BAUMGOLD, John Victor, 1940-
THE RELATIONSHIP BETWEEN VISUAL DEPTH PERCEPTION AND PHARMACOLOGICALLY INDUCED ALTERATIONS OF THE MOTHER-NEONATE BOND IN SHEEP.

The University of Oklahoma, Ph.D., 1967
Psychology, clinical

University Microfilms, Inc., Ann Arbor, Michigan

THE UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THE RELATIONSHIP BETWEEN VISUAL DEPTH PERCEPTION AND PHARMACOLOGICALLY INDUCED ALTERATIONS OF THE MOTHER-NEONATE BOND IN SHEEP

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

BY

JOHN VICTOR BAUMGOLD

Norman, Oklahoma

1967

THE RELATIONSHIP BETWEEN VISUAL DEPTH PERCEPTION AND PHARMACOLOGICALLY INDUCED ALTERATIONS OF THE MOTHER-NEONATE BOND IN SHEEP

APPROVED BY

W B Lemmon

John H Morris Jr.

J. E. Oakes

Maurice Temerlin

E. W. Berends

DISSERTATION COMMITTEE

ACKNOWLEDGEMENTS

The author gratefully acknowledges the invaluable assistance given to him by Dr. W. B. Lemmon. Dr. Lemmon was involved in this project at every juncture, and has been of help in ways that are too numerous to mention. The assistance of the members of the Dissertation Committee; Dr. C. W. Berenda, Dr. A. E. Dahlke, Dr. J. R. Morris and Dr. M. K. Temerlin is also acknowledged.

The author wishes to express special thanks to several good friends whose assistance was invaluable in the actual collection of data: Charles B. Gantz, Kathy Jacobs, and Alan and Sally Lemmon. These friends were present in the wee hours when we all prayed that the next lamb would be born at a sensible hour.

TABLE OF CONTENTS

Page

LIST OF TABLES v

Chapter

I. INTRODUCTION 1

II. PROBLEM 28

III. METHOD 32

IV. RESULTS 41

V. DISCUSSION 49

BIBLIOGRAPHY 60

APPENDIX I. Drug Dosages 67

LIST OF TABLES

Table Page

1. Means and Variances for all Groups of Lambs 42

2. Analysis of Variance of the Effects of Drugs the Development of Visual Depth Perception 43

3. t Tests Between all Groups 44

4. Data for Lambs that were given the Tranquilizer or Sedative after the Development of Visual Depth Perception 46

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CHAPTER I

INTRODUCTION

For centuries it has been a truism that early experience has a profound effect upon subsequent development. Folk sayings have cast this concept in varying forms, and a host of cultural and religious groups have utilized this approach in the indoctrination of their children. There is also much anecdotal data from shepherds and stockmen as to the significance of early experience for the later development of animals. Nevertheless, the scientific examination of this notion did not begin until approximately 1940 (Beach and Jaynes, 1954). Although Freud, as early as 1915 emphasized the effects of early experience upon subsequent development, his writings have a speculative quality. Whereas Freud's works are replete with penetrating clinical insights, they lack the rigor of controlled experimental investigation.

Beach and Jaynes in 1954 reviewed the existing literature related to the effects of early experience on subsequent behavior. Very few of the articles cited in this review were published before 1940. Nevertheless, between 1940 and 1952 a great number of studies of the effects of early experience were reported. These studies typically deal with the relationship between early experience and subsequent sensory discrimination, perception, feeding behavior, reproduction, gregarious and filial behavior, emotion, temperament, and learning (Beach and Jaynes, 1954). Although the disciplines of embryology and teratology have long since recognized the profound effects of early experience on subsequent development (Stockard, 1921), the behavioral sciences have not examined this field scientifically until relatively recently. Yet, the vast majority of contemporary behavioral scientists would undoubtedly agree with Denenberg's statement that "environmental factors have profound and drastic effects upon the immature organism, and one can literally change an animal's behavioral and physical capabilities through the appropriate manipulation of environmental dynamics" (Denenberg, 1962).

Maternal Behavior and Maternal Deprivation

It is tempting to agree with Rheingold that "maternal behavior during the animal's infancy may be viewed as the main source of environmental events affecting the behavior of the young" (Rheingold, 1963). Although in some species factors such as siblings, other adult members of the species and the physical environment are of great importance to the neonate, they are generally overshadowed in significance by maternal behavior. Some authors (Rheingold, 1963) have insisted upon viewing the mother-neonate relationship as being merely a conditioning situation. Nevertheless, other theoretical formulations can be and are employed to systematize this relationship and correlate it with subsequent development.

Many investigators of the development of human infants have been impressed by apparent absolute importance of proper maternal care. Bowlby has concluded that

> For the moment it is sufficient to say that what is believed to be essential for mental health is that the infant and young child should experience a warm, intimate, and continuous relationship with his mother (or permanent mother substitute) in which both find satisfaction and enjoyment (Bowlby, 1951).

Rene Spitz has described the effects of maternal deprivation in human infants in much detail. He observed that in the absence of a stable mother-neonate relationship a syndrome developed which often led to death.

> The fate of the Foundlinghome babies was tragic on all these counts: (a) The general impression was one of apathy and deathly silence. (b) The mean developmental quotient of the group dropped progressively with age to a group mean of 45 (low-grade moron). This statistical finding is made more vivid by the statement that among 21 children aged 2½ to 4½ years (there were 91 in the total group), only five could walk unassisted, eight could not even stand alone, only one has a vocabulary of a dozen words, six could not talk at all, and eleven had only two words. (c) The health records show that, despite elaborate medical precautions ("No person whose clothes and hands were not sterilized could approach the babies") 34 of these 91 babies died. All but one of the older group was seriously underweight despite a carefully supervised and varied diet (Munroe, 1955).

The behavior of these children was highly sterotyped, and in many cases their tragic death seemed to be inevitable. Indeed, Spitz noted that there appeared to be a point in this process subsequent to which intervention was totally ineffectual.

Patterson (1965) has reported similar findings with sheep. He notes that in his study several lambs were isolated from their mother at birth. They were cleaned and were fed through holes in the walls of their isolation pens. He states that within 100 hours "these lambs were observed to lose muscle tone and appetite and collapse and die with dramatic speed apparently as a direct result of being isolated" (Patterson, 1965). These findings are consistent with the reports of other researchers (Hersher, Richmond and Moore, 1963; Moore, 1958; Liddell, 1960). The similarity of this rapid degenerative process in both humans and sheep is rather striking. Indeed, there is some anecdotal evidence to suggest that in sheep too there is a point in time subsequent to which this terminal process cannot be reversed.

Critical Periods

Concurrent with the increased scientific interest in the effects of early experience upon development many investigators focused their attention upon the concept of the "critical period". This concept referred to periods in the development of the organism during which certain types of stimulation have profound effects on subsequent development. Actually, this approach to development originated in the field of embryology.

> In the anatomical development of the embryo, there exist precise critical periods in which specific tissues are susceptible to environmental influences acting at that time but at no other, the fate and future of the tissue being fixed thereafter. It is now apparent that similar critical periods exist in

> behavioral development also--specific stages in ontogeny during which certain types of behavior normally are shaped with fate and molded for life, environmental influences losing effect after that time (Jaynes, 1957).

Although many authorities in the field of development disagree as to the nature and temporal characteristics of various critical periods, the concept of critical period is one of the most widely accepted notions in the behavioral sciences.

Freud's View

Freud postulated the existence of four critical periods in human development--the oral, anal, phallic and genital stages. Although these stages do not represent discrete temporal entities, Freud theorized that the oral stage lasts from birth until perhaps one year of age, the anal stage from about the first year to approximately the third year of age, and the phallic stage from perhaps the third to about the fifth year. The genital stage is contemporaneous with mature adulthood beginning at puberty. Each of these stages is related to a locus of psychosexual satisfaction or tension reduction. At each stage of development this locus represents the primary source of gratification for the developing individual. In the event that an infant experiences excessive frustration or anxiety at one of the first three stages a fixation will take place. That is, upon encountering a stressful situation in later life the person will tend to behave in ways which were appropriate to the developmental stage at which a strong fixation took place. Since every human being experiences some degree of frustration and anxiety at every stage of psychosexual development, character can be described in terms of the various fixations at these stages or critical periods. Thus, Fenichel (1945) relates the hysterical character to the oral stage, the obsessive-compulsive character to the anal stage and the narcissistic character to the phallic stage.

Erikson's Stages

Erikson (1950) has theorized that there are eight stages or critical periods of development. Whereas Freud's conceptualization of the process of development related to the formation of character, Erikson's stages represent critical periods in the elaboration of the ego. These stages are critical to the individual in that they reflect periods of crisis and possible amelioration of these crises. Also, Erikson's stages are an amplification of the critical period concept in that they span the individual's entire lifetime.

The first stage, the oral-sensory, relates to the crisis inherent in the demands which the infant makes upon his environment. The resolution of this crisis will take the form of either basic trust or basic mistrust, depending upon the degree of homeostatic balance which these demands attain. The muscular-anal stage reflects the most basic demands which the environment makes upon the infant. Bladder and bowel control are paradigms for the restraint with which the infant must come to terms. Resolutions of this crisis may lead to either autonomy or shame and guilt. The locomotor-genital stage reflects the crisis arising from the infant's developing agressiveness (as distinct from hostility) and the environment. The child's active knowing of his environment will lead to either "the initiative of mastery or the guilt of goals merely contemplated." As with

Freud, the latency stage represents a period during which hostile and agressive impulses are sublimated. The child works at producing things, and if successful a sense of industry ensues. Yet, if the child's efforts fall short of satisfaction profound feelings of inferiority may develop.

The onset of puberty and adolescence is a major crisis in the individual's development. Because of the physiological changes which take place at this time the adolescent is called upon to integrate childhood identifications, newly merging sexual impulses and societal demands. A viable integration of these elements will result in a firm identity, whereas a faulty integration may result in role diffusion. In the stage of young adulthood the individual encounters the possibility of mature intimacy. His ability to negotiate this type of relationship is predicated upon a meaningful identity. The inability to tolerate or share mature intimacy leads to isolation.

In the stage of adulthood generativity is one possible solution to the crisis of the future. It represents a parental and guiding interest in the next generation. The child is not treated as a narcissistic extension of the ego but rather as an individual whose integrity is taken for granted. The alternate solution to this crisis is stagnation. The final stage of maturity, reflecting the acceptance of all that has been, results in integrity; the absence of this type of unique acceptance results in disgust and despair.

Most theorists who have addressed themselves to the problem of critical periods make the implicit assumption that the infant's ability to negotiate subsequent stages is predicated upon his having come to terms with prior critical periods. Erikson, however, makes this an explicit assumption of his theory. Thus, for Erikson each stage builds upon the foundation which has been established for it by the successful or unfulfilled negotiation of previous stages.

Scott's Approach

Scott views critical periods as being turning points in development. He, like Erikson, theorizes that an organism's negotiation of a subsequent critical period will depend upon how that organism fared during prior critical periods. There is, however, a basic difference between the approaches of Scott and Erikson. Whereas Scott focuses his attention upon the behavior of the organism, Erikson concentrates upon intrapsychic and interpersonal variables. Nevertheless, Scott has developed a general theoretical statement with reference to critical periods which is probably universally accepted. Scott reasons that

> Both growth and behavioral differentiation are based on organizing processes. This suggests a general principle of organization: that once a system becomes organized, whether it is the cells of the embryo that are multiplying and differentiating or the behavior patterns of a young animal that are becoming organized through learning, it becomes progressively more difficult to reorganize the system. That is, organization inhibits reorganization. Further, organization can be strongly modified only when active processes of organization are going on, and this accounts for critical periods (Scott, 1962).

Scott has elaborated six developmental or critical periods which appear to exist in at least altricial mammals. The <u>neonatal</u> period is characterized by the essential passivity of the infant except for the nursing process. During this period the organism's dependency is at a maximum. While in the transition period the organism begins to develop adult motor and sensory capacities. This period represents a departure from the passivity of the neonatal period. Next is the socialization period which is characterized by the development of primary social bonds between the infant and the significant others in its environment. During the juvenile period there is a dramatic development of physical skills. The young organism begins to be independent of its parents and exploration of the environment increases appreciably. The pubertal period reflects the development of sexual relationships, and the parental period represents the establishment of relationships with offspring.

Scott points out (1962) that there are interspecies differences in the duration of these periods. He also notes that the time at which they appear after parturition is not uniform from species to species. For example, when a lamb is born it is in the transition period and immediately enters into the socialization period (Scott and Marston, 1950).

It is tempting to view critical periods as being descriptive only of the young organism. Since attention is usually focused upon the developing organism, the tendency often is to speak of critical periods as if they were attributes solely of the neonate. Scott points out, however, (1962) that the concept of critical period is, by definition, a statement about the interactional processes of the organism and its environment. Schneirla and Rosenblatt (1961) elaborate upon this point.

> From birth, in neonate mammals, behavior is typified by reciprocal stimulative relationship between parents and young. The neonate attracts the female stimulatively; the female presents to the newborn a variety of tactual, thermal and other stimuli, typically of low intensity and therefore primarily approach-provoking. On this basis the process of socialization begins. Behavioral development, because it centers on and depends upon reciprocal stimulative processes between female and young, is essentially social from the start.

This theoretical point gains support from a study conducted by Hersher, Moore and Richmond (1958). In this experiment twenty-four goat mothers were separated from their new-born kids for the first hour immediately following birth. After two months "these mothers were observed to nurse their own kid less and alien kids more than non-separated mothers." Thus, it appears that the separation had a lasting effect upon the mother as well as on the infant.

Imprinting

The concept of *imprinting* has traditionally referred to a special type of learning which takes place early in the life of many species of birds and water fowl. It has been repeatedly observed that if a Mallard duck (for example) is exposed to a moving object during the first few days of life, it will subsequently follow that object. This following behavior may be observed in spite of the fact that the followed object does not necessarily resemble the Mallard hen. A unique feature of this type of learning is that it apparently is not dependent upon any type of positive or negative reinforcement.

Lorenz (1939) attempted to relate imprinting to his "lock and key" theory of instincts. He adds that this type of learning is both dramatic and prevalent in birds because "Apparently it is in birds that the parallel differentiation of releasers and inate perceptory patterns has reached the highest development it ever attained in animals" (1937, p. 245). In support of this contention Lorenz cites the highly ritualized patterns of courting behavior which have been observed in many species of birds.

Lorenz has elaborated four characteristics of the imprinting process. The process itself is both defined and limited by these characteristics. First of all, Lorenz notes that the process of imprinting is confined to a very definite period of the individual's life. This period is often at the beginning of life and is usually of a relatively short duration. Second of all, once the initial imprinting process is completed it appears to be totally irreversible. Thus, it is virtually impossible to condition an animal not to follow an object to which it has been previously imprinted. Thirdly, however, a degree of generalization of the process is possible. That is, the "individual from whom the stimuli which influenced the conditioning of the reaction are issuing does not necessarily function as an object of this reaction" (Lorenz, 1937). When a duckling, for example, is imprinted to a specific person it will subsequently follow many human beings. Finally, the process of acquiring the object of a reaction is in many cases completed long before the reaction itself has become established. Thus, Lorenz insists that the acquisition of the object of the response is not necessarily contingent upon the performance of the response during the imprinting situation.

Hess takes issue with Lorenz's fourth characteristic of imprinting. Indeed, he claims that he has developed a formula for imprinting which expresses the strength of imprinting as a function of the amount of effort expended by the animal to get to the imprinting object during the critical period (1959, p. 136). As possible verification of this hypothesis Hess found that the strength of imprinting was appreciably reduced by restraining the infant during the imprinting period.

Hess (1957) noted that social facilitation will extend the critical age for imprinting. Thus, chicks who are reared in groups will have longer critical periods than chicks who are isolated. Many investigators have noted, however, that a chick will display a general elevation in its level of arousal upon being isolated. Defecation and the emission of the typical "distress call" will increase markedly under these conditions. On the basis of these observations Hess theorized that the termination of the critical period may be related to the onset of fear. In order to test this hypothesis Hess used meprobamate, a drug which has metabolism lowering and muscle relaxing properties. Using dosages of about 25 milligrams of meprobamate per kilogram of body weight, Hess found that the drug appears to extend the critical period for imprinting. Although the normal critical period for the imprinting of Mallard ducks is 12 to 17 hours, animals given meprobamate at 12 hours can be imprinted fairly successfully at 24 to 26 hours. Thus it appears that in Mallard ducks the length of the critical period for imprinting is intimately related to the level of arousal and the onset of fear.

As stated previously, Lorenz has suggested that imprinting takes its most dramatic form in birds because in this class of animals "the parallel differentiation of releasers and inate perceptory patterns has reached the highest development" (1937, p. 245). It is crucial to note, however, that this type of learning has also been observed in other classes of animals. In one study, for example, lambs and kids were imprinted to does and ewes respectively (Hersher, Richmond and Moore, 1963). It has also been found that sheep (Patterson, 1965) and dogs (Scott, 1950, Boyd, 1964) can be imprinted to humans. Thus it appears that imprinting is a process which can be found in many species of higher animals.

Maternal Behavior in Sheep

The similarity between the establishment of the mother-neonate bond in sheep and goats and the phenomenon of imprinting in precocial neonatal birds has been noted (Hersher, Richmond and Moore, 1963). This similarity is suggested by the fact that in sheep and goats there is a rapid development of differential maternal responsiveness to a young animal during a sensitive period in the dam's life. In sheep, maternal care is highly limited by a ewe to her own offspring. Whereas mothers of many species distinguish between their own and alien young, ewes are particularly vigorous in their rejectipn of lambs which are not their own. This is generally true irrespective of the size of the herd. (Hersher, Richmond and Moore, 1963). Thus, one advantage of studying the mother-neonate relationship of sheep is the highly specific nature of the maternal response in this species.

There is an additional factor which makes the maternal behavior of sheep very amenable to scientific investigation--stereotopy. Individual differences among sheep are usually limited to the several variables of dominance in the herd. Although most species display well patterned systems of maternal behavior, the naturally occurring mother-neonate relationship of sheep admits of practically no deviations from the stereotype. Smith (1965) has examined the ewe's behavior prior to and just after parturition, and on the basis of his observations he has outlined eight stages of maternal behavior. In non-experimental animals there is virtually no variation in the order of the stages or in the types of behavior which the ewe sequentially displays. The first stage consists of the ewe withdrawing from the flock. She will go off by herself, and other sheep will not approach her. The second stage reflects a quasi-nesting behavior. The ewe will paw the ground and clear an area which is large enough for her to lie in. In this process she will have created a slight but definite depression in the ground. The third stage consists of her walking around the depression and sniffing it. During this stage the amniotic sac usually protrudes from the vagina. Labor usually begins with the protrusion of the amniotic sac, and the ewe will begin to stretch her body into an arched position. During this fourth stage, she will repeatedly lay down in the "nest" which she has dug. The fifth stage consists of the actual delivery. The ewe lies in the "nest", and when about half of the neonate is visible she will stand up. The actual delivery of the infant will be assoociated with her standing. The sixth stage consists of the licking of the amniotic fluid and membrane. The first part of the infant's body to be licked is the head, and the licking strokes will typically follow the contour of the infant's body -- from head to anus. The seventh stage consists of the infant's attempts to stand; and the eighth is the first attempts on the part of the lamb to suck. There is some data to suggest that the mother will not permit the lamb to nurse until she has delivered the placenta. This cannot, however, be considered a conclusive finding (Smith, 1965).

With respect to the first attempts at nursing Smith has observed that

> The placing of the head under any convenient projecting surface would appear to be an instinctive act by the lamb. The eventual finding of the teat is sometimes aided by the ewe and probably assisted by olefactory cues for the lamb. Once the lamb has been suckled, repeated approaches to the teat could be explained by reference to the reinforced learning. An element of reenforcement in the process of attachment arrives from the fact that the process of suckling is satisfying to the ewe (1965, p. 86).

Initially the infant seems to thrust with its head and mouth in a rather indiscriminate fashion. Subsequently, its first few attempts at nursing will be faulty in that the neonate will not be able to keep the nipple in its mouth. Nevertheless, the lamb will display accurate teat seeking behavior soon after its first successful attempts to nurse. Baluvelt (1956) has noted that in this process the mother is by no means passive. The lamb will typically align his body parallel to that of the mother, and as he seeks the teat she will lick his anus. As the mother licks the infant's anus, she pushes him toward the teat and successful nursing (Alexander and Williams, 1964).

It should be noted that like most precocial animals (Hess, 1958) the new-born lamb will typically move toward any large objects in view, "preferring a moving object to a stationary one and an object with which it has already made contact to an untouched one (Blauvelt, Richmond and Moore, 1960)." The young lamb will continue to move until stopped by an obstruction. He will suck and nibble on anything with which his mouth comes into contact, and this is normally first on the mother's hair (Hersher, Richmond and Moore, 1963).

There is general agreement in the literature that in sheep a critical period exists for the establishment of the mother filial bond (Smith and Van Toller, 1966; Hersher, Richmond and Moore, 1963; Alexander and Williams, 1966; Collias, 1956). The temporal characteristics and mitigating parameters of this critical period, however, are somewhat obscure. For example, Smith and Van Toller found that a 20 to 30 minute period of licking was sufficient for the establishment of the filial bond. Collias found (1956) that if a lamb is removed from its mother at birth and kept isolated from her for a period of two hours or more she is very likely to reject it upon its return to her. "This rejection is evidenced by persistent withdrawal from the nursing attempts of the lamb or kid and by the mother's actively butting it away when it comes near her" (1956,

p. 234). Hersher, Richmond and Moore found (1958) that these separations had enduring effects. When kids were separated from their dams for as little as 30 minutes after birth the effects could be observed three months later. The results of this study suggest, however, "that as little as 5 or 10 minutes of contact during the critical period (perhaps only if licking is permitted then) is sufficient for the mother to establish the identity of her own kid" (Hersher, Richmond and Moore, 1963).

During the critical period, however, the rejection behavior of the mother is reversible. Hersher, Richmond and Moore (1963b) placed 16 sheep and goat dams in restraining harnesses between 2 and 12 hours after parturition. Alien young were placed in their proximinity, but because of the harnesses the dams could not actively reject the intruder. Five of nine goats were placed with lambs and three of seven sheep were placed with kids. All of the dams were kept in the harnesses until they did not reject the young. In this study it was found that although species differences between dam and young affects different maternal behaviors, all the adoptions were successful.

It appears that five factors can be isolated which have a considerable influence upon the degree to which the separation of mother and infant affects the mother filial bond in sheep. The first factor is the time of separation. It has been found, for example, (Hersher, Richmond and Moore, 1958) that even five or ten minutes of licking immediately after parturition may be a sufficient foundation for the establishment of the mother-neonate relationship. The second factor is the duration of the separation. Collias (1956) separated newborn lambs from their mother shortly after birth for periods ranging from 15 minutes to 4½ hours. He found that if the separation was for more than two hours, rejection was almost inevitable. In contrast to this, however, recent studies at the Cornell Behavior Farm Laboratory (Moore and Moore, 1960) suggest that goats which are separated from their new born kids for as long as eight hours after birth will subsequently accept their kids. The third factor relates to the experience of the mother during the separation. Moore and Moore (1960) stress that dams will accept their young after separation only if they have been isolated from the flock during the period of separation. If the dams were not isolated from the flock they will have more difficulty in accepting their young upon reunion.

The fourth factor relates to the degree to which the mother is restrained and thus forced to accept the young. Hersher, Richmond and Moore conclude that

> Though the appropriate stimulating conditions for the development of individual specific maternal behavior in goats and sheep normally may be effective during a brief time span shortly after parturition, results of this study suggest that the effective period may be considerably prolonged by enforced contact between dam and young after this post-partum period (p. 316).

Finally, the fifth factor which mediates the effects of mother-neonate separation is the presence or absence of siblings. Collias found (1956) that of two does separated from their newborn kids for two hours the mother who had contact with one of her twin kids during the separation rejected the separated twin upon its return. In contrast to this the mother remaining without any young to care for during the two hour separation accepted the returned kid at once. Blauvelt (1956) reported an experiment in which an alien kid was rejected by a mother when added to the mother's own twins, but was accepted by the same mother when substituted for one of the twins.

Ulric Moore has summarized his findings by stating that in "all cases where the maternal neonate bond has been tampered with, the survival of the young has been gravely threatened and the viability of the individual greatly diminished."

Visual Depth Perception and the Visual Cliff

The early development of visual depth perception is of great importance to the survival of many species. It is consistent with evolutionary theory that visual depth perception is critical to an animal's survival to the extent to which a fall may be fatal. Thus, for example, water turtles (as opposed to land turtles) do not have accurate visual depth perception. A fall onto a hard object is highly unlikely for members of their species. In contrast to turtles, it would be expected that visual depth perception plays a very important role in the survival of animals that are mobile at or soon after parturition.

Scott (1962) has suggested that when lambs are born they are already in the transition stage of development. That is, very soon after parturition they begin to stand and walk. Within the first few hours of life they are able to walk with appreciably increased agility. Thus, on the basis of evolutionary theory it is expected that lambs will display visual depth perception either at birth or very shortly thereafter.

Because of the vital importance of visual depth perception for various species it is reasonable to expect that this capacity is not dependent upon learning; for learning of this type would place the life of the infant in very serious jeopardy. In considering the critical importance of visual depth perception from an evolutionary standpoint Gibson and Walk have stated that

> All our observations were in agreement with what is known about the life history and ecological niche of each of the animals tested. The survival of a species requires that its individuals develop discrimination of depth by the time they can take up independent locomotion, whether at one day (the chick and goat), three to four weeks (the cat and the rat), or at 6 to 10 months (the human infant). That such a vital capacity is not dependent on learning by possibly fatal accidents in the lives of individuals is, of course, entirely consistent with evolutionary theory (1961, p. 55).

In 1957 Walk and Gibson introduced an apparatus for the study of visual depth perception -- the visual cliff. This apparatus consists of a sheet of glass which is mounted parallel to the floor in a large box. The glass is several feet square, and is mounted about two feet above the bottom of the box. The bottom of the box is covered with a patterned material. A red and white (one inch square) checkered pattern has been found to be very effective. Cloth bearing the same pattern covers a portion of the underside of the glass, thus giving it the appearance of solidity. This side of the glass is called the solid side. The other side of the sheet of glass is called the deep side since the patterned surface is about two feet below the glass. Animals may be tested for visual depth perception by placing them on the solid side. If an animal crosses over onto the deep side it is reasonable to conclude that visual depth perception has not yet been developed. Obviously, the cues employed by an animal in such a situation are functions of the different apparent depths of the red and white checkered pattern under the glass.

Gibson and Walk (1961) have tested chicks, turtles, rats, lambs, pigs, dogs, kittens, kids and human children on the visual cliff. The authors considered an animal to have "passed" the cliff if it does not cross over onto the deep side of the glass. The animal "fails" the cliff if it does cross over onto the deep side in spite of the depth cues which are available to it. Gibson and Walk found that once an animal passed the visual cliff it never subsequently failed it. Indeed, the authors point out that if a lamb that had passed the cliff was placed on the deep side of the glass by the experimenter it would behave in a highly characteristic fashion.

> It would refuse to put its feet down and would back up into a posture of defense, its front legs rigid and its hind legs limp. If pushed forward across the glass until its head and field of vision cross the edge of the surrounding solid surface, the animal would relax and spring forward upon this surface (1961, p. 54).

Gibson and Walk (1961) report a study which was carried out with kids and goats at the Cornell Behavior Farm. A piece of patterned material was attached to a sheet of plywood; enabling the experimenter to adjust the apparent depth of the deep side of the cliff very rapidly. When the pattern was held immediately below the glass the animals would move freely. When the optical floor was dropped more than a foot below the glass the animal would immediately freeze into its defensive posture. The animals never learned to function without optical support in spite of their repeated experience of the tactual solidity of the glass.

From the above it appears that visual depth perception, as ascertained by visual cliff performance, has several salient characteristics. First, there is a good deal of data to suggest that visual depth perception is not learned. Also it does not appear to be related to previous visual experience (Walk and Gibson, 1957; Carr and McGuigan, 1965; Tallarico and Farrell, 1964; and Walk, Gibson and Tighe, 1957; Lemmon and Patterson 1964). Second, there is no apparent positive or negative reinforcement inherent in the visual cliff situation. The situation appears to be neutral with respect to reinforcement, and thus amenable to the repeated testing of individuals. Third, the visual cliff apparatus appears to be an excellent indicator of the presence or absence of visual depth perception (Walk and Gibson, 1957; Gibson and Walk, 1960). Finally, visual depth perception is displayed by most animals early in life -- in some cases within the first few hours after birth.

Depth Perception of Mothered and Unmothered Sheep

Patterson (1965) noted that if the mother-neonate bond of sheep was tampered with, dramatic alterations in the infant's subsequent behavior would be observed. Specifically he observed that if a lamb was isolated from its mother during a critical period immediately after birth, it would fail to display visual depth perception at the expected age. Patterson's study represents an attempt to examine the relationship between these apparently disparate phenomena.

In the first phase of the study 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 their mothers in individual indoor stalls. The unmothered lambs were taken from their mothers immediately at birth and treated in a standard fashion. This standard treatment consisted of cleaning them with cloth, the texture of which was similar to a ewe's tongue. Once they were able to stand they were fed colostrum from either their mother or another lactating ewe. They were isolated from their mother until the end of the experiment.

All lambs were tested every hour on the visual cliff. It was found that unmothered lambs displayed visual depth perception appreciably later than mothered lambs. It thus appears that the age (in hours) at which a lamb displays visual depth perception on the visual cliff is related to the nature of the relationship that it has had with its mother during a critical period.

It might still be argued, however, that visual depth perception is strictly a function of the development of vision. The second phase of Patterson's study was designed to answer this objection.

Five pairs of lambs were used in this part of the experiment. Each lamb was single born and from a different ewe. Members of each pair, which were matched for sex and weight, were randomly assigned to either a mothered or unmothered condition. Treatment for the unmothered lambs consisted of a routine of isolation, stimulation and feeding which was identical to the treatment of the unmothered lambs in the first phase of the study. The mothered lambs were fitted with translucent goggles. 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).

From these data it was concluded that experience with patterned visual stimuli is of lesser importance in the development of visual depth perception than the relationship of the lamb to its mother.

Depth Perception in Sheep as a Function of Degrees of Mothering

Little's study (1966) used Patterson's work (1965) as a point of departure. Little reasoned that in sheep visual depth perception has been shown to be a function of mothering. Patterson had previously demonstrated that mothered lambs will display visual depth perception much earlier in life than their unmothered counterparts.

Little argued that it should be possible to experimentally establish degrees of mothering. Such degrees of mothering could be specified in terms of discrete variables in the mother-neonate relationship. Thus interfering with one or a combination of these variables should have differential effects upon the emergence of visual depth perception. Specifically, Little predicted that increased interference (in terms of the number of variables) in the mother-neonate relationship would result in a retardation of the emergence of visual depth perception.

Little used 43 lambs in his study, including 9 sets of twins. At birth each mother and her lamb were randomly assigned to one of eight treatment groups:

> 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 behaviorally 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 mother's 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 in a small wire pen within the mother's stall in such a fashion that lamb and mother had visual and auditory contact with each other, but little physical contact other than that possible 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 annointed with oil of anise.
>
> Group N Lambs and ewes were similarly annointed 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 gang isolation pens. These lambs were completely unmothered by other sheep.
>
> Group H This group served as a control in that the lambs and ewes were confined together and not restricted in any manner. (1966, pp 36-67).

By manipulating the variables outlined above Little attempted to operationally establish degrees of mothering. All lambs were tested on the visual cliff at four hour intervals, and a given lamb was tested repeatedly until he passed the cliff.

Little's general finding was that lambs under various conditions, ranging from mothered to unmothered, passed the visual cliff at significantly different ages. More specifically, however, he concluded 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" (1966, p. 45). It appears, therefore, that Little was able to isolate relevant variables in the mother-neonate relationship. Furthermore, he was able to ascertain that each one of the isolated variables accounted for a significant portion of the variance in the age at which visual depth perception was displayed.

Summary

A considerable amount of interest has been shown recently in the effects of early stimulation upon subsequent behavior. Much data has been gathered which supports the hypothesis that the effects of specific types of stimulation during critical periods in the development of the organism are unique in terms of subsequent development. The effects of the mother-infant relationship upon later behavior have been of special interest to many investigators.

Patterson has demonstrated that the age at which visual depth perception (as determined by the visual cliff) develops is related to the presence or absence of a mother during a lamb's first few hours of life. Little has elaborated upon Patterson's study, demonstrating that the age at which visual depth perception develops is functionally related to the degree of mothering experienced by the lamb.

Little manipulated certain variables which are directly related to the ewe. It is the purpose of this study to directly manipulate the experience of the lamb with respect to its mother, and to ascertain the effects of such intervention upon the age at which visual depth perception is displayed.

CHAPTER II

PROBLEM

It is the purpose of this study to manipulate systematically variables which are primarily related to the infant lamb, and to study the effects of such manipulations upon its subsequent development of visual depth perception. The variables chosen for study should have a direct bearing upon the infant's ability to interact with its mother. Such systematic manipulation of the mother-neonate relationship should effect the onset of visual depth perception in predictable ways.

Psychoactive pharmacological agents have repeatedly been used in the study of behavior. The effects of such drugs can be dramatic at times. Certain drugs (tranquilizers and sedatives) tend to slow down behavior, making the subject more lethargic and less interactive with its environment. Another group of drugs (stimulants) typically accelerate behavior, increasing the rate of activity and the degree of attentiveness. A third group of drugs (muscle relaxants) relax skeletal muscles; having effect principally on the voluntary musculature.

It would seem that varying psychoactive drugs might have differing effects upon a subject's ability to interact with its environment. If such drugs are administered during a critical period they may sufficiently alter the experience of the subject so as to have significant effects upon subsequent behavior and development. Specifically, if such drugs are given to lambs at birth it is reasonable to expect that they might affect the mother-infant interaction; and that various types of stimulation during a critical period would have differential effects upon the age at which criterion behavior (visual depth perception) is displayed. Stated formally,

> Hypothesis 1. Lambs to whom various pharmacological agents are administered at birth will differ significantly in regard to the age at which they display visual depth perception.

More specific statements could be made about the effects of drugs which are representative of various groups of psychoactive agents. The effects of a "tranquilizer", for example, would be reflected behaviorally in a degree of sedation and lethargy. If such a drug is administered to an infant at birth it may well have an appreciable effect upon the ability of the infant to interact with its mother. This should subsequently retard the appearance of visual depth perception. Thus,

> Hypothesis 2. Lambs to whom a "tranquilizer" is administered at birth will display visual depth perception at an age which is significantly later than control subjects.

An identical effect would be expected upon the administration of a "sedative" at birth.

> Hypothesis 3. Lambs to whom a "sedative" is administered at birth will display visual depth perception at an age which is significantly later than control subjects.

It has been hypothesized that tranquilizers and sedatives will alter the behavior of the infant to the extent that the mother-neonate relationship will be changed significantly. It has been thus far assumed, however, that these drugs will have no direct effect upon a subject's ability to perceive depth as indicated by the visual cliff situation. This assumption must be substantiated in fact. If this assumption cannot be verified, the first three hypotheses are meaningless and untestable as stated. Thus,

> Hypothesis 4. Tranquilizers and sedatives will have no effect on visual depth perception when administered to subjects that have previously displayed visual depth perception.

It has been argued that tranquilizers and sedatives will decelerate an infant's interaction with its mother during the critical period. Thus, these drugs would indirectly delay the development of visual depth perception. Conversely, it is expected that a stimulant, administered at birth, should accelerate the infant's interaction with its mother during the critical period. This accelerated interaction should result in the earlier development of visual depth perception.

> Hypothesis 5. Lambs to whom a stimulant is administered at birth will display a visual depth perception at an age which is significantly earlier than control subjects.

Patterson has demonstrated that the development of visual depth perception in lambs is not contingent upon prior experience with patterned light. Nevertheless, it is still possible that the ability to perceive depth visually may be a function of learning or conditioning. That is, visual depth perception may be acquired by the lamb from the mother and be mediated by some subtle form of reinforcement. If this is so, it is probable that the infant employs his musculature during the learning process. The administration of a muscle relaxant during infancy would consequently retard the learning of visual depth perception. Conversely, if the acquisition of visual depth perception is not mediated by a simple learning or conditioning principle then the administration of a muscle relaxant during the critical period should have no effect upon the age at which visual depth perception is displayed. Stated formally,

> Hypothesis 6. Lambs to whom a muscle relaxant is administered at birth will not differ significantly from control subjects in the age at which visual depth perception is displayed.

In this study, variables of the infant's experience and behavior will be manipulated in a systematic fashion. This manipulation will be done in terms of drugs which fall into the following groups: tranquilizers, sedatives, stimulants, and muscle relaxants. These drugs, administered to the infant at birth, should have marked effects upon the infant's side of the infant-mother interaction; in turn resulting in appreciable differences in the ages at which visual depth perception is achieved.

CHAPTER III

METHOD

Description of Subjects

The subjects were lambs born into a flock of registered Suffolk ewes which were bred to the same registered Suffolk ram. Of the 41 lambs used in this study 20 were twins. There were 23 male and 18 female subjects. The ram was introduced into the flock on approximately November 1, resulting in rather constricted lambing period -- March 25 through April 6, 1966. The distribution of births over the 13 day lambing period was rather uniform. This is consistent with Little's findings (1966).

Considering the time of day for which births were recorded, the results show the number of births to be 10, 4, 9, 8, 10 and 0 for each four hour segment beginning at midnight. Thus, 17 of the 41 subjects were born between the hours of 8 a.m. and 4 p.m. These data are consistent with the findings of Hersher, Richmond and Moore (1963) that sheep show no tendency to deliver at any particular time of day. These data are also consistent with Little's findings (1966). He noted that 20 of 43 subjects were born between the hours of 8 a.m. and 4 p.m.

Treatment of Subjects

During the lambing season the flock was kept in an enclosure of relatively small dimensions. This enclosure comprised approximately 675 square yards. Even though the flock was geographically concentrated, a ewe going into the first stages of labor was able to isolate herself within the enclosure. The flock was observed continuously. When delivery seemed imminent the ewe was installed in a separate small pen. She was not permitted to have any initial contact with her young.

A new born lamb was immediately taken into the laboratory. To simulate a ewe's licking behavior the lamb was rubbed with a burlap cloth in the following manner. First, the head, snout and neck of the infant were cleaned. Then the lamb was rubbed following the line of its body -- from head to anus. In this process the lamb was weighed, tagged, and the umbilicus painted with iodine. The lamb was not given any food until it was able to stand on all four legs. As Patterson (1965) has noted: "This procedure paralleled the sequence observed in normal ewe-lamb interaction where the lamb is denied nourishment until able to stand and approach (p. 34).

When the lamb was able to stand it was given a maximum of three ounces of colostrum from either its own mother or another lactating ewe. After feeding, the drug was administered intramuscularly and the infant was returned to its mother. The infant and its mother remained in the isolation pen for the duration of their participation in the experiment.

Subjects were assigned sequentially to one of five groups: tranquilizer, sedative, stimulant, muscle relaxant and control. The only difference in the treatment of these groups was the drug which they received at birth. Control subjects received an injection of normal saline solution. As has been noted above, the 41 subjects of this experiment included 10 sets of twins. In the case of twins, both siblings were assigned to the same treatment group. This was done in order to minimize the effects of the dominance variable. There is some data to suggest that upon birth one member of a set of twins can become dominant over the other (Hersher, Richmond and Moore, 1963; Blauvelt, 1956). It is quite possible that this dominance factor would produce differential effects in the age at which visual depth perception is displayed. Had members of a set of twins been assigned to different treatment groups, it is possible that this dominance factor would have contributed to the between-groups variance; inflating this measure spuriously. Thus, both twins were always assigned to the same treatment group, and any effects of the dominance factor contributed only to the within-groups variance.

Experimental Design

The experimental day was divided into six segments of four hours beginning at midnight. All animals were tested at the end of these segments: at 4:00, 8:00, 12:00, 16:00, 20:00, and 24:00 hours. At these times all animals to be tested were placed on the visual cliff. After a subject was tested it was immediately returned to its mother in the pen. Subjects were tested on the visual cliff at four hour intervals until they displayed visual depth perception. Once a lamb passed the visual cliff both it and its mother were released from the pen and permitted to rejoin the flock. In this respect the current study is identical with Little's (1966) procedure.

An exception to this general design was made in the case of lambs who received the stimulant. These subjects were tested on the visual cliff every hour instead of at four hour intervals. This was done because the stimulant was predicted to result in an earlier display of visual depth perception. In order to validate this hypothesis accurately it was necessary to test subjects who received the stimulant at hourly intervals. It should be noted in this context that Patterson's (1965) data suggests that the development of visual depth perception is not affected by repeated trials on the visual cliff apparatus.

In order to test the third hypothesis (that the tranquilizer and sedative have no effect on visual depth perception <u>per se</u>) it was necessary to administer the tranquilizer or sedative to selected subjects after they had performed the criterion response in the visual cliff situation. The control group was selected for this purpose. After each member of the control group had performed the criterion response it was placed into one of two sub-groups. The subject then received the appropriate dosages of either tranquilizer or sedative, and was tested on the visual cliff at the usual four hour intervals. Since these subjects had already demonstrated their ability to perceive depth visually, it was possible to ascertain the effects of the tranquilizer and sedative on visual depth perception <u>per se</u>.

The Visual Cliff

The visual cliff apparatus which was used in the current study is the same as that used by Little (1966).

The overall dimensions of the apparatus were 73½" (high) by 46" (long) by 31" (wide). It was built out of 3/4 inch plywood, and was painted with a flat black paint in order 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 3/4" x 29 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 with (sic) a red and white 1½" 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 florescent lights. After being placed on the interior platform, the lambs were observed through tapered peepholes in the end opposite the platform (Little, 1966, pp. 38-39).

The lamb was placed on the interior platform and the hinged flap was closed. If the animal stayed on the platform for three minutes and did not put both of its front feet over the vacant area it was considered to have "passed" or demonstrated the criterion response. If the animal placed either or both of its hind legs over the vacant area it was removed from the apparatus for a few minutes and subsequently replaced on the interior platform. When a subject passed the cliff an additional trial was attempted immediately. During this second trial the lamb was gently pushed "over the edge" of the cliff.

The age at which the criterion response was first elicited was recorded in terms of hours and minutes after birth. This was the critical measurement used in the present study.

Drugs

Drug selection. The pharmaceutical agents used were selected from the following groups: tranquilizers, sedatives, stimulants, and muscle relaxants. Thorazine (Smith, Kline and French brand of chlopromazine) was selected as the tranquilizer. This drug has been used with dogs (Knowles, 1957), cattle and horses (Turbes, 1958), horses (Martin & Beck, 1956), swine (Kristjansson 1957), cats (Kaelber & Joynt, 1956), poultry, (Burger & Lorenz), and sheep (Turner & Hodgetts 1960). All of these investigators reported that animals treated with chlorpromazine were more quiet, tranquil and docile than controls. Burger (1957) points out that the phenothiazines in general and chlorpromazine in particular can be classified as autonomic supressants. In support of this contention he indicates that chlorpromazine produces a sleep pattern in the electroencephlogram without producing actual sleep. Hess (1957) has used chlorpromazine in his studies of imprinting in ducks, and has concluded that it retards metabolism. In any event, there is general agreement in the literature that the effects of this drug are relatively uniform from species to species, and that it induces a decelerated rate of behavior (Sherman & Carr, 1962).

Phenobarbital was selected as the sedative. It characteristically produces sleep or hyponosis, but in small doses produces lethargy. It is generally considered to be a central nervous system depressant. Sherman and Carr (1962) have concluded that the barbiturates, of which phenobarbital and pentobarbital are probably the best known,

> produce varying degrees of sedation in animals and man depending upon the dose. The barbiturate hypnotics characteristically elicit depression of the cerebal cortex and influence the thalamus of the brain. Here they interfere with the passage of nerve impulses to the cortex and the effect is manifested on the sensory and motor cortical areas of the brain. (1962, p. 185).

Sherman and Carr add that the effects of phenobarbital are highly uniform from species to species.

Ritalin (Ciba's brand of methylphenidate) was selected as the stimulant. Originally, one of the amphetemines was considered. Yet, because of the paradoxical effects that drugs in this group often have on infants (it seems to stimulate some infants and tranquilize others in an apparently random fashion), the possibility of using amphetemines was discarded. Ritalin, on the other hand, has not been used extensively with animals. Sherman and Carr (1962) have concluded that Ritalin produces symptoms of central nervous system stimulation and results in increased activity. These effects are apparently uniform in most species tested.

Robaxin (Robin's brand of methocarbamol) was selected as the muscle relaxant. Initially, two other drugs were considered: curare and carisoprodol. Curare was eliminated from consideration because it tends to relax the muscles of the diaphragm, and could thus result in death. Carisoprodol was rejected because there is some suggestion in the literature that it has tranquilizing properties (Hess, 1957). Robaxin was finally selected in spite of the fact that little research with animals has been done with it. Its manufacturers claim that it is a potent skeletal muscle relaxant which has an unusually selective action on the central nervous system, specifically on the inter-nuncial neurons of the spinal cord.

A small pilot study (outlined below) was performed during which the predicted behavioral effects of all drugs was ascertained.

The control group in the present experiment was given an injection of normal saline solution.

Dosages. There is little data on appropriate drug dosages for sheep. Berger (1957) and Ross & Carr (1962) indicate, however, that dosages required to produce a specified effect vary appreciably from species to species. For this reason it was decided to perform a small pilot study. Ten young sheep (one year of age) were selected and numbered. They were isolated in pens and given dosages of the above-mentioned drugs. The initial dosages used in this pilot study were established on the basis of 1/3 the recommended dose for a human adult. After the drug was administered the animal was observed continually. Changes in his behavior were compiled and note was taken of the time at which each change took place. This process was repeated at one week intervals; with a modification of dosage according to the effect desired. (This data is presented fully in Appendix I.) The final dosages established in this fashion were stated in terms of milligram per pound of body weight. Needless to say, sheep used in the pilot study were not involved in the ensuing experiment.

The dosages which were established on the basis of this pilot study were as follows: .75 mg of Thorazine per pound, 6 mg of phenobarbital per pound, 20 mg of Robaxin per pound, and .3 mg of Ritalin per pound. These dosages were established by "trial and error" administration of the drugs to year old sheep. Subsequently, however, the dosages were corroborated for infants. This was done by administering the specified dosage of a drug to each of the first four lambs that were born. Their behavior was observed continuously, and the drugs appeared to have the identical effects on the infants as on the older sheep. Thus the exact dosage for each drug was ascertained.

As was noted above, normal saline solution was used for the control subjects. The dosage for the saline was determined by computing the average amount of fluid per pound of body weight that was injected into each subject. It was thus determined that this average was equal to 1 cc of liquid per 4.5 pounds of body weight. Dosages for the animals who received the saline solution were computed on the basis of this ratio. All drugs were given intramuscularly in the gluteal muscle.

CHAPTER IV

RESULTS

The measured variable was the age (in hours and minutes) at which the lamb first exhibited the criterion response. All statistical treatments were performed with these measures. Table 1 presents the mean ages and standard deviations for each of the five groups.

The first hypothesis stated that groups of lambs to whom various pharmacological agents are administered at birth will differ significantly in the age at which they display visual depth perception. A one way analysis of variance for all five groups was significant beyond the .01 level. Since the treatment groups were not of uniform size, the Harrington method (Walker and Lev, 1953) was used. The obtained F was 26.32 with 4 and 36 degrees of freedom (Table 2). Thus, the first hypothesis was supported.

The second hypothesis stated that lambs to whom a tranquilizer (Thorazine in this case) is administered at birth will display visual depth perception at an age which is significantly later than control subjects. Table 3 presents all possible t tests. The obtained t for the camparison of the saline and Thorazine groups is 5.49, which is significant beyond the .05 level of confidence. Thus, the second hypothesis was supported.

The third hypothesis stated that lambs to whom a sedative

TABLE 1

Means and Variances for all Groups of Lambs

Group	N	Mean	σ
Saline	11	7.0764	3.097
Thorazine	7	28.6785	11.686
Phenobarbital	7	30.1314	11.485
Ritalin	7	5.1671	1.729
Robaxin	9	14.7222	10.946

TABLE 2

Analysis of Variance of the Effects of Drugs upon the Development of Visual Depth Perception

Source	Sum of Squares	df	MS	F
between	4,220.72	4	1055.18	26.32**
within	1,443.57	36	40.09	
total	5,664.29	40		

** Significant at .01 Level of Confidence

TABLE 3

t Tests between all Groups

	Saline	Thorazine	Phenobarbital	Ritalin	Robaxin
Saline		5.49*	5.95*	1.49 ns	2.10*
Thorazine			$<$1.00 ns	4.91*	2.30*
Phenobarbital				5.31*	2.56*
Ritalin					2.15*
Robaxin					

* Significant at the .05 level of confidence

(phenobarbital, in this case) is administered at birth will display visual depth perception at an age which is significantly later than control subjects. The obtained t for the comparison of the phenobarbital and saline groups is 5.95 which is significant beyond the .05 level of confidence. Thus, the third hypothesis was supported. It should be noted in this context, however, that the difference between the Thorazine and phenobarbital groups was not significant.

The fourth hypothesis stated that tranquilizers and sedatives will have no effect on visual depth perception when administered to subjects that have previously displayed visual depth perception. In order to validate this hypothesis tranquilizers and sedatives were administered to lambs that had previously displayed the criterion response in the visual cliff situation. The results for these two groups, in terms of number of trials required for the criterion to be displayed, is presented in Table 4. It is apparent that all of these "sophisticated" lambs who received Thorazine passed the visual cliff on their first trial after the administration of the drug. Similarly, phenobarbital did not interfere appreciably with the visual depth perception of "sophisticated" lambs. Thus, the fourth hypothesis was supported.

Hypothesis five stated that lambs to whom a stimulant is administered at birth will display visual depth perception at an age which is significantly earlier than control lambs. The obtained t for a comparison of the Ritalin and Saline groups is 1.49 which is not significant. Nevertheless, it should be noted that the results are in the expected direction. Moreover, the differences between

TABLE 4

Data for Lambs that were given the Tranquilizer or Sedative after the Development of Visual Depth Perception

	N	Mean	σ
Thorazine	5	1.00	0
Phenobarbital	5	1.40	.69

the variances of these two groups (3.097 for the saline group and 1.729 for the Ritalin group) is appreciable, althought not significant. Nevertheless, the fifth hypothesis was not supported.

Hypothesis six stated that lambs to whom a muscle relaxant is administered at birth will not differ significantly from control subjects in the age at which visual depth perception is displayed. The obtained $\underline{t}$ for the comparison of the Robaxin and saline groups is 2.10 which is significant at the .05 level of confidence. It thus appears that lambs to whom Robaxin was administered at birth do differ significantly from control subjects in the age at which they passed the visual cliff. The sixth hypothesis, therefore, was not supported.

Before the criterion response was observed the lambs typically behaved in a manner similar to that described by Collias (1956), Patterson (1965) and Little (1966). On these early trials they tended to orient themselves along the surface of the wall. They seemed to be completely oblivious to the apparent drop beneath them. The eyes of all of the lambs were open and they could follow a moving ewe or a moving person at less than one hour of age.

The onset of the avoidance behavior was invariably dramatic. The lamb would exhibit the typical startle response for sheep and goats when it first appeared to notice its seemingly precarious position. This involved the extension and stiffening of the front legs and the flexion of the rear parts. If a lamb who had already displayed the criterion response was placed on the vacant side of the cliff, it behaved in a similar fashion. That is, the front legs were extended and stiffened, and it "back-pedaled" with its rear legs. Also, an identical response was elicited from lambs who had passed the visual cliff and were "pushed over the edge". These animals attempted to "dig" their front feet into the glass and "back-pedal" with their rear legs.

The lambs that failed a trial on the cliff apparatus usually did so with a minimum of hesitation. Their head was in the normal position, or at times raised and oriented along the surface of the wall. Once the avoidance response was achieved the lamb no longer oriented upward or along the surface of the wall. Instead, they maintained the startle response and continued looking down at the apparent precipice. This is completely consistent with both Patterson's (1956) and Little's (1966) findings.

An additional observation is reported which may be of interest to future investigators in the area. During the course of this investigation five lambs were rejected by their mothers. That is, the ewe did not permit them to nurse or even to appraoch her, butting them away frequently and savagely. These lambs were placed in small individual pens with their rejecting mothers and were tested on the visual cliff apparatus at the regular intervals. Three of these five lambs displayed visual depth perception at an age which is comparable to normally mothered lambs. Yet, all of the rejected infants had to be removed from their mothers because of the vigor of the attacks upon them. Subsequently one of them died of pneumonia and the other four raised successfully by hand.

CHAPTER V

DISCUSSION

The results of this study lend credence to the contention that the development of visual depth perception, as measured in the visual cliff situation, is functionally related to an animal's early experience.. The present data are also consistent with the findings of Patterson (1965) and Little (1966). Specifically, it seems reasonable to conclude that the experience of a lamb with its mother is intimately related to the infant's subsequent development of visual depth perception.

The first four hypotheses were unequivocally supported by the present data. Lambs that received either Thorazine or phenobarbital at birth displayed visual depth perception at an appreciably later age than subjects who were not so treated. Further, it was demonstrated that neither Thorazine nor phenobarbital have a direct effect upon a lamb's ability to perceive depth. Visual depth perception is not impaired by the administration of these drugs to subjects who have previously demonstrated the ability to perceive depth in the visual cliff situation. Also, it should be noted that the physiological locus of effect of these two drugs is dissimilar -- Thorazine being an autonomic supressant and phenobarbital effecting the central nervous system. From the above data it seems reasonable to conclude that these two drugs interfere significantly with the interaction of the lamb and its mother. Whereas all of the ewes in this study were treated similarly, lambs that received these two drugs seemed to be less responsive to their mothers than control subjects. This aspect of the study suggests that the deceleration of the mother-infant interaction induced by both Thorazine and phenobarbital resulted in a retardation in the age at which the infant displayed visual depth perception. Further, the generalization can be advanced that in sheep any form of interference with the mother-infant relationship that decelerates the rate of this interaction, providing that it takes place during the critical period, will retard the development of visual depth perception.

The fifth hypothesis states that lambs to whom Ritalin is administered at birth will display visual depth perception at an earlier age than control subjects. This hypothesis was not validated at the .05 level of significance. Nevertheless, both the mean and variance for the subjects who received Ritalin were appreciably, although not significantly, below the comparable measures for the control group. Thus, these data were found to be in the expected direction, but not to the requisite extent. The present findings suggest, but do not indicate, that subjects who received Ritalin might display visual depth perception at an earlier age than control subjects. It appears, therefore, that the efficient process relative to the development of visual depth perception is similar for lambs who received Thorazine and phenobarbital and for those who received Ritalin. In the former groups drugs that decelerate the mother-infant interaction were administered which, in turn, resulted in a delayed display of visual depth perception. In the latter group, however, a drug was administered which accelerates the interaction between the infant and its mother. This accelerated interaction appears to result in the comparatively premature development of the ability to perceive depth. Clearly, it was in no way meaningful to ascertain the effects of Ritalin upon visual cliff behavior *per se*.

The sixth hypothesis states that lambs to whom Robaxin is administered at birth will not differ significantly from control subjects in the age at which visual depth perception is displayed. This hypothesis was formulated in order to further test the contention that the ability to perceive depth visually is not mediated by a learning or conditioning principle. It was reasoned that the administration of Robaxin (a voluntary muscle relaxant) at birth will delay the development of visual depth perception only if the development of such perception is contingent upon the use of voluntary muscles in a conditioning situation. Nevertheless, the data for subjects who received the muscle relaxant is somewhat ambiguous. Specifically, it was found that these subjects did differ significantly from control lambs; but that they also differed significantly from subjects who received either Thorazine or phenobarbital.

Three explanations of the data gathered from lambs who received Robaxin at birth are offered. First of all, it is possible that some subtle form of conditioning is involved in the development of visual depth perception. Patterson, however, has demonstrated that the ability to perceive depth is not contingent upon prior experience with patterned light. Thus, in the absence of a visual stimulus it is highly unlikely that depth perception is mediated by a conditioning process _per se_. Alternately, one could speculate that the muscle relaxing properties of Robaxin have a global tranquilizing effect upon the subjects. Nevertheless, no data has been found in the pharmaceutical literature or in clinical reports to support this contention. The third, and probably most parsimonious explanation of the above data is that the Robaxin interfered with the lamb's agressive behavior _vis-a-vis_ its mother. Specifically, it may be the case that the muscle relaxing properties of Robaxin inhibited the lamb's usual behavior towards its mother which typically consists of nuzzling, approaching, rubbing, butting and seeking a teat. Following this line of reasoning it appears that the Robaxin interfered with the mother-infant relationship to the extent that it inhibited these usual behaviors. If this is indeed the case, the data obtained from subjects who received the muscle relaxant is consistent with the contention that the development of visual depth perception in sheep is a function of the quantity and quality of mothering interaction to which a lamb is exposed during a critical period in its development.

Present Data in the Perspective of Prior Findings with Sheep

Patterson (1965) found that mothered and unmothered lambs differed significantly in the ages at which they displayed visual depth perception. An additional finding was that the ability to perceive depth visually does not depend upon prior experience with patterned light. Thus, Patterson concluded that the development of visual depth perception is related to the presence or absence of the lamb's mother during a critical period in development. Little (1966) subsequently manipulated variables which are primarily on the mother's side of the mother-infant relationship. By the manipulation of these factors he was able to vary the quality and quantity of mothering which the infant received. Little concluded that "the appearance of the criterion avoidance response varied proportionately with the strength of the ewe-lamb interaction" (p. 59). In the present study the experience and behavior of the lamb during the critical period were systematically manipulated. It was found that the development of visual depth perception is directly related to the rate or pace of the mother-infant interaction. When the rate of the lamb's behavior was pharmacologically decelerated visual depth perception was retarded; and conversely when the pace of the subject's behavior was accelerated visual depth perception was displayed "prematurely".

Nevertheless, an elaboration of the mediating factors in this process has not been proposed. Specifically, the relationship between the experience of the infant with its mother and subsequent development of visual depth perception has not been elucidated. What is the connection between the mothering which a lamb experiences and the development of its ability to perceive depth visually?

Both Patterson and Little have hinted at the development of a "self-concept" or "ego" in the lamb as a function of its interaction with the mother. They apparently reason that the lamb develops a "self-concept" as a function of its interaction with its mother and that this "self-concept" is critical to the elaboration of visual depth perception. Patterson and Little view the development of basic trust in Erikson's first stage as being analogous to the lamb's formation of this "self-concept". Although the hypothetical construct of the "self-concept" has been proposed as a mitigating factor, it does not clarify the relationship between the mothering that a lamb experiences during a critical period and the lamb's subsequent development of visual depth perception. Also, it seems that the notion of "self-concept" loses its meaning when applied to sheep. Perhaps a more fruitful approach can be formulated by considering the perceptual development of sheep.

Perceptual Integration and Visual Depth Perception in Sheep

As noted previously, a pregnant ewe begins to demonstrate territorial behavior prior to delivery. She will typically withdraw from the flock, dig a small hole or trench in the ground, and generally keep to herself. The onset of this behavior is rather dramatic, and the members of the herd will generally respect the integrity of a ewe's territory. When the lamb is delivered, the mother will immediately commence to lick it. This licking behavior appears to block all responses in that the mother will permit other sheep to approach the infant. Once the licking is completed and the lamb is standing on its feet, the mother will once again enforce the integrity of her territory. Blauvelt notes (1956) that the vigor with which the territory is maintained will decrease as a function of the age of the lamb. The mother will permit the lamb an increasingly larger radius of movement until the time of weaning. It is clear, however, that during the first few days of life the infant is limited in its interactions to its mother. Blauvelt also points out that as the mother begins to relax the enforcement of the territory, the infant is permitted to move increasingly farther from her. Although the distance between mother and lamb increases, they will continuously face each other and glance up from time to time. In the event that they are frightened by a loud noise or the intrusion of a stranger, mother and infant will immediately look at each other. This is the orienting response. After displaying this response, they will run to each other.

It may be the case, therefore, that during the first few days (or perhaps hours) of the infant's life perception is integrated in terms of the mother. She appears to be the major compelling source of all stimuli, and all responses seem to be focused upon her. This process obviously involves visual, tactual, kinesthetic, olfactory and gustatory cues. Although many of these cues are obvious (such as bleating, licking and nuzzling) the process probably is mediated by additional cues which are of a highly subtle nature. The integration of perception clearly involves the integration of the several sensory modalities. Yet, the process itself appears to transcend the individual senses. That is, this integration probably takes place in terms of a series of elaborate <u>gestalten</u>.

The development of visual depth perception does not appear to take place in a vacuum. That is, it seems reasonable to think of it as being a landmark or milestone in the course of perceptual integration. It undoubtedly reflects the attainment of a stage of perceptual integration, but not necessarily the termination of that process. Visual depth perception is a conspicuous or dramatic landmark because of its survival value to the species. Yet, there is reason to believe that additional landmarks in the perceptual integration of sheep will be discovered. When such indices are elaborated, they will undoubtedly be similar to visual depth perception in their relationship to mother-infant behavior.

To recapitulate, it seems that the infant's perceptual integration takes place with reference to its mother. The mother appears to be the compelling source of stimulation for the infant, and the lamb's responses seem to be made in terms of her. Visual depth perception develops as a function of the ongoing perceptual integration. Although visual depth perception is not predicated upon prior experience with patterned light, it does develop as a function of the total perceptual integration of the infant.

Supporting Data

A conceptualization of the relationship between the lamb's experience with its mother and the subsequent development of visual depth perception has been presented. This conceptual framework seems to account for the data obtained by Patterson (1965) and Little (1966). It is also consistent with the data from the present study. In addition to this, the proposed conceptual orientation accounts for two observations -- one by Little and the other by the present author.

Little has noted that

> ... 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 (1966, p. 44).

It thus appears that during the first few post-natal hours these lambs did not have an object in terms of which perceptual integration could take place. Consequently, they did not develop visual depth perception. Yet, when all of the lambs were placed together in the same stall the integration took place in terms of each other. That is, each lamb (and perhaps the group as a whole) served as a source of stimulation for every other lamb. Their perception was consequently integrated in terms of each other.

It was noted in the present study that five lambs were rejected by their mothers. That is, the mother did not permit the lamb to nurse or even approach her. She butted them away frequently and savagely, apparently not being able to tolerate their mere presence. These lambs were placed in small individual pens with their rejecting mothers, and were tested on the visual cliff apparatus at the regular intervals. Three of these five rejected lambs displayed visual depth perception at an age which was comparable to normally mothered lambs. Yet, all of these infants had to be removed from their mothers because of the vigor of her attacks upon them. On the basis of this observation, it seems that perception for some of these rejected infants was integrated in terms of the negative (and at times toxic) stimuli emanating from the mother. It might be the case, therefore, that any consistent pattern of stimulation emanating from the mother is sufficient for the perceptual integration of the infant. The stimulation, apparently, does not have to be positive or even benign.

Suggested Research

The conceptual formulation which has been offered of the relationship between the mother-neonate interaction and the subsequent development of visual depth perception is obviously based upon a great degree of conjecture and relatively little data. Nevertheless, it is possible to suggest experiments which would support or refute this conceptualization.

It has been pointed out that the ewe establishes a territory even before the lamb is born. For at least several days after birth she defends this territory and actively insures its integrity. Blauvelt (1956) has pointed out, however, that there is a specifiable dominance order within the flock. She further notes that a ewe's ability to maintain the integrity of her territory is a function of her position in the dominance order. If the integrity of the territory is related to the intensity of the reciprocal mother-infant stimulation, it stands to reason that the rate of perceptual integration in the infant should be positively correlated with the mother's position in the dominance heirarchy. It therefore can be expected that infants of mothers who are high in dominance should display visual depth perception at an earlier age than infants of mothers who are low in dominance.

As noted previously, rejecting mothers are rather vigorous in their attacks on their lambs. Indeed, the observed reaction is that which one would expect in response to a violation of the ewe's territory. When the lamb is placed in a small stall with its rejecting mother, the infant is ipso facto within the mother's territory. It is reasonable to believe that if this rejecting mother and her infant were not forced into physical proximity by the stall, the mother would merely avoid the infant. It seems that the enforced proximity which is an artifact of the stall results indirectly in the active and violent rejection of the infant by the mother. Yet, it has been theorized that even such active and violent rejection may serve as a focus for the infant's perceptual integration. Therefore, it stands to reason that the rate of perceptual integration of rejected infants should be negatively correlated with the size of the stall which they (and their mothers) occupy. Once again, the age of the development of visual depth perception can be taken as an index of the rate of perceptual integration.

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APPENDIX I

DRUG DOSAGES

There is little data on appropriate drug dosages for sheep. Berger (1957) and Ross & Carr (1962) indicate, however, that dosages required to produce a specified effect vary appreciably from species to species. For this reason it was decided to perform a small pilot study. Ten young sheep (one year of age) were selected and numbered. They were isolated in pens and given dosages of the drugs to be used. The initial dosages used in this pilot study were established on the basis of one third of the recommended dose for a human adult. After the drug was administered the animal was observed continually. Changes in his behavior were compiled and note was taken of the time at which each change took place. This process was repeated at one week intervals; with a modification of dosage according to the effect desired. This data is presented fully in the following pages.

The dosages which were established on the basis of this pilot study were as follows: .75 mg of Thorazine per pound, 6 mg of phenobarbital per pound, 20 mg of Robaxin per pound and .3 mg of Ritalin per pound.

The Effects of Thorazine on Sheep

March 12, 1966

11:50	.5mg/lb., I.M.
12:04	head down
12:09	head down and some swaying
12:20	eating - little movement
12:26	eating
12:35	vigorous eating
12:40	vigorous eating
1:40	lethargic movements, just barely noticeable

The Effects of Thorazine on Sheep

March 13, 1966

9:47	lmg/lb., I.M.
9:48	head down
9:50	stands motionless
9:54	head up - responsive
9:56	head down - in corner
10:07	movements slow, tends to stand still, does not flee vigorously
10:11	some slight swaying - head down - some nibling
10:15	eating and licking wire, nails, and paper
10:18	down - in usual sheep position - gets up in response to my entry into pen
10:22	resumes usual sheep position - down
10:25	breathing slow, deep and regular - eyes almost completely shut - does not respond to presence of food immediately
10:28	eats slowly
10:33	eating more vigorously
10:56	stopped eating - in usual (down) position
11:00	deep, slow breathing - responsive to my approach (turns head)
11:08	on feet spontaneously
11:10	movements still somewhat fewer and slower than other sheep
11:15	eating slowly
11:23	down in usual sheep position - still nibbling
11:25	back up on feet and still nibbling
11:26	down again in usual sheep position - deep and regular breathing

11:29 still down - responsive to my approach

11:34 up - just standing

11:45 down in usual sheep position - head in corner chewing

11:50 still down - eyes closed - does not move away from me - does not get up in response to pain - slightly inhibited pain response - lets E touch her without getting up - deep and regular breathing

12:10 spontaneously on feet

12:11 back down in usual sheep position - very unresponsive - no usual fear of flight responses to E - head down

12:20 spontaneously back on feet - head down - then down again - chewing

12:30 still down - deep and regular breathing - eyes closed, pretty responsive - head down

12:40 breathing faster and shallower - still in down position - eyes closed - still pretty unresponsive

12:45 gets up in response to E - head down and in a corner - some slight increased resistance to E's presence - movements are few and slow - when pushed out of one corner it goes to another - still the rapid and somewhat shallow breathing

1:10 gets up in response to E - stands in corner - breathing is still rather rapid and shallow

1:15 down again - head up, looks more alert

1:25 once again down - pretty responsive, gets up in response to twisting of ear - chews cud occasionally

1:55 down - slightly more responsive than previously, but still not too responsive - gets up in response to ear pain, but then goes down again

3:00 withdrawal rather than flight in response to human approach

4:00 continued withdrawal in response to human approach

this pattern lasted approximately 5 more hours. Thus the effect of the drug is noticeable for a total of about 12 hours - at least at this dosage (1mg/lb) with this size animal (68 lb.).

The Effects of Phenobarbitol on Sheep I

March 20, 1966

2:55	2.7 mg/lb. I.M.
3:11	stands still
3:20	bleating
3:30	eating
3:50	lying in usual position - persists in lying, even though she gets up from time to time

This is obviously not a sufficient dose to produce observable effects.

The Effects of Phenobarbitol on Sheep II

March 21, 1966

10:43	5.4 mg/lb., I.M.
10:48	bleating
10:57	eating
11:03	slightly slower walking
11:07	licking and slurping - mouth that does not appear to be rumination - chews on wire - licks chops
11:25	aside from the unusual mouth movements this drug at 5.4 mg/lb does not appear to have any effect
11:29	coordination slightly impaired - very slight; drunk - slow, wavy movements - this is most apparent when the animal is moving of its own volition and not in response to threat.

This does not appear to be a sufficiently large dose and it would probably be best to double it.

Subsequently another sheep of approximately the same weight (80 lbs.) was given two cc ampules (640 mg) of phenobarbitol, and no increased effect was observed.

The Effects of Phenobarbitol on Sheep III

March 23, 1966

7:20	13.8 mg/lb., I.M.
7:30	some questionable staggering
7:40	walking backward with head down
7:42	some unsteadiness
7:48	flees from E, almost hyperactive
7:50	muffled bleat
7:55	swaying and drunk kind of walk, never in response to E's approach but spontaneously
7:57	drunk restlessness - coordination poor
8:07	drags feet when walking
8:25	attention does not seem to be impaired - if anything, it is increased - still some deficit in coordination - there does not seem to be any effect on respiration
8:30	faulty step - slightly increased difficulty in coordination. It seems as if she gets mobilized in response to E's approach and her coordination improves
8:37	eats - pays less attention to other sheep and E
9:20	no appreciable change in coordination
10:10	only the slightest coordination deficit. The effects of the drug seem to have worn off

The Effects of Robaxin on Sheep

March 12, 1966

11:55	5mg/lb., I.M.
12:04	not much movement
12:20	very wide eyes
12:22	head down - looking for food
12:26	eating
12:35	vigorous eating
12:40	vigorous eating

This is clearly too small a dose - at least no dramatic effects were noted.

The Effects of Robaxin on Sheep

March 20, 1966

3:10	10 mg/lb., I.M.
3:12	eating
3:15	shallow, rapid breathing
3:22	does not appear to be too sure of footing
3:30	eating
3:36	laying down in usual position - ruminating
3:40	gets up in response to E but lies down very soon after
3:43	back on feet

This is obviously not a sufficient dose to produce observable effects.

The Effects of Robaxin on Sheep

March 21, 1966

10:36	14.3 mg/lb., I.M.
10:40	hyperventilation
10:45	coordination is poor - slight tremor
10:55	still heavy breathing - eating
11:24	thus far, the only apparent effect of the drug is the hyperventilation

This does not appear to be a sufficiently large dose and it would probably be best to double it.

Subsequently, another sheep of approximately the same weight (80 lbs.) was given two 10 cc ampules of Robaxin and no increased response was seen.

The Effects of Ritalin on Sheep

March 24, 1966

7:20	.27 mg/lb., I.M.
7:40	appears to be very alert to sound - stands motionless and appears to attend
7:55	eats but frequently stops eating to attend to some noise - backs off at my mere approach
8:00	stands still and attends to noises
8:45	down when E approaches - jumps up in response to E's approach
9:30	no change

Since the effects of this dosage were not dramatic, we should increase the dosage to 40 mg.

Sernalyn in Adult Sheep I

March 5, 1966

4:14	1 mg/lb., I.M.
4:19	head drooping
4:24	can't get up, some salivation, supports head
4:26	can't lift head, in ventral-down position
4:27	eyelash reflex present, some response to pain, hind is flacid, some salivation, head rolls from side to side
4:30	apparent maximum effect
4:38	fore-quarter control, head between front feet
4:45	head roll from side to side, slight chewing
5:02	front foot under body, rolls self over
5:04	regains front quarter control - kicks
5:09	moves body from side to side spontaneously
5:15	increased rolling and kicking
5:30	struggles to get on feet - does not succeed
5:45	moves (not rolls) head - holds head up briefly
5:50	on hind legs and front knees, eating hay - back legs spreading, "drunk"
5:52	on four feet by itself, still "drunk"; moved away from food, "shakes" - tremor, involving whole body
5:57	head drooping, bumps into wall
6:10	looks like effects of drugs have ended

Sernalyn in Adult Sheep II

March 6, 1966

10:30	½ mg/kg., I.M.
10:35	slight impairment of coordination
10:36	jerks, tremors, head drooping
10:37	falls to front knees, gets back on all four feet, walks into walls
10:42	falls and gets back onto feet with much difficulty
10:48	head down - drooping
10:50	is still able to struggle back onto all four feet
10:54	much mouth movement
11:10	shakes, tremors; head up, stands in corner; mouth movements
11:17	approaches food and smells it
11:25	nibbles on food
11:35	½ mg/kg., I.M.
11:40	standing stupor, falls on front knees; head down - in corner
11:42	body tremor
11:44	falls and does not get up
11:45	much salivation, rocks head; very slight response to pain
11:50	retinal reflex in lash only - not in head jerk
11:55	licks floor and salivates
12:05	no pain response, retinal reflex intact; struggles to get up, but can't threshing, near random kicking, very rapid breathing
12:12	tremor - especially in front legs
12:18	almost on feet

12:23	twitching of legs
12:30	slight pain response, retinal reflex intact
12:50	increased pain response, decreased twitching
1:05	on feet, "drunk", eating vigorously
1:15	looks like the drug effects have ended

The Effects of Sernalyn on Sheep III

March 12, 1966

11:47	1.3 cc, .5 mg/kg., I.M.
12:03	bleating - moves about pen
12:06	mouth movements - chewing
12:08	coordination getting poor - some staggering
12:15	staggering - beginning of drunk
12:16	jerky movements
12:20	many rapid, jerky movements
12:21	bleating
12:26	eating
12:35	vigorous eating
12:40	vigorous eating
12:47	.25 mg/kg., I.M.
12:51	slight neck tremor
12:56	head down - shallow pant
1:20	staggering - swaying
1:45	.25 mg/kg., I.M.
2:00	staggering, jerky movements
2:10	drunk - difficulty getting up

Optimal dosage seems to be ½ mg/kg initially and ¼ mg/kg at hourly intervals.