels after a period of about four to seven days.

Grouped Items

The play behaviours and "active contact" were grouped and reanalysed with the paired-sample t-test. Referring to Figure 22 for the new grouping "active contact", it can be seen that the DMI treated group did not experience the decreased duration of play seen in the controls. Values for the control group in this case declined to 22% of their preseparation levels, whereas those of the DMI group remained stable. The columns representing pre-separation include only the drug pretreatment period , 7 days before separation. The other columns represent separation days 1-6 and 7-10; these are expressed as a percent of the pre-separation value. A single asterisk indicates significance relative to the pre-separation period and a double asterisk indicates significance relative to the other group. The duration of this class of behaviours is expressed in terms of machine time.

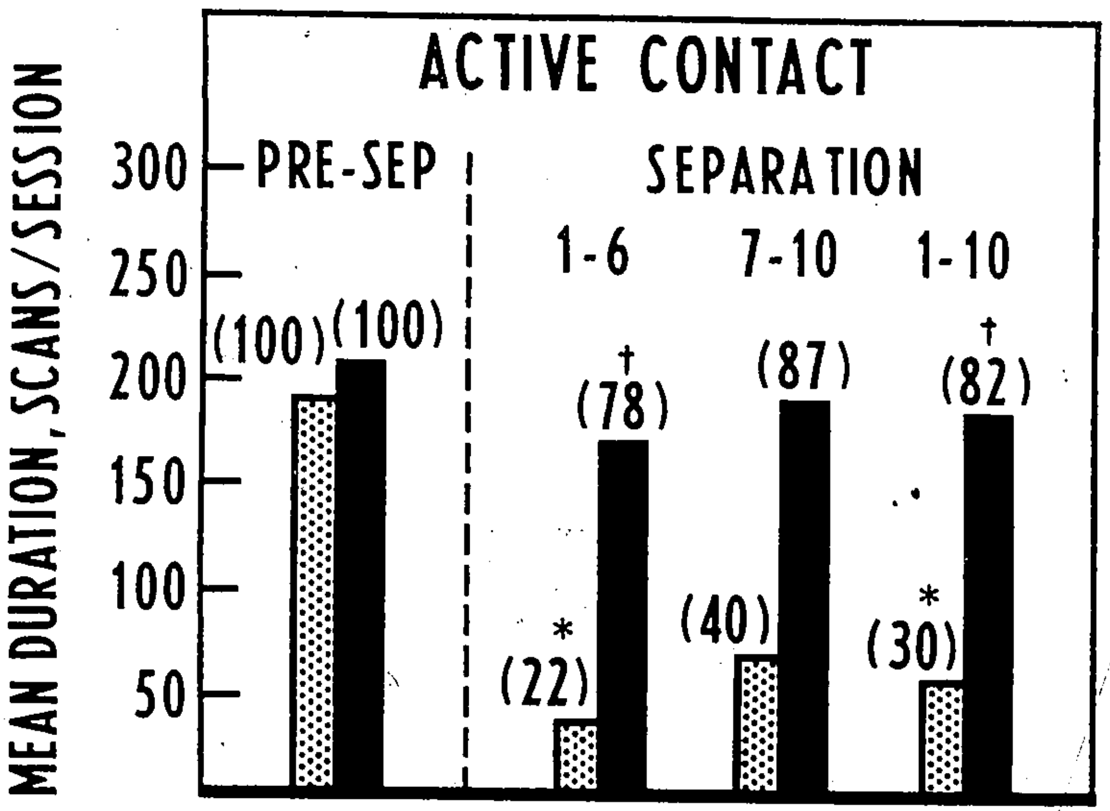
ACTIVE CONTACT
MEAN DURATION, SCANS/SESSION
300
250
200
150
100
50
PRE-SEP
SEPARATION
1-6
7-10
1-10
(100)
(100)
*
(22)
†
(78)
(40)
(87)
*
(30)
†
(82)

Figure 22.

DISCUSSION

Discussion of results

The evaluation of possible drug effects on separation-induced behavioural changes was an important goal of this project. Under the hypothesis it was expected that the DMI group would engage in a greater amount of social, peer-directed activity while the controls would show more behaviour indicative of social disengagement. Some of the noted effects include differences that suggest intrinsic group differences existing prior to separation. These results show generally higher rates of both social and individual play behaviors in the DMI group from the start. Such initial differences may obscure possible effects seen at a later time.

It appears, however, that initial group differences tend to be erased by the experience of separation. At separation I, play behaviours fell away from both groups and differences in "approach" and "locomotion" were not maintained. In the case of "initiates play", contrary to the usual pattern, it was the control group that showed a modestly higher rate ($f=4.1, df=3/15, p=.02$), yet at separation II they showed rates as low as those of the

DMI group. At separation I, other social items such as passive contact and active contact are indeed strongly affected, but are not discriminative of groups. This group of seven infants certainly did not form two neat and homogeneous groups at the baseline, and yet there were few significant group by condition interactions by separation II that would indicate a very different course of reaction for either. The evidence appears to show that all infants tend to react to separation in a similar way such that there are fewer differences between them during separation than before. This statement is not meant to give the false impression that all infants appear the same in separation; in fact there is great variability as Lewis et al, (1976) have aptly noted. However one can only agree with Suomi et al, (1970), that this kind of chronic stressor appears to delay or arrest the normal "psychosocial" development of the infants.

In <u>individual behaviours</u>, the expected increase in passive sitting as well as in "body play", "eat and chew", and "still" occured equally in both groups. However the solitary behaviour 'Forage' was more prevalent in the untreated controls. "Exercise play" was initially higher in the DMI group but was reduced to comparably low levels in Div 2 and 3 of separation. It must be noted however that the effect seen in the DMI group on this item was not as abrupt and the recovery in Div 4 of Separation I was stronger. This recovery was influenced by one particularly active infant (Fonzie). Vocalization did however significantly differentiate the groups during separation. At separation I (but not separation II), the control group was significantly more vocal. Most individual behaviours, in the comparison of baseline with separation II, items generally did not distinguish groups during separation; the only exceptions being 'locomotion' and 'forage'. The DMI group was more active in locomotion at baseline as previously explained, but at separation, the rates for both groups equalized at high levels. During divisions 1 and 2 of separation however, where the DMI group recovered in divisions 3 and 4, the control group further increased their rates indicating even greater arousal and agitation. In that "Forage" is an item of solitary activity it also indicates a somewhat lesser amount of socially directed behaviour in the control group. In these cases it is possible that DMI exerted a controlling and/or moderating effect .

In the comparison of social behaviours during baseline and separation II some of the expected effects could be generally seen but did not reach significance. For instance, there was a modest tendency for the drug group to maintain more social "moe" or manual-olfactory-explore; the level of significance however reached only .07. Similarly, there was a non-significant tendency in the treated infants to maintain higher rates of responding in both "accepts play" and "initiates play". Because these items are of theoretical importance but failed to individually show a drug effect, the last three were combined and re-evaluated with the student's t. Referring to Figure 22 it is clear that the socially directed activity of the DMI group is not significantly different from their behaviour before separation. By contrast, the control group showed a large decline during this time. It therefore appears that DMI may be responsible for the maintenance of active contact in the experimental group. The durations referred to in figure 22 as opposed to those in Table 14 are durations summed and averaged over entire recording sessions. The results of these experiments leave no doubt that maternal separation does indeed have powerfully disruptive effects on infants. All sociopetal activities such as "active contact", "mutual object interest" and play showed significant decreases as well as individual play activity. In addition, the specific hypothesized increases in sociofugal and agitative behaviours such as sitting, locomotion, and vocalization, occurred to a significant degree in most of the infants. Such evidence clearly epitomizes the dysphoric effects of separation on the emotional expression of the young monkey. The infants were quite unable to engage some of their most common and developmentally important behaviour patterns. Instead they reverted to simpler patterns of social avoidance and basic solitary activity.

It is patent from the foregoing discussion of the results that while there is some evidence to suggest that DMI is effective in reversing some of the effects of separation, this evidence is not conclusive. Few items, when examined alone, support a drug effect. Problems have inevitably arisen from the small number of subjects and the limited dose range used in the study. It is possible that another drug such amitriptyline or diazepam would be more effective or that a higher dose of the same drug would prove more effective. Yet another possibiłity is that DMI requires a pretreatment period longer than one week as was done here. Such questions are presently the focus of current research at this laboratory.

In spite of experimental limitations, the results reported here, for "locomotion" and "social play" appear to show an effect due to DMI in the appropriate regrouping of the items. This result is in close accordance with those reported by Suomi et al (1978). It is significant that these results were obtained in the face of a powerful event (separation) that tended to eliminate many differences between infants. It is possible that DMI had a normalizing effect on the infants, one which enabled a faster rate of behavioural stabilization and regulation in the treated infants in this experiment. Such an interpretation is supported by the recovery of "locomotion" in the DMI group and the contemporaneous increase in the control group. The antidepressant appears to have exerted a damping effect on some of the extremes of behavioural oscillation typically seen in separated infants. If this conclusion is supported by continuing research, then the pharmacological control of separation-induced behavioural disruption may allow the subject the extra stability required to gain control over a difficult situation a little more quickly.

Discussion of Theoretical Context

The results of the present experiments have mixed consequences for the status of the separation model of depression as presented in the review of literature (page 61). The primary goal of the study i.e., further validation of the model by the extension of the fourth (treatment effectiveness) criterion has not been completely accomplished. As detailed in the statement of of the problem and hypotheses, it was expected that DMI treatment would reverse the separation-induced disruption and regression from normal infant behaviour. It was also stated that such a finding would further validate the separation model by the extension of it's fourth (treatment) criterion to the area of chemotherapy. Only a partial differentiation of groups on the basis of DMI treatment was possible.

The evidence for this comes primarily from the result that the control group appeared to be over-all more agitated and less socially active than the DMI group on the second separation. While the strength of "active contact", in terms of its frequency, did not increase, the duration of this category (regrouped) did remain significantly higher in the DMI treated group. It must be recalled now that a lack of persistence in active or performing behaviours is one of the outstanding signs of human depression. Teaching patients perseverence is also one of the main aims of behaviour therapy for the disorder. A somewhat greater degree of social interest (p=.07) in the DMI group is also seen in the item "manual-olfactory explor" or social "MOE". By contrast, the control group did not appear to recover from high levels of agitation (locomotion) as the DMI group did. It thus appears that treatment means involving antidepressant drugs are indeed effective in moderating some behavioural categories of the separation reaction. Unfortunately however, not enough categories in this experiment were affected to give an unequivocal affirmation to the treatment (4th) criterion.

The purely behavioural results of these experiments allow a degree of greater precision in the second criterion of the model, which states that, behavioural and affective states produced by separation should be similar in man and monkey. The increased specificity may be gained by the inclusion of the four following points within criterion two:

1. <u>The overall rate of all behaviours should be significantly lowered</u>. Nearly all the changes reported above, involved significant decreases in behaviour rates; the most notable exceptions being vocalizations, locomotion and sitting.

2. <u>Behaviours related to any kind of euphoric state and active sociopetal behaviours should be sharply reduced</u>. In this case the best examples are the disappearance of different forms of play and social contact.

3. <u>Passive behaviours, of both the social and individual kinds, should increase</u> by virute of the absence of the above-mentioned active repertoire. This can be seen in the increase in behaviours such as sitting, and "passive contact".

4. <u>Behaviours related to dysphoric affective, distress and restlessness should show a phasic increase</u>. The best examples here are vocalizations

or "woo" calls, "body play" locomotion and occassionally stereotypies.

Lewinsohn (1969, 1970, 1974), again illustrates similar results in man since he uses a rather similar method of behavioural quantification. His depressed patients showed an overall decrease in all activity, a specific decrease in performing (active) behaviours, a generalized restriction of social contact and an increase in restlessness (eg. early awakening) and dysphoric mood.

The first criterion of the model at least, is is no longer disputed since these experiments and those reported by others (see chapter 1), demonstrate beyond any reasonable doubt, that the loss of significant others is effective in inducing distress in both man and animals. Criterion three is validated as well because it is apparent that the separation reaction is not merely an acute, phasic response. The sixth criterion, which specifies a recovery factor, also receives support from these results. Given sufficient time, about two weeks, separated monkey infants do begin to resume normal forms of social interaction, provided no new stresses are introduced. An additional factor of importance in this criterion is the distinction, it makes possible between separation and extended isolation. It cannot be assumed that because separation and isolation are related conceptually, they also produce similar effects.

Since this experiment was not designed to investigate neurobiological mechanisms or to demonstrate any specific form of stimulus control, it cannot have a direct bearing on the fifth and seventh criteria. However, the experiments of Coe et al (1978), Reite et al (1974, 1978), Butler et al, (1978), Breese et al, (1973), have shown, as noted above, specific similarities of neurobiological mechanisms. It thus becomes apparent that all the criteria of the model except the last, have received at least limited affirmation from the mother-infant separation procedure. It therefore seems possible to view the separation reaction as a true form of the depressive syndrome.

The question of the disruption of behavioural controls and other regulatory mechanisms is of special importance in the early part of the separation, assuming separation occurs without further recurrent stresses as in the experiment by Suomi et al, (1970). Prior to separation, an infant's behaviour is characterized by an almost ritual pattern of repeated approaches to a new or social situation and withdrawal to a safe area of the cage or the mother. The relatively high frequency of this behaviour shown in Table 19, attests to it's importance in social contact. Once the encounter beginns, it usually has an appreciable duration; in other words, it does not appear to be given up in the same moment it is begun. Table 14 for instance shows the average duration per event for the item "initiates play" at different times during the experiment. During separation, the duration is decreased to the point of virtual disappearance; it is always considerably less than a second.

The interpretation given the shorter durations during separation must vary according to the stage of the separation. Table 14 shows that the durations of play incidents remain consistently low throughout the entire four divisions of the separation. However, in Table 22 , it becomes apparent that some change has taken place in division 4. While the mean duration per event remained extremely low, the number of occurrences of the behaviour actually rose and gradually recovered to preseparation levels by the end of div 4. This would seem to indicate that the infants were learning to re-initiate normal social contact although the low durations shows their uncertain or tentative character. Coping skills appear to increase and new social learning can take place in the absence of the mother; that is, to the extent that the infants are able to increase the generality of their known or cognized environment, they are able to assimilate new social information. In this new learning, the usual maternal protection and endorsement of experience is unnecessary. After a certain amount of time, and given a minimum of social stability, the infant aquires its own endogenous regulatory mechanisms and behavioural controls.

The early part of separation is, of course, the point where the mother-mediated behavioural and physiological controls are lost. Behaviour during the early 'protest' appears not to be amenable to any form of control other than the mother's return. However, while the infant's known world had been shrinking, it's chaotic behaviour did eventually subside and trophotropic functions became dominant (Kaufman and Rosenblum, 1967). Table 5 for instance shows a gradual decline in the frequency of distress calls from the early to late divisions of the separation. This trend is opposite to that seen in Table 22 for "initiates play". It is possible that because of the slowing mediated by the parasympathetic system, the infant is able to discern enough sameness or familiarity in the environment to form the basis for new behavioural excursions.

According to Piaget (1970), wholenesess, transformation and self-regulation are the essential characteristics of all structures. In the case of biological structures (as opposed to logical ones for example) these characteristics have a special significance because of the non-reversable nature of the transformations and the early ontogenetic dependency of the young.

"At every stage of development of the living structure it is clear that in fact, the essential question is that of the regulation mechanisms." Piaget cited in Laughlin and d'Aquili (1974).

At the physiological level the processes are those of homeostasis and at the cognitive level the problem is one of an inability to use anticipation and correction (feedback) to regulate and maintain the boundaries of structures in the cognized environment. The processes of assimilation and accomodation are temporarily overwhelmed, and the equilibrium of a relatively simple cognitive apparatus is lost.

In the terms of "biogenetic structuralism", (Laughlin and d'Aquili, 1974,1979), the function of the nervous system is to construct neural models that are maximally isomorphic with the environment. The process involved is, ontologically speaking, a dialectic between the CNS and the environment and is called "neurognosis". What the infant knows is what it has been able to model. Neurognostic models then are anatomically based structures whose informational content must be sufficiently isomorphic with the environment to allow assimilation of new information and transformation (growth). In the case of the separated infant, the fault appears to lie in an inability to properly utilize its new information load. The infant's cognitive structures are regressed to a state of simplicity such that the degree of isomorphism, or fit with reality, is insufficient to allow successful interaction.

The mother, of course, is the single crucial variable upon which all else hinges at this stage of the infant's development. In her capacity as mother, the mother provides both internal and external regulatory mechanisms for the infant along species-specific channels. Reite (1978) found disturbances in the regulation of autonomic correlates of the separation reaction in rhesus macaques. In the case of rat pups, this channel or modality is primarily olfactory (Hofer, 1975). Anosmic rat pups are almost incapable of auto regulation, physiologically, when they cannot recognize (smell) their mother. While cercopithecoid monkeys are certainly very different from rats, the work of Harlow (1958) suggests that the tactile modality may have similar importance in that genus.

It is the function of the mother to make interaction with the environment possible. She controls the way the environment impinges upon her infant and she provides regulation and modelling for her infant's congitive and physiological processes. Her presence and activity regulates the infants' autonomic tone, hormonal balance, acid-base balance and emotional stability through the limbic effects of her touch, grooming and (most importantly) rhythmic stimulation of the infant. The infant is able to master and know its environment only in terms of its mother. In biogenetic structural terms, the mother is the medium through which the infant is able to expand his cognitive representations of the environment and perform operations on it. Harlow has shown on film that rhesus infants alternately approach a fearful object and return to the mother in a recurring pattern until the infant knows the object.

In the course of a separation then, disruption occurs along many idiopathically important dimensions. There is a loss of the comforting and reassuring stimulation inherent in the rituals of mother-infant and peer interaction, a loss of predictability in the environment, along with an overload of sensory stimulation and anxiety. Most obviously, the mother is gone; with her disappearance however, the infants known universe has shrunk severely. The problem of coping with a now unfamiliar world imposes a staggering increase in sensory and informational complexity; old familiarites, informational redundancy and certainty are lost. Not only is the infant initially incompetent to deal with this problem, due to it's inadequately modelled environment, but it also does not possess efficient means of self-regulation. Self-regulation must be achieved before the environment can be sucessfully re-engaged, or the mother must be returned. The pattern of recovery seen in this and other experiments suggests that the means of auto regulation are being acquired during the second week of separation and that the process is largely complete at the end of the third week.

Acquired competence in auto-regulation poses some very interesting problems in itself. The problem for the infant is how to relate to the mother when she eventually does return. As we have seen, some infants deal with the problem by an unwillingness to return to the mother after a period of forced independence. A case in point is Kaptain Hook who was very mother-dependent and who acquired most of his early social experience during separation. For this infant, it seemed that, during the half hour of his "denial", the reunion was almost as traumatic as the separation itself.

The macaque infants used in this type of experiment do recover fairly quickly. Their great locomotor ability allows them practically unrestricted movement and leaves them free to approach or avoid any object in the physical and social environment. In this way the infants of these experiments underline an an important difference between the syndrome of "hospitalism" or marasmus observed by Spitz (1945) and the syndrome of controlled separation described by Heinecke et al (1962). Marasmus is a state of permanemt deprivation, neurally structured, in which future growth is exceedingly difficult. On the other hand, temporarily separated infants, or infants cared for during separation, are capable of new learning if a sufficient amount of controlled stimulation is available, especially after some degree of self-regulation is aquired. While the new learning may not always be favourable, as in the stage of denial after separation, there will be no direct threat to survival.

The infant that can assimilate new information more quickly and establish new congruities earlier, will suffer less or become less depressed. But, the infant that clings to old congruities, i.e. which over-assimilates those isomorphisms which remain, will have the greater difficulty in the accomodation of new experience. Perhaps, to end on a philosophical note, this can be viewed as the pathological meaning of attachment. The insistent desire to experience reality only in preferred ways, says J. Krishnamurti (1954), can set a pattern of continual resistance, self-enclosure and despair. Thus the problem will have changed from regaining a lost object of love to one of being capable of any new love at all.

Appendix A

BEHAVIOURAL ITEMS AND RATIONALE

Behavioural Items Used in Experiment II

Maternal Behaviours

1) OTHER VENTRAL; physical contact in which the vertral surface of the infant is pressed against the mother's body, other than her ventrum.

2) NIPPLE CONTACT; any oral contact with the nipple.

3) VENTRAL-VENTRAL CONTACT; when the ventral surface of the infant is pressed against the ventrum of the mother. Usually the infant will be enclosed or embraced by the mother in this position.

4) PASSIVE CONTACT; incidental contact or contact initiatives by the mother that are not responded to or mer·ly sitting quietly beside the mother with minimal contact.

5) (be) GROOMED; physical contact with the mother in which she grooms the infant ie. picks through the

infant's hair. Occasionally the infant will display a revery response while being groomed.

6) (be) RESTRAINED; the infant is actively prevented from breaking physical contact or from leaving the mother's immediate vicinity.

7) MOE; manual-oral-olfactory-explore, with the mother as object. eg. the mother is groomed, sniffed, gently manipulated or otherwise investigated.

8) ACTIVE CONTACT; active physical interaction directed towards the mother such as climbing on or over, jumping on, grabbing.

9) PROXIMITY; the maintenance of a distance of one body length or less from the mother without physical contact.

10) VOCALIZATION; (a) a smooth tonal 'coo' or 'hoo' or 'woo' (b) schreech, a shrill irritating sound of acute distress.

Social Behaviours

1) REACH; extending one or both arms towards the partner as if to grab him.

2) MUTUAL OBJECT INTEREST; two infants interested in and investigating the same object at the same time.

3) APPROACH; an oriented movement into the immediate personal space of another infant from within the same play-cell.

4) PASSIVE CONTACT; when physical contact is made by the partner, either active or passive, to which no response is made or which is ignored.

5) ACCEPTS PLAY; an overture or invitation to play is initiated by the partner to which the subject responds with a return or acceptance of play.

6) INITIATES PLAY; the subject attempts to initiate a bout of play by actively and vigorously contacting the partner, with a grab or push or mouthing etc. Note, if such an overture does not result in play but contact is never the less maintained, then active or passive contact must be logged.

7) MOE; as above except that the peer is the object of interest and manipulation, .eg. grooming, clasping ,sniffing etc.

8) ACTIVE CONTACT; the initiation and/or acceptance of physical contact which is actively directed to a partner but which is less vigorous than a bout of play.

9) WITHDRAW; breaking contact, moving away from or avoiding the partner in rersponse to an approach, movement or other physical / vocal gesture.

10) VOCALIZATION; as before but while in contact with the partner.

Individual Behaviours

1) SIT; largely self-explanatory; the ischial callosities must be on or near a surface with the body erect.

2) EAT AND CHEW; when the subject eats or chews or puts into his mouth any object small enough to handle. This is also logged when the contents of the cheek pouches are being chewed.

3) LOCOMOTE; is scored when an infant crosses the boundary between two play cells or the boundary between a playcell and a cage or when the entire width of a play cell or cage is crossed.

4) BODY PLAY; clasping parts of own body, scratching, autogrooming, playing with the tail etc.

5) EXERCISE PLAY; any vigorous activity alone; eg jumping, walking on the ceiling, swinging.

6) STILL; a posture held static during which no other defined behaviours occur except sit.

7) MOE; manual, oral-olfactory, explore; grasping, sniffing , licking, mouthing or otherwise manipulating an object that cannot be eaten.

8) FORAGE; sitting and/or creeping about in short movements and poking around in the bedding in search of objects to eat and chew.

9) LOOK; the assumption of a static but oriented posture in which attention is focused on an object or event.

10) VOCALIZATION; as before but done while alone.

Behaviour Ranges or Modes

It has already been explained that the organization of the behaviour categories or ranges is tied to the functional operation of the encoders. The first range is the maternal behaviours, range 1 or A, where the 1 refers to the indexing of the tape and disk files and the letter A referrs to the indexing of the encoder output. The second range is the social behaviours, range 2 or B; and the third range is the individual behaviours, 3 or AB.

Definitional Criteria

A) INFANT-MOTHER INTERACTION; whenever there is physical contact with the mother or an active attempt to stay near her. This category takes priority over infant-infant behaviours should an infant be visiting.

B) INFANT-INFANT INTERACTION; the social behaviours are defined by actual physical contact between infants or by behaviour clearly directed at an infant as in reach or approach. This category takes priority over individual behaviours.

AB) INDIVIDUAL BEHAVIOURS; these are logged when there is no physical contact between a peer or the mother.

Rationale

The behaviours within each range are organized into classes such that any one item such as exercise play for instance, actually includes a number of different motoric events such as jumping or swinging etc. This has been done for reasons of parsimony.

In accordance with the hypothesis stated earlier, these behaviour items and ranges are expected to differentially show the effects of the stress of separation. Ferster (1966) among others has pointed out that behaviour classes seen frequently in psychosis are the result of the absence of other positively reinforced behaviours; that is, schedule changes alone might account for some changes. In the same way, during separation it is expected that some behaviours, more active and other-directed in nature will default to more passive and self-directed activity. To some extent this is a matter of a conceptualization which may also be read as the result of depressive affect. In addition to this some behaviours are conceived as representative of agitation or fear and anxiety. These are also expected to rise. Other behaviours which are active but environment directed are also expected to rise during separation and are considered to be indicative of social disengagement.

Active, peer-directed behaviours, indicative of normal social intercourse include play behaviours and active contact primarily , but also approach, mutual object interest, withdraw, reach and moe. These behaviours are expected to be high under baseline conditions and diminished during separation. Active behaviours that are normally directed to the environment include eat and chew, forage, moe, and look. These are expected to rise during separation. Active self-centered activities like exercise play which are high under normal individual conditions are expected to decrease dramatically during separation. Passive behaviours such as passive contact, sit, still are expected to rise during separation. Active behaviours which are conceived af indicative of agitation include locomotion, body play, eat and chew and vocalization. These are expected to rise sharply during separation. The expected overall pattern in those infants that get depressed is one of low animation at certain points (for which there is no adequate measure), a decrease of social interaction and a concommitant rise in behaviours relating to the self and the environment. During reunion , peer-related behaviours are also expected to be low, at least at first, due to increased preoccupation with the mother.

Behavioural Items Used In Experiment I

Infant-Mother

1) NIPPLE CONTACT; any oral contact with the nipple.

2) VENTRAL-VENTRAL CONTACT; any contact involming the apposition of the ventral surfaces of the mother and infant.

3) VENTRAL CONTACT; any other contact with the ventral surface of the mother.

4) MOUTHING THE MOTHER; any oral-olfactory contact with the mother except nipple contact.

6) PLAY ON MOTHER; jumping onto her, sitting on her, scrawling over her, manipulating her body,

7) VOCAL; vocalizations of distress i.e. a shrill screeching or a smoother tonal cooing.

8) MOTHER AVOID; ducking or avoiding a maternal bite, clasp-pull, cuff or other punishment.

9) TOUCH MOTHER; clasping fur of mother, embracing, holding on to her or being in gross body contact with her that is not included in the above.

10) GIRN; a soft, unsteady, whimper-like sound.

Infant-Infant

1) SOCIAL EXPLORE; licking, sniffing, mouthing another infant, closely inspecting visually, grooming another infant.

2) SPORTIVE ATTEMPT; a gentle, playful contact with the hands and arms, a cage shake in the presence of other or other vigorous manoeuvers in front of and aimed at another.

3) TOUCH INFANT; non-specific physical contact, gross and passive body contact eg. having foot or tail on other while doing no other defined activety.

4) PLAY; rough-and-tumble, wrestling, chasing, pushing, pulling etc.

5) APPROACH; an oriented movement aimed directly at another infant.

6) AGGRESSION; very vigorous clasp-pulls, cuffs, scratches, bites, piloerection and threats.

7) PRESENT; assumption of a posture in wich the hendquarters, or ano-genital area are raised and oriented towards a partner.

8) MOUNT; generally one animal inferior, one superior; ano-genital areas in contact- often seen with pelvic thrusts. In young monkeys this may involve the mother in which case play on mother is scored.

9) WITHDRAW; a retreat from another in reaction to a contact, movement, or threat.

10) VOCAL; same as above.

__Individual Infant__

1) HUDDLE-CROUCH; sitting hunched-over, ball-like; belly may be close to floor.

2) SELF-ORALITY; mouthing or smelling any part of own body, except penis suck.

3) OBJECT INTEREST; oral-olfactory investigation, manipulation or play with any object in the environment, including toys, food trays, cage mesh, etc.

10) LOCOMOTE; ordinary movement ;through the environment ie. walking, climbing easily or non-vigorously up the walls, moving at ease from wall to wall. movement on the ceiling is scored play.

5) EXERCISE PLAY; vigorous jumping, climbing, swinging, brachiation, use of ropes, bars and rings- while alone.

6) BODY PLAY; manipulation of body and limbs, tail, hands, feet and self grooming. auto erotic behaviour is not included.

7) AUTOEROTIC; any manipulation of the ano-genital area of own body-

8) STEREOTYPY; repetitive movements such as pacing, rocking, etc.

9) SELF-CLASP; embracing own body with one or both arms; covering of head with one or both arms.

10) VOCALIZATION; as before except done in the individual context.

Appendix B

OBSERVER AGREEMENT

All projects employing naturalistic observations, whether the subjects are young children or monkeys, face the problem of the degree of agreement between different independent observers. The writings of several authors attest to the continuing concern over this important issue. (Bijou 1969, Box and Pook, 1974; Thorne, Schlottman and Seay, 1969, Hartmann, 1977; Baer, 1977)

If observer X is to agree with observer Y, it is clearly better if the phenomenon in question is something distinctive and obvious, as when a monkey crosses a boundary or swings from the ceiling. When events become more subtle, especially since there is no time for debate, compensations must be made in the amount of practice and the clarity of definitions. Bijou (1969), in a very complete article, explains it well.

> "The main problem in defining a response event is establishing criteria so that two or more observers can agree..... The definition of hitting must be described so that an observer can discriminate among hitting, patting and shoving responses." Bijou pp184

If difficulties do occur, the problem can usually be traced to the precision of behavioural definitions rather than an inherent difference between people acting as observers. Observers, as a class, tend to be homogeneous (Baer 1977).

Because of core limitations in the PDP-8, the project resorted to the method of Bijou to determine agreement rather than electronic measures. This method, which has seen numerous variants, is probably the most common way to collect observational data and of determining observer concordance. In primate research, a homologue of the method is described in Hansen (1966).

Bijou, like many behaviourists, prefers the frequency of response and measures of response probability as the best indicators of response strength. For this, very precise and concrete response events are best, but he admits that studies investigating clinical problems may employ larger response classes indigenous to the problem.

In the actual recording of data, the observer makes entries with a pencil, on a sheet marked with successive time units. In this case, simple check marks replaced codes because each scored behaviour occupied its own row. The time frames, which segment each row, are of 15 seconds duration, so that in a 5 minute reliability session there were 20 segments. If a behaviour occurs twice within the interval, it is scored only once. The resulting data are therefore termed "modified frequencies".

The observers were asked to score 5-minute segments of video recordings, each watching the same subject. The experimenter sat by and called the end of each 15-second epoch. The coefficient of agreement is actually a percent figure of agreement. It is calculated by scoring each interval in terms of whether the two observer agree or or disagree; the number of agreements is totalled and divided by the number of agreements plus disagreements.

$$\% \text{ agreement} = \frac{\text{sum agreements}}{\text{sum agreements} + \text{sum disagreements}}$$

Intervals without an entry are not counted as agreements as this would inflate the coefficient. However, it is indeed valid that observers can agree both on the occurrence and non-occurrence of an event. For this reason a coefficient of agreement is calculated for non-occurrences as well.

A number of 5-minute sessions were held before and during baseline to determine the initial agreement. The procedure was repeated again during the second separation and final reunion. The percent agreement and disagreement scores varied between 76% and 95%. Included below are two sample concordance records.

NAPOLEON

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FORAGE	1	1						1			1	1		1	1					1
HOE				1	1	1	1						1			1				
BODY PLAY	1	1						1	1										1	
LOCOMOTE			O							1						1	1			1
SIT	1	1	1				1	1	1		1	1	1	1	1	1		O	O	
WITHDRAW																				
APPROACH																		1	1	
HUT. OBJ. INT.				1																
ACC PLAY																				
WIT PLAY																				

79%

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
FORAGE	1	1						1			1	1			1	O				1
HOE				1	1	1	1						1	1			1			
BODY PLAY	1	1		1		1			1	O										
LOCOMOTE			O							1	1					1				
SIT	1	1	1	1			1	1	1	1		1	1	1	1	1			1	
WITHDRAW																				
APPROACH																				1
HUT. OBJ. INT.																				
ACC. PLAY																				
INIT PLAY																				

85%

182b

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
(-																								
DR. GV		1									1	+		1	1					0				
NO				1	+	1	1						1											
ODY PLAY		1						1	1										1					
RC NOTE			1							1						1				1				
L T	1	1	1	1			1	1	1		1	1	1	1	1			1	1					
ITHDRAW																								
AP. P. RGH																			1					
M. I																								
A P																								
L P																								

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
ORFGE	1	1						1			1	1			1	1				1
NO				1	1	1	1						1	1			1			
DI PLAY		1				1			1	1										
ACOM			1							1	1					1				
IT	1	1	1				1	1	1	1		1	1	1	1	1			1	
ITH																				
RP																				1
N.E																				
AT																				
P																				

6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46

Appendix C

ANOVA TABLES AND DATA

Individual Behaviours

Baseline-Separation I

Analysis of Variance for "Sit".

Source	SS	DF	MS	F	Tail
G	242.88	1	242.88	1.07	.347
Error	1129.8	5	225.96		
C	8260.03	1	8260.03	25.67	.003
CG	22.88	1	22.88	0.07	.800
Error	1608.83	5	321.76		
D	1836.90	3	612.30	3.76	.034
DG	284.90	3	94.96	0.58	.635
Error	2441.66	15	162.77		
CD	225.47	3	75.15	0.65	.596
CDG	161.47	3	53.82	0.46	.711
Error	1738.66	15	115.91		

Analysis of Variance for "Locomotion".

Source	SS	DF	MS	F	Tail
G	3857.29	1	3857.29	2.17	.200
Error	8891.20	5	1778.24		
C	3575.14	1	3575.14	3.32	.128
CG	5497.14	1	5497.14	5.10	.073
Error	5393.20	5	1078.44		
D	6331.10	3	2110.36	4.99	.013

DG	908.24	3	302.74	0.72	.557
Error	6346.54	15	423.10		
CD	7100.19	3	2366.73	5.74	.008
CDG	4005.05	3	1335.01	3.24	.052
Error	6182.87	15	412.19		

Analysis of Variance for "Exercise Play".

Source	SS	DF	MS	F	Tail
G	2419.08	1	2419.08	9.23	.028
Error	1310.09	5	262.01		
C	2862.75	1	2862.75	47.49	.001
CG	600.03	1	600.03	9.95	.025
Error	301.42	5	60.28		
D	785.02	3	261.67	3.35	.047
DG	55.59	3	18.53	0.24	.868
Error	1171.36	15	78.09		
CD	117.09	3	39.03	0.86	.483
CDG	487.81	3	162.60	3.58	.039
Error	680.86	15	45.39		

Analysis of Variance for "Forage".

Source	SS	DF	MS	F	Tail
G	12.32	1	12.32	0.08	.788
Error	767.92	5	153.58		
C	468.33	1	468.33	1.75	.243
CG	1.62	1	1.62	0.01	.941
Error	1339.84	5	267.96		
D	331.82	3	110.60	1.35	.295
DG	29.54	3	9.84	0.12	.946
Error	1227.78	15	81.81.85		
CD	561.12	3	187.04	2.82	.074
CDG	54.69	3	18.23	0.28	.842
Error	993.69	15	66.66.24		

Analysis of Variance for "Vocalization".

Source	SS	DF	MS	F	Tail
G	1646.88	1	1646.88	3.68	.113
Error	2239.08	5	447.81		
C	3828.59	1	3828.59	10.15	.024
CG	1429.16	1	1429.16	3.79	.109
Error	1886.08	5	377.21		
D	1107.29	3	369.09	3.20	.054
DG	913.86	3	304.62	2.64	.087
Error	1732.16	15	115.47		
CD	1434.44	3	478.14	6.32	.005
CDG	1025.01	3	341.67	4.51	.019
ERROR	1135.16	15	75.67		

BASELINE-SEPARATION II

ANALYSIS OF VARIANCE FOR "SIT".

SOURCE	SS	DF	MS	F	TAIL
G	18.66	1	18.66	0.03	.87
ERROR	3219.33	5	643.86		
C	11867.52	1	11867.52	17.17	.009
CG	609.52	1	609.52	0.88	.390
ERROR	3455.83	5	691.16		
D	462.08	3	154.02	1.02	.412
DG	257.22	3	85.74	0.57	.645
ERROR	2271.91	15	151.46		
CD	201.94	3	67.31	0.63	.605
CDG	171.36	3	57.12	0.54	.664
ERROR	1598.41	15	106.56		

ANALYSIS OF VARIANCE FOR "LOCOMOTION".

SOURCE	SS	DF	MS	F	TAIL
G	2182.32	1	2182.32	0.85	.399
ERROR	12881.17	5	2576.23		
C	32578.93	1	32578.93	13.07	.015
CG	8016.43	1	8016.43	3.22	.132
ERROR	12463.42	5	2492.68		
D	4701.11	3	1567.03	4.38	.021
DG	4192.04	3	1397.34	3.90	.030
ERROR	5369.03	15	357.93		
CD	1976.98	3	658.99	1.50	.254
CDG	562.05	3	187.35	0.43	.736
ERROR	6574.94	15	438.32		

ANALYSIS OF VARIANCE FOR "EXERCISE PLAY".

SOURCE	SS	DF	MS	F	TAIL
G	2858.62	1	2858.62	13.30	.014
ERROR	1074.37	5	214.87		
C	1988.59	1	1988.59	16.34	.009
CG	408.59	1	408.59	3.36	.126
ERROR	608.33	5	121.66		
D	407.02	3	135.67	1.45	.269
DG	274.02	3	91.34	0.97	.431
ERROR	1407.54	15	93.83		
CD	141.51	3	47.17	1.08	.385
CDG	5.79	3	1.93	0.04	.987
ERROR	652.41	15	43.49		

ANALYSIS OF VARIANCE FOR "FORAGE".

SOURCE	SS	DF	MS	F	TAIL
G	34.83	1	34.83	1.39	.291
ERROR	125.59	5	25.11		

C	907.68	1	907.68	7.84	.038
CG	66.25	1	66.25	0.57	.483
ERROR	578.67	5	115.73		
D	54.00	3	18.00	0.91	.461
DG	15.29	3	5.09	0.26	.855
ERROR	298.28	15	19.88		
CD	87.61	3	29.20	8.76	.001
CDG	48.46	3	16.15	4.84	.015
ERROR	50.03	15	3.33		

ANALYSIS OF VARIANCE FOR "VOCALIZATION".

SOURCE	SS	DF	MS	F	TAIL
G	25.53	1	25.53	0.09	.77
ERROR	1352.17	5	270.43		
C	1455.53	1	1455.53	4.77	.080
CG	5.18	1	5.18	0.02	.901
ERROR	1525.67	5	305.13		
D	673.84	3	224.61	2.60	.090
DG	19.92	3	6.64	0.08	.971
ERROR	1297.36	15	86.49		
CD	855.82	3	285.27	3.81	.032
CDG	61.04	3	20.34	0.27	.845
ERROR	1124.53	15	74.96		

SOCIAL BEHAVIOURS

BASELINE-SEPARATION II

ANALYSIS OF VARIANCE FOR "PASSIVE CONTACT".

SOURCE	SS	DF	MS	F	TAIL
G	97.25	1	97.25	1.77	.240
ERROR	274.83	5	54.96		
C	337.16	1	337.16	9.51	.027
CG	1.16	1	1.16	0.03	.863
ERROR	177.33	5	35.46		
D	84.21	3	28.07	1.09	.385
DG	85.35	3	28.45	1.10	.379
ERROR	388.00	15	25.86		
CD	47.19	3	15.73	0.91	.459
CDG	10.61	3	3.53	0.20	.891
ERROR	259.16	15	17.27		

ANALYSIS OF VARIANCE FOR "ACCEPTS PLAY".

SOURCE	SS	DF	MS	F	TAIL
G	141.16	1	141.16	2.64	.165
ERROR	267.33	5	53.46		
C	205.92	1	205.92	4.39	.090
CG	94.50	1	94.50	2.01	.215
ERROR	234.50	5	46.90		
D	188.01	3	62.67	6.67	.004
DG	115.72	3	38.57	4.11	.025
ERROR	140.91	15	9.39		
CD	245.05	3	81.68	8.00	.002
CDG	159.63	3	53.21	5.21	.011
ERROR	153.08	15	10.20		

ANALYSIS OF VARIANCE FOR "INITIATES PLAY".

SOURCE	SS	MS	F	TAIL	
G	0.25	1	0.25	0.00	.947
ERROR	259.17	5	51.83		

C	175.07	1	175.07	2.84	.152
CG	7.50	1	7.50	0.12	.74
ERROR	307.92	5	61.58		
D	176.48	3	58.82	1.80	.190
DG	140.19	3	46.73	1.43	.273
ERROR	489.94	15	32.66		
CD	170.34	3	56.78	4.07	.026
CDG	184.77	3	61.59	4.41	.020
ERROR	209.36	15	13.95		

ANALYSIS OF VARIANCE FOR "ACTIVE CONTACT".

SOURCE	SS	DF	MS	F	TAIL
G	0.07	1	0.07	0.00	.99
ERROR	2330.92	5	466.18		
C	1726.08	1	1726.08	4.15	.097
CG	3.87	1	3.87	0.01	.926
ERROR	2081.34	5	416.26		
D	769.96	3	256.65	1.33	.301
DG	523.75	3	174.58	0.91	.461
ERROR	2890.53	15	192.70		
CD	196.24	3	65.41	0.89	.467
CDG	560.17	3	186.72	2.55	.094
ERROR	1097.61	15	73.17		

BASELINE-SEPARATION II

ANALYSIS OF VARIANCE FOR "PASSIVE CONTACT".

SOURCE	SS	DF	MS	F	TAIL
G	45.57	1	45.57	0.48	.520
ERROR	477.92	5	95.58		
C	432.32	1	432.32	9.35	.028
CG	4.18	1	4.18	0.09	.775
ERROR	231.17	5	46.23		

D	17.37	3	5.79	0.22	.87
DG	0.23	3	0.07	0.00	.999
ERROR	391.69	15	26.11		
CD	8.36	3	2.78	0.18	.908
CDG	52.21	3	17.40	1.12	.372
ERROR	233.28	15	15.55		

ANALYSIS OF VARIANCE FOR "ACCEPTS PLAY".

SOURCE	SS	DF	MS	F	TAIL
G	133.03	1	133.03	2.78	.156
ERROR	239.17	5	47.83		
C	142.08	1	142.08	2.46	.177
CG	101.37	1	101.37	1.75	.242
ERROR	288.80	5	57.76		
D	176.37	3	58.79	5.02	.013
DG	169.51	3	56.50	4.82	.015
ERROR	175.69	15	11.71		
CD	290.27	3	96.75	9.34	.001
CDG	108.70	3	36.23	3.50	.042
ERROR	155.36	15	10.35		

ANALYSIS OF VARIANCE FOR "INITIATES PLAY".

SOURCE	SS	DF	MS	F	TAIL
G	11.26	1	11.26	0.20	.675
ERROR	286.09	5	57.21		
C	142.08	1	142.08	2.06	.210
CG	0.01	1	0.01	0.00	.989
ERROR	344.84	5	68.96		
D	174.94	3	58.31	3.80	.032
DG	106.87	3	35.62	2.32	.116
ERROR	230.19	15	15.34		
CD	182.33	3	60.77	2.51	.09
CDG	207.83	3	69.27	2.86	.07
ERROR	363.44	15	24.22		

ANALYSIS OF VARIANCE FOR "ACTIVE CONTACT".

SOURCE	SS	DF	MS	F	TAIL
G	85.71	1	85.71	0.25	.640
ERROR	1740.00	5	348.00		
C	1365.72	1	1365.72	2.45	.178
CG	132.14	1	132.14	0.24	.646
ERROR	2783.70	5	556.74		
D	416.50	3	138.83	1.12	.372
DG	896.50	3	298.83	2.41	.107
ERROR	1862.50	15	124.16		
CD	438.30	3	146.10	1.42	.275
CDG	257.87	3	85.95	0.84	.494
ERROR	1542,12	15	102.80		

Listing of Individual Frequencies

Computer File Description

The two data files presented here have been transformed and formatted. The first file is the frequencies of individual behaviours and the second is social frequencies i.e. behaviours involving a partner. Social frequencies, evidently, are lower than individual ones. Each value represents the mean for a block of 3 days.

Each file contains 15 variables in card images. The first 5 represent the indexing or tagging information. From left to right it reads subject I.D., group I.D., condition, behaviour class (individual= 3; social=2), and day. The remaining variables are behavioural items and are each expressed in a 4-column field in a fixed format. The format statements included below, express a logical record length of 20 card images, i.e. all the data for any one subject in the file. This format was necessary to allow the BMDP2V (Dixon and Brown, 1977), programme to read the data correctly.

In the case of the 'individual' file the behavioural variables represent, from left to right; sit; eat and chew; locomotion; body play; exercise play; still; MOE; forage;

look; and vocalization. For the social file, which uses a 3-column field, the variables are reach; mutual object interest; approach; passive contact; accepts play; initiates play; MOE; active contact; withdraw; and vocalization.

FORMAT IS (4F1.0,F2.0,10F4.0/18(6X,10F4.0/)6X,10F4.0)

111301	13	11	35	2	17	0	22	5	9	0
111302	28	24	52	6	22	10	27	4	17	0
111303	9	1	32	3	5	0	4	0	10	0
1113 4	12	16	130	3	41	7	46	4	16	0
1123 1	20	16	92	5	8	9	35	5	9	10
1123 2	31	12	105	5	22	10	42	6	16	9
1123 3	16	12	62	2	12	2	22	2	3	2
112304	54	42	109	1	20	0	36	8	2	1
1133 1	3	0	23	1	13	2	9	1	2	1
1133 2	24	21	154	2	8	2	10	14	12	5
1133 3	22	8	48	1	8	5	27	7	8	5
1133 4	12	10	59	6	23	2	33	13	18	2
1143 1	34	39	118	18	10	8	36	25	13	3
1143 2	26	40	168	3	11	5	50	18	8	2
1143 3	40	16	131	3	8	7	35	18	12	3
114304	11	33	171	3	15	5	24	11	7	0
1153 1	8	11	106	2	37	7	29	4	7	1
1153 2	25	3	79	1	23	0	53	2	8	0
1153 3	18	1	82	2	21	13	32	1	29	1
1153 4	17	5	89	2	27	7	38	2	15	1
2113 1	21	3	25	8	10	2	17	3	17	7
2113 2	21	5	33	3	5	5	18	1	22	0
2113 3	17	9	46	5	5	8	19	3	9	0
2113 4	28	6	65	6	19	1	22	3	17	23
2123 1	43	12	117	8	2	8	21	14	9	78
2123 2	54	20	48	5	2	12	30	13	9	33
2123 3	52	23	48	8	2	1	14	48	3	5
212304	66	41	37	9	0	0	15	12	0	31
2133 1	5	4	9	2	2	1	4	2	3	4
2133 2	47	26	47	4	6	1	22	22	9	39
2133 3	34	20	27	3	1	1	28	39	9	13
2133 4	26	23	22	3	2	1	9	27	9	18
2143 1	68	19	88	8	3	3	14	25	6	21
2143 2	68	33	77	11	0	12	21	18	7	8
2143 3	51	25	47	5	6	1	20	20	4	20
214304	84	39	90	7	5	2	25	17	1	13

2153	1	11	2	26	2	11	2	18	9	7	1
2153	2	11	2	36	1	13	4	27	5	12	1
2153	3	16	2	45	2	18	11	35	3	32	8
2153	4	12	2	36	2	14	6	26	6	17	3
3113	1	9	4	3	8	2	1	11	3	4	0
3113	2	31	23	0	13	17	0	21	7	10	0
3113	3	5	2	5	5	19	0	10	4	11	0
3113	4	16	13	13	10	11	1	21	18	9	0
3123	1	57	13	90	13	4	14	42	3	13	77
3123	2	44	7	90	15	3	7	48	5	10	63
3123	3	36	7	11	21	1	15	14	3	21	28
312304		47	15	64	5	3	12	6	2	7	16
3133	1	12	2	2	19	1	25	16	4	2	0
3133	2	22	8	26	1	13	4	13	7	29	1
3133	3	37	6	75	13	21	10	28	44	29	2
3133	4	27	8	66	7	5	7	27	9	16	1
3143	1	56	9	108	4	5	34	19	5	34	47
3143	2	65	18	77	9	3	32	34	4	18	18
3143	3	71	20	89	18	8	16	32	7	17	26
314304		69	44	150	0	20	2	27	11	6	0
3153	1	27	8	85	2	12	9	35	2	4	11
3153	2	14	1	150	7	42	22	48	0	4	0
3153	3	16	5	65	11	42	18	33	5	30	5
3153	4	19	5	65	7	32	16	38	2	12	5
4213	1	21	5	66	5	40	5	45	5	25	10
4213	2	18	5	98	4	47	0	48	8	51	0
4213	3	29	7	80	4	22	11	51	5	35	1
421304		49	32	90	3	28	4	59	12	17	5
4223	1	23	31	89	2	14	6	17	7	6	4
4223	2	12	3	15	6	3	6	13	4	3	3
4223	3	45	25	60	15	12	6	26	17	13	13
422304		66	35	59	11	29	7	18	18	3	3
4233	1	20	18	16	1	5	1	4	3	5	16
4233	2	40	30	65	3	13	3	20	11	25	32
4233	3	32	19	92	6	20	6	19	19	29	29
4233	4	16	2	104	4	44	7	44	7	45	41
4243	1	30	25	125	0	42	7	38	4	16	5
4242	2	30	14	96	5	29	9	45	11	13	1
4243	3	32	24	66	6	10	6	27	15	5	1
424304		26	30	82	4	22	2	21	13	7	0
4253	1	17	2	63	1	16	20	30	3	24	7
4253	2	22	1	105	2	47	15	41	6	33	18
4253	3	16	0	115	1	46	12	35	1	46	20
4253	4	18	1	94	1	36	15	35	3	34	15
5213	1	17	9	35	5	29	4	24	7	16	1
5213	2	18	3	61	10	28	7	21	1	11	0
5213	3	12	3	60	2	25	1	28	2	4	1
5213	4	42	29	68	2	41	0	32	8	16	5
5223	1	40	20	93	11	15	8	23	5	10	3
5223	2	49	32	51	14	9	3	32	7	9	5
5223	3	28	14	39	6	6	2	22	2	8	3
522304		48	9	116	14	42	32	35	7	18	3
5233	1	8	6	29	2	13	2	4	3	5	1
5233	2	15	5	59	10	19	3	19	4	4	2

5233	3	22	3	89	19	26	3	33	5	3	3
5233	4	14	8	92	7	40	6	18	7	9	1
5243	1	26	25	134	8	15	14	19	9	17	3
5243	2	29	18	133	5	20	22	27	8	13	3
5243	3	44	14	137	18	21	18	23	13	15	2
524304		68	21	92	11	23	42	28	10	3	2
5253	1	5	4	49	2	20	8	6	12	6	1
5253	2	24	3	74	9	39	0	43	11	11	0
5253	3	12	3	108	6	47	15	14	1	20	1
5253	4	13	3	77	6	35	8	21	8	12	1
6213	1	17	9	45	3	22	2	26	8	10	1
6213	2	37	32	56	2	38	0	18	4	2	0
6213	3	29	5	80	7	32	1	60	5	14	2
6213	4	23	21	55	11	22	3	22	6	11	1
6223	1	40	46	80	6	6	1	13	0	6	12
6223	2	52	29	56	15	1	14	23	2	4	42
6223	3	38	21	58	5	11	1	27	6	6	7
622304		76	47	110	6	7	4	20	6	5	2
6233	1	9	2	27	7	9	3	22	1	6	4
6233	2	15	9	53	6	28	8	25	5	9	17
6233	3	24	15	101	4	50	11	28	7	12	25
6233	4	21	4	83	6	27	3	25	4	12	20
6243	1	56	36	98	3	4	2	20	12	11	65
6243	2	59	47	72	5	8	0	34	2	17	24
6243	3	53	20	90	15	13	12	52	8	12	23
624304		68	31	118	46	5	4	23	7	3	0
6253	1	54	24	85	2	16	14	41	43	32	18
6253	2	7	4	78	2	33	3	40	7	14	37
6253	3	16	0	86	6	26	14	32	4	28	18
6253	4	26	9	83	3	25	10	38	10	24	24
7213	1	23	17	92	5	39	1	29	4	9	0
7213	2	8	0	106	5	46	3	27	1	6	0
7213	3	6	1	63	1	38	2	22	2	6	0
7213	4	19	12	119	3	52	4	53	5	14	1
7223	1	60	33	103	5	18	3	30	6	21	10
7223	2	63	7	49	5	13	6	57	15	6	8
7223	3	56	23	68	6	3	2	26	62	2	14
722304		44	32	66	9	23	3	28	18	4	0
7233	1	11	7	50	4	8	2	11	2	8	4
7233	2	30	13	78	2	20	2	25	11	19	3
7233	3	33	19	69	2	12	0	22	38	10	12
7233	4	23	9	78	5	24	1	33	12	28	30
7243	1	57	18	89	4	3	11	29	15	3	21
7243	2	63	35	101	15	19	2	38	17	11	4
7243	3	54	19	74	9	20	1	42	17	9	14
724304		37	26	60	10	15	16	29	17	6	15
7253	1	20	22	125	4	24	2	30	8	16	18
7253	2	14	13	137	0	51	3	45	34	17	6
7253	3	21	9	92	6	33	10	34	14	34	4
7253	4	18	15	118	3	36	5	36	19	22	9

/*

Listing of Social Frequencies

Format is (4f1.0,f2.0,10f3.0/18(6x,10f3.0/)6x,10f3.0)

1112	1	8	4	13	8	2	2	8	17	4	1
1112	2	35	40	0	0	0	0	23	1	2	0
1112	3	0	2	16	1	0	3	12	65	1	0
1112	4	18	2	26	3	2	20	9	15	6	0
1122	1	7	2	14	14	0	0	2	7	0	1
1122	2	8	3	30	9	1	6	7	8	1	0
1122	3	6	2	12	1	0	6	15	32	2	2
1122	4	15	3	40	1	3	18	11	12	1	0
1132	1	0	0	0	0	0	0	0	0	0	0
1132	2	23	3	9	0	0	2	17	11	4	0
1132	3	1	3	10	2	1	4	7	25	2	2
1132	4	11	2	18	0	7	12	7	28	2	0
1142	1	6	4	11	15	0	0	2	14	0	0
1142	2	5	1	6	1	0	1	0	1	3	0
1142	3	3	3	4	4	1	1	2	14	1	1
1142	4	7	3	22	6	4	6	5	16	2	0
1152	1	17	3	23	2	42	6	10	7	16	0
1152	2	11	3	51	0	24	13	2	3	65	0
1152	3	23	0	2	1	1	2	24	16	6	0
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2112	1	17	2	9	1	2	10	15	23	21	1
2112	2	9	15	13	6	10	14	6	35	27	0
2112	3	21	9	30	3	2	14	11	40	26	0
2112	4	21	2	5	9	5	12	13	45	2	4
2122	1	1	1	4	3	0	0	1	2	14	4
2122	2	2	8	6	5	1	2	9	13	4	2
2122	3	1	2	1	4	0	0	0	0	8	1
2122	4	6	7	4	11	1	2	6	8	2	3
2132	1	0	0	0	0	0	0	0	0	0	0
2132	2	8	3	2	6	0	1	3	4	3	0
2132	3	11	4	4	13	0	3	4	8	3	1
2132	4	15	5	4	6	3	2	5	13	2	1
2142	1	2	4	3	3	0	0	2	9	3	1
2142	2	7	3	3	14	0	1	3	4	8	1
2142	3	5	5	3	17	0	0	5	5	5	3
2142	4	9	8	12	17	0	3	10	8	8	1
2152	1	22	4	10	4	3	6	13	25	7	6
2152	2	26	2	16	1	6	10	26	20	9	0
2152	3	44	2	15	3	6	10	39	28	19	2
2152	4	23	3	14	2	5	7	26	24	12	3
3112	1	1	0	0	0	0	0	0	0	1	0
3112	2	2	0	5	1	0	0	1	0	1	0
3112	3	0	0	0	0	0	0	1	0	0	0

3112	4	3	0	2	1	0	0	0	1	1	0
3122	1	12	5	6	8	0	0	4	3	41	2
3122	2	11	1	25	10	0	1	8	7	17	4
3122	3	4	1	2	4	0	0	1	8	23	0
3122	4	8	1	9	19	2	6	2	1	40	21
3132	1	0	0	0	0	0	0	1	0	1	0
3132	2	0	0	2	0	0	2	1	2	11	0
3132	3	5	1	2	2	3	3	2	3	11	0
3132	4	8	0	5	1	0	5	2	4	6	0
3142	1	6	1	9	6	0	3	3	5	14	2
3142	2	6	5	13	13	0	3	2	3	9	0
3142	3	6	5	10	7	2	6	0	5	7	0
3142	4	14	3	15	4	10	12	2	1	25	1
3152	1	17	2	36	2	0	17	5	4	4	1
3152	2	23	0	41	1	4	37	11	1	8	0
3152	3	20	1	9	0	3	9	8	1	12	1
3152	4	20	1	28	1	2	21	8	2	8	1
4212	1	32	6	24	1	3	14	6	6	23	5
4212	2	4	8	38	4	7	20	2	4	11	0
4212	3	11	0	13	2	1	9	6	4	12	0
4212	4	12	2	2	0	0	5	2	8	13	0
4222	1	18	2	18	3	0	8	3	12	1	6
4222	2	1	1	5	3	0	1	6	9	0	1
4222	3	2	3	8	2	0	1	5	6	0	1
4222	4	5	15	19	8	0	1	8	8	1	0
4232	1	2	1	0	2	0	0	1	2	1	0
4232	2	8	0	2	0	0	1	3	1	2	0
4232	3	7	3	13	0	0	2	4	13	9	0
4232	4	19	1	5	2	0	4	6	7	8	0
4242	1	2	0	18	2	0	0	5	17	0	0
4242	2	3	3	24	2	0	3	8	22	0	0
4242	3	4	4	17	6	1	7	8	24	0	0
4242	4	3	2	30	0	0	20	9	30	0	0
4252	1	19	0	6	0	0	9	6	9	4	0
4252	2	18	1	28	0	2	11	24	23	33	2
4252	3	61	0	28	0	3	3	53	3	39	2
4252	4	32	0	20	0	2	8	28	12	25	1
5212	1	18	9	4	1	2	1	5	13	2	0
5212	2	4	3	28	3	22	16	1	35	5	0
5212	3	7	4	17	6	2	1	4	28	1	0
5212	4	15	4	2	3	1	0	7	12	2	2
5222	1	19	4	19	19	0	2	7	25	1	3
5222	2	11	7	15	22	1	0	9	8	2	1
5222	3	3	6	5	11	2	0	0	30	0	0
5222	4	7	2	23	5	6	12	10	7	1	0
5232	1	3	1	0	3	1	0	0	1	1	0
5232	2	7	7	22	17	17	14	3	60	5	0
5232	3	2	2	14	0	2	2	2	45	1	3
5232	4	16	2	34	2	8	19	7	30	4	0
5242	1	12	3	5	20	1	0	2	16	5	0
5242	2	3	6	5	15	3	1	8	13	2	0
5242	3	5	4	5	16	0	2	4	12	4	0
5242	4	10	5	10	15	5	6	4	8	10	0
5252	1	3	2	3	3	6	4	2	5	3	0

5252	2	0	1	23	26	25	5	3	21	25	3
5252	3	19	3	20	4	19	14	12	28	22	3
5252	4	7	2	15	11	17	8	6	18	17	2
6212	1	13	4	10	4	2	2	5	8	7	1
6212	2	9	4	16	7	15	19	1	54	4	1
6212	3	5	3	4	6	2	1	3	7	7	0
6212	4	8	6	9	12	1	2	6	30	26	0
6222	1	4	5	5	5	1	0	0	1	16	1
6222	2	9	7	3	19	0	1	4	9	21	8
6222	3	5	3	28	6	0	0	2	5	0	1
6222	4	6	5	10	11	5	15	1	7	19	1
6232	1	0	0	0	2	0	0	0	0	0	0
6232	2	1	1	2	5	2	1	2	0	5	0
6232	3	15	0	15	0	2	19	10	0	3	11
6232	4	15	5	26	10	9	20	4	26	13	8
6242	1	6	6	18	8	2	2	4	7	7	4
6242	2	12	8	6	8	1	2	6	15	24	5
6242	3	4	2	14	3	4	6	6	10	9	1
6242	4	14	4	19	13	6	13	6	6	21	1
6252	1	17	7	21	19	10	15	5	7	5	2
6252	2	17	3	15	12	6	23	5	40	3	20
6252	3	6	1	16	8	3	9	7	13	4	3
6252	4	13	4	17	13	6	16	6	20	4	8
7212	1	8	2	9	10	5	2	2	17	13	1
7212	2	17	1	35	13	34	5	5	30	7	0
7212	3	8	9	33	8	20	15	6	42	15	0
7212	4	12	1	20	2	7	2	4	15	9	0
7222	1	6	3	2	20	1	0	4	1	19	0
7222	2	5	10	5	12	1	1	3	4	3	1
7222	3	5	4	3	12	0	0	2	2	1	0
7222	4	4	12	12	8	3	3	4	8	2	0
7232	1	0	0	2	0	0	0	0	0	1	1
7232	2	3	2	5	8	1	0	1	8	7	0
7232	3	7	3	15	12	2	0	2	12	7	0
7232	4	2	1	3	4	1	1	1	9	3	0
7242	1	4	3	3	11	0	0	2	3	1	1
7242	2	3	4	3	10	2	0	3	14	3	0
7242	3	2	6	4	10	0	0	2	2	0	0
7242	4	4	8	3	24	4	1	1	4	7	0
7252	1	3	6	5	13	4	1	1	9	6	1
7252	2	10	10	3	9	17	14	1	35	9	0
7252	3	8	7	19	10	15	7	8	25	9	2
7252	4	7	8	9	13	12	7	3	23	8	1

/*

Appendix D

ELECTRONIC ENCODERS

The light weight encoders are constructed of plastic sections which are bent and fitted around standard metal cabinets; the dimensions are 32cm x 24cm x 10cm. It uses transistor-transistor logic (TTL) and needs only readily available components. The total cost per unit in parts is about 300 dollars.

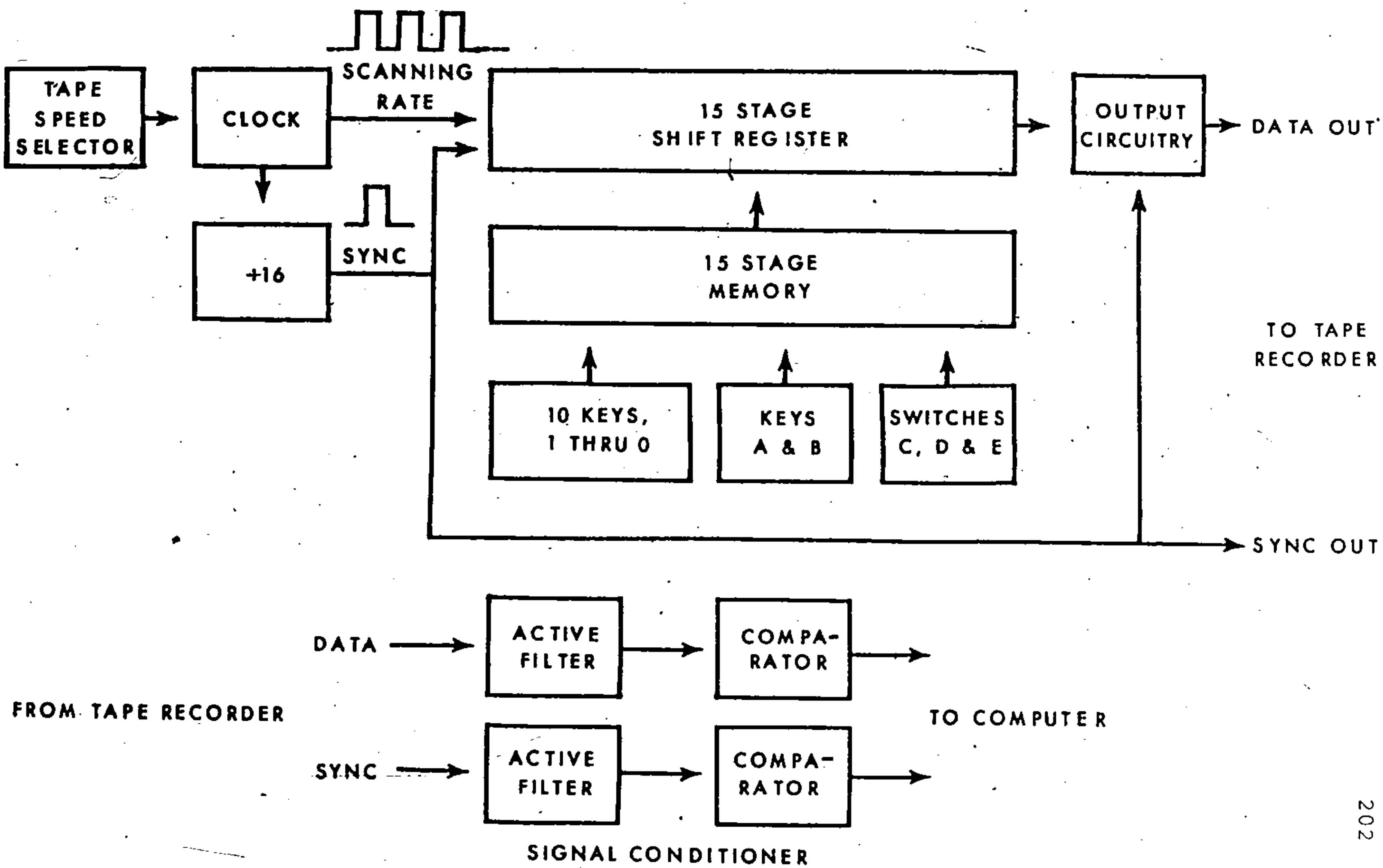
Data Format

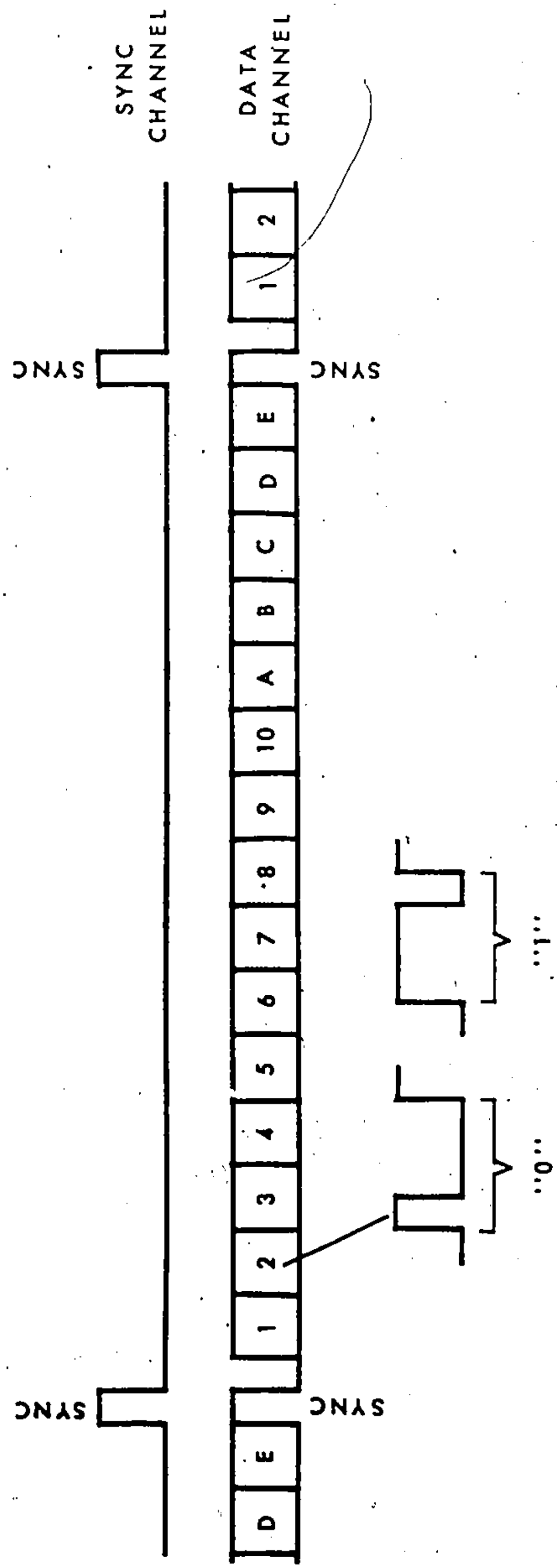
There are 16 bits that can be transmitted (see the accompanying figures); ten bits are controlled by microswitches 1-10 and used to log data. Two bits are the range switches 'A' and 'B' which are mutually exclusive except when pressed simultaneously, and three bits are controlled by toggle switches 'C', 'D' and 'E'. (see figure 5). The last (16th) bit, controlled by the 'E' switch, is always a zero because it is used to mark the synchronization (sync) pulse. Sync and data bits are transmitted on separate channels

All 15 data entry points are scanned once between sync pulses. data entered through keys and switches are stored in a memory untill the end of the scan cycle, when they are loaded into a shift register with the sync bit. All 15 data bits are then shifted out serially before the next sync pulse arrives. Should the same switch be depressed twice within one scan cycle, it will register only once.

The binary format of the shift register is put out in the form of 1's and 0's. The duration of a behavioural event is given by the number of successive times that a 1 appears at the location for its key. Thus the product of the time in seconds and the rate of scanning gives the duration of the event in terms of the number of scan cycles it lasted. Frequency is given by the first '1' of each such train of pulses at that location. Because the proportional lengths of '0' and '1's remain constant, this output format can be used independently of tape speed and voltage (within limits).

An internal clock controls the rate of scanning in the master unit. A second or slave unit is triggered or controled by the clock in the master. This ensures that the two units Figures 23 and 24 show a flow plan of the 'organ' or encoder with the signal conditioner as well as the conceptual appearance of the serial data stream on two channels. are always on the same scan and are functioning at the the same rate.


TAPE SPEED SELECTOR
CLOCK
SCANNING RATE
+16
SYNC
15 STAGE SHIFT REGISTER
15 STAGE MEMORY
10 KEYS, 1 THRU 0
KEYS A & B
SWITCHES C, D & E
OUTPUT CIRCUITRY
DATA OUT
TO TAPE RECORDER
SYNC OUT
FROM TAPE RECORDER
DATA
SYNC
ACTIVE FILTER
ACTIVE FILTER
COMPA-RATOR
COMPA-RATOR
TO COMPUTER
SIGNAL CONDITIONER


SYNC CHANNEL
DATA CHANNEL
SYNC
SYNC
SYNC
SYNC
D E 1 2 3 4 5 6 7 8 9 10 A B C D E 1 2
"0"
"1"

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