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THE EFFECTS OF MAGNESIUM PEMOLINE AND THYROXINE ON THE DEVELOPMENT OF VISUAL DEPTH PERCEPTION IN LAMBS: ENDOCRINOLOGICAL ASPECTS

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THE EFFECTS OF MAGNESIUM PEMOLINE AND THYROXINE ON

THE DEVELOPMENT OF VISUAL DEPTH PERCEPTION

IN LAMBS: ENDOCRINOLOGICAL ASPECTS

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CHAPTER I

INTRODUCTION

This and related studies would probably not have been done during the first decade of this century, even if the technological essentials had been available, for the psychological *Zeitgeist* of the time held that the structure and the nature of the organism was determined solely by genetic endowment (Davenport, 1911; Goddard, 1912; Murphy, 1949; Peterson, 1925). However, by the third decade, more equitable importance was being given to each side of Galton's "nature-nurture" problem (Carmichael, 1925, 1926; Stone, 1934; Woodworth, 1941). Science no longer asks "if" but periodically asks "how much" and "how" heredity and environment contribute to the organic process (Anastasi, 1958; Cattell, 1968; Hollingshead & Redlich, 1965; Srole, Langner, Michael, Opler, & Rennie, 1962). These questions remain in a state of agnostic unrest and are therefore researchable.

More specifically, there have been immense amounts of research and thinking directed to the environmental (especially the maternal) influences on the very young organism (Angyal, 1965; Bovard, 1954, 1958; Cooper & Zubek, 1958; Freud, 1939; Gesell & Ilg, 1949; Harlow, 1959; Levine & Alpert, 1959; Riesen, 1950; Rosen, 1958; Schaffer, 1958; Senden, 1932; Thompson & Heron, 1958; and others). The great importance placed on observing the effect of the environment on the neonate is probably due to the "green twig" concept -- the notion that most of what happens to the very young organism will have crucial and enduring consequences. The results of such studies can often be validly generalized to other species of organisms if care is taken to determine whether or not the qualities in question are truly homologous (Hinde & Tinbergen, 1965).

Since the turn of the century when McDougall (1905) defined Psychology as "... the positive science of the conduct of living creatures", the bulk of psychological research has involved the observation of behavior. However, there has been a gradual blossoming of the realization that behavior is inextricably related to physiological phenomena. Thus there has been a growing tendency to borrow new research techniques from the physiological sciences (Inbau, 1942; Lindsley, 1950; Masserman, 1942; Scott, 1930) with a recent emphasis on hormonal measures (Whalen, 1967).

Critical Periods

The critical period concept was originally the province of embryology but more recently has been applied to the observation of the influence of the environment on behavior (Jaynes, 1957). Beach (1954) points out that frog embryo tissue which ordinarily would have become an eye lens can be transplanted at a given time to the frog's belly where it will make a drastically misplaced lens. If this tissue is transplanted earlier however, it will become belly tissue. Beach continues by explaining that blood cells are constantly being replaced in the animal but their type remains exactly the same. Therefore, he reasons, some permanent psychological factors may be genetically transmitted just as blood cells are and their change may also depend on certain events happening to them at critical times. The discussion of critical periods has become of foremost importance in the behavioral sciences and has been observed both in humans (developmental approach) and in lower animals (ethological approach).

Developmental approach. Most of the thinking pertaining to the growth and development of the human infant was only philosophical and speculative in nature until the latter two decades of the nineteenth century. Some of the early conceptions of human ontogenetic development include: that the child is a small, weak, ignorant version of the adult and that maturation is quantitative but not qualitative in its changing; that the male sperm contains the homunculus -- the miniature but completely formed adult -- that has only to acquire larger size, strength, and knowledge to reach maturity. Another view is that the child is conceived and born in sin and must be subjected to purification through harsh and rigid discipline in order that he may reach moral adulthood; or Rousseau's postulated "noble savage" who was thought to be born inherently good and unspoiled but who invariably becomes corrupted through his interaction with adults and society (Dennis, 1949; Watson, 1959). During the early seventeenth century, Heroard kept a record of the early development of the young Louis XIII and it is known that many men kept records or diaries of the development of their own children. These records include an account published in 1787 by Tiedman of his son's development, and Pestalozzi who, in 1774, kept a diary of his son's early behavior and education. We also have Charles Darwin's diary of his infant son's development in 1840 (Dennis, 1949). After Darwin, Thomas Huxley, and others had excited the scientific world with the concept of evolution, thinking was turned toward viewing the child as a stage of evolution, linking man with the lower animals (Asimov, 1965). G. Stanley Hall developed the theory that the ontogenetic development of the individual man recapitulates the phylogenetic and cultural history of mankind (Hall, 1895). This analogy provided the thinkers of the time with an explanation for the seemingly internal regulation of development and for the apparently predetermined inevitability of its outcome (Ausabel, 1958).

Freud's developmental theory. Taken in terms of organized change from birth (or conception) to maturity, Freud's views must be considered from two dimensions. First, he described the sequential unfolding of the three elements of the personality. The initial one of these, the _id_, he considered to be inherited and present at birth. He described the id as a _chaos_, "a cauldron seething with excitement". He felt that the id endows the somatic processes with mental expression and he added "... it has no organization and no unified will, only an impulsion to obtain satisfaction for the instinctual needs in accordance with the pleasure principle" (Freud, 1933). However, he continued, the pleasure principle is not enduringly adequate for need-satisfaction so a secondary process belonging to the _ego_ is developed out of the id. He believed that the ego mediates between sensory stimuli and motor activity, that it has the task of self preservation, and that it is aware and selective in dealing with the environment. "The ego...is concerned with discovering the most favorable and least perilous method of obtaining satisfaction, taking the external world into account" (Freud, 1949). Finally, Freud felt that the parents and other inhibiting forces from the environment become internalized to form the superego. The function of this element of the personality is the limiting of satisfaction; it is the "policeman", the conscience. "The superego is the successor and representative of the parents and educators who superintend the actions of the individual in his first years of life; it perpetuates their function almost without a change" (Freud, 1939).

It is the second dimension however in which Freud's developmental schema casts the importance of stages or critical periods. Freud named his four psychosexual stages: the oral stage which occupies about the first calendar year of life; the anal stage which lasts from about the first to the third years; the phallic, lasting perhaps from the third to the fifth years; and the genital stage which lasts from puberty through adulthood. Each of the stages represents, during its developmental period, the chief means of tension reduction; the primary source of gratification. Excessive anxiety or frustration experienced in the resolution of any of the stages results in behavior during adult life which would have been appropriate during the particular stage in which the frustration occurred. Such fixations on the early stages are, when experienced in the extreme, neurotic. Thus, though Freud's stages are not divided into clearly discrete temporal separations, his theory places great emphasis on the importance of the happening of certain events at an ideal time and it suggests that a disturbance in the timing may have grave consequences.

Erikson's developmental theory. Erikson felt that all aspects of the individual, physiological, psychological, and social, unfold from a predetermined epigenesis. He described eight phase-specific psychological crises from which, he said, the ego must emerge with new and accumulated identities. The early struggles with which the infant ego must cope are: 1) basic trust vs. mistrust (the Oral-Sensory Stage); 2) autonomy vs. shame and doubt (the Muscular-Anal Stage; 3) initiative vs. guilt (the Locomotor-genital Stage); and 4) industry vs. inferiority (the Latency Stage). Erikson (1950) also implies that a prescribed sequence of stages must be maintained:

> A lasting ego identity, we have said, cannot begin to exist without the trust of the first oral stage; it cannot be completed without a promise of fulfillment which from the dominant image of adulthood reaches down into the baby's beginnings and which, by the tangible evidence of social health, creates at every step an accruing sense of ego strength [p. 218].

Piaget's concept of stages. Piaget makes a very complex and sharply deliniated definition of developmental stages. As Spitz (1965) put it:

> Piaget's concept of stages, his sharp division of psychic unfolding into distinct episodes, finds no corresponding parallel in classic psychoanalytic theory. While the concept of libidinal phases accounts for psychosexual development, these phases are not true steps like those envisaged in Piaget's system [p. 315].

In order to make his explanation complete, Piaget examined his stages through many dimensions and avenues which cut across them in complex patterns. He speaks of development in terms of structure, function, and content and examines "horizontal and vertical decalages" (simultaneous occurrences of behavior on different levels) (Flavell, 1963). He conceived many sets of stages having different defining elements and occupying longer or shorter periods of duration. For example, he speaks of a <u>sensorimotor phase</u> (from birth to the end of the second year) followed by a <u>preconceptual phase</u> (lasting from the 3rd to the 5th year) but, in another context, places the <u>reflex or hereditary stage</u>, the <u>stage of first motor habits</u>, and the stage of <u>sensorimotor or practical intelligence</u> all within the period prior to the development of language (Piaget, 1967). In speaking of intelligence, Piaget feels that certain developmental stages unfold in an unchanging, constant, ontogenetic sequence (Flavell, 1963). This theory implies a natural and ordinal (but not interval) scale of intelligence that contrasts in important ways with the view of a more or less fixed IQ (Hunt, 1961).

> Piaget's description of the transition from one stage to another, and indeed from one substage to the next, includes four main factors. The first is <u>maturation</u>, the increasing differentiation of the nervous system. The second is <u>experience</u> with the physical world. The third, social <u>transmission</u>, involves encounters with other human beings, and more specifically, education. The fourth, <u>equilibration</u>, or self-regulation, is for Piaget the fundamental factor (Almy, 1966, p. 20).

It will be seen shortly that these factors present excellent analogies with findings and ideas that have come from ethological and comparative psychological studies.

The present trend in the study of human development is toward an ever increasing specialization and diversity. Careful experimental techniques are used with vast samples of children and sophisticated statistical and factor-analytic methods are employed in processing the obtained data. Observations are reported on such special behavioral phenomena as activity, motor behavior, perception, social behavior, responsiveness, vocalization, cognitive processes, etc. with many subdivisions of those topics. Stevenson (1967) has said:

> A review of the research reveals a profusion of data. Unfortunately, a great deal of this information is bound to be lost, at least temporarily, because of the lack of a coherent framework into which it can be assimilated [p. 87].

In summary, the study of human ontogenetic development has moved from early anecdotal and philosophic literature to ever more careful and scientific observations. Kessen (1963) has said, "The old classic view of the helpless, passive infant is simply not true -- he is active, competent, and in reciprocal interaction with the environment". The psychoanalytic theorists as well as Piaget and Sears among others have recognized characteristic phases or stages in child development that incorporate the child's establishing primary dependency followed by the attaining of means of self care and, finally, his achieving meaningful secondary relationships (Maier, 1965). In the next section, an attempt will be made to show how the concept of critical stages of development has been elucidated through the study of animals.

Animal Research

During the past forty years, there has been an overlapping of methods and processes used and of information gleaned from several disciplines whose workers have variously called themselves experimental psychologists, comparative psychologists, animal behaviorists, and/or ethologists. The Division of Physiological and Comparative Psychology of the American Psychological Association at a meeting in Detroit in 1947 decided to merge with the Division of Experimental Psychology, a larger division. According to Scott (1967), the result of this merger was that "...comparative psychology sank without a trace as far as its formal existence was concerned, and it did not emerge again until 1963, when Division 6 was formed anew" [p. 65]. Thus, an era in which one of the key Darwinian concepts -- the evolution of intelligence -- had reached its time of experimental fruition (Warden, Jenkins, & Warner, 1935 - 40) had come to an end. Scott (1967) adds:

> Ironically enough, the time of submergence of the Division of Physiological and Comparative Psychology was also the time of a great resurgence of interest under the names of "animal behavior" and "ethology". This new wave has not yet reached its full height, nor is it likely that it will ebb as suddenly as did that of the old comparative psychology. It is much more broadly based and the facts which remain to be discovered are almost innumerable [p. 65].

Scott (1958, 1962a) has described stages in the growth of animals that are similar to the critical periods discussed earlier in the section on developmental psychology. His particular critical period divisions are quite reminiscent of those of Piaget. Scott's periods are: the <u>neonatal</u>, in which the process of nursing is established; a <u>transition</u> period in which sensory and motor capacities are developed; and a period of <u>socialization</u>. These are followed by a juvenile period during which physical skills and growing independence from parents are developed, a <u>pubertal</u> period ushering in the development of sexual relationships, and, finally, a <u>parental</u> period in which there develops a relationship with offspring. The specific durations of these stages have been observed and recorded in puppies (Scott, Fredericson, & Fuller, 1951), in mice (Williams & Scott, 1953), and in lambs (Scott, 1945; and Scott & Marston, 1950). Writing of the findings of Scott & Marston (1950) and others, Patterson (1965) says:

> They [Scott & Marston] point out that the lamb is born with adult motor and sensory capacities, i.e., the usual acquisitions of the <u>transition</u> period. This means that the <u>socialization</u> period is already underway at birth, and it may be speculated that any experimental interference introduced will have dramatic and almost immediately observable effects [pp. 5-6].

Many studies support the conclusion that adequate social adjustment (and ultimately the survival) of sheep and goats is dependent on certain kinds of stimulation of the animals during the <u>transition</u> period (Blauvelt, 1955; Collias, 1956; Liddell, 1955; and Moore & Moore, 1960). Schneirla (1965) has observed that there is a stage during the late embryonic and early neonatal periods during which sensory integration and feedback effects come under the control of external stimuli and that this process influences the organism's early potential for contiguity-type conditioning.

<u>Ethology.</u> Ethology is a special discipline having as its central process the observing and recording of the consistent behavior of various species of animals. Until the 1950s, most ethological work was being done by European zoologists. Acceptance of the discipline was slow in the United States because the early ethologists seemed to be reviving the locally unpopular idea that there may be a genetic transmission of behavioral characteristics. Also, experimental psychologists and others were probably rankled by Tinbergen's (1951) definition of ethology as "...the <u>objective</u> study of behavior". His definition seemed to imply that other methods of studying behavior had not been objective. This notion (however incorrect) was particularly offensive to experimental psychologists. However, in spite of its difficult introduction to this country, ethology seems gradually to have gained ground and its literature now flourishes here as well as in Europe.

Hess (1962) has given an excellent description of the recent work and thinking of the ethologists:

> The major premise of ethology is that the study of animal behavior must begin by obtaining as complete a knowledge as possible of the behavior of the species in question during the entire life cycle. A collection of such observations on one species is called an ethogram. It simply describes what an animal does, not why it does it. This goes beyond the usual naturalistic approach, since the various behaviors are then classified and compared with those of many other species, particularly related ones. The ethologists consider it very important that the animals be observed in surroundings that closely approach their natural habitats. It is preferable, if possible, to study them in the wild rather than in captivity, because in captivity it is more difficult to keep the animals in a state of optimum health and, when they are not in a state of optimum health, some aspects of behavior may not be manifested [pp. 159-160].

Further, ethologists seek to understand four important elements of a specific animal's behavior: 1) its probable evolution, 2) its ontogenetic development, 3) the survival value it provides and 4) its physiological bases.

Among the special ethological concepts is the fixed action pattern (FAP). The FAP may be defined as a sequence of coordinated motor actions that appear without the animal's having to learn it by the usual learning process and which the animal can perform without previous exercise and without having seen another species member do it. In the FAP, the sequence of motor elements never varies. Another ethological concept, the innate releasing mechanism (IRM) refers to a single stimulus which is always followed by the same characteristic behavior. The term "instinct" has fallen into bad repute with ethologists. An important reason for current avoidance of the term is that many actions formerly taken for granted as being instincts have now been shown to be learned actions. In Schneirla's (1966) words:

> There is no concept of instinct. Behavior is genetically programmed and then modified by environmental forces - <u>that is all</u>. So we should forget the terms <u>instinctive</u> and <u>learned</u>. All behavior falls on a continuum between the two [p. 287].

The concept of <u>imprinting</u> is so important to the present study and to ethology in general that it will be discussed alone in the following section

<u>Imprinting</u>. This term refers to a relatively sudden change in the behavior of the young animal in which a single IRM is selected from a large range of potential IRMs and the selected one is strengthened so that only it (from the whole potential range) is the one to which the animal responds (Hess, 1962, p. 187). For example, very young ducks will follow almost any moving object or animal regardless of its shape or size. The exposure to the moving object must occur during a critical period but the effects of this exposure are enduring and have profound influences on the later sexual and socializing behavior of the organism. Though earlier workers had observed the phenomenon, Lorenz was the first to name it "imprinting" and the first to point out that it occurs during a critical period in the early life of the animal (Hess, 1959a, p. 133). Though mainly observed in birds, imprinting has also been seen to occur in insects, fish, rodents, sheep, deer, and buffalo. By means of carefully controlled experiments, Hess showed that ducklings learn to follow a decoy much faster and better at 13 to 16 hours of age that at any other time. Social facilitation can prolong the time during which imprinting is possible but dissipation of the effect is very rapid as age increases beyond the critical period. In his studies, Hess found the auditory and color cues simulating the call and color of the adult

of the species will facilitate the following-response but changes in size and shape of the decoy have little effect.

It is important to the principles of the present study that Hess (1959b) observed that the critical imprinting period terminates at the same time that the animal becomes able to experience fear. Scott (1962b) also found that the critical period is terminated by the onset of fear responses. These findings will be discussed in connection with other material later in this chapter. Though a critical period for imprinting has been observed across many species, the optimal period varies between kinds of animals. Hess (1959, p. 140) found the effect working best at about 24 hours of life in guinea pigs, Ginsburg (1965) found that wolves adapt to humans better at less than three weeks of age than at other ages, and Hersher, Richmond, & Moore (1965) observed, in sheep and goats, that a mother-neonate bond is formed within a few hours after the infant's birth and that the mother thereafter rejects any strange infant.

In summary, observation and research with animals has shown that critical periods play an essential part in ontogenetic development. Lambs, unlike humans and many other animals, are born with motor and sensory capacities already operating. Thus, very early socialization can be available and important to them developmentally. The ethological concept <u>imprinting</u> is dramatically dependent on a critical period. Observers have reported that the critical period for imprinting ends when the animal's ability to experience fear begins.

Visual Depth Perception

It is obviously important to any animal that moves about that it not only be able to detect both needed and dangerous objects but that it also understand the distance of those objects from itself. Some animals such as bats, whales and a few others can apparently determine relative location and distance of objects by means of reflected sound waves (Tinbergen, 1965, pp. 107-125). Animals such as limpets and migrating birds and fishes can arrive at apparently predetermined locations by means that, at this time, are not clearly understood. However, nearly all animals that have well developed eyes apparently perceive and judge depth from visual cues. These cues may include the animal's perception of the relative size of the object, the perceived textural detail of it, or cues coming from the binocular parallax adjustments in the eyes themselves. Perhaps the animal may perceive depth through a combination of these and other cues, but it is the visual sense that allows most higher animals to make judgements of distance with enough accuracy to serve the purpose of avoiding danger, getting food, navigating, etc.

Lashley & Russel (1934) reared rats in darkness for 100 days and observed their ability to jump various distances between two platforms as compared with the same ability in normally reared rats. They conclude

> that the visual perception of distance and gradation of force in jumping to compensate for distance are not acquired by learning, but are the produce of some innately organized neural mechanism [p. 143].

This experiment has been criticized on the grounds that the dark-reared rats saw some light while being fed, that motor skills (jumping) were involved and might be confounding, and that practice trials were sufficient to allow the rats to acquire learned skill in depth perception (Greenhut & Young, 1953; Munn, 1955). The case for the innate development of depth perception was strengthened by a study in which dark-reared chicks jumped from a raised platform to about the same height and at about the same frequency as light-reared chicks (Kurke, 1955). However, as part of this same study, Kurke found that older (10 day old) chicks would jump from a higher platform when normally reared than when reared in darkness. From this observation he concluded:

> ...the further development of depth descrimination apparently depends in some manner on the integration of experientially determined kinesthetic cues [p. 196].

Fantz (1958) found that chicks born in total darkness will, on their first exposure to light, peck at a three-dimensional object significantly more often than at a plane surface with the same outlines. Thus it appears that the naive chicks discriminate and show a preference for objects having the third dimension.

These studies suggesting that depth perception is innately acquired seem inconsistent with the earlier studies of Senden (translated, 1960). Senden, observing humans immediately following surgery to remove congenital cataracts, found that his subjects were unable to translate visual cues into meaning in the same way as persons who have been normally sighted since birth. Senden concluded that visual perception in humans must, in part, be acquired through learning. This apparent conflict in results from human and animal studies probably arises from assuming generalizations that are too broad. It may be that different animals develop depth perception in different ways. It is pointed out by Little (1966):

> This capacity (depth perception in chicks) has obvious survival value; the chick being a precocial bird, one whose young at birth are covered with down and are able to run about, it must provide for its food from the beginning and therefore must be endowed from birth with an innate, unlearned ability to perceive the food object. ...Since man is born helpless, immature, and requires early care, such visual discrimination is unnecessary in the early periods [p. 22].

Another possible resolution for the "innate perception vs. learned perception" controversy is made by Gibson (1963) by taking credence from the Senden study:

> The classic technique for investigation has always been the study of the effects of deprivation of some normally present environmental contribution, such as stimulation by patterned light. The 'born blind' patients corrected (or somewhat corrected) by surgery are the most dramatic cases. The cases summarized by von Senden...shed no more light (since translated) than they ever did, since all the confounding effects of nystagmus, emotional upset, interference from old habits, and unreliable testing procedures are still inevitably present in the reports [p. 5].

However, by studying dark-reared and blindfolded infant chimpanzees, Riesen (1950) arrived at essentially the same conclusions as did Senden.

> Some responses that bear a close resemblance to reflex behavior, such as blinking at something rapidly approaching the face, become automatic only after considerable practice. Visual pursuit of moving objects, the coordination of the two eyes and convergent fixation, and the first recognition of objects come only after many hours or weeks of experience in use of the eyes. ...the postponement of light exposure for too long can result in making the development of normal visual mechanisms extremely difficult if not impossible [p. 19].

After many years of study (and many publications), Fantz (1961) concluded:

> ...results to date do require the rejection of the view that the newborn infant or animal must start from scratch to learn to see and to organize patterned stimulation. Lowly chicks as well as

> lofty primates perceive and respond to form without experience if given the opportunity at the appropriate stage of development [p 42].

Thus Fantz has implied not only that visual perception is innately acquired but that developmental stages are crucially involved in its growth. Spitz (1965, p. 59) agreed with the findings of Fantz but, in explaining the findings, took a "middle of the road" view of the "innate vs. learned perception" argument. Spitz, for example, was convinced that the human infant is neurologically and physiologically capable of seeing very shortly after birth. However, Spitz felt that the infant must acquire the apperceptive function over time and "through experiences provided in the course of affective exchanges with another person in the setting of object relations". According to Spitz, it is the oral-tactile sense that is most important at first. The human infant, he felt, first senses taste, touch, temperature, smell, and pain through the oral receptors as it nurses at the breast, "feeling the nipple in the mouth while at the same time seeing the mother's face". Thus, he said, the contact (oral) sense is blended with the distance (seeing) sense.

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

After Maturna (1960) had been able to identify specific receptors in the frog retina in which he could find area-specific sensitivity to form and to light intensity, Sackett (1963) made some further generalizations. Sackett postulated that certain instinctual behaviors are triggered by the excitation of appropriate retinal elements (Little, 1966, p. 25). Using ethological terms, Sackett said:

> It is hypothesized that this mechanism is responsible for the onset of the imprinting critical period, inborn preferential choice responses, innate object recognition, and the stimulus-specific releasing function involved in fixed action patterns (Sackett, 1963, p. 40).

In summary, the development of depth perception seems to be related to the nature-nurture problem and to converge on agreement in that visual perception may be innately determined but develops with practice. Many of the studies imply that visual depth perception normally develops along a sequence of stages that come into being at critical times in the life of the organism.

Locomotion and vision. A visual cliff is an experimental apparatus which has, as its essential elements, a horizontal glass plate covering, in part, a solid platform and, in part, a deep space to a solid surface far below. After placing both dark-reared and light-reared rats on the glass plate of the visual cliff and observing their behavior, Gibson and Walk (1960) concluded:

> (We) venture the rather broad conclusion that a seeing animal will be able to discriminate depth when its locomotion is adequate, even when its locomotion begins at birth [p. 71].

Feeling that Gibson and Walk had built a fault into their experiment by allowing the dark-reared rats a 20 minute light-adaptation-period prior to testing, Nealy and Edwards (1960) repeated the Gibson and Walk study but they placed the dark-reared rats for 20 minutes in a "detention box" which was contrived to permit light adaptation without pattern vision. Nealy and Edwards also tested enunceated (blinded) rats on the visual cliff to determine whether they would respond (choose the shallow side of the glass) on other than visual bases. The enunceated rats showed no reliable preference of position in the visual cliff and the remainder of Nealy's and Edwards' study suggested the same conclusions as those of Gibson and Walk.

Epstein (1964), citing the cases reviewed by Senden (1943), noted that most of them indicate inability in the newly operated humans to distinguish between solid (three dimension) and plane objects. Epstein further cites Senden in showing that the newly-seeing may reach for an object which is several yards away or they may overreach an object that is only 1 foot from the eye.

> However, he <u>does</u> reach out into space and does <u>not</u> localize the object at the plane of the eye (Epstein, 1964, p. 122).

Thus Senden is telling us that some aspects of depth can be perceived, however primitively, by the newly-seeing but others such as solidity cannot. From reports of cataract removal and subsequent visual testing with two children in Russia, London (1960) wrote that

> the children were unable by vision alone to determine distance or, more exactly, the distance of the nearest objects. When walking, they collided with these objects (London, 1960, p. 479).

Fantz (1961b) reported finding that infants under 3 months of age did not give preferential responses to solid and plane figures when they were allowed to use both eyes but did show a preference for textured (as opposed to smooth) objects when seeing with only one eye. He then concluded

> that the use of both eyes interferes with vision in the early months before the development of good binocular coordination, while binocular vision does improve visual performance later on [pp. 29-30].

Patterson (1965) demonstrated that the age at which visual depth perception (as determined by the visual cliff) develops in lambs is related not to their ability to walk but to the presence or absence of a nurturing mother during the lamb's first few hours of life. Little (1966) showed further that the age at which visual depth perception develops in lambs is functionally related to the <u>degree</u> of mothering experienced by the lamb.

Gibson and Walk have made the statement 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 (Gibson and Walk, 1961, p. 55).

Their use of the phrase "independent locomotion" perhaps places their statement in better agreement with the available data but the exact meaning of the statement in terms of developmental time is still obscure. For example, both Patterson and Little observed that lambs ~~can~~ walk within a few minutes after birth but do not apparently acquire visual depth perception until some hours after birth. At what point the lambs are capable of "independent locomotion" however cannot be determined because the term has not yet been operationally defined. The experimenters are apparently aware of the lack of closure as they have stated

> From our first few years of work with the visual cliff we are ready to venture the rather broad conclusion that a seeing animal will be able to discriminate depth when its locomotion is adequate, even when locomotion begins at birth. But many experiments remain to be done, especially on the role of different cues and on the effects of different kinds of early visual experience (Gibson and Walk, 1960, p. 71).

Depth perception as a developmental stage. Fantz (1958a) hatched chicks in total darkness and tested them at the time of their initial experience with light. In testing, he gave them 5 minute exposures to a pair of stimuli consisting of two hemispheres, one presented so that the curved surface faced the chicks and the other exposed so that only the flat (plane) surface was visible. One group of chicks was exposed to the stimuli under direct lighting which produced strong shadows and another group under diffuse lighting. Under both lighting conditions, the curved surfaced objects received significantly more pecks than did the flat surfaces.

> While these newborn chicks seemed to make no use of light and shade distribution of discriminating depth, Fantz reported that slightly older chicks that had visual experience showed an enhanced preference for spherical surfaces when shading was present (Epstein, 1964, p. 119).

Here the aging of the chicks has seemed to make a difference in the manner in which they use visual cues for perceiving depth. These findings are consistent with those of an earlier study by Hess (1956b). Hess fitted newborn chicks with hoods containing goggles whose lenses displaced the field of vision either 7 degrees to the right or 7 degrees to the left or not at all (control group). The chicks were allowed to peck at a small brass nail embedded in modelling clay and the pecks could be observed by the peck-marks left in the clay. Thus the pecking accuracy of the chicks could be measured by the diameter of the pecking pattern left in the clay, a smaller and more focused pattern indicating better accuracy. The chicks were tested when they were one day old, then divided into two groups: one placed in a living enclosure in which grain was loosely scattered on the floor and the other in housing in which the only food was mash placed in small bowls. Further testing (with the lumps of clay) at 3 or 4 days of age revealed that all chicks were improving their pecking accuracy (making smaller patterns in the clay) though the chicks with the experimental lenses were making their improved peck-patterns at 7 degrees to the right or left. Moreover, the chicks housed in the cages containing the small bowls of mash were healthy but those housed with the scattered grain were obviously starving. Two of them died on the fifth day. It was concluded that spatial localization is innate for the chick and that the chick is unable to unlearn the innate localization of objects even when survival is at stake (Hess, 1956b).

These studies by Fantz and Hess suggest that the chick's ability to locate and respond to objects through the visual sense is an innately programmed ability. It also seems that at least some elements of the chick's visual perception development are irreversible.

<u>The visual cliff</u>. Forerunners of the kinds of testing done on the visual cliff date back at least to Thorndike. He had placed 95 hour-old chicks on platforms of varying heights and noted that the chicks almost always jumped off quickly from platforms placed 1 to 10 inches above the table, that they spent a long time in hesitation before jumping 22 inches and that they nearly always refused to jump from a height of 39 inches. He concluded that chicks discriminate depth through an innately acquired process (Thorndike, 1899). Tortoises were placed individually on platforms of various heights over a net by Yerkes (1904). Observing the interval of time elapsing between their being placed on

the platform and their falling into the net, he found that water species fall earliest, amphibious species next, and land species stay on the platform longer than the others. This sequence of species difference was maintained at each of the three platform heights Yerkes used (30, 90, and 180 cm. respectively). He concluded from his observations that vision plays a part in determining the responses and that the species differences reflect differences in the evolutionary importance of depth discrimination for animals who live in different environments. Waugh (1910) attached a horizontal disc to a rod which passed through a hole in a table. He placed mice individually on the disc arranged at various heights above the table and induced the mice to jump by means of mild electric shock. He found a positive correlation between the height of the disc and the time between shock and jump. Kurke's (1955) study, in which he placed chicks on a platform having adjustable heights, has been cited earlier in this chapter.

A fault in Thorndike's study is that he did not explain to what extent he controlled the visual experience of his subjects prior to testing. It is not known how much difference there had been in the visual and taxis experiences between types of tortoises before being tested in Yerkes' study. Waugh apparently did not control for the kinesthetic and aural sensory inputs afforded his mice during the ascent on the horizontal disc (Patterson, 1965, pp. 19-21). All these studies and especially Kurke's become less convincing in light of the fact that the response of jumping (or crawling) may be determined by other variables than perceived height.

> Difference in performance may reflect differences in depth discrimination, but it could also be the case that subjects who are equally able to discriminate depth will vary in performance because of different levels of motor achievement (Epstein, 1964, p. 118).

Thus, though all the studies above utilize a "cliff" effect, they bear a common defect in that their measurements confound visual with non-visual factors.

Aware of those difficulties and shortcomings, Gibson and Walk set about to find another method. Their method involved the use of the apparatus which they named the visual cliff, (Gibson and Walk, 1960). Some kind of artificial cliff seemed desirable from the start. The desired apparatus would be one which could be used in the laboratory and with which not only optical stimuli but also auditory and tactual stimuli could be controlled. The apparatus also had to be one in which the animals (and humans) would not be injured. Several versions of the visual cliff have been used for various special studies but the one with which most of the Gibson and Walk experiments at Cornell University were done was described as follows:

> It consists of a board laid across a large sheet of heavy glass which is supported a foot or more above the floor. On one side of the board a sheet of patterned material is placed flush against the undersurface of the glass, giving the glass the appearance as well as the substance of solidity. On the other side a sheet of the same material is laid upon the floor; this side of the board thus becomes the visual cliff (Gibson & Walk, 1960, p. 64).

With this instrument, Gibson and Walk observed the behavior of chicks, turtles, rats, lambs, kids, pigs, kittens, and dogs. Another version of the visual cliff was used at the Cornell Behavior Farm to study kids and goats. In this version, the "deep" surface of the cliff was a plywood sheet covered with the patterned material and capable of being lifted and dropped. When the animals were placed on the glass while the platform was flush against the undersurface of the glass, the animals moved about freely. But when the optical floor was then dropped more than a foot below the glass, the animals "froze" into their characteristic defensive posture. Gibson and Walk then tried various changes in the design of the apparatus. For example, they tried various combinations of small and large pattern sizes (of the patterned material) and placed them at various combinations of depth beneath the glass. Thus they were able to reach some conclusions about the animal's response to texture and to motion parallax. When they covered both sides (deep and shallow) of the cliff with a homogeneous gray surface, rats showed no preference for either side of the cliff. Not only have they developed and refined the apparatus, they have done an enormous amount of experimenting with it. Yet they have raised at least as many questions as they have answered and the area is open for much investigation.

Drug Studies

In addition to the enormous amount of drug research carried on by the pharmacological and medical disciplines, there is a substantial amount of drug research reported in the psychological literature. Woodworth and Schlosberg (1938) cite some of the early psychological studies of the effects of drugs. Most of these were of the "brass instrument" variety of experiments. For example, they recount that Kraepelin (1883) studied the effects of alcohol on humans and reported that small doses will bring about a quicker reaction time for a short period followed by a long period of slowed reaction time. Kraepelin also found that large doses of alcohol bring on only the retarded phase of reaction time. Hollingsworth (1912) is cited as having found that large doses of caffein increase the speed of "disjunctive reactions" (reactions involving discrimination and choice) and Schilling (1921) reportedly found that caffein hastens motor responses such as rapid tapping but has little effect on actual reaction time. Woodworth and Schlosberg report one early study involving the use of drugs with animals: Richter's (1924) report on the effects of depressants and excitants on the behavior of animals in activity cages. A careful study following Kraepelin's was done by Straub (1938) in which he found that reaction time is slowed 10 percent when the alcohol content of the blood is .35 percent by volume; it is retarded by 24 percent when the alcohol level reaches 1.4 percent.

Morgan and Stellar (1950), in their book on Physiological Psychology, say no more about drug studies than a brief explanation of the use of insulin and Metrazol in shock therapy and the perfunctory paragraph on the effect of drugs:

> There are a good many studies of the effect of various drugs upon the intelligence and learning ability of animals and man. In general, although drugs like benzedrine and caffeine may speed up performance for a time, they do not produce any marked effects on intelligence-test scores of learning. Similarly, depressants like phenobarbital and alcohol in moderate doses may impair performance temporarily, but they do not have any particular effects on intelligent behavior (Morgan and Stellar, 1950, p. 535).

Very little (if any) research had been done on the effects of drugs on sheep until Baumgold's (1967) study on the effects of a variety of drugs on the development of visual depth perception in neonate lambs. In its use of the visual cliff to observe the development of visual depth perception, Baumgold's study directly followed those of Patterson (1965) and Lemmon and Patterson (1964) who studied the effects of mothering or lack of mothering on the development of depth perception. Little (1966) manipulated variables directly related to the ewe to show that the age at which the lamb develops depth perception is variable and functionally related to the degree of mothering experienced by the lamb.

Baumgold (1967) found 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" [p. 41].

He found that lambs administered Thorazine (a tranquilizer thought to be an autonomic suppressant of cerebral cortex activities) also showed criterion responses on the visual cliff significantly later than controls. Baumgold found that neither tranquilizers nor sedatives will bring about the reversal of the lamb's ability to discriminate depth once the animal has made the criterion response on the visual cliff. A group of lambs administered Ritalin, a stimulant, showed the criterion response on the visual cliff earlier than controls though the difference between the Ritalin and control groups was not statistically significant. A group of lambs administered Robaxin, a muscle relaxant, developed visual depth perception later than controls.

Following the reasoning of the experimenters whose studies had preceded his (Lemmon and Patterson, 1964; Patterson, 1965; Little, 1966), Baumgold (1967) reasoned that the various drugs he had administered would have either an enhancing or an impairing effect on the interaction between the lamb and its mother and that the quality and quantity of this interaction would have a direct bearing on the age at which the lamb will develop visual depth perception. Thus, for example, the administering of a tranquilizer to a neonate lamb will retard the process which includes nuzzling, nursing, and butting of the mother and may also retard the lamb's responding to the mother's licking, nuzzling, etc. It is postulated that the slowing of these mother-lamb processes then is directly related to the retarding of the developmental change in the lamb.

Special performance-enhancing drugs. There has been widespread recent interest in the United States in magnesium pemoline, a relatively new drug which, at first, seemed to have a positive effect on the development of intelligence and the acquiring of learning. Developed by Abbott Laboratories, magnesium pemoline is the generic name of the drug which is also identified by the trade name Cylert (Abbott 30400). The chemical description given by Abbott is "a combination of 2-imino-5-phenyl-4-oxazolidinone and magnesium hydroxide".

Observations of the effects of magnesium pemoline have been made on both rats and humans and these studies have given rise to several hypotheses regarding the exact organismic effects of the drug. Plotnikoff (1966), studying the drug's effect on conditioned avoidance performance in rats, has postulated that magnesium pemoline's apparent enhancement of learning and memory may be explained in terms of possible changes in anxiety or alertness levels (or both) in animals. Plotnikoff's results were not supported by Cyert, Moyer, & Chapman (1967) who observed that neither the rate of learning nor the rate of extinction in rats was significantly affected by the administration of magnesium pemoline. However, the apparently conflicting results of these two studies may be accounted for by the fact that the experiments differed both in amounts of electric shock administered to the animals and in the topographical structures of the apparatuses employed. Glasky & Simon (1966) demonstrated that magnesium pemoline causes activation of the nuclear aggregate enzymes responsible for RNA synthesis although their data do not give a basis for determining how this activation comes about nor for determining whether a causal relationship exists between learning and RNA synthesis. Beach & Kimble (1967) reported that rats injected with magnesium pemoline had shorter latencies in responding to shock than did control animals. They observed in subsequent studies that drugged rats showed less decrease in activity level and more sustained responsiveness to the sound of a buzzer than did controls. They feel that this may account for the latency differences they observed in the avoidance task. Frey & Polidora (1966) reported that the acquisition of learning an avoidance response by rats was generally accelerated by the administration of magnesium pemoline. However, they recognized that some rats in experimental situations adopt a motionless, rigid posture and refuse to leave the chamber of the apparatus in avoidance type experiments. In an effort to control for the "freezing" behavior which slows the learning process, Frey & Polidora used diverse levels of electric shock. They thus recognize that their observed rates of acquisition of the avoidance response were affected not only by the magnesium pemoline but also by the shock levels and by the interaction between the two conditions. Frey & Polidora advanced three hypotheses as possible explanations for the apparent affect of magnesium pemoline on the enhancement of learning, pointing out that further behavioral testing may clarify their views. Their hypotheses are: (i) that learning may be facilitated by the increased motor activity resulting from the drug's stimulation of the central nervous system, (ii) that the drug may make rats more reactive to electric shock which would have the same effect as increasing the effective shock intensity, and (iii) that the action of magnesium pemoline upon some general learning mechanism by means of its action on biochemical systems which synthesize nucleic acids may account for the facilitative effect. Studies of the effects of magnesium pemoline on human subjects (Talland, 1966; Burns, House, Fensch, & Miller, 1967; Smith, 1967) have not given consistent results but seem to suggest that sustained attention and accuracy of performance are facilitated by the drug but learning and memory are not.

A second substance, thyroxine, has been shown to accelerate learning and to hasten several kinds of early development in rats. Thyroxine in strict terminology is not a drug because, although it can be chemically synthesized, it is the hormone produced by the thyroid glands. Eayrs & Levine (1963) found that a conditioned avoidance response in rats was impaired by thyroidectomy. Many additional studies support the general observation of retardation with impaired learning accompanying lowered amounts of thyroxine in the organism (Whalen, 1967, pp. 8, 17, 18, 188, 247). Levine & Mullins (1966) have written:

> The number of studies dealing with early thyroid deficiency or excess has been growing. Absence of thyroid hormone in the developing organism has significant consequences for more physiological and behavioral functions than does the absence of androgen. ...Opening of the eyes and vagina is retarded, and maturation of many reflex behaviors, such as the righting response, is delayed. In the central nervous system, myelination is retarded, and there is less-than-normal branching and connecting of cell processes in the cortex [p. 1587].

Observing these known effects of thyroxine deficit, Schapiro & Norman (1966) also note that injections of thyroxine in the neonate rat will accelerate the deposition of brain cholesterol, advance the age of eye opening, and increase spontaneous locomotor activity. They also note that "Thyroxine added to an *in vitro* cerebellum from a newborn rat or mouse has been shown to accelerate myelinogenesis".

Starting from those observations, Schapiro & Norman (1966) performed an experiment in which they demonstrated

> that administration of thyroxine to the newborn rat will: (i) accelerate the maturation of the pituitary adrenal response to stress, (ii) accelerate the development of the electroencephalogram and advance the age at which the rat will respond behaviorally and neurophysiologically to acute environmental stimuli, and (iii) increase the ability of the infant rat to learn a conditioned-avoidance response [p. 1279].

Hormones and Emotion

W. B. Cannon, as early as 1915, suggested that adrenaline is secreted into the system when external stimuli produce fear and rage in the organism (Cannon, 1915). Since that time, an enormous amount of literature has appeared on the subject of hormones and their relationship to behavior but the exact and specific nature of the relationship is complex and difficult to unravel. The authors of a recent review article on the subject cited over one hundred "representative" studies but summarized the findings by writing:

> The interactions between environmental determinants of affect, various physiological factors, and the complexity of physiological determinants, including cognitive factors derived from the individual's remote and immediate past experiences, have received only limited study under adequately controlled conditions. It may be anticipated, however, that this will prove to be a particularly fruitful area for future research, for only within such a multifactorial framework may one expect to understand fully the relationship of the biogenic amines to emotional state (Schildkraut & Kety, 1967, p. 30).

However, very recent technical developments have apparently brought about means by which valid inferences about emotions can be made through hormonal measures.

The circularity of the hormonal-emotional interaction is apparently often overlooked. Whalen (1967, p. iii) points out that current texts on physiology and introductory endocrinology usually note that hormones influence behavior but fail to consider the important influence that behavior has in determining the secretion of hormones. Christian and Davis (1964) relate an important sequence of events (of which the Cannon-Bard Theory is probably a forerunner) which controls animal populations. Their experimental evidence shows:

> . . . that populations are limited because, as size increases, social and particularly aggressive interactions between individuals increase in frequency. These social interactions cause changes in the secretory patterns of adrenal and gonadal hormones, and these changes reduce mating and reproduction and increase the animal's susceptibility to disease (Whalen, 1967, pp. 11-12).

Thus Whalen has defined a tripartite sequence consisting of stimulation followed by endocrinal changes leading to both physiological and behavioral changes.

Relative systemic levels of adrenocortical hormones can now be accurately measured by means of either chromatography (Bush, 1961;

Gasztonyi, Marton, Keming & Vecsei, 1963) or fluorometric methods (Rudd, Samson, & Brook, 1963). Studies involving hormonal measures have been done with many different animals including the horse (Zolovick, Upson, & Eleftheriou, 1965), the dog (Metzler, Eleftheriou, & Fox, 1966), the rat (Levine, Haltmeyer, Karas, & Denenberg, 1967), and the catfish (Boehlke, Church, Tiemeier, & Eleftheriou, 1966). Changes in hormone levels have been measured both in connection with organismic functions such as diurnal rhythms and estrous cycles and as a function of exogenous stimuli. A recent experiment (Haltmeyer, Denenberg, Thatcher, & Zarrow, 1966) suggested the important conclusion:

> These results clearly indicate that severe stress can elicit an adreno-cortical response in the neonatal rat shortly after birth [p. 1373].

It is important that we learn whether hormonal responses can be seen in very young animals (others as well as rats) because these early responses may have a bearing on the ability of the animal to survive. Emotional behavior, according to Schneirla (1959), seems to have something to do with the animal's approach and withdrawal to and from the environment. The ability to appropriately approach or withdraw would seem more important to the survival of the precocial animals than to others though it may be a crucial issue in the early lives of all organisms. In particular, the visceral component of emotional behavior is less well understood than the others (environmental and behavioral components) because it has been more difficult to observe and measure (Mandler, 1962).

The mere measuring of hormonal levels would obviously have no value unless we can substantiate the inferences we choose to make from such measurements. Funkenstein (1955) was able to make well supported inferences in terms of hormonal differences associated with anger in humans. Through physiological measures, he was able to identify and differentiate between persons whose anger was directed outward and those who experienced anger directed inward. Bronson and Eleftheriou (1965a) found that the secretion of ACTH and adrenal corticoids is increased in mice when they engage in fighting. However, they were not, at that time, able to determine whether the hormonal increase was directly related to physical injuries received by the mice, the experience of fear, or the increased activity and expenditure of energy. In a later study (Bronson & Eleftheriou, 1965b), they found that the adrenal hormones are increased in response to the presence of dominant animals even if no fighting (with its injuries and increased activity) takes place.

> This finding is particularly interesting because it shows that the meaning of stimuli, in this case the threat of aggression, can cause the secretion of hormones (Whalen, 1967, p. 12).

Further, Levine, Haltmeyer, Karas & Denenberg (1967) found a closely correlated relationship between corticosterone level and other measures of emotion such as field activity and amount of defecation in mice. They also found changes in the corticosterone levels parallel to their expectations regarding emotional response to the length of time the animals spent in confinement and time in the open field. Thus, the studies related to this paragraph represent a substantial literature indicating that emotional responses such as fear and anger can be observed by means of measuring systemic levels of adrenocortical hormones.

One final consideration to be taken into account in regard to endocrine activity is that it, like all organic processes, changes in terms of critical periods.

and developmental stages. It has long been believed that gonadal hormones in mammals are secreted according to an almost unvarying developmental sequence. Eayrs (1961) found that depriving newborn rats of thyroid hormone will have profound and permanent effects on the animal when it reaches adulthood. The effect is similar to cretinism in humans, a condition characterized by hypothyroidism during infancy in association with reduced intellectual development later in life. However, Eayrs has shown that no permanent reduction in learning ability occurs in rats when they are initially deprived of the thyroid hormone at the age of twenty-five days or older. Following this study, Levine and Mullins (1966) have shown that the effects of early thyroidectomy in rats can be partially or wholly reversed if thyroxine "replacement" is begun within a certain critical period after thyroidectomy (15 days). However, the effects of hypothyroidism are irreversible if the thyroid replacement is begun after the critical period has passed. Inconsistent findings appeared when Schapiro, Geller and Eiduson (1962) reported that the two-day-old rat is not hormonally responsive to stress and Zarrow, Haltmeyer, Denenberg and Thatcher (1966) did find response at that age. However, the later and more detailed work of Zarrow et al. allowed them to conclude that corticosterone levels in the two-day-old rat will rise in response to heat stimulation but not to electric shock although the corticosterone levels in the nine-day-old animal will increase in response to both heat and shock. This finding not only explained the inconsistency (the experimental methods in the two studies had been different) but also made it clear that certain hormonal responses to stimuli and certain hormonal influences on the organism first appear at specific critical stages after the animal's birth.

Summary

A review of literature has shown that developmental stages follow an apparently innately determined sequence. It is suggested that these developmental stages may unfold during critical periods analogous with the critical periods associated with imprinting. If this were true, organisms would be found to develop according to an innately determined sequence of critical periods. The development of visual depth perception is apparently subject to these postulated principles of critical periodicity. Many different species of animals as well as humans are similar and consistent in many developmental respects including the discrete sequences involved in developing visual depth perception.

Certain drugs have been shown to have retarding or accelerating effects on development. Both magnesium pemoline and thyroxine have been shown to bring about acceleration of some development and learning though the nature of the changes involved in administration of the drugs is not as yet clearly understood.

Recently, techniques have been developed which afford the measurement of emotional changes by means of determining relative amounts of adrenocortical steroids in the blood.

This study is focused on the problem of the determination of the effects of magnesium pemoline and thyroxine on the developing organism and searching for physiological and behavioral concomitants of developmental changes which may give clearer insight into the nature of those changes.

CHAPTER II

PROBLEM

The literature reviewed in the preceding chapter supports the notion that differential treatments, including the administration of drugs to the neonate animal may have dramatic and enduring consequences on the animal's later life. The development of visual depth perception, as observed on the visual cliff, can apparently be made to occur somewhat earlier or later in the animal's early life as a function of treatments administered to the neonate. Inferences about the occurence of emotionality in the young animal have been made from measures of hormonal changes in the animal's blood.

Many well known psychoactive pharmacological agents have had widespread use in the study of their effects on behavior. In particular, dramatic changes in the age at which newborn lambs will exhibit avoidance behavior on the visual cliff were induced by the administration of tranquilizers, sedatives, stimulants, and muscle relaxants by Baumgold (1967).

Visual depth perception in lambs seemsto be characterized by a relatively sudden onset, presumably at a critical period in the animal's life. This timing may be crucially important for the animal's survival and may be related to the critical period for imprinting observed by ethologists.

In many studies involving both humans and rats, learning and performance have apparently been facilitated by the administration of the newly developed drug, magnesium pemoline. However, there is lack of agreement among workers with this drug as to its specific effects on the organism. Writers have variously postulated that the drug's observed effects are the results of increased anxiety or alertness levels, increased RNA synthesis in the organism, increased motor activity, increased sensitivity to stimuli such as shock, or changes in the animal's biochemical system.

Since the development of visual depth perception comes about in the absence of external reward or reinforcement and since visual depth perception does not extinguish, it can be assumed that it is not a learned acquisition. However, visual depth perception has been observed to occur earlier as an apparent function of increased mother-neonate interaction. If then, magnesium pemoline administration can be observed to facilitate the acquisition of visual depth perception some generalizations can be made in terms of either an increase in early activity level or an increase in sensitivity of the young animal to its mother. The first hypothesis then is:

> Hypothesis 1. Lambs administered magnesium pemoline immediately after birth will avoid a visual cliff at a significantly earlier age than will control subjects.

Some of the specific physiological effects of the administration of thyroxine to neonate rats and mice are known. These include: acceleration of eye and vagina opening, increased spontaneous locomotor activity, and acceleration of the deposition of brain cholesterol and of subsequent myelinogenesis. Assuming that lambs would be similarly affected by throxine, it is reasonable to postulate that the administration of thyroxine would hasten the development of visual depth perception. Therefore, the second hypothesis dealt with that probability:

> Hypothesis 2. Lambs administered thyroxine immediately after birth will avoid the visual cliff significantly earlier in life than will control subjects.

Both Hess and Scott hold that the phenomenon of imprinting is associated with a critical period and that the critical period ends with the onset of fear. Because of its apparent involvement with a critical period, it seems quite possible that the visual cliff phenomenon represents, in part, an analog of the imprinting phenomenon. If neonate lambs were threatened with a visual drop both before and after they had developed visual depth perception, it might be expected that their adrenocortical hormone levels associated with fear would be higher after the manifestation of visual depth perception than before. In the first chapter, many studies were cited in which plasma steriod measures have been used to make inferences about emotionality and the effects of stress on various animals. The majority of these studies involved the fluorometric assays of plasma corticosterone in rats. In lambs hydrocortisone is more abundant, hence more easily measured, than corticosterone. Since hydrocortisone and corticosterone are of the same class of adrenocortical steriods, it might be expected that the rise and fall of their levels associated with other psychological and physiological phenomena would be similar. It was thus postulated:

> Hypothesis 3. Lambs will have relatively higher levels of steriod hydrocortisone after displaying avoidance of the visual cliff than before.

Stated formally, the aim of the present research project was to determine if the administration of magnesium pemoline or thyroxine to newborn lambs will have a marked effect on the subsequent developmental growth of the animal. A second aim of the project was to evaluate the role of emotionality as it relates to the acquiring of developmental changes.

CHAPTER III

METHOD

Description of Subjects

Subjects for the present study were 49 lambs born into a flock of registered Suffolk ewes which had been bred to the same single registered Suffolk ram. There were 23 male and 26 female subjects. Among the 49 births, there were 30 single births, 8 sets of twins, and a set of triplets. The ram was kept separated from the ewes until the first of November and the subjects were all born during the period from March 26 through April 11, 1967. Two lambs were born earlier and five later than this period but these were not used as subjects in the present experiment. Three lambs born within the named period were not used as subjects; two because they were born with physiological anomalies and one because of an accident regarding the experimental procedure which would have caused data from that animal to have been spurious.

Births occurred with about equal frequency with respect to clock hours. For example, 14 births occurred between midnight and 6:00 a. m., 13 between 6:00 a. m. and noon, another 13 between noon and 6:00 p. m. and 9 lambs were born between 6:00 p. m. and midnight. Hersher, Richmond, & Moore (1963) had also found that sheep have no tendency to deliver their young at any particular time of day. These findings are also consistent with those of Little (1966) who noted that 20 of 43 subjects were born between 8:00 a. m. and 4:00 p. m. and with those of Baumgold (1967) who found that 17 of 41 subjects were born between 8:00 a. m. and 4:00 p. m.

Treatment of Subjects

From the time the ram was put into the flock and until about one week before lambing began, the flock was kept in a large open pasture. During this period, supplemental feeding in the form of a standard feed-meal was given the flock daily. On alternate days, the feed-meal was mixed with Trolene FM (Dow Chemical Company), a vermifuge containing the anthelmintic agent ronnel, one of the class of organophosphates.

During the lambing season, the flock was kept in a fenced enclosure bounding approximately 675 square yards. The flock was observed continuously "around the clock" during all the days of the lambing season. The characteristic behavior of the ewe nearing her time of delivery is clearly described by Pearce (1967):

> The first sign that parturition is near occurs when the ewe withdraws or isolates herself from the rest of the flock. She typically locates herself on the outer perimeter of the flock, lies down, and remains in this location until parturition. ...As parturition nears, the ewe's head typically droops and she remains in a prostrate position . . . With the passage of time the ewe becomes increasingly more active physically, particularly with the onset of labor contractions. A yellowish-brown bag extrudes from the ewe's vagina shortly before birth and when the bag bursts the ewe frequently rises to her feet and sniffs the ground where the contents of the bag are spilled.
>
> Shortly before giving birth, when the labor contractions are most intense, the ewe points her nose upward in conjunction with each contraction, wrinkles her nose, and emits a very shrill bleating sound apparently in response to the pain involved in this process [pp. 26-27].

When, by observation of the behavior described by Pearce, delivery seemed imminent, the ewe was confined in a small pen measuring approximately 4 feet by 8 feet. When the lamb was born, it was immediately taken from the ewe, given standard treatments as described in the next paragraph, and returned to the ewe in the pen. As much uniformity as possible was maintained in terms of quantity and quality of mothering among the subjects.

As soon as the lamb was completely out of the birth canal, it was taken to the laboratory. It was rubbed with a burlap cloth; starting at the snout and head and working along the entire body to the anal area. The anus was massaged for about 30 seconds with the bare hand coated with mineral oil. This rubbing and massaging simulate the mother's characteristic pattern of licking the infant. It is believed that the mother's licking (and the laboratory treatment described) serve not only the purpose of cleaning and drying the newborn lamb but are also important in getting the process of elimination (of both urine and feces) started. Following this, the lamb was weighed and its temperature taken with an anal thermometer. The umbilicus was trimmed and painted with iodine to prevent infection and the lamb was given an identification collar.

Three ounces of colostrum taken from the lamb's mother or another newly lactating ewe were given the lamb in a nippled bottle as soon as (but not before) the lamb was able to stand on its feet. Denying the lamb any nourishment until it is able to stand is consistent with the treatment the lambs would receive from their own ewe-mothers (Patterson, 1965, p. 34). After the colostrum feeding, the lambs were given an intraperitoneal injection of either magnesium pemoline, thyroxine, or tragacanth (in the case of the control animals). Within 15 minutes after the drug injection, the wool was shaved from the middle joint of one of the hind legs and a blood sample drawn from the long saphenous vein. The lamb was then returned to its mother; both mother and lamb remained in the isolation pen for the duration of their participation in the experiment.

Subjects were assigned by sequence of birth to one of three groups: a magnesium pemoline group, a thyroxine group, or a control group. It was intended that, near the end of the lambing period, group assigning would be altered to get an equal number of males and females in each group. However, this adjustment was not needed because equal numbers of males and females (within one lamb) were found to have been placed in each group by the original sequential selection. However, an exception was made to the group placement routine in the case of double and triple births. Following the practice of Baumgold (1967), siblings in sets of twins and triplets were assigned to the same group. Baumgold explained the rationale for this method of assignment:

> This was done in order to minimize 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, & Moore, 1963; Blauvelt, 1959). 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 [p. 34].

Experimental Design

During the experiment, the experimental day was divided into segments of four hours each beginning at 8:00 a. m., noon, 4:00 p. m., 8:00 p. m., midnight, and 4:00 a. m. respectively. When born, each lamb was given its assigned treatment as described in the preceding section and then tested on the visual cliff at the next occurring time period. Each lamb was then tested on the visual cliff at every succeeding time period until that lamb exhibited the criterion avoidance response. Following the criterion response, a second blood sample was immediately taken from the lamb. The lamb and its mother were then returned to the flock in the pasture. Between visual cliff tests, the lambs were kept with their mothers in the small pens.

The Visual Cliff

The visual cliff apparatus used in this study was the same as that used by Little (1966) and Baumgold (1967). The outer structure of the apparatus was essentially a large box measuring 73 1/2 inches high by 46 inches long by 31 inches wide. The large surfaces of the enclosure were made of 3/4 inch plywood with an outer reinforcing structure of 2" by 4" wooden stock. All inner and outer surfaces were painted with flat black enamel to minimize stray light and glare. Little described the apparatus thus:

> 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 a (sic) red and white 1 1/2" checkerboard cotton material which dropped from the front edge of the platform perpendicular to the bottom of the apparatus. From that point it was flush on the bottom to the end opposite the platform. The platform was lighted from beneath by two vending machine 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).

Lambs were lowered through the hatch in the top of the apparatus onto the "platform" section of the glass plate. Ordinarily, neonate lambs will initially move about freely on the glass plate over the visual cliff, exploring the walls of the enclosure with no observable regard for the apparent drop beneath them. At the time of avoidance response the lambs, when placed on the glass, refuse to move beyond the edge of the platform and they exhibit a characteristic "back-pedalling" motion with stiff forelegs and curved hind legs in an apparent effort to move farther from the edge of the cliff. When a lamb remained on the platform for three minutes without placing either of its front hooves beyond the edge of the apparent drop, it was considered that the criterion avoidance response had been attained.

The age at which the criterion response was first elicited was recorded in terms of number of trials to criterion. This was the measurement used as part of the data for this study.

Drugs

Abbott Laboratories, North Chicago, Illinois, who manufacture magnesium pemoline (also identified as Cylert and Abbott 30400) supplied literature on dosages they had found effective in rats, guinea pigs and humans. In all cases, they had found doses as low as 10 mg/kg of body weight to be effective. However, since they also reported that triple that amount had produced negligible toxicity in rats and since it had been reported by Baumgold (1967) that lambs do not respond to some drugs as readily as do rats, it was decided to use an experimental dose of 15 mg/kg of body weight in this study.

The dosage used by Schapiro and Norman (1966) was adopted for the thyroxine group of this study. Thus the lambs in the thyroxine group received the prepared drug at 1 µg/gram of body weight.

Both drugs were prepared in a tragacanth suspension because magnesium pemoline does not maintain suspension readily in water. The control animals in this study were injected with 1 cc of tragacanth per three pounds of body weight. (This is the same volume to body-weight ratio used with both drug dosages.) All injections were done intraperitonially with 10cc syringes and #20 x 1 1/2" needles.

Blood Processing Procedure

All blood samples consisted of 5 ml of blood drawn from the long saphenous vein at the second joint of the hind leg. The samples were drawn with #20 x 1 1/2" needles which, as well as the 10cc syringes, had been rinsed with heparin. The blood samples were expressed into centrifuge tubes that had been standing in beakers of water and cracked ice. The centrifuge tubes containing the blood were kept in the icewater for five minutes. The samples were then put into a centrifuge and spun for 15 minutes at 2,500 RPM. The clear plasma was then drawn from the centrifuge tubes with a pipette. The serum was expressed from the pipette into 5cc glass vials which were placed in a beaker of acetone and finely chipped dry ice. This froze in the vials almost instantaneously. The vials were labelled, placed in wire racks, and set in a freezer which kept them at a temperature of zero degrees fahrenheit.

The Fluorometric Assay

The fluorometric assay for plasma hydrocortisone was accomplished by Dr. B. E. Eleftheriou and his assistants, R. L. Norton and M. L. Pattison in the laboratories of the Department of Endocrinology at Kansas State University, Manhattan, Kansas. The plasma samples were transported to Dr. Eleftheriou's laboratory by automobile in styrofoam soft drink coolers packed with finely cracked dry ice. The assay was accomplished with the process described by Rudd (1963).

1. Pipette one ml plasma into a 15 ml centrifuge tube. Add 0.1 ml of 0.25 N NaOH and 5.0 ml of methylene chloride and shake gently for 15 sec. Centrifuge 5 min. at 1500 g.

2. Remove top layer, transfer 4.0 ml of bottom layer to a clean centrifuge tube and evaporate under Nitrogen.

3. Add 0.5 ml EtOH and mix; and 1.5 ml H^2O and remix.

4. Extract aqueous phase 2x with 10 ml carbon tetrachloride and discard the lower CCl4 layer. Centrifuge at 1500 g for 5 min.

5. Transfer 1.5 ml of the aqueous phase to a 15 ml centrifuge tube. Add 7.5 ml methylene chloride and shake for 15 sec. Centrifuge for 5 min. at 1500 g.

6. Transfer 5 ml of the methylene chloride to a clean 15 ml centrifuge tube. Add 1 ml of ethanolic-sulphuric acid (reagent added) and shake for 15 sec.

7. Let the extract stand for 1-2 min. to allow separation. The upper methylene chloride layer is removed by suction.

8. Transfer to cuvetts and read in fluorometer.

Samples were read at least twice (on different occasions) to assure accuracy of the fluorometric readings. The readings (which ranged from 0.3 to 5.0) were then used to calculate a standard curve by means of a least-squares regression line. The standard curve then was used to translate the fluorometric readings into μg hydrocortisone per ml plasma.

CHAPTER IV

RESULTS

The first hypothesis tested was that lambs administered magnesium pemoline will exhibit avoidance behavior on the visual cliff earlier in life than will control lambs. Each lamb was placed on the visual cliff apparatus at the next scheduled testing period following its birth and all lambs were tested every four hours from that time until the criterion avoidance response was seen. The means and standard deviations based on numbers of trials required by the lambs before exhibiting the criterion response are shown for all groups in Table 1. The variances in terms of numbers of trials to criterion for both drug groups and for the control group were tested by the Cochran method described in Winer (1962, p. 94). Using the three treatment groups ($k = 3$) and with 19 degrees of freedom, a C of .417 was obtained indicating the variances to be homogeneous. Though the data were based on equal intervals of clock hours, it was felt that these intervals cannot be said to represent equal periods of development in the animal. Put differently, it cannot be assumed that the animal changes the same amount from the 4th to the 8th hours of life as it did from birth to the 4th hour of life. Therefore, the obtained data for this measure are not based on an equal-interval-scale and do not represent a normal distribution. For these reasons, the data were processed by nonparametric methods. A Kruskal-Wallis analysis of variance (Siegel, 1956, pp. 184-94)

TABLE 1

MEANS AND STANDARD DEVIATIONS BASED ON NUMBERS OF TRIALS REQUIRED BY THE LAMBS BEFORE EXHIBITING THE CRITERION RESPONSE ON THE VISUAL CLIFF

(N = number of lambs per group)

Group	N	Mean	σ
Mag Pem	20	5.65	4.31
Thyroxine	12	9.25	5.45
Control	17	8.00	4.79

TABLE 2

MEANS AND STANDARD DEVIATION OF MICROGRAMS HYDROCORTISONE PER ml OF BLOOD PLASMA FOR EACH DRUG GROUP UNDER THE TWO EXPERIMENTAL CONDITIONS

(N = number of lambs in each group)

Group	N	Before Avoidance	After Avoidance	σ
Mag Pem	12	1.90	0.85	3.53
Thyroxine	12	2.05	1.06	5.59
Control	14	0.83	1.86	2.68

was used to test for significance of variance differences between groups. With this method, at two degrees of freedom, a chi square value of 6.85 was obtained which indicates differences of variance with a probability of less than .05 alpha error (two tailed). Following this, the Mann-Whitney-U Test (Siegel, 1956, pp. 116-127) was used to determine whether there was a significant difference between trials to criterion for the magnesium pemoline group and the control group. With this method, at 17 and 20 degrees of freedom, a U of 101.0 was obtained which shows a difference in the predicted direction at the .025 level of significance (one tailed). Thus the first hypothesis was supported, the group of lambs administered magnesium pemoline required fewer trials (5.65) to criterion than did the lambs in the control group (8.00).

The second hypothesis was that lambs administered thyroxine would exhibit the criterion avoidance response on the visual cliff in <u>fewer</u> trials than control subjects. Table 1 shows that the mean number of trials to criterion is <u>larger</u> for the thyroxine group (9.25) than for the control group (8.00). Using the Mann-Whitney-U Test, with 12 and 17 degrees of freedom, a non-significant U of 90.5 was obtained. This U score indicates that the difference in means between these two groups is not significant. Thus the second hypothesis was not supported, the difference in means between the thyroxine and control groups was in a direction opposed to the predicted one though the difference is not at a significant level.

The third hypothesis was that lambs would have a higher relative level of hydrocortisone in the blood plasma after they had exhibited the criterion avoidance response on the visual cliff than before they had exhibited the avoidance response. Table 2 shows the means and standard deviations in micrograms of hydrocortisone per ml of blood plasma for each drug group under the two experimental conditions (before and after criterion response). The data for this part of the experiment were obtained by converting readings from the fluorometer to micrograms of hydrocortisone by means of a least squares regression curve. Since these data may be considered to represent an equal-interval-scale and since they were taken from correlated (before and after) samples, the t ("Student's") statistic (Winer , 1962, pp. 31-32) was used for determining levels of significance. Using this statistic with the two experimental conditions for the control group, with 12 degrees of freedom, a t-score of 1.62 was obtained which indicates a difference in means in the predicted direction at the .05 level of significance (one tailed). The same statistic applied to the two experimental conditions for the magnesium pemoline group rendered, with 10 degrees of freedom, a t-score of .38 which is not significant. Applied to the two experimental conditions for the thyroxine group, the statistic, with 9 degrees of freedom, gave a t-score of .15 which also indicates the difference to be below a significant level. Thus the third hypothesis was partially supported in that the lambs in the <u>control group</u> had significantly more hydrocortisone in the blood after exhibiting the avoidance response than before. However, the lambs in both drug groups did not have significantly different levels of hydrocortisone in their blood after exhibiting the criterion response. From Table 2 it may be seen that the means of micrograms of hydrocortisone were lower for both drug groups after the display of the avoidance response than before, which is contrary to the prediction made. However, the very large variances among the drug group blood samples caused the statistical treatment to give results below significant levels.

Further consideration of the data in Table 2 shows that the mean level of hydrocortisone was considerably higher in both drug groups than in the control group before the criterion response was observed. The blood samples from which these data were taken were drawn from the lamb during its first hour of life and within 15 minutes after the administration of either the drug or tragacanth. A Kruskal-Wallis analysis of variance was done on the hydrocortisone level data from samples taken before criterion response for each group. With this statistic from these data, at two degrees of freedom, a chi square value of .42 was obtained. This is below significant levels. Table 2 also shows that the mean levels of hydrocortisone were lower for both drug groups than for controls in the samples taken after the lambs had exhibited the criterion response. A Kruskall-Wallis analysis of variance of the levels of hydrocortisone from samples drawn after the criterion reponse for the drug and the control groups gave, with two degrees of freedom, a chi square value of .83 which is also lower than significant levels. Though significance was not obtained in the statistical processing of the steroid data across drug groups for the two experimental treatments, the data suggest the strong possibility of interaction between drugs and the age variable. It appears that the administration of both drugs was followed within minutes by an increase in the hydrocortisone level in the blood. It is possible that both magnesium pemoline and thyroxine brought about the effect of changing the endocrine balance in the lambs. If this were the case, it is possible that the homeostatic mechanisms of the endocrine system brought about the lowered level of hydrocortisone found in the drug groups after they had displayed the criterion visual cliff response. If these endocrine changes had an effect on the time at which the lambs showed the criterion cliff response, magnesium pemoline apparently hastened the onset of visual depth perception but thyroxine apparently did not.

Table 3 shows the mean number of hours from birth to avoidance of the visual cliff for all lambs not administered drug or experimental treatment in the studies of Patterson (1965), Little (1966), Baumgold (1967) and for the control group in the present study. As nearly as possible, the lambs and their mothers involved with these data were treated alike in all respects. The mean number of hours to criterion is considerably greater for the present study than for any of the other three studies. It may be that there is a trend toward increase of the mean in each succeeding year.

Table 4 shows the percent of births that involved multiple deliveries for the lambing season of each of the studies cited in the above paragraph. Though the lambing for the present study was the only one in which triplets were born, there was a smaller percentage of multiple births during the lambing for the present study than for any of the others in this series.

TABLE 3

MEAN NUMBER OF HOURS TO CRITERION RESPONSE FOR CONTROL GROUPS OF THE FOUR STUDIES IN THIS SERIES

Study	Number in Group	Mean number of Hours
Patterson (1965)	26	4.77
Little (1966)	5	5.80
Baumgold (1967)	11	7.08
Skinner (1968)	17	32.00

TABLE 4

PERCENTAGE OF BIRTHS INVOLVING MULTIPLE DELIVERIES IN THE FOUR STUDIES IN THIS SERIES

Study	Total Births	Births Involving Twins or Triplets	Percent of Multiple Births
Patterson (1965)	55	27	49
Little (1966)	43	18	42
Baumgold (1967)	41	20	49
Skinner (1968)	49	19	39

CHAPTER V

DISCUSSION

Some of the results of this study lend support to previous findings, particularly those showing that drugs can alter the time of occurance of critical periods and those postulating a relationship between critical periods and emotion. In a specific sense however this study was not a replication of any known experiments and its results are therefore generalizable to some new inferences. Perhaps this study's greatest value lies not in what ideas it did or did not support but in the great number of questions that arise from observations of phenomena among the data -- phenomena that were not expected nor planned for in the original design. Certainly, the study raises more questions than it answers.

Effects of Drugs on the Subjects

As mentioned earlier, Baumgold's (1967) study may be the only one predating this study in which the effects of drugs were observed on lambs. Berger (1957) and Ross & Carr (1962) have been cited by Baumgold (1967, p. 39) as indicating that species differ considerably in the amounts of drugs they require for the production of specific effects. Also, the blood chemistry differs from species to species. This is demonstrated by the fact that the major (most plentiful) plasma glucocorticosteroid is cortisol in the horse (Zolovick, Upson, &

Eleftheriou, 1965), cortisone in the catfish (Boehlke, Church, Tiemeier, & Eleftheriou, 1965), and corticosterone in the rat (Haltmeyer, Denenberg, Thatcher, & Zarrow, 1966). Thus it is again pointed out that generalization of the behavior of one species cannot be made beyond that particular species until the same behavior is observed in a great number of species. To that end, it is hoped that this study will join that of Baumgold in expanding the generalization of several notions growing from the vast research done with rats, particularly in terms of drug effects (as well as visual perception phenomena).

Data from the subjects administered magnesium pemoline.

The first hypothesis of this study was supported, showing that lambs administered magnesium pemoline reach a certain critical period earlier than lambs who have not received the drug -- a critical period during which visual depth perception apparently begins to serve the animal in alerting it to the danger of heights. Most of the previous studies involving the use of magnesium pemoline with animals and humans were cited in the first chapter of this work. The majority of studies involving magnesium pemoline have shown that learning or performance of one kind or another is improved by the drug. However, the physiological or neurological means by which the drug makes its improvement in behavior have been a matter of controversy and speculation.

Plotnikoff (1966) postulated that magnesium pemoline may enhance learning and memory by causing an increment in either the levels of anxiety or the level of alertness experienced by the animal during a performance situation. His experiment, using rats as subjects, involved both an acquisition task and a memory task. His rats were placed in a box in which they were given electric shock through a grid floor. He measured the time required for them to learn to jump out of the box to avoid the noxious stimulus and again measured the time required for them to leave the box 24 hours later when no shock was applied. The rats administered magnesium pemoline in Plotnikoff's study learned the initial response and retained the learning better than control animals. Thus he had observed positive results with the drug on both a learning and a memory task.

Glasky & Simon (1966) may have shed more light on the nature of magnesium pemoline's effect on the organism. By means of brain tissue assays, they found that rats administered the drug had much higher levels of brain nucleic acid than did controls. They also found that magnesium pemoline brings about the synthesis of the RNA polymerase in brain tissue in vitro. The finding that magnesium pemoline brings about an increase in RNA levels is important because RNA is thought to bring about protein molecules essential to the process of memory.

Beach & Kimble (1967) took a different approach and found that rats administered magnesium pemoline have a shorter latency in responding to shock than controls. They also found that magnesium pemoline apparently facilitates activity levels and prolongs the activity rats display in response to a buzzer. Thus, they have apparently demonstrated that rats are more alert and more responsive when given the drug.

Frey & Polidora (1966) did a study similar to Plotnikoff's in that the observed response was the avoidance of an electric shock. They recognized the possibility that magnesium pemoline's enhancement of this task might be accounted for in terms of the drug's producing an increased sensitivity to the shock. That is, the effect of the drug would be the same as increasing the amount of electric current to which the animals were exposed.

In the present study, the dependent variable associated with magnesium pemoline was the time to development of visual depth perception -- a phenomenon that presumably is not involved with either learning or memory. This does not seem to rule out any of the hypothetical effects of magnesium pemoline postulated with the previous studies. The developmental change observed seems unrelated to Frey's & Polidora's notion that the drug may increase the animal's sensitivity to electric current. However, there is no ground on which observations from the present study could take credence from the hypothesis of Frey & Polidora.

In each of the studies in the series that led to the present study, the early experience of the lamb was found to have essential bearing on the age at which the criterion response was exhibited on the visual cliff. Patterson (1965) concluded that the mother-neonate interaction led to early avoidance of the cliff and that lambs deprived of their mothers avoided the cliff at a later age. Little (1966) carried this notion further by showing that better quantity and quality of mothering produce lambs who avoid the cliff relatively early. Baumgold (1967) concluded that drugs bring about either early or late cliff avoidance by causing the mother-neonate interaction to be relatively inferior or superior. It follows that the more plausible explanation of relatively early cliff avoidance by lambs administered magnesium pemoline would be in terms consistent with the earlier lamb studies cited. Thus, relatively early development of visual depth perception associated with the administration of magnesium pemoline could be explained in terms postulating that the drug facilitates the mother-neonate interaction or the lamb's response to the interaction. Following this reasoning, a reasonable assumption would be that the early administration of the drug to the newborn lamb brings about either an increased activity level or an increased alertness in the young animal or both. Thus, the results of the present study regarding the effects of magnesium pemoline would seem to best support the hypotheses of Plotnikoff (increased alertness) and of Beach & Kimble (increased and prolonged activity levels). Nothing can be said from analysis of the present data either to support or refute the findings of Glasky & Simon related to magnesium pemoline's facilitation of the production of RNA. Considering the present findings in terms of increased alertness and increased and prolonged activity levels would seem consistent with the finding of most magnesium pemoline research done with humans which tends to support the notion that sustained attention and accuracy of performance are facilitated by the drug but learning and memory are not (Burns, House, Fensch, & Miller, 1967; Smith, 1967; Talland, 1966).

Results following the administration of thyroxine to lambs. In the present study, lambs administered thyroxine at birth failed to display the avoidance criterion on the visual cliff at an age significantly different from control animals though there was a slight tendency for the thyroxine-treated-lambs to avoid the cliff later than controls (contrary to the hypothesis based on earlier research). Schapiro & Norman (1966) had observed that the administration of thyroxine to newborn rats will accelerate the deposition of brain cholesterol, advance the age of eye opening, increase the spontaneous locomotor activity, and (on the behavioral level) will advance the age at which the rat will respond behaviorally to acute environmental stimuli (shock) and increase the rat's ability to learn a conditioned-avoidance response. It is true that none of the developmental phenomena here listed by Schapiro & Norman were directly observed in the present study. However, it does seem surprising that the large number of physiological and behavioral changes shown to be facilitated by thyroxine were not reflected in the present study by relatively early avoidance of the cliff. On closer examination of the data concerned, several possible explanations occur for the apparent discrepancy between findings in the present study related to the administration of thyroxine and the results reported by Schapiro & Norman.

It must be considered again that the development of visual depth perception as measured in the present study is not a product of learning. Nor is it known from available data whether development of depth perception is associated with brain cholesterol, myelinization, or maturation of the pituitary-adrenal secretions. Therefore, it may be that the present study measured a phenomenon not associated with any of the phenomena observed by Schapiro & Norman.

Another possible explanation for the differences in results between the two studies in question is that Schapiro & Norman administered the same relative amounts of thyroxine to their rats as were given to the lambs but Schapiro & Norman administered the preparation on three successive days. Thus it is possible that the lambs in the present study received too little thyroxine to bring about any significant change in the age at which the criterion response was displayed. The fact that the thyroxine-injected lambs in this study showed a tendency to avoid the cliff later than controls casts some doubt on this explanation but, since significance of difference was not reached, one cannot be sure.

A third possible explanation for the lack of positive results in lambs receiving thyroxine lies in the time-lag involved between administration of the drug and physiological or behavioral changes that might be attributed to it. Schapiro & Norman (1967) had observed that some effects of thyroxine injections in rats do not appear for as long as ten days. Because of the nature of the present study, most of the data were collected before the animal were four days old. Thus, it is possible that the thyroxine injections given the lambs in this study could not have had an effect on the criterion response because there was insufficient time for the thyroxine to have its effect on the animal before the cliff avoidance was seen.

A fourth explanation for the lack of support for the thyroxine hypothesis is perhaps the strongest explanation of all. Levine & Mullins (1966) have explained as follows:

> There is recent evidence that administration of thyroid hormone, thyroxine, to a newborn rat will cause permanent hypothyroidism in the animal. It is not known whether this is a result of damage to the thyroid itself or of an alteration in the central-nervous system control mechanisms, but disruption of the 'hormonostat' is indicated by the fact that pituitary and blood concentrations of thyroid-stimulating hormone are consistently low even though there is a deficit of thyroxine. As is the case in animals subjected to thyroidectomy shortly after birth, there is an impairment in both body growth and thyroid goiter responses in these rats which received thyroxine in infancy [p. 1588].

Related to this statement by Levine and Mullins are the findings of Steinetz & Beach (1963) in which data were obtained showing that hyperthyroidism in rats (induced by thyroxine administration) decreases the distribution of corticosterone and likely disrupts the hypophyseal ACTH release mechanism. It thus appears that the injecting of thyroxine in animals can upset the endocrinal homeostatic mechanisms in such a way as to cause an enduring condition of thyroid deficiency. Stated differently, very early injections of thyroid hormone may bring about subsequent thyroid deficiency with all the physiological and behavioral anomalies consistent with such a deficiency. These anomalies include cretinism, retarded maturation of many reflex activities, delayed myelination, less-than-normal branching of the cell processes in the cortex, and impaired protein synthesis. Thus the slight tendency for the thyroxine-injected lambs in this study to yield data opposing the hypothesis seems best explained by the possibility that the results of administering thyroxine to the lamb may be that the lamb eventually becomes thyroxine-deficient.

Inferences Derived from Steroid Measures

The third hypothesis of this study was that hydrocortisone levels would be higher in lambs immediately after they had exhibited the avoidance criterion on the visual cliff than before they had avoided the cliff. Among the 14 lambs in the control group, the number of micrograms of hydrocortisone per each ml of blood plasma gave a mean of .83 before the criterion response and 1.86 after criterion. Statistically the data shows a difference that is significant beyond the .05 level and supports the hypothesis. It has long been known that adrenocortical hormones increase in the blood of both animals and humans concommitant with the subject's experiencing fear. Levine, Denenberg, Eleftheriou, and others were cited in the first chapter in showing that they infer emotionality from relatively high levels of adrenocortical hormones in the blood. It can thus be reasonably inferred that lambs experience more fear immediately after having perceived the apparent drop on the visual cliff than they experienced before they were able to perceive the apparent drop.

The studies of Patterson, Lemmon & Patterson, Little, and Baumgold as well as the earlier studies of Gibson & Walk have each shown that the visual cliff phenomenon occurs at a critical period and is irreversible once the avoidance behavior has been elicited. By combining the finding that visual depth perception develops at a critical period and the finding that the development of depth perception is immediately succeeded by the onset of fear, support seems to be given to the observations of both Hess (1959b) and Scott (1962b). Hess and Scott, working separately have both observed that the critical period for imprinting is terminated with the onset of fear. The inference can now be taken further by postulating that the onset of the ability to perceive visual depth has an analog in the imprinting phenomenon. Further studies might support the analog and afford wider possibilities for generalization of inferences from one phenomenon to the other.

Scott (1958, 1962a) was cited in the first chapter as having described definite and identifiable stages in the growth of animals. His stages are named: neonatal, transition, socialization, juvenile, pubertal, and parental. Scott & Marston (1950) pointed out that the lamb is born with adult motor and sensory capacities and is thus already in the transitional stage at birth. Since he describes the transitional stage as one in which sensory and motor capacities are developed, present observations support his contention since lambs certainly develop sensory and motor capacities during the first days of life. However, lambs do not entirely circumvent the neonatal stage (in which the nursing process is developed). Observations from the present study and the series of lamb studies leading up to it suggest that it would be more accurate to say that lambs pass through the neonatal stage very quickly or that they begin the transition stage very early. It seems likely that lambs spend a considerable period in which they are in both the neonatal and the transitional stages simultaneously.

In the first chapter, it was noted that there is a similarity between Scott's description of stages in animal development and certain descriptions of stages in human development. The similarity seems particularly clear in comparing Scott's notion with that of Piaget. Spitz (1965) has said that Piaget conceived developmental stages as being "sharp divisions of psychic unfolding into distinct episodes". Piaget's sensorimotor phase seems, for example, very like Scott's transitional stage. In both, the organism becomes able to receive environmental stimuli and to act upon them with appropriate behavior -- behavior that may be important for the organisms' survival.

It was observed in the present study that the onset of visual depth perception is followed by the ability of the animal to experience fear. If it is assumed that this observed sequence of events is invariable among lambs, then another of Piaget's postulates may be seen as an analog. Piaget, according to Flavell (1963), feels that certain developmental stages unfold in an unchanging and constant ontogenetic sequence. Further studies may show that the above sequence (development of depth perception followed by the onset of fear) is only one of many sets of phenomenal changes that occur in a fixed order in animals.

As explained in Chapter III, blood samples were taken from the lambs both before and after the criterion response was displayed. In order to make certain that one blood sample was obtained from each lamb before the lamb avoided the cliff, that sample was taken very early in the lamb's life. The planned experimental procedure was to take the first blood sample when or before the lamb was one hour old. Because of experimental procedures preceding the taking of the blood sample, the drug (or tragacanth) injections preceded the taking of the blood sample by only 15 minutes (approximately).

Fluorometric assays of the initial blood samples show a distinct tendency (though not at significant levels) for the lambs from both the drug groups to have higher levels of hydrocortisone than lambs from the control group. Means of micrograms hydrocortisone per ml of plasma for the drug groups were: 1.90 for the magnesium pemoline group, 2.05 for the thyroxine group, and only .83 for the control group. Though this could have been chance occurance, these findings strongly suggest that the administration of both magnesium pemoline and thyroxine brought about a very rapid increase in the hydrocortisone level. It is likely that a much greater difference in hydrocortisone levels between the drug and the control groups would have been seen if the blood sample had been taken one or two hours after the injection of the drugs.

Further study may help to explain the observations of the above paragraph. However, some consideration can be taken at this time of possible explanations for the rapid apparent rise in steroid levels in the groups receiving drugs. Eayrs (1961) found that impairments in the adult rat will be more severe in a ratio to the earliness of thyroid deprivation. In his study, eventual impairment seemed to become greater as the time of thyroidectomy occurred earlier in life and the correlation continued all the way to animal's having thyroidectomy at birth. Those operated at birth had the greatest impairment as adults. In view of these findings, it is not surprising that lambs in the present study showed an apparent endocrinological response at one hour of age. Also, Levine & Mullins (1966) and Whalen (1967) have noted that any change induced in the endocrine system brings about a total change in the balance of all hormones. The complexity of such a reaction has far reaching effects on the animal and could account for the sudden rise in hydrocortisone in lambs; especially those injected with thyroxine.

Data from the present study also show that the hydrocortisone levels had a tendency (again below significant levels) to fall in both drug groups after the animals had avoided the visual cliff. The magnesium pemoline group had a mean level of hydrocortisone (.85 micrograms per ml of plasma) barely higher at the time of cliff avoidance than the control group had at time of birth (.83 micrograms per ml of plasma). A possible explanation for these findings may be given by Steinetz & Beach (1963). These authors note that:

> Hyperthyroidism was found to decrease the volume of distribution of corticosterone, suggesting the operation of a homeostatic mechanism to prevent concomitant hypercorticoidism [p. 46].

These findings of Steinetz & Beach are similar to the ones noted by Levine & Mullins (1966) in which the "hormonostat" seemed to malfunction in the rats who had received early doses of thyroxine. The findings of both

Steinetz & Beach and Levine & Mullins suggest a possible explanation of the sudden rise and eventual fall of hydrocortisone levels in the drugged lambs in the present study. No data are yet available which would afford similar explanations for the lamb's hormonal reaction to magnesium peomline. However, the noted concept of general change throughout the endocrine system in response to any hormonal disturbance may be directly or indirectly related to the parallel effect seen in the magnesium pemoline group.

It is possible that magnesium pemoline has hormone-like effects on the animal. If this were the case, then the administration of magnesium pemoline may, as hormones do, bring about rapid changes in the endocrine balance. It is reasonable to postulate that magnesium pemoline may also bring about the aforementioned homeostatic lowering of adrenal output. These possibilities offer one possible explanation for the observed parallelism between the effects of magnesium pemoline and thyroxine on the hydrocortisone levels of the lambs both before and after they had exhibited visual depth perception.

Other Considerations

A comparison of the data from the present study with that of the three studies leading up to the present one (Patterson, Little, and Baumgold), shows that lambs receiving no special experimental treatment required a mean number of hours to visual cliff criterion that was five to six times greater in the present study than in the earlier studies. A slight trend toward an increase in mean number of hours to criterion is seen in the earlier studies as the mean increased from one to two hours in each succeeding year. These differences are not great and may be possibly attributed to aging of the parent animals. However, the difference in number of hours to criterion for the present study is a considerable one.

Further comparisons of the data from the four studies show that there were slightly fewer multiple births during the lambing for the present study than in any of the studies preceding it. The difference (49% multiple births vs 39%) is substantial when a comparison of the data from the present study is made with that from the studies of Patterson and Baumgold.

All four studies were made with lambs from the same flock, carried out at the same location, and done at the same time of year with very similar weather conditions prevailing. However, the animals in the present study were treated differently in two ways from the animals in the preceding studies. First, the lambs in the present study had blood samples taken from them during the first hour of life and immediately after they had exhibited criterion avoidance behavior on the visual cliff. This particular experimental procedure had not been done with the three earlier studies. Secondly, the ewes in the flock were fed a kind of vermifuge during their pregnancy before the present study -- a vermifuge that was not the same as that used before the other three experiments.

The taking of blood samples was found to be a difficult task. All persons involved in taking the samples practiced the blood sampling technique under the help of a person skilled in the process but the task remained a rather involved one. In the sampling, the lambs first had their hind legs shaved with a veterinarian's clipper. This instrument made a fairly loud humming sound and imparted a distinct vibratory tactile sensation when touched to the skin When the shaving had been completed, the lamb was held in a trough-shaped wooden cradle while an experimenter punctured the saphenous vein and withdrew the blood. This process may have stressed the lambs in such a way that the development of depth perception was retarded. This hypothesis is not consistent with finding noted by Baumgold [1967]:

> It was noted ... that five lambs were rejected by their mothers. That is, the mother did not permit the lamb to nurse or even to 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 regular intervals. Three of these five rejected lambs displayed visual depth perception at an age 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 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 [pp. 57-58].

However, there is one important difference between the kind of stressing explained by Baumgold and the stressing that might have been experienced by the lambs in the present study. Namely, Baumgold's lambs were being stressed by their own mothers while the lambs in our study were being subjected to machinery and humans -- entities far more foreign to the lamb's ordinary environment. Thus, stressful factors in the blood sampling procedure must be considered as only one possible reason for the finding that lambs in the present study required a greater mean time to criterion visual cliff response than did lambs in the previous studies of the series though grooming and other kinds of care were the same in all four studies.

A second consideration in terms of differences in treatment may be important in explaining both the differences in time to criterion and in numbers of multiple births between the present study and its earlier counterparts. During their periods of pregnancy, the ewes for the three previous studies were given regular doses of phenothiazine, a common practice among sheep growers. This drug or a similar preparation is necessary for the control of growth of parasitic worms in the adult animals. However, during the pregnancy period of the ewes whose lambs were used in the present study, the ewes were fed an organophosphate-based vermifuge. The preparation used consisted of a standard feed-meal mixed with Trolene FM which is manufactured by the Dow Chemical Company. The Dow Company states (ACD Information Bulletin No. 118, Dow Chemical Company, Midland, Michigan, 1961, pp. 7-10) that Trolene FM contains 40 percent of the active chemical ronnel, one of the class of organophosphates having the specific classification: 0,0-dimethyl 0-2,4,5-trichlorophenyl phosphorothioate. This anthelmintic agent was fed to the ewes on alternate days beginning at the time of impregnation and ending a week before the first lamb was born. Dosage was kept well within limits recommended by the Dow Company and no typical toxic reactions (such as pupillary miosis, lachrimation, salivation, or muscular weakness) were observed in either ewes or lambs.

Organophosphates are anticholinesterase agents. Thus they bring about an accumulation of acetylcholine and are potentially capable of producing effects equivalent to continuous stimulation of cholinergic fibers in the central and peripheral nervous systems. Further, the organophosphates are known to have a longer lasting effect than other anticholinesterase (anti-ChE) agents and have been described as "irreversible" for that reason. There seems little reason to doubt that ronnel could reach the fetus in utero via the "placental barrier", especially since organophosphates are known to have high lipid solubility (which may also facilitate their penetration of the central nervous system). Thus, the possibility of placental penetration and long lasting effects of the chemical suggest that the lambs in the present study could have been affected by it both before and for a considerable time after birth.

Koelle (1965) notes that " . . . several organophosphorus compounds can produce a peculiar syndrome of neural degeneration, associated with demyelination, following chronic exposure" [p. 452]. It then follows that the normal process of myelination of the lambs in this study could have been disturbed and that this could possibly account for the relative lateness of avoidance response in the lambs.

A connection between ronnel and the observed decrease in numbers of multiple births in the present study might also be postulated though an explanation of the process involved would require special research.

Suggestions for Further Study

The results of the portion of this study having to do with magnesium pemoline support most of the findings of other experiments done with that drug but employing other animals (or humans) and with other tasks (such as learning and memory tasks). Research is needed to learn what effects the drug may have through the facilitation of RNA production. Glasky & Simon (1966) have noted such a need. Further study with magnesium pemoline might also shed light on the drug's affect on the organism's sensitivity to stimuli. This question was opened when Frey & Polidora (1966) postulated that the drug may have made their animals more responsive to electric shock.

A study designed to learn why there were discrepant results between the thyroxine-injected lambs in this study and the thyroxine-injected rats in the study of Schapiro & Norman might clarify that problem. It might be learned that visual cliff activity of the kind observed in this and its preceding studies is simply a different process than the learning phenomena observed by Schapiro & Norman. It might also be found that an increase in the dosage of thyroxine would bring about an earlier avoidance of the visual cliff. A careful measure of thyroid hormone levels of lambs given thyroxine might reveal (as Levine & Mullins have suggested) that the drug brings about an enduring deficit in thyroid hormone levels with the associated impairments of functioning.

The rapid rise in hydrocortisone levels in lambs given drugs in this study could be explored. This drug interaction goes even further for it was found that hydrocortisone levels did not rise at the time of cliff avoidance in the drug groups as in the control group. It is even suggested that the hydrocortisone levels in the drugged animals was lower after cliff avoidance than before. These findings were seen in terms of trends that are below significant levels. Replication of this part of the study but with larger groups of animals might show significant and conclusive results.

Finally, it was noted that results from the present study were different from those of the studies in the same series in ways that cannot be easily explained. The possibility that the results in the present study were influenced by the stressing of the lambs by the process of extracting blood samples could be examined. For example, it may be possible that hormonal measures can be taken from the urine of the lambs. If so, a method might be devised in which urine could be collected in appropriate samples for hormone measures such that the process might not be stressful to the lambs. A replication of the parts of this study having to do with steroids might show different result if the urine analysis were used instead of the blood analysis. Also, a study with lambs in which some mothers were given ronnel and a control group was given phenothiazine would perhaps support or refute the postulated effects of ronnel on the animals of the present study.

CHAPTER VI

SUMMARY

The nature of the physiological and psychological changes involved with critical periods and developmental stages has long been a subject for much theorizing. Considerable evidence has shown that pharmacological and behavioral manipulation of the neonate organism can result in disruption of the natural chronology of developmental events. Most of the appropriate literature suggests that a causal factor exists between mother-neonate relations and the infant's pattern of development and that manipulations of either infant or mother may affect the infant's growth by means of changes brought about in the mother-neonate relationship.

This study had a bi-dimensional design in which pharmacological agents were tested for their effects on the developmental timing of infant animals and in which blood plasma assays served as measures of endocrinological changes associated with developmental changes. Lambs in all groups were tested for their capacity to react adaptively to the stimulus of depth on a visual cliff. Magnesium pemoline appeared to accelerate the development of visual depth perception and thyroxine apparently brought about no significant effect. The hydrocortisone level of lambs was higher at the time of the development of visual depth perception than it had been earlier in the lives of the animals. However, the experimental drugs apparently caused an interaction effect such that the drugged animals showed a trend toward having an early hormonal reaction followed by a lowered reaction at the time of development of depth perception.

The explanation offered for the effect of magnesium pemoline is that the drug increases the alertness and motor activity levels of the young animal which, in turn, increases its response to the mother-neonate interaction which hastens developmental growth. The observed reaction to thyroxine was explained as a delay in development brought about by disruption of the normal homeostatic balance of the endocrine system. The adrenocortical data supported the thesis that the critical period associated with the development of depth perception is similar to or identical with the critical period associated with imprinting, at least in chronological, behavioral, and hormonal respects.

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APPENDIX I

AGES AND NUMBER OF VISUAL CLIFF TRIALS AT THE TIME OF CRITERION AVOIDANCE RESPONSE FOR EACH DRUG GROUP

Magnesium Pemoline Group

Lamb	Age (hrs.)	Trials
3	5.75	2
4	65.00	16
5	16.00	4
6	24.00	6
7	4.50	1
8	11.33	3
9	11.00	3
10	5.75	2
11	(anomalous animal)	
12	7.75	2
13	23.00	6
14	8.50	3
15A	20.00	5
15B	3.25	1
16	78.50	17
17	28.00	7
36	8.50	2
37	(anomalous animal)	
38	18.42	5
40	10.25	3
41	12.75	4
42	7.75	2

Thyroxine Group

Lamb	Age (hrs.)	Trials
18	29.00	8
19A	11.50	3
19B	58.00	15
20	9.25	3
22	23.50	6
23B	41.25	11
24A	62.58	16
24B	9.75	3
26	12.00	3
27A	18.50	5
30	25.50	7
32	74.25	19

Control Group

Lamb	Age (hrs.)	Trials
1A	6.50	2
1B	14.50	4
2	13.50	3
21	(anomalous animal)	
23A	5.58	2
25	17.50	5
27B	10.25	3
28	41.00	11
29A	17.33	5
29B	17.17	5
31	42.75	11
33A	18.75	5
33B	26.42	7
34A	28.50	5
34B	27.50	7
34C	22.50	7
35	63.00	16
39	77.50	20

APPENDIX II

MICROGRAMS HYDROCORTISONE PER ml OF BLOOD PLASMA FOR EACH DRUG GROUP UNDER THE TWO EXPERIMENTAL CONDITIONS

Magnesium Pemoline Group

Lamb	Before Avoidance	After Avoidance
12	0.0	0.0
13	0.1	4.6
14	4.34	0.0
15A	.21	0.1
16	6.62	1.03
17	0.0	1.03
36	7.85	0.0
38	0.0	1.77
40	0.0	.42
41	0.0	0.0
42	3.72	.83

Thyroxine Group

Lamb	Before Avoidance	After Avoidance
18	0.1	0.1
19A	0.1	3.1
19B	1.24	0.0
20	0.0	1.01
22	0.0	.83
23B	(anomalous data)	
24A	6.5	0.0
26	1.77	1.03
27A	14.9	.21
30	0.0	6.4
32	0.0	0.0

Control Group

Lamb	Before Avoidance	After Avoidance
23A	3.1	0.0
25	.83	.10
27B	.83	0.0
28	4.75	8.89
29A	0.0	0.0
29B	0.0	0.0
31	0.0	1.86
33A	0.0	5.78
33B	0.0	0.0
34A	(anomalous animal)	
34B	.62	5.75
34C	0.0	0.0
35	1.55	0.0
39	0.0	4.75