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VISUAL CLIFF PERFORMANCE OF DOMESTIC LAMBS

AS A FUNCTION OF VARIOUS MOTHERING

CONDITIONS

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1966

VISUAL CLIFF PERFORMANCE OF DOMESTIC LAMBS
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CONDITIONS

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CHAPTER I

INTRODUCTION

The relationship between mothers and their offspring has long been considered an important one. In particular, there have been numerous theories and studies concerned with infantile experiences in these relationships, and the resultant effects on developmental behavior. Many studies clearly indicate the immediate and, frequently, long-lasting effects of interrupted or unusual parental care during the early periods of the neonate's life (Harlow, 1961; Lorenz, 1937, 1952; Scott, 1962; Spitz, 1965).

Within the past fifteen years a plethora of research has been concerned with the effects of these early experiences upon later behavior, and a number of survey articles covering various aspects of this field of investigation have, consequently, appeared (Anastasi, 1958; Beach & Jaynes, 1954; Bindra, 1957; Drever, 1955; King, 1958; Yarrow, 1961). To a large extent, this research seems to have been stimulated by interest in three theoretical areas (Levine, 1962).

The first of these is psychoanalysis. Studies falling in this category have been primarily concerned with the effects of various degrees of traumatic childhood experience upon adult performance (Hall & Whitman, 1951; Hunt et al., 1947; Levy, 1934, 1938; Seitz, 1954). Only recently have extensive attempts been made to utilize psychoanalytic formulations in theorizing about early experiences with comparative species (Spitz, 1962, 1965).

A second area of consideration comes from the field of ethology. The phenomenon of imprinting is a direct result of investigations in this field, which were, initially, concerned with observing the effects of placing a young animal with a foster species to be reared (Lorenz, 1937, 1952). More recently, studies in this area have been concerned with the possible existence within the animal's life of critical periods during which learning and development of various modalities can be optimally accomplished (Denenberg, 1964; Hess, 1959; Jaynes, 1956, 1957, 1958a; Levine, 1956; Levine & Otis, 1958; Moltz, 1963; Sackett, 1963; Scott, 1958, 1962; Scott, Fredericson, & Fuller, 1951; Scott & Marston, 1950; Williams & Scott, 1953).

Finally, a number of investigations have resulted from the theory proposed by Hebb (1949) which postulates early sensory experience as a prerequisite for later learning ability. A number of these studies have dealt with the effects of various degrees of sensory deprivation in infancy upon later learning performance (Duke & Seaman, 1964; Gibson & Walk, 1960; Nealey & Edwards, 1960; Reisen & Aarons, 1959; Walk & Gibson, 1961).

The recent investigations of Lemmon & Patterson (1964) have encompassed formulations from all three of the above theoretical areas in

their work with domestic sheep. They demonstrated that a disruption of the usual mother-neonate bond in sheep drastically alters the normal development of depth perception. The present study is an attempt to evaluate more closely those critical aspects of the ewe-lamb relationship relating to factors affecting the normal development or retardation of depth perception.

Early Experiences

Psychoanalytic theory. Psychoanalytic approaches to the study of human behavior place great importance on early experiences in the developmental process of the infant (Erikson, 1950; Fenichel, 1945; Freud, 1915, 1923, 1940). In considering the theoretical dynamics in the development of the organism, Fenichel (1945) conveys the suggestion of Freud that two kinds of excitation should be distinguished: the one being evoked by perceptual, external, discontinuous stimuli and the other that arises from continuous instinctual stimuli within the organism. Instincts are considered therefore to be the propelling factors of development and, ultimately, the personality of the individual. Not only do the instincts drive behavior, but they also determine the direction that the behavior will take. Thus, an instinct exercises selective control over conduct by increasing sensitivity for particular kinds of stimulation. Although Freud relegated environmental stimuli to a secondary role, they were considered of extreme importance under certain conditions. For example, excessive stimulation during the early years of life when the immature ego lacks the capacity for binding large amounts of free energy (tension) may have drastic effects upon the personality. This is best exemplified in Freud's theory of anxiety. Freud's (1940) writings concerning early

experiences also included the concept of discrete stages in psychosexual development and the possible effects of fixation at one or another level. Each stage of this development during the first five years of life is defined in terms of the modes of reaction of a particular zone of the body. As we shall see later, this concept of discrete stages in development is closely paralleled by that of the critical period concept formulated by the ethologist, Lorenz (1935).

Erikson (1960) states that identity appears as only one concept within a wider conception of the human cycle which envisages childhood as a gradual unfolding of the personality through phase-specific psychosocial crises. In another context, Erikson (1950) expressed this epigenetic principle in psychoanalytic theory by defining eight stages of ego development with their characteristic inner psychological conflicts, physiological maturational possibilities, and observable social behavior. These eight stages are called "a list of ego qualities---criteria by which the individual demonstrates that his ego, at a given stage, is strong enough to integrate the timetable of the organism with the structure of social institutions" (1950, p. 218).

Furthermore,

The emerging ego identity, then, bridges the early childhood stages, when the body ego and the parent images were given their specific meanings, and the later stages, when a variety of social roles became available and increasingly coercive. A lasting ego identity, we have said, cannot begin to exist without the trust of the first oral stage; it cannot be completed without a promise of fulfillment which from the dominant image of adulthood reaches down into the baby's beginnings and which, by the tangible evidence of social health, creates at every step an accruing sense of ego strength (1950, p. 218).

In summary, psychoanalytic theory places much emphasis on a rather

clearly delineated, deterministic, and epigenetic approach to the development of the human organism. This conceptual framework involves certain critical stages in the early experiences of the child as they relate to later behavior. In the next section an attempt will be made to show how numerous studies and theories have evolved from an application of these psychoanalytic principles in experiments and observations of normal and deviant children. In addition, a focus on those particular areas of early experience which seem most important to the disruption of future developmental modalities will be made.

Early infantile experiences. Research in this area has, for the most part, always given some degree of consideration to the mother-neonate relationship and interaction (Spitz, 1962, 1965). Other investigators (Casler, 1961; Yarrow, 1961) have approached and surveyed this area from a viewpoint largely concerned with maternal deprivation per se and its effects on the infant. Theoretical issues aside, there is general agreement that early mother-child relationships are of tremendous importance and can have profound effects on development and later behavior.

Man is born immature and helpless. Initially, he is not capable of locomotion or of any of the directed, volitional behavior essential for survival. Thus, survival of the human infant is predicated on devoted parental care, as it is in other altricial animals, species whose young are born in an immature and helpless condition requiring care and nursing for some time after birth. This early care, then, involves some amount of contact, physical and otherwise, with a mother object that provides for the infant's needs.

The bulk of reported studies concerning human infant experiences

have revolved around a described pattern of events which has been assumed to be associated with the "trauma" of maternal deprivation (Bowlby, 1951; Ribble, 1944, Spitz, 1945). This pattern of events includes a retarded rate of development, greater susceptibility to disease and less adaptability in adulthood. Since most of the studies in such instances have consisted of longitudinal observations over a period of months, they have been consistently criticized for their obvious methodological weaknesses (Casler, 1961; Yarrow, 1961). Both of these reviews attempt to demonstrate that maternal deprivation can no longer be considered a simple, or even a single, variable. However, each of these writers differ in their conclusions concerning this area.

Casler (1961) critically reviewed studies on maternal deprivation in infants under six months of age. In general, these were studies of infants in institutional settings. He exposed the contradictions within and between such studies on the effects of institutionalization, and sees as a major methodological weakness the assumption that children in these situations are random samples of the population. Therefore, on these and other grounds, Casler concludes that an hypothesis alternative to maternal deprivation per se may be entertained. Thus, he proposes perceptual deprivation, stressing the tactual aspects. This proposal was supported by a review of some related studies of sensory deprivation, animal behavior, and neuroanatomical mechanisms.

Yarrow (1961) covered a wider age range in the child in his review, and attempted to define maternal deprivation more inclusively. His stated objective was "to clarify the concept of maternal deprivation by identifying the basic variables and concepts which have been indiscriminately

combined under this term" (Yarrow, 1961, p. 459). He identified four kinds of deviations from a hypothetical mode of maternal care: institutionalization, separation from a mother or mother-substitute, multiple mothering, and distortions in the quality of mothering. After analyzing each kind of maternal deprivation into the components of both antecedent events and consequent effects, Yarrow concluded that "institutionalization is not a simple variable, and cannot be used as a simple research variable or explanatory concept" (Yarrow, 1961, p. 461). Rheingold & Stanley (1963) have concluded from the Casler and Yarrow reviews the need for direct measurement of mother-infant behavior. Ferster (1961) is cited as providing one approach to this problem. According to Ferster (1961), what is needed is the study of "the actual parental and child performances... and their specific effects on each other, rather than global statements such as dependency, hostility, or socialization" (Ferster, 1961, p. 455).

Despite the above criticism directed toward most of the human infant-mother studies, the evidence points, nevertheless, to the fact that, depending on the type of relationship, the early experiences of the infant can profoundly influence later development and behavior. As has been shown, there seems to be no quarrel that these relationships are important; rather, the criticism is leveled at the methodological weaknesses which have resulted in far too many inferences. With this in mind, the work of Shevrin & Toussieng (1965) and Spitz (1965) with children will be examined. Although the studies reported by these writers are subject to the same criticism cited above, they have attempted to formulate theories of explanation which seem to be consistent with the conclusions expressed by Casler (1961) and Yarrow (1961).

Referring to an earlier paper, Shevrin & Toussieng (1965)

state:

At the heart of our proposal was a clinical and developmental model based on the assumption that infants have a need for optimum tactile stimulation (tactile stimulation includes not only stimuli emanating from receptors in the skin but also from deeper tissues giving rise to proprioceptive and kinesthetic sensations). When they receive too little or too much such stimulation in the early months of life, the ensuing conflict appears to interfere seriously with psychic development. The course of this conflict can be traced in the thoughts and actions of severely disturbed children of all ages. Rather than using repression or other psychic defenses directed at ideational derivatives of instincts, the main ways in which these children cope with tactile conflicts is either by a defensive raising of thresholds for all stimuli emanating from the environment or from inside the body, or through protective fluctuations in the physical distance between themselves and other people. The conflict can also be observed in their fantasy productions, usually in the form of an elaborate denial of the need for closeness. Despite these efforts the need for tactile stimulation persists. We have hypothesized that certain rhythmic behavior, such as rocking, often observed in severely disturbed children, is used to prevent a total loss of tactile stimulation resulting from excessive raising of thresholds (Shevrin & Toussieng, 1965, p. 311).

This model is used to explain many otherwise puzzling phenomena occurring in the treatment of some severely disturbed children. For example, those instances in which such children display an inordinate fear of being touched, while revealing in their behavior a great yearning for contact. One child would at times move within a fraction of an inch of the therapist, yet when he was touched he would flee in terror. Further, Shevrin & Toussieng were able to postdict from current clinical material that there had been severe disturbances in physical contact between all children and their mothers studied in the early months of life.

Support for this model came from Bronson (1963) in his review of Conel's morphological study of the infant cortex. Bronson states:

From neurological data the infant in the first weeks following birth must be largely dependent on innate reflexes mediated at lower neural centers, and would be primarily responsive to internal stimuli (pain, hunger) which have little direct representation in the neocortex. With maturation the increasing responsiveness to the external environment is mediated through tactile and, to a lesser extent, auditory and visual input. One would predict therefore that tactile experiences during these earliest months would be particularly salient (Bronson, 1963, pp. 57-58).

Shevrin & Toussieng (1965) expanded their original model to include additional definitions of terms which are used to delineate the nature of the need for tactile stimulation and the threshold mechanism, and their relationship to psychoanalytic instinct theory. Evidence from clinical research done by others unaware of their hypothesis is also reported. For example, in a study of seventy-five institutionalized infants compared with a like number raised in families, Provence and Lipton (1962) observed that institutionalized children: (1) reacted peculiarly to being held; (2) engaged in much rocking behavior; and (3) were unusually quiet and slept excessively. Specifically, by the second month of life all of the institutionalized children reacted abnormally to being held: "They did not adapt their bodies well to the arms of the adult, they were not cuddly, and one noted a lack in pliability . . . they felt something like sawdust dolls; they moved, they bent easily at the proper joints, but they felt stiff or wooden" (Provence & Lipton, 1962, p. 56). This odd response to holding was the first notable symptom Provence and Lipton found in institutionalized infants. Drawing on these findings in support of their model, Shevrin & Toussieng state:

It is important to note that feeding disturbances or intestinal upsets were rare. The tactile modality rather than orality as such was thus most sensitive to revealing

the effects of maternal deprivation, which is consistent with our expectations and accords well with Bronson's conclusion based on neurological data that tactility is the most salient sensory channel in the first three months of life (Shevrin & Toussieng, 1965, p. 329).

Provence and Lipton (1962) hypothesized that the "sawdust doll" infants responded as they did because they lacked the opportunity for experiences in mutual adaptation with a mother and had thus failed to learn to respond adaptively to being held. Similar interpretations concerning the rocking behavior and excessive sleeping observed in this study were also offered by Shevrin & Toussieng, with the nuances of the mother-infant relationship and tactile stimulation given emphasis.

Another investigator, Spitz (1962, 1965), has reported observational, longitudinal, and comparative studies involving human and animal experience during the early, formative periods. Years of observations of infants in the first year of life have resulted in Spitz (1965) supporting a critical period theory. This theory, for him, evolved from the embryological concept of "organizer" which refers to the convergence of several lines of biological development at a specific location in the embryonic organism. This leads to the induction of a set of agents and regulative elements called organizers which influence subsequent developmental processes. These organizers have long been considered (Needham, 1931) pacemakers for particular developmental axes. Before the emergence of such organizers, segments of tissue can be transplanted from one part of the body to a completely different area. There each will develop identically to the surrounding tissue. For example, tissue from the eye region will develop as dorsal tissue in such a transplant. But, if the same tissue is transplanted after the

organizer for the eye region has been established, the transplant will develop as eye tissue, even in the midst of the dorsal epidermis.

As a result of this concept, Spitz states:

About thirty years ago I advanced the proposition that analogous processes with concomitant critical nodal points were operating also in the psychic development of the infant. The findings made since in my longitudinal studies on several hundred infants have lent support to my proposition, so that I have attempted to formulate it more precisely and to apply it to subsequent age levels (Spitz, 1965, p. 118).

Thus, these turning points are of paramount importance for the orderly and unimpeded progression of infantile development. If the child successfully establishes and consolidates an organizer at the appropriate level, his development can proceed in the direction of the next organizer. But, when the consolidation of the organizer aborts, development is arrested. Since experimentation in infants is often limited to observational studies, Spitz frequently cites comparative animal studies to support his findings. In this case he mentions the work of Scott and Marston (1950) and their work with puppies involving critical periods. Another area of considerable interest to Spitz (1945, 1962) has been early mother-infant relationships and deprivation. One such study involved a total of two hundred forty eight children. Of these subjects one hundred seventy were housed in a penal nursery with their mothers; sixty one were observed in a foundling home, and seventeen in their parents' home. In this study Spitz reports an unexpected finding. "In the course of our investigation we were struck by the fact that in the first year of life the presence of genital play is covariant with the subject's developmental quotient on the one hand, with the quality of the existing mother-

child relations on the other" (Spitz, 1962, p. 284). In view of the findings of the decisive role of mother-child relations in autoerotic activities, a comparison of the three groups was made with the mother-child relations as the independent variable and the children's autoerotic activities as the dependent variable. Spitz found that (1) where the relations between mother and child were optimal, development in the first year of life surpassed the average in all respects, and genital play was present in all cases. (2) In the case of the infants where the relations between mother and child were problematic, genital play was much rarer and other autoerotic activities tended to replace it, while development, satisfactory on the average, was rather erratic. (3) Where the relations between mother and child were absent, general development dropped below the average, and genital play was completely missing. Again, Spitz cites animal experimentation to support his findings, in this case the work of Harlow (1958, 1962) on rhesus monkeys raised with surrogate mothers. Spitz parallels the lack of sexual development in the surrogate-raised rhesus monkeys with the absence of genital play and other autoerotic activities of the maternal-affection-deprived foundling home infants. Despite the obvious inferences drawn from this study, there were observable developmental and behavioral differences in the three groups as defined by certain mother-infant interactions. How these early contact-affective relationships relate to the emergence of other developmental modalities, especially perception, according to Spitz will be discussed later in this paper.

In summary, psychoanalytic theory and the emphasis it places on early infantile experiences and subsequent development has been examined.

That it is a deterministic, epigenetic approach to human behavior which can, nevertheless, be profoundly altered as a result of deviations in early mother-infant relationships has been suggested. Numerous writings have suggested that proper development can only come about through a mother-infant relationship involving consistent, contact-tactual stimulation, and some basic trust in the service of ego development. Similarly, many studies are reported which attempt to support these theoretical formulations. Although many of them are inferential from observational data and, hence, subject to methodological weaknesses, their findings cannot be ignored. That early experiences and mother-infant relationships are of paramount importance is, seemingly, without question. Moreover, as will be taken up in the next section, animal studies involving similar situations and relationships, while experimentally superior, are in general agreement with the results and theoretical formulations reported in the human infant studies.

Imprinting. One of the primary and most significant formulations of the ethological school has been that of imprinting. In general, this word has been used to symbolize a process seemingly present in the following typical observations. Very young animals of various species will readily respond to foster parents, even of another species, as if they were their own. This process of attachment is not easily reversed and the young animal quite often seeks the company of the foster species in preference to its own native species. Observations of this process have been noted in dogs, pigeons, geese, ducks, goats, and sheep, among others. As used here, imprinting refers only to the observed attachment of the

young animal to a parent figure and is not intended to imply knowledge of occurrences inside either participant. Historically, this phenomenon has been observed for centuries, but Heinroth (1910) appears to have been the first to take note of it in a scientific manner. More recently, Lorenz (1937, 1952) and Tinbergen (1951) have continued its investigation and given it wide publication.

For these authors, the imprinting process appears to be limited by at least three restrictions. First, to be acceptable to the young, the parental substitute must fall within a certain range of either size or coloration or both. Second, the parental figure has to engage in certain behaviors. For example, Lorenz (1937) found that if young ducks were to accept him as a mother substitute, he had to squawk in his best approximation of the mother duck's call. A third restriction has to do with the time when imprinting can take place. Though the optimal time varies with the species and to some extent with the individual, it must always take place early in the animal's life (Fabricius, 1951; Hess, 1959; Jaynes, 1957, 1958a, 1958b).

These observations led Lorenz to conclude that "there are specific and restricted periods during which the stimuli which will evoke certain instinctive responses are permanently determined. After the critical period has passed, the environment cannot alter the nature of the effective stimulus" (Lorenz, 1939, p. 248).

The recent research resulting from these conclusions has been concerned with two lines of investigation and, frequently, a combination of both. First, there are those studies which attempt to examine the underlying mechanisms of the imprinting-critical period concept (Sackett,

1963). Second are those investigations which have focused primarily on subsequent developmental behavior in animals resulting from manipulation during the critical periods (Blauvelt, 1955; Collias, 1956; Hess, 1962; Liddell, 1955; Scott, 1945, 1958, 1962; Scott, Fredericson, & Fuller, 1951; Scott & Marston, 1950; Williams & Scott, 1953). Finally, recent investigation has shown that the absence of maternal care during the critical period stage can drastically alter the appearance of survival responses involving depth perception in sheep (Lemmon & Patterson, 1964). Here, an attempt has been made to encompass the many aspects of early experiences and their effect on later behavior.

In the next section an attempt will be made to examine studies of the early experience of animals, following the general format as reported in the human infant studies earlier in this paper.

Early animal experiences. The concept of critical periods has received considerable attention in the past twenty years, with some interesting consequences. Scott (1945) first noted that lambs removed from their mothers during the first ten days of life and reared in association with humans were subsequently unable to make adequate social adjustment to the original flock. Such associational difficulties with the flock lasted several years. Later, Scott, Fredericson, & Fuller (1951) extensively investigated the problem of critical periods with regard to socialization in dogs. These investigators divided the developmental sequences of the puppy into distinct periods, starting with the neonatal period, lasting about ten days, during which the principle activities of the puppy are nursing, defecation, and urination. Since the animals are essentially blind and deaf during this period, it was

assumed that they were isolated from the environment. The second period, the transition period which begins at about the age of ten days and terminates at three weeks, is characterized by the development of perceptual motor capacities which now make the puppy vulnerable to environmental changes. Period three, the period of socialization, lasting to ten weeks, is described as the critical period during which socialization takes place. Finally, there ensues a juvenile period, which lasts from weaning at ten weeks to sexual maturity. Further, similar sequences of development were worked out for the mouse (Williams & Scott, 1953). Thus, experimental evidence for the critical period hypothesis with reference to socialization is fairly clear, and generally indicates that if there is some disturbance in the social environment, such as removal from the litter or isolation, during this critical period for socialization, there then appears a marked destruction of the social capacity of the organism (Scott, 1958). However, it is important to note that so far as critical periods and socialization are concerned, no experience occurring during the neonatal period of dog development appeared to have any permanent effect on subsequent behavior. That this is in contrast to the earlier study (Scott, 1945) on lambs is important, though understandable. Scott and Marston (1950) have pointed out that the lamb is born with the ability to walk, its eyes and ears are functional at birth, and within ten days it is eating solid food. Thus the lamb at birth is already in what has been described as the transition period of development and isolation may be expected to have a profound and prolonged effect. However, an examination of the critical period hypothesis in the rat and mouse--which have a developmental pattern similar to the dog--have resulted in findings

that suggest the experiences occurring at the neonatal stage do have their effects.

Writing about critical periods, Levine states:

That there are different critical periods for different species is undoubtedly true, but the statement is based not merely on the fact that species differ but also on the fact that they differ in their developmental stage at birth; it is thus reasonable to assume that critical periods are critical only when defined in terms of the developmental status of the organism at the time of stimulation. In the case of the species under discussion this is not so; although the temporal aspects of the sequence of development are different, the same phases are present following birth. The crucial difference seems to lie in the type of behavior being investigated. Thus, Scott, et al., were concerned with social behavior and the early developmental factors related to such behavior, whereas the investigations which demonstrated extremely early critical periods were concerned with parameters of behavior which appear more closely related to the emotional status of the organism. This would indicate therefore the existence of, not one critical period, but of several critical periods during which environmental stimuli have the most profound effects; it indicates further that the behavior which is modified by these environmental stimuli will differ according to the development stage of the organism at the onset of stimulation and the type of environmental stimuli which are imposed upon this developing organism. (Levine, 1962, p. 147).

Other studies involving the early experiences of rats have been reported by Maccoby (1964). Several findings support the generalization that early stimulation in these animals produces greater resistance to stress in adulthood, although there are exceptions. In addition, it has also been found that the presence of a mother during the early period of life in rats serves to prevent excessive stress-vulnerability. Support for this was found in early weaned male rats that were more susceptible to gastric ulcers under adult stress than were controls.

Again, there seems to be no quarrel among the investigators that critical period concepts are of utmost importance in early development.

Instead, critical reviews of recent studies suggest that, in general, the critical period has been found to be more labile than was previously thought (Wood-Gush, 1963). Similarly, Moltz (1963) suggests that moving toward a flashing light and following a moving imprinting object both are initiated by a given stimulus magnitude acting on the central nervous system and both serve to adjust these magnitudes until an optimal level of excitation prevails.

The effects of early mother-neonate relationships will again be cited as evidence for subsequent behavioral developments relevant to the focus of this paper. As with human infants, the kind of mothering which the animal neonate receives during critical periods is of paramount importance. This includes, of course, studies of maternal deprivation, with emphasis on tactual and contact stimulation.

According to Mason & Riopelle (1964), "Harlow and his associates (1958, 1959, 1962) in a well-known series of experiments with artificial mothers have provided convincing evidence that a primary factor in the infant rhesus monkey's tie to an artificial mother is contact stimulation, but the mechanism of reinforcement is not yet known (Mason & Riopelle, 1964, p. 167). Jensen & Tolman (1962) reported that brief separation of mother from infant was extremely stressful to two mother-infant pairs of pig-tailed macaques. In this study, mothers and own infants displayed maximal "directed" behavior toward each other. When the mothers were separated from their own infants and placed with a strange infant, they disregarded him, displaying neither approach nor aggressive behavior. In contrast, the infant at first attempted to achieve closeness with the strange mother, but in the next two days avoided her with increasing frequency.

Other reactions to maternal deprivation are reported by Benjamin (1961a, 1961b). These reactions in nonhuman primates consist of non-nutritive sucking. Habitual digit sucking is reported to be a common occurrence in monkeys and apes reared apart from the mother and is seldom seen in mother-reared animals. In an account of the development of a rhesus monkey raised in isolation from its kind, Foley (1935) described oscillating or swaying movements of the trunk which were present in the animal from early days of life and which were especially prominent in stressful situations. Subsequent observations have shown that repetitive stereotyped movements, particularly rocking or swaying, are characteristic of the young chimpanzee or macaque raised apart from its mother, whereas such behaviors do not occur in free-ranging animals, nor in laboratory-born subjects allowed to remain with the mother (Davenport & Menzel, 1963; Jensen & Tolman, 1962; Mason & Green, 1962). According to Mason and Riopelle, "The specific etiological factors in the development of repetitive stereotyped movements in nonhuman primates have not yet been established, but a reasonable assumption is that the physical relationship to the mother prevents the development of these responses by providing adequate sources of stimulation, and by placing constraints on the kinds of activities in which the infant can engage (Mason & Riopelle, 1964, p. 170). Examining this interpretation of repetitive movements in unmothered primates, it is tempting to view it as being too conservative, in the same way that the psychoanalytic theories are accused of being overly liberal. Nevertheless, it appears warranted to keep in mind the parallels described in the above study with the findings and theories proposed by Shevrin & Tousseing earlier in this paper.

In addition, Seay, Alexander & Harlow (1964) report that monkeys raised without mothers were observed with their own infants. They report that all four mothers were violent, abusive, and often neglectful of their infants.

Finally, it is well to mention the results of observations on extended periods of isolation and perceptual restriction. Reporting on the long range effects of early isolation, Melzack & Scott (1957) observed that dogs reared in a drastically restricted environment required more shock trials to acquire avoidance responses and that the general reactivity to pain was severely limited when compared with normal reared litter mates. It was concluded that early perceptual experience determines in part the emergence of overt responses such as avoidance of noxious stimulation and the actual capacity to perceive pain normally. In another study involving early perceptual restriction, Melzack (1962) raised dogs from infancy to maturity in lighted cages that restricted their visual experience but did not deprive them of all patterned stimulation. When released from their cages, the restricted dogs had greater difficulty than normally reared litter mates in performing a simple black-white discrimination and in subsequent reversal training.

Summary

An examination of early experiences relating to mother-infant relationships in human and animal subjects has been made. Likewise, the theoretical formulations relative to early development in various species were included. Comparisons between species, while not always explicitly stated, were implied. The evidence seems conclusive that initial mother-infant relationships can, in various ways, dramatically alter subsequent

behavior and performance. In addition, there appear to be certain temporal critical periods during which development of various modalities make their appearance or are retarded as a function of early experiences.

The fact that neonates of many species have demonstrated a capacity to perceive depth as soon as they are functionally able to move about indicates tremendous implications for research in this area. Its ultimate benefit can be readily appreciated in view of the fact that the development of this capacity is essential for survival in certain species such as goats and sheep.

Perception

Theoretical considerations. Spitz (1965) prefaces his theoretical formulations on perception with a statement by Freud (1923): "For the ego, perception plays the part which in the id falls to instinct" (Spitz, 1965, p. 53). Such a theory of newborn human infant perception must involve inferences. Thus, Spitz draws from the experimental work of von Senden (1932) and Fantz (1957, 1958a, 1958b) to support these inferences. von Senden investigated the development of visual perception in individuals who had been born blind because of congenital cataract and whose cataract had then been removed at a later age. Post operative descriptions by these people concerning what they saw have resulted in these general conclusions: (1) Perception appears to begin as a totality, and the various perceptive modalities have to be segregated from each other in the course of development. Perhaps even maturation plays a role in this process. (2) Perception in the sense in which adults perceive is not present from the beginning; it must be acquired, it must be learned.

An interest in the von Senden work led Fantz to carry out a series of observations and experiments on newly hatched chicks and infant humans from one to fifteen weeks of life. These experiments were designed to validate the proposition that form perception in both animal and man is already present at birth, hence innate, and inherited. This thesis was confirmed in the chick. This capacity has obvious survival value; the chick being a precocial bird, one whose young at birth are covered with down and are able to run about, it must provide for its food from the beginning and therefore must be endowed from birth with an innate, unlearned ability to perceive the food object. As mentioned earlier in this paper, since man is born helpless, immature, and requires early care, such visual discrimination is unnecessary in the early periods. However, in testing thirty infants, aged one to fifteen weeks, Fantz found that, like the newly hatched chicks, they had innate form perception. Upon close examination, these results do not contradict von Senden's work. The patients studied by von Senden were incapable of seeing forms, they did not see shapes, they could not distinguish sizes---but from the beginning, they did visually distinguish differences and could state that two objects were different from each other. Spitz contends that the infants studied by Fantz fail to prove that the neonate at birth, or even in the first weeks of life, distinguishes forms or patterns, the studies merely show that the infant notes differences. Spitz offers the following explanation:

The discrepancy between the claims made by Fantz and my own (as well as von Senden's) findings is due to a difference in conceptual approach. What von Senden and I call 'seeing' refers to an act of perception involving an apperceptive process, without which 'seeing' (in the sense

in which the adult perceives visually) cannot be achieved. This is quite different from what Fantz designates as 'seeing'. This statement is not arbitrary; it rests upon neuroanatomical and physiological givens, in that it is supported by the experimental work of von Holst (1950) in the visual sphere and that of Rosenblith (1961) in the auditory sphere. Owing to this apperceptive process man has, among others, the capacity to lay down mnemonic traces suitable to be reactivated as presentations, this is, as memories and as images; and also to activate such traces without the stimulus of a corresponding external perception. The work of Fantz ignores apperception (Spitz, 1965, p. 59).

In a review of perceptual learning studies, Gibson states:

The classic technique for investigation has always been study of the effects of deprivation of some normally present environmental contribution, such as stimulation by patterned light. The 'born blind' patients corrected (or somewhat corrected) by surgery are the most dramatic cases. The cases summarized by von Senden have appeared in an English translation (1960), but shed no more light than they ever did, since all the confounding effects of nystagmus, emotional upset, interference from old habits, and unreliable testing procedures are still inevitably present in the reports (Gibson, 1963, p. 36).

With this criticism in mind, a further examination of the theory set forth by Spitz (1965) is made:

Again when Fantz claims that he has 'disproved the widely-held notion that very young infants are anatomically incapable of seeing anything but blobs of light and dark' he is perfectly correct. Anatomically they are indeed capable of seeing more than just blobs. The eye is there, ready and willing; neuroanatomically and physiologically it does function. But this function does not extend to central processes, particularly to mentation. The apperceptive function is not yet available. It will be acquired through experiences provided in the course of affective exchanges with another person in the setting of object relations (Spitz, 1965, p. 59).

While maintaining the significance of the above studies, Spitz (1965) is, likewise, critical of these works. Thus, he differs with von Senden's on the grounds that the conceptual framework is different and a strong bias against introspective psychology is made. The studies by

Riessen (1947) on the consequences of visual deprivation in man and chimpanzee, and Fantz's (1957, 1958a, 1958b) observations are similarly criticized, not for the results, but because the role of emotion in perception is ignored. Spitz considers emotion within the framework of object relations the most potent incentive for learning.

From this somewhat extended examination of Spitz's basic concepts for the development of perception, it has been shown that this capacity is innate and relies on object relations with the mother for further expansion. Spitz contends that the oral cavity with its equipment of tongue, lips, cheeks, and nasopharynx is the first surface in life to be used for tactile perception and exploration. That it is well suited for this purpose is suggested by the representation in it for the sense of touch, taste, temperature, smell, pain, and of deep sensitivity, as the latter will be involved in the act of swallowing. However, all perception which takes place through the instrumentality of the oral cavity is still contact perception and thus basically different from distance perception.

Spitz postulates that, "a shift from contact perception to distance perception, from tactile to visual perception, is of paramount significance for the infant's development" (Spitz, 1965, p. 65). This shift is mediated through the instrumentality of object relations, and is seen when the infant nurses at the breast, feeling the nipple in the mouth while at the same time seeing the mother's face. Thus, contact perception blends with distance perception, with this blending opening the path for a gradual shift from orientation through contact to orientation through distance perception. In summary, Spitz states:

The shift to distance perception does not supersede and even less abolish the role of contact perception, it only narrows it down. The addition of distance perception enriches the spectrum of perceptual sectors; it facilitates orientation and mastery; it expands the autonomous functions of the ego; and eventually contributes importantly to the primacy of the reality principle (Spitz, 1965, p. 68).

Another writer (Sackett, 1963) has proposed a theory of visually controlled instinctive behaviors, including imprinting. Referring to the earlier work of Maturana (1960) who identified form and intensity-specific receptors in the frog retina, Sackett generalizes this work, suggesting that visually controlled instinctual behaviors are triggered by excitation of appropriate retinal elements. "It is hypothesized that this mechanism is responsible for onset of the imprinting critical period, inborn preferential choice responses, innate object recognition, and the stimulus-specific releasing function involved in fixed action patterns" (Sackett, 1963, p. 40).

More recent studies by Fantz (1963) on pattern vision in human infants tend to support the view that a marked degree of patterned vision is present at birth, before there has been an opportunity for learning. According to Day, "Although the controversy concerning innate and learned determinants of perception is no longer a central issue, the systematic investigation of perceptual responses which occur independently of prior learning has continued" (1964, p. 16). Thus, the crucial factors for investigation are those which can either facilitate or retard early developmental processes, including later learning and normal nature-nurture interactional processes. In particular are those studies involving depth perception as measured by a "visual cliff."

Depth perception discrimination in animal and human neonates.

As has been stated earlier in this paper, development of the capacity to perceive depth is demonstrated in many species. Moreover, this ability is apparent under normal conditions as soon as the neonate is able to move about alone. That depth discrimination is essential for survival in certain species, and of great consequence in others, speaks highly for the importance of its investigation.

The apparatus used in studies of depth perception is called a "visual cliff." It is designed and constructed in such a manner that, although it is at all times "safe," an illusion of depth is conveyed to the young subject which they usually avoid. A number of variations in construction can be effected, but the usual requirements are a smooth glass surface under which a patterned, usually square, material is affixed. This material is flush under the surface for some area and then drops down to the bottom of the apparatus, covering this surface for the rest of the area. A neutral platform of wood or some other material is provided in the center as a runway from which the subject is coaxed after being placed there. For studies involving animals that tend to orient or move readily, as in the present study, the center runway can be eliminated and the animal placed at one end on the "safe" area. If depth discrimination is present the animal will "avoid" the visual drop with extreme consistency. In those animals in which this development has not taken place the "danger" area is not avoided and they move about on it indiscriminately.

Some historical problems concerning innate determinants of depth perception can be found in a review and evaluation by Shrinkman (1962).

In addition, studies of the visual cliff have been collected and extended in monograph form by Walk & Gibson (1961). A history and criticism of early studies can also be found in Patterson (1965).

Some of the findings of Walk & Gibson (1961) utilizing a visual cliff are: The young, and some adults, of ten species from turtle to man were studied. All subjects showed discrimination of depth by more frequent descents from a centerboard to that side of the apparatus with the shallower visual drop-off. Young organisms avoid the deep side as soon as they are able to walk, and before they have had experience with falling, climbing, or walking into things. Chicks and goats were reported to avoid the deep side before they were twenty-four hours old. Human infants could not be tested until they could crawl resulting in their initial exposure to the apparatus at between six and one-half months and one year, but they usually avoided the deep side. Dark-reared rats avoided the deep side on initial exposure to the apparatus, just as did their normally reared controls. However, dark-reared kittens did not perform similarly, and their locomotion as well as their depth-perception seemed to be impaired. With respect to the kittens, Gibson (1963) concluded that discrimination of depth matures, when normal conditions of development are provided, without benefit of reward or punishment or associative learning. Other investigators (Ganz & Riesen, 1962, Nealey & Edwards, 1960; Riesen, 1961; Riesen & Aarons, 1959; Tallarico, 1961) have reported findings consistent with the above.

Theoretically, Gibson (1963) argues on the side of innate organization of the visual field---in the studies cited, an organization such as to permit discrimination of depth. In contrast, the Hebb (1949)

position concludes that patterned perception requires learning and hence should develop rather slowly in the infant as it established "phase sequences." As was mentioned earlier, the innate versus learned determinants of perception is no longer a central issue of controversy. However, Maccoby (1964) has attempted to blend the two positions toward a more meaningful concept of perceptual determinants. Thus,

An alternative interpretation of Gibson's (1963) results could be made that would be more consonant with the Hebb position. First one could assume, as Hebb does, that the dependence of patterned perception on learning is greater as one goes up the phylogenetic scale; thus the fact that dark-reared rats can immediately use cues for depth upon exposure to the light does not imply that human being could do so. And, while most human infants avoid the deep side before they had been locomoting long enough to have much experience with falling, they have nevertheless been moved about in a visual environment, and have played with toys which they brought up close to their eyes and moved away again, etc. so that some of the cues for distance have had an opportunity to be established through learning in other contexts. The Hebb position does not require that whatever learning underlies the establishment of phase sequences will have occurred exclusively on the basis of reward and punishment (Maccoby, 1964, p.209).

Summary

A number of theories and studies involving the determinants and development of perception in animals and humans have been examined in this section. It may be noted that some investigators have, seemingly, drawn conclusions from methodologically weak studies, while others have adhered to strict experimentation and did not draw generalized inferences from the data. Nevertheless, it appears that the development of perception in neonates follows some rather innate and species-specific determinants. Further, the appearance of this capacity to perceive appears to be tied closely to the imprinting-critical period concepts

as set forth earlier in this paper.

Studies involving the specific quality of depth discrimination were also mentioned. Its appearance in most testable neonates at a very early age speaks for the significance of this modality, especially in those animals where its presence is necessary for survival. The following section is concerned with a study involving a species of animal for whose ancestors the depth perception phenomenon was essential for survival purposes. The study to be reported concerns the visual cliff performance of mothered and unmothered domestic sheep.

Visual Cliff Performance of Mothered and Unmothered Domestic Sheep

Lemmon and Patterson (1964) noted dramatic and significant effects when the mother-neonate bond is interrupted in sheep. This resultant behavior was measured by investigating the effects on early depth perception by means of a visual cliff apparatus. Lambs of registered Suffolk ewes bred by the same Suffolk ram were used. In the initial experiment, thirteen sets of twins were alternately assigned to mothered and unmothered groups on the basis of first- or second-born alternation. The mothered lambs remained with the ewes in individual indoor stalls, while the unmothered lambs were taken from their mothers immediately after birth. They were cleaned with textured cloths approximating the ewe's tongue, and fed colostrum from their own mothers or from another lactating ewe until the depth perception trials were completed. Lambs in both groups were tested once every hour on the visual cliff and observed through a peephole in the enclosure in the end away from the platform where the animal was standing. A smaller

version of the Gibson and Walk (1960) visual cliff was utilized. The construction consisted of a pane of glass (46 X 92 cm), enclosed on all sides and at the top with solid painted wood, and was lighted from beneath to minimize glare. At one end and beneath the glass was a wooden platform, 15 X 46 cm. The rest of the glass conveyed an "apparent drop" illusion of one meter.

The stimulus for the lamb to move onto the "drop" was the overhead intersection of the planes of the wall and the ceiling of the visual cliff enclosure. The rationale for this aspect was reported by Collias (1956) who noted the tendency of the newborn lamb to orient itself along a plane or intersection of planes and to move in such a relation until stopped by some obstruction. Lemmon and Patterson (1964) report that the youngest lambs in their experiments behaved in the manner described by Collias, moving without regard to the apparent drop beneath them. Nevertheless, a few hours after birth they began to exhibit the "characteristic stereotyped behavior" as described by Gibson and Walk (1960). This involves the lamb backing into a posture of defense with its front legs rigid and its hind legs limp. The animals never learned to function without optical defense despite repeated experience of the tactual solidity of the glass (Gibson and Walk, 1960).

In their experiment, Lemmon and Patterson (1964) defined "passing" on the cliff as remaining on the 15 X 46-cm platform for 3 minutes without placing any two feet simultaneously on the pane of glass over the vacant or "drop" area. The results of this study showed that the mothered lambs "passed" or avoided the cliff on an earlier trial than did the unmothered twin lamb. The number of trials needed to "pass"

the cliff ranged from one to seven for the mothered pairs, and from two to twelve trials for the unmothered group.

The second part of the Lemmon and Patterson experiment likewise involved mothered and unmothered groups. Five pairs of lambs were used in this study; each lamb single born and from a different ewe. They were matched on the basis of sex and birth weight. The unmothered lambs were treated the same as in the previous study. The mothered lambs were fitted with translucent goggles which, presumably, would give some advantage to the unmothered group. According to Lemmon and Patterson:

The goggles were left on while the lamb remained with its mother in an individual indoor stall, and were worn for a period of time equal to half the age at which its matched pairmate displayed adaptive reaction to the testing apparatus. For example, pair 16, the unmothered lamb did not successfully avoid the vacant area of the glass pane until its 12th trial at the age of 12 hours. The mothered member of pair 16 thus wore goggles for 6 hours. When the goggles were removed, the lamb successfully avoided the glass immediately, on the first trial, without previous experience on the visual cliff apparatus (Lemmon & Patterson, 1964, p. 835.).

Again, as in the previous experiment above, every mothered lamb of the matched pairs exhibited avoidance behavior at an earlier age than the lambs in the unmothered situation.

The authors of these experiments cite ample evidence which suggests that interference with the formation of the mother-neonate bond in goats and sheep clearly affects later social and other behavior. In such animals there is great survival value in the closely related development of the abilities to perceive depth and to be mobile. Lemmon and Patterson point out that: "The results of these experiments present

striking evidence that some unspecified elements in the mother-neonate relationship are closely related to the development of perceptual skills, particularly depth perception, as well as subsequent adjustive avoidance behavior" (1964, p. 836).

Summary

A rather lengthy and extensive history of observations and research experiments have pointed out that future behavior of human and sub-human animals can be drastically altered when the mother-neonate bond is interfered with in single or multiple ways. Only recently have attempts been made to study the effects of disrupting influences in early experiences as relating to later development and perceptual discriminations in precocial animals, particularly sheep and goats.

The focus of the present study is the investigation of previously unspecified elements in the early ewe-lamb relationship as possible causal factors relating to subsequent developmental and survival behavior.

CHAPTER II

PROBLEM

The present investigation was an extension of the recent demonstration that newborn lambs left with their mothers develop the capacity to perceive depth (as measured on a simulated visual cliff) significantly sooner than paired lambs who are taken from their mothers and raised by humans. It was proposed in this study that a number of mother-young interactional processes in sheep be systematically controlled to determine which of such processes are most significantly related either to the appearance or to the suppression of depth perception. The first hypothesis dealt with the general theory that under varying conditions, unmothered animals show slower development of adjustive behavior on a continuum than do normally mothered animals:

Hypothesis 1. In a visual cliff situation, groups of lambs under various types and degrees of mothering will avoid the cliff at differing ages to such a degree that the groups will vary significantly.

The second hypotheses was concerned with the investigation of the various mother-young interactional processes, and to try and determine which of such processes were most significantly related either to the appearance or to the suppression of depth perception. Thus, it was hypothesized that the effective variable related to the onset of depth perception would be the development of a durable mother-neonate bond.

This, in turn, would have to do with the circumstances or conditions which best met the biological and social needs of the organisms in interaction, i. e., the capacity to perceive visual depth would be facilitated by the development of the ewe-lamb bond rather than by the fulfillment of hunger needs, sucking needs, contact needs, and so on, at a segmental level. It appeared possible that the mother-neonate bond could be estimated to exist in degree of "strength," so to speak.

Subjective observations in conjunction with performance on the visual cliff apparatus would serve as partial criteria to estimate the strength of the ewe-lamb interactional bond.

Thus:

Hypothesis 2. Comparing all groups with the mothered lambs, avoidance of the visual cliff will vary according to the amount and quality of contact between mother and neonate.

Stated formally, the aim of the present research project was to determine what variables are related and significant to the onset of depth perception as a result of early and various mother-young interactional processes. Further, an attempt was made to evaluate unspecified factors which contribute to the strength of a mother-neonate bond, assuming the validity of the first hypothesis.

CHAPTER III

METHOD

Description of Subjects

The subjects were lambs born into a flock of registered Suffolk ewes which had been bred to the same registered Suffolk ram. A total of 43 lambs were used in this study, including 9 sets of twins. Of this total, 19 were males and 24 were females. All births were recorded between March 27 and April 11. The distribution of births according to days, and time of day, were relatively uniform. The sixteen day period of lambing recorded for this study, when divided into four-day segments, resulted in 12, 11, 9, and 11 births, respectively. Similarly, considering the time of day for birthing activity, the results show numbers of births at 5, 8, 10, 10, 4, and 6 when the day is divided into four hour segments beginning at midnight. However, 20 of the 43 lambs in this study were born between the hours of 8 A. M. and 4 P. M. These results would tend to confirm the findings of Hersher, Richmond, and Moore (1963) that sheep show no tendency to deliver at any particular time of day. This is not consistent with that found by Patterson (1965). He reported that the period of greatest activity for births occurred before sunrise and after sunset. It seems possible that the present sample is not large enough to confirm or deny either set of findings related to time of deliveries.

Treatment of Subjects

At birth, each ewe and her lamb were randomly assigned to one of the eight treatment groups. These groups were as follows:

Group A Lambs were installed with their mothers in a small stall in which the ewe was confined in a muzzle and attached rope and suspended in a sling, so that while the lamb had free access to the udder, the passive ewe was prevented from nuzzling or licking the lamb or inhibiting its nursing.

Group B Ewes were similarly muzzled and slung, but were, in addition, fitted with a brassiere such that the lambs had as much contact as they wished with their passive mothers' bodies, but could not nurse.

Group C Lambs were left with a loose, but brassiered mother in the stall. Although the ewe in this case could not nurse her own young, maximal lamb-ewe interaction was permitted in other respects.

Group E Lambs were confined a small wire pen within the mother's stall in such fashion that lamb and mother had visual and auditory contact with each other, but little physical contact other than that which was facilitated by pressing against the wire pen.

Group F Lambs were fostered onto a recently delivered ewe, not their own mother, in the ewe's stall with the ewe's nose and face and the lamb's nose, face, and buttocks area anointed with oil of anise.

Group N Lambs and ewes were similarly anointed with anise oil as in group F, but in this group the lambs were returned to their own mothers.

Group O Lambs were removed from their mothers and placed in isolation pens. These lambs were completely unmothered by the ewes.

Group H This group served as controls in that the lambs and ewes were not restricted in any manner concerning the normal mothering process, although they were, as with Group C, subjected to the initial cleaning procedures, described below, for other groups.

Immediately after delivery, each ewe-lamb combination was confined in individual stalls where they remained for the duration of the testing situation. It was observed that at birth the ewes commenced cleaning the lamb by licking it vigorously, usually starting at the head and working backwards. This cleaning process frequently lasted until the lamb was able to stand alone. Consequently, in all treatment groups an attempt was made to provide the lambs with similar kinds of early tactual experiences. Taken immediately after delivery, each animal was rubbed and cleaned with a warm dampened sponge and dried with burlap and terrycloth until it stood alone. This was followed by weighing, tagging, painting the umbilical area with iodine, and then returning the lamb to the appropriate treatment condition.

The feeding procedure depended on the particular treatment of each lamb, although the first feeding for all lambs took place within two hours after birth. Those lambs requiring bottle feeding were fed colostrum taken from their own mothers or from other lactating ewes. These feedings followed a regular schedule for all bottle fed lambs from birth to the conclusion of the testing situation. Observations were made of all other lambs permitted to suckle normally in order to determine that proper nutrition was being obtained. In those situations where the ewe was not permitted to facilitate nursing or by circumstances of the design not amenable to allowing the lamb to suckle, the experimenter

assisted the animal in obtaining the nipple.

Experimental Design

The experimental day was divided into six segments of four hours each, beginning at midnight. All lambs, regardless of time of birth or treatment situation, were tested on the visual cliff apparatus at the next time period. Thus, all lambs were tested and fed the first time as soon as they were able to stand and move about to some degree. Those animals requiring hand feeding with a bottle were fed immediately after testing to minimize any lethargy. After testing, each lamb was immediately returned to its treatment stall. This procedure was continued at four hour intervals until the response criterion was elicited on the visual cliff which then signified completion of the testing situation. Upon completion of testing, all restrictions were removed and the normal ewe-lamb interaction allowed to take place.

The Visual Cliff

A permanent visual cliff apparatus, comparable to the one employed by Lemmon & Patterson (1964), was constructed of somewhat more durable design. The overall dimensions were $73\frac{1}{2}$ " (high) x $46\frac{1}{4}$ " (long) x 31" (wide). Basic materials for the apparatus consisted of $\frac{3}{4}$ " plywood which was painted flat black inside to minimize glare.

The top of the apparatus was fitted with a 17" x 31" hinged flap through which the lamb was placed onto a platform. The hinged flap was edged with rubber strips to eliminate all external sources of light. The glass surface utilized for the test situation measured $44\frac{3}{4}$ " x $29\frac{7}{16}$ " and was fitted into slotted grooves to eliminate cues. From

the surface of the glass to the inside top of the apparatus measured 24", while beneath this was a 48" simulated drop. The glass platform onto which the lamb was introduced through the top measured 29 7/16" x 12". Directly beneath the glass surface of the platform was fitted a red and white 1 1/2" checkerboard cotton material which dropped from the front edge of the platform perpendicular to the bottom of the apparatus. From that point it was flush on the bottom to the end opposite the platform. The platform was lighted from beneath by two vending machine fluorescent lights. After being placed on the interior platform, the lambs were observed through tapered peepholes in the end opposite the platform.

Lambs were placed on schedule on the interior platform and observed. A simple Pass-Fail criterion was used with passing defined as staying on the platform for a period of three minutes without placing any two feet simultaneously on the pane of glass over the vacant area. When such criterion response was exhibited on any trial, a subsequent trial involving the use of gentle pressure to push them forward "over the cliff" was attempted. The age at which the criterion response was first observed was recorded as the critical value, and the results were stated as hours of age at criterion.

CHAPTER IV

RESULTS

The first hypothesis tested was that groups of lambs under various conditions, ranging from mothered to unmothered, will avoid the visual cliff situation at differing ages to such a degree that the groups will vary significantly. All lambs were placed in a visual cliff apparatus every four hours from birth until they exhibited the criterion avoidance response. Ages at which the criterion responses were first exhibited are given in Table 1. These are shown as the mean number of hours for each treatment group in ascending order. A one-way analysis of variance for all eight treatment groups was significant at the .001 level. Since the treatment groups were not of uniform size, the Harrington method cited in Walker and Lev (1953) was used. The obtained F was 7.61 with 7 and 35 degrees of freedom (Table 2). Thus, the first hypothesis was supported.

The second hypothesis tested was that comparing all groups with the mothered lambs, avoidance of the visual cliff will vary proportionately as the "strength" of the mother-neonate bond decreases in each group. Thus, in addition to overall variance considerations of the first hypothesis, there was an interest in making group comparisons with the control and tests on differences between all pairs of means. These were tested using the Dunnett t statistic and the Newman-Keuls method

TABLE 1

AGES IN MEAN NUMBER OF HOURS AT WHICH EACH
GROUP EXHIBITED CRITERION RESPONSE

Group	Number of Lambs	Mean Number of Hours
H	5	5.8
C	5	6.4
A	5	10.4
B	5	13.4
E	5	15.8
F	5	18.6
N	6	24.0
O	7	29.2

TABLE 2

ANALYSIS OF VARIANCE OF AGES IN HOURS AT WHICH EACH
GROUP EXHIBITED THE CRITERION RESPONSE

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	F .001
Total	4675.07	42			
Between Means	2821.24	7	403.03	7.61	4.66
Within Groups	1853.82	35	52.96		

described in Winer (1962). Comparing all means with a control (Dunnett, 1955), the obtained t for Group F was 2.78 and significant at the .05 level, for Group N it was 4.14 and significant at the .01 level, and for Group O it was 5.57, which is significant at the .01 level. Groups A, B, C, and E had t 's of 1.00, 1.65, .13, and 2.17, none of which were statistically significant. All t 's were obtained with a k of 8 and the degrees of freedom for the mean square error were 35. Table 3 gives the level of significance for tests on differences between all pairs of means (Winer, 1962). Thus, the results would suggest that the second hypothesis has been supported.

Before the criterion avoidance responses were observed, the lambs behaved in the manner described by Collias (1956) and Patterson (1965). Thus, on the early trials the lambs tended to orient themselves along the surface of the wall and to be completely oblivious to the apparent drop beneath them. Vision appeared to develop normally; eyes were open in all cases, and even at less than an hour of age all of the lambs could follow a moving ewe or a moving human.

The development of avoidance behavior was usually sudden and somewhat dramatic in nature. When the lamb first appeared to notice its seemingly precarious position, it would exhibit the typical startle response of sheep and goats. This involved the extension and stiffening of the front legs and flexion of the rear parts with a "back-pedalling" motion of the rear legs.

The lambs which failed a trial on the cliff apparatus usually did so with a minimum of hesitation. The behavior was somewhat exploratory in that they moved forward with their head in the normal position,

TABLE 3

LEVELS OF SIGNIFICANCE FOR TESTS ON DIFFERENCES
BETWEEN ALL PAIRS OF MEANS

Treatment	H	C	A	B	E	F	N	O
Means	5.8	6.4	10.4	13.4	15.8	18.6	24.0	29.2
H 5.8							.01	.01
C 6.4							.01	.01
A 10.4							.05	.01
B 13.4								.01
E 15.8								.05
F 18.6								
N 24.0								
O 29.2								

or in butting movements with the head raised and orienting along the surface of the wall, as mentioned above. Once the avoidance response was achieved the lamb no longer oriented upward or to the surface of the wall. Instead, they maintained the startle response and continued looking down at the cliff. Attempts to push the lamb over the cliff, once the avoidance response was made, resulted in increased resistance and "back-peddaling" behavior.

The avoidance behavior displayed by these four-footed animals is paramount to survival for those of the species living in areas where steep inclines are common. In a pilot study prior to the present experiment, a group of ten new born kids were similarly tested on the visual cliff. Since the natural habitat of goats is characteristically found to be in environments of more rugged terrain, it was interesting to note that the kids were more precocial than their lamb counterparts. In every case the kid displayed the startle avoidance response as soon as it was able to stand alone. Thus, this behavior occurred when each kid was less than one hour old.

One other observation is reported which may be of interest to future investigators in this area. Again, in a prior pilot study with four lambs, it was found that lambs taken from the ewe at birth, and isolated in individual stalls, became increasingly lethargic and failed to pass the cliff until all four were placed together in one stall. On the next trial three of the four lambs exhibited the criterion avoidance response.

CHAPTER V

DISCUSSION

The results of the present experiment significantly support the many previous findings that the development of depth perception, and subsequent performance on a visual cliff apparatus, is functionally related to early experiences in animals and humans. More specifically, the mothered and unmothered lambs in this study performed consistently with their counterparts as reported by Lemmon & Patterson (1964). Further, the criterion avoidance response, as measured in mean number of hours for each treatment group, was achieved by every group before the unmothered lambs.

An analysis of the treatment groups relating to the second hypothesis tested that, comparing all groups with the mothered lambs, avoidance of the visual cliff would vary proportionately as the "strength" of the mother-neonate bond decreases in each group, points to some rather striking correlates in other animal studies, and raises some rather provocative questions in other areas.

First, the findings of this study suggest that the degree and/or quality-quantity of the mother-neonate bond is functionally related to the subsequent development of depth perception as measured by performance on a visual cliff. A consistent increase in group mean times to display the criterion avoidance response was found to vary proportionately with

the amount of possible ewe-lamb interaction allowed in the specific treatment situations. For example, comparing the results of the Control Group H with those of the Binder Group C, the only difference between the groups involved the addition of a brassiere on the Group C ewes. Superficially, at least, this afforded maximal ewe-lamb interaction and was restrictive only in the lack of nursing experiences. The slight difference in the results would tend to suggest, then, that all other things being equal, the actual nursing experience is not statistically significant in the development of depth perception as measured in this study. However, those lambs deprived of this experience did, overall, take longer to achieve the avoidance response than the Control Group H. Likewise, the increase of restrictiveness in Groups A, B, E, and O, resulted in correspondingly greater amounts of time for the response to occur.

The most intriguing results, however, concern Groups F (cross-fostered and anointed with anise oil) and N (anise oil only) which permitted the same ewe-lamb interaction to occur as with the Controls H, but were, nevertheless, significantly different. In addition, when compared with the Controls, the Group N lambs took significantly longer in their performance responses than did those in Group F. It is interesting to note that the Group N lambs were, theoretically, allowed the same quality/quantity interaction with the ewes, but displayed the second longest amount of time as a group to pass the visual cliff. This is quite interesting in light of the fact that the group requiring the greatest amount of time, Group O, was completely unmothered.

The important question, then, would seem to revolve around some mother-neonate bond nuances which may not have been readily apparent. For

at least four of the treatment groups it appears that, although there is no significant difference between them, (A,B,C,E) and Control (H), there is an observable increase in time as the possibilities for interaction decrease. In this regard, the results could be explained in terms of experimentally induced "good" and "bad" mothering in which the lamb or ewe had no control over the resultant behavior. Thus, the ewe cannot interact with the lamb, and likewise, the lamb with the ewe while each is restricted in some manner. The extreme, of course, is manifest in the Group O lambs which had no possible contact with the mother.

The other major aspect concerns Groups F and N which were not experimentally restricted in the obvious sense. These treatment groups were allowed free access in terms of the mother-neonate relationship, with the exception that both groups were subjected to the application of oil of anise on the ewe and lamb, and Group F involved cross-fostering techniques. In these two groups there appears to be justification for a departure from the usual explanations applicable to behavior controls imposed from without. Thus, the lack of development of avoidance behavior in the visual cliff situation in Groups F and N would seem to be mediated through some unspecified behavioral indices brought about by the application of the anise oil. The fact that lambs with their own mothers took longer to display the criterion response than did those in the cross-fostered situation would seem to argue against these results being an extension of mother-neonate bond strength.

Parallel Comparisons in Mothered-Unmothered Relationships

Certain aspects of this study have replicated the findings reported by Lemmon & Patterson (1964) and Patterson (1965). Specifically,

this concerns Group H (mothered) and Group O (unmothered) lambs, and supports their findings in that every Group H lamb achieved the criterion avoidance response before its Group O counterpart. Patterson (1965) draws upon the writings of Erikson (1950) and Ribble (1943, 1955) concerning organismic homeostasis and contact need gratification to explain his findings. Erikson stressed the importance of attaining early organismic homeostasis or equilibrium at the physiological level and a sense of "basic trust" at the psychological level. Ribble's theories and observations suggest that the organismic homeostasis may be aided initially by adequate contact stimulation. Other writers, Shevrin and Toussieng (1965), report on institutionalized children to support their model of the need for tactile stimulation. They relate maternal deprivation to important factors in many severe childhood disturbances. Provence and Lipton (1962) report that by the second month of life all of the institutionalized children in their study reacted abnormally to being held. In addition, the infants engaged in much rocking behavior, and were unusually quiet and slept excessively. --

The present writer is well aware of the dangers of anthropomorphism in this discussion. However, the criticisms leveled against inferences drawn from maternal deprivation studies involving institutionalized infants is much the same as that found in comparable studies with animals. Thus, Wohlwill states:

An intriguing result on this same question has been reported by Lemmon & Patterson: Mother-deprived sheep show retardation in performance on the visual cliff, even in comparison with control animals deprived of patterned vision for twice the amount of time as their matched experimentals. No direct effect of deprivation of the mother-object as such need be assumed, of course, to account for this finding;

rather, it is likely that the effect is mediated by reduced levels of exploratory behavior resulting from maternal deprivation (Wohlwill, 1966, p. 223).

Wohlwill's comments that performance on the visual cliff is mediated, in this case, by reduced levels of exploratory behavior resulting from maternal deprivation, and not effected through deprivation of the mother-object, is not a sufficient explanation in light of the present experiment. Visual observations of the lambs in all but the statistically significant groups resulted in no detectable decrease of exploratory behavior. Nevertheless, as the experimental interference of ewe-lamb interaction increased, so, likewise, did the amount of time taken to display the avoidance performance response.

It was noted, however, that in the two groups anointed with oil of anise the lambs appeared to be more lethargic and less exploratory than lambs in the other groups, despite the fact that these lambs were not deprived or restricted from possible interaction with the ewe. This behavior was strikingly similar to that displayed by the lambs completely deprived of any mothering.

The most notable feature of these two groups was the behavior of the ewe toward the lamb. Behaviorally, the ewes were inconsistent in their interactions with the lambs. For example, they were both accepting and rejecting of the lambs with no apparent consistency. At times, the lamb was allowed to approach for nursing and contact allowed for a few seconds before the lamb was pushed away or stepped away from by the ewe. Frequently, the ewe would begin to lick the lamb in the usual manner and then abruptly cease this activity, breaking contact with the seeking or nursing lamb. At other times, the ewe would con-

tinually circle and back away from the approaching lamb while watching it, nevertheless. In no case did the ewe appear "natural" with the neonate as did mothers in the other groups. This abnormal behavior was, statistically, more striking in those ewes with their own lambs (Group N) than those in the cross-fostered (Group F) situation when both groups are compared with the controls. Thus, it seems apparent that the resultant development of avoidance responses in a visual cliff situation is, in some ways, contingent upon the reciprocal behavior and interaction of both the lamb and the ewe.

Possible Mechanistic Explanations

In the present study it is presumed that factors involved in early ewe-lamb interactions result in the development or retardation of visual depth discriminations. The appearance of retinal sensitivity to motion parallax--according to Walk and Gibson (1961) the most important single cue to distance--seems to depend, in large part, for its expeditious appearance on the gratification of early contact needs through consistent and accepting mothering behavior.

The work of Gibson (1963), Hebb (1949), Moltz (1963), Patterson (1965), and Sackett (1963) can, again, be examined for some theoretical explanations of the results in this study. The performance of the mothered and goggled lambs in Patterson's study would certainly argue for the innate position of Gibson generally, and the position of Sackett specifically. Sensitivity to depth appeared on the first trial in some lambs, moments after the goggles were removed. This indicates that sensitivity to depth was developing without the experiencing of distance cues and without practice. Thus, the cataract patients discussed by

Hebb may also have perceived depth immediately, although identification of forms may have taken some time and conscious practice. For Sackett, the onset of the critical period for imprinting is determined by the maturation of retinal cells responsive to movement, in Moltz' case, movement and intensity change. In the present study it may be that this maturation occurred when there was some cumulative, or adequate, amount of interaction between the lamb and the ewe. Since there appears to have been such a regular and consistent increase, as measured in hours, for each group of lambs from mothered to unmothered, the above explanation seems warranted. The position of Hebb cannot be discounted due to the fact that, in the extended amount of time taken by the Group O unmothered lambs in this study, some degree of imprinting was attained in the feeding and handling of these animals by humans. The amount or quality of learning cannot, of course, be determined.

Effects of Experience

The present study suggests that, aside from the underlying neural and physiological mechanisms concerning perceptual development, a variety of interactional processes result in significant behavioral performances. In addition, the factors which may be identical in terms of perceptual development for both animals and humans may not functionally manifest themselves in later behavior in the same way. For example, in human infants the results of maternal deprivation, rejection, or "bad" mothering may be manifested as severe disturbances as described by Casler (1961), Shevrin & Toussieng (1965), Spitz (1962, 1965), and Yarrow (1961). Regarding causal factors in such disturbances, and, an attempt at re-

solving them through conclusions drawn by the above writers, might involve an autistic child who, through contact stimulation, can derive therapeutic value in psychological treatment as illustrated by Waal's (1955) report of a special technique of psychotherapy with such a child. In the animal realm, the very survival of a lamb or goat may frequently depend on the first tendency of the neonate to orient to the safety of the mother's side or to the side of an embankment, thus avoiding the danger of falling. Still later, this behavior is quite valuable to survival if edges of solid ground overlooking vacant spaces elicit the back-peddling startle reaction, and ultimately, to avoid situations in which this response would become necessary. However, if some disturbance or critical factor interferes with the normal mother-infant relationship and retards the early development of these responses, the consequences can be severe.

Other Considerations

Further considerations at this point would seem to justify a somewhat different statement of the treatment groups in this experiment for purposes of clarification. Thus, in terms of the ewe-lamb bond as stated according to the earliest appearance of the avoidance response, and progressing to the latest, it is, by groups: (1) H, natural mothering; (2) C, natural mothering except for nursing; (3) A, lamb free to have contact and nurse but no response possible by ewe; (4) B, lamb free to have contact but no nursing or response possible by ewe; (5) E, lamb and ewe free, with lamb contained within a pen inside pen of ewe--no interaction except through visual contact; (6) F, lamb and ewe permitted complete interaction, but cross-fostered and oil of

anise applied; (7) N, lamb and ewe (own) permitted complete interaction, but oil of anise applied; and (8) O, lambs un-mothered except for human contact in feeding.

Stating again the awareness of possible implications in the anthropomorphic view, the lack of an appropriate, specialized language makes it difficult to avoid these errors. With this in mind an attempt to draw some further conclusions from this study will be made.

First, the results suggest that, in general, "inconsistent" or "bad" mothering can be more detrimental than mothering where interaction and contact is not possible, and, in addition, only slightly better than no mothering at all. This is consistent with the interpretations and findings of Harlow (1961) and Seay, Alexander, and Harlow (1964) in the infant rhesus.

Any attempt to explain the reasons for the Group N lambs taking longer than the Group F lambs to display the avoidance criterion response would involve pure speculation. It might be that the obtained difference was an artifact of the particular treatment group, although the difference appears too large to accept this explanation. Another approach might be the possibility that the ewes in the Cross-Fostered Group "recognized" that the lambs were not their own, but as a result of the oil of anise were in some way ambivalent and provided some semblance of care. From this it could be inferred that the ewes with their own lambs, and anise oil, "knew" that the lambs belonged to them, but were so disturbed by the obvious "wrongness" of the smell that they reacted even more violently toward the lamb. However, since the treatment between this latter group and the control group was the same, except for the

anise oil, and yet were statistically different from each other when compared with the control, it would appear that a more basic explanation would suffice. To understand this a few statements concerning early feeding experiences in lambs is warranted. Hafez and Scott (1962) report that the lamb at birth soon rises on wobbly legs and directs its head towards the body of the mother. Many attempts later the neonate finds the nipple and begins to suckle. A few days later, the lamb can run directly to the udder and begin to suckle immediately. Between each few sucks, the lamb pushes suddenly with its head, almost like butting, except that the mouth is directed forwards. For the most part, the lamb rapidly wiggles its tail while the nursing is taking place. Observations during the current experiment support the above descriptions of the lamb's behavior. However, the ewe does not remain passive under normal conditions while this behavior is taking place. During these initial nursing experiences, the ewe was frequently observed engaging in a licking process that began at the lamb's pelvic area and proceeded forward to the head region and then back again. The licking is usually vigorous and appears to stimulate both internal and external processes. Returning again to the ewes and lambs anointed with anise oil, it was observed that the licking process described above was, at best, sporadic when it took place at all. Patterson (1965) states:

As for contact need gratification, we may speculate holistically that sheep mothers, as well as mothers of other species, answer a number of needs besides those for contact, probably out of motivation unconnected with the needs themselves. In other words, the ewe may lick the lamb because of the olfactory attraction of the membrane. Furthermore, we may speculate that much of the need-answering is so subtle that human observers may be entirely oblivious to the care-soliciting behavior of the lamb or its closure in the care-giving behavior of the ewe (Patterson, 1965, p. 50).

From this the following interpretation and conclusions can be made concerning the differences between the Groups with the oil of anise and the Control Group. The behavior displayed by the ewes toward the lambs was precipitated by the absence of "proper" olfactory attraction. Since the ewe was not attracted by the lamb's smell, in addition to her own being interfered with, the lamb received inconsistent contact stimulation, nursing, and other need-answering maternal care. The effects of this relationship resulted, then, in a retardation of perceptual development in much the same way as those lambs which received no mothering, except by humans. It seems obvious that lambs in the other treatment groups were developmentally retarded proportionate to the limitations of the possible interactions. None, however, were so disruptive as the two groups just discussed.

Implications for Human Study

It would appear that some general parallels can be made from this study to those involving human infants. For example, Shevrin & Toussieng (1965) and Spitz (1962, 1965) describe children who have experienced maternal deprivation and others who were raised at home with families. Both groups, however displayed similar disturbances in behavior and development. Other studies (Casler, 1961; Yarrow, 1961) have reported similar observations to the above. As was mentioned earlier in this paper, many studies of human infants were experimentally weak as a result of the subjects under investigation. Therefore, many inferences have been drawn to support the findings. It would seem that the current experiment with ewe-lamb relationships has a great deal to

offer by way of explanation concerning similar situations in humans. Thus, it is tempting to conclude that despite the fact that a child has a mother, his development and behavior can be drastically altered as a function of the quality and quantity of mothering. Too, the kind of mothering can be, and often is, as debilitating as no mothering at all.

These conclusions are not new, but there has been very little evidence to support them heretofore.

In discussing implications of this study with reference to humans an attempt has been made to refrain from being overly theoretical. However, if it can be assumed that for the ego, perception plays the part which in the id falls to instinct (Freud, 1923), then a similar parallel can be drawn with respect to the general development of the lambs in this study. In other words, animals whose basic equilibrium and basic trust is established efficiently seem to have a better chance to realize the potentialities of their genetic endowment and, thus, ultimately increase the probability of their survival.

Synthesis of Findings

The first important finding of this research study was that groups of lambs under various conditions, ranging from mothered to unmothered, avoided a visual cliff situation at differing ages to such a degree that the groups varied significantly. This finding was interpreted as evidence that certain innate determinants of perceptual development can be significantly altered as a result of various ewe-lamb relationships.

A second finding concerned the investigation of the "strength" of the mother-neonate bond and the possible nuances in such a relationship which affect later behavior. Here, comparing all groups with the mothered lambs, avoidance of the visual cliff varied proportionately as the quality and quantity of the ewe-lamb relationship decreased. This finding was interpreted to mean that, regardless of the causal factors involved, inconsistent or "bad" mothering can result in profound disturbances of the early developmental process. In addition, this finding suggests that inconsistent or rejecting behavior toward the lamb can be nearly as drastic in its effects as no mothering at all.

Suggestions for Future Research

As indicated earlier, a striking finding in this study was the dramatic effects which the applications of anise oil, on both the ewe and the lamb, had on the care behavior of the ewe and the resultant retardation of depth discrimination in the lamb. It appears warranted that future research in this area should attempt to discover if this resulted from an innate olfactory reaction to the smell of the lamb, or the possibility that rejection and inconsistent behavior by the ewe was the result of not "knowing" whether the lamb was hers. Attempts might involve treatments consisting of cross-fostering techniques without anise oil, desensitization of olfactory senses in the ewes, or applications of various other "pleasant" and "unpleasant" oils.

Since the observed rejecting and inconsistent behavior displayed by the ewe resulted in such dramatic effects, a need to explore other

variables to instill this behavior is indicated. Thus, another line of investigation might entail a normal mother-lamb situation with the addition of some irritating factor to the ewe which would cause her to behave abnormally. This could involve the withholding of food or the presence of another ewe within the confines of the lambing pen.

The effects of no mother contact are obvious from this and other studies. However, the role of surrogate mothers has thus far not been explored in terms of a woolly facsimile for the lamb. This could provide a realistic appraisal of any facilitating effects in development as measured in this experiment.

Imperative in any studies involving these suggested variables is the need for extended observations which might reveal other nuances worthy of measurement in these relationships.

CHAPTER VI

SUMMARY

The relationship between mothers and their offspring has long been considered an important one in animal studies. Numerous theories and studies concerned with infantile experiences in these relationships and the resultant effects on certain developmental processes have been reported. Considerable evidence has shown that interference in the formation of the mother-neonate relationship in sheep produces remarkable effects in later perceptual and social behavior. These disturbances have generally been attributed to a stress reaction. The present research was designed to explore certain aspects of the mother-neonate relationship in sheep to determine which of these are most influential in facilitating or suppressing the development of depth perception.

Eight treatment groups were used in this study ranging in strength of relationship from mothered to unmothered. Lambs in all groups were tested for the capacity to react adaptively to the stimulus of depth on a visual cliff apparatus. All lambs receiving some own-species mothering avoided the visual cliff "drop" before those that were unmothered. Further, the appearance of the criterion avoidance response varied proportionately with the strength of the ewe-lamb interaction. The results also suggested that maternal behavior described as inconsistent and ambivalent can produce effects on development almost as

drastic as a complete absence of maternal care.

The explanation was suggested that the appearance of avoidance behavior along a continuum, as found in this study, is predicated on the strength of a basic holistic equilibrium and basic trust established in the lamb through the relationship with the ewe. This development of certain perceptual modalities increases the chances to realize the potentialities of their basic endowment and, thus, increase the probability of survival.

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APPENDIX I

TIMES IN HOURS FOR EACH LAMB IN EACH GROUP TO EXHIBIT CRITERION RESPONSE

Raw Data

Treatment	Times in Hours						
A	13	6	10	7	16		
B	13	12	9	14	19		
C	5	9	5	6	7		
E	23	17	9	18	12		
F	15	15	19	20	24		
H	5	5	7	6	6		
O	36	13	14	39	24	42	37
N	15	45	25	25	13	21	

APPENDIX II

TESTS ON DIFFERENCES BETWEEN ALL PAIRS OF MEANS

Raw Data

Treatment		H	C	A	B	E	F	N	O
Means		5.8	6.4	10.4	13.4	15.8	18.6	24.0	29.2
H	5.8	-	.6	4.6	7.6	10.0	12.8	18.2	23.4
C	6.4		-	4.0	7.0	9.4	12.2	17.6	22.8
A	10.4			-	3.0	5.4	8.2	13.6	18.8
B	13.4				-	2.4	5.2	10.6	15.8
E	15.8					-	2.8	8.2	13.4
F	18.6						-	5.4	10.6
N	24.0							-	5.2
O	29.2								-