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To the Graduate Council:

I am submitting herewith a dissertation written by Ellis Sutton Bacon, entitled "Investigation on Perception and Behavior of the American Black Bear (Ursus americanus).". I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Psychology.

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126

INVESTIGATION ON PERCEPTION AND BEHAVIOR OF THE
AMERICAN BLACK BEAR (Ursus americanus)

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

by
Ellis Sutton Bacon

June 1973

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ABSTRACT

Behavioral information concerning the American black bear (Ursus americanus) is limited. The present study was conducted to assess various aspects of ingestive behavior and visual discrimination of the black bear using two captive females. Information available pertaining to the management of black bears in captivity is also limited. Therefore, a large portion of the study revolved around the care and maintenance of the bears in a semi-natural enclosure.

The ingestive behaviors were studied using ethological observations and a longitudinal food preference test. Observations were obtained as the subjects procured and consumed food items both naturally occurring and introduced into the enclosure. The observed feeding behaviors were discussed in three categories: foraging, predation, and consumption. The foraging behaviors appeared to be uncomplicated and consisted primarily of apparently random walking and use of the front paws to dig and manipulate objects in the enclosure. Olfactory scanning was integrated with locomotion and use of the paws. Predatory behaviors were infrequently observed but are described.

Detailed descriptions of the consumption of the native food items (acorns, blackberries, and grass) were based on motion picture analysis. Visual orientation toward the food items was particularly evident and is considered an important facet of the ingestive behaviors. The bears were also found to be very clean feeders, consuming very little debris.

The preferences for two sets of food items (native food items and non-native food items) was determined during a one year testing program. The bears were found to exhibit definite scalable preferences among both sets of foods. The preferences were significantly correlated between the subjects and were consistent throughout the one year period. The consistency of preference among seasons indicated that the naturally occurring diet of the black bear is controlled by availability of the foods. In the native food test acorns were the most preferred. In the non-native food test fish was the most preferred food.

The foods most highly preferred were rich either in protein or carbohydrates. The carbohydrate preference, unusual for a member of the order Carnivora, is considered a function of the change to herbivorous dietary patterns in the bear.

The research on visual capacities of the captive bears consisted of two discrimination studies. The

bears were tested for their abilities to perform discriminations on the basis of hue and pattern using specially designed methods involving small painted containers. The basic task was a two-choice correction procedure with food reinforcement.

The results of the color vision testing indicate that blue was successfully discriminated from gray, green, red, and yellow. Green was successfully discriminated from gray, blue and red. The acquisition of the discriminations was very rapid. The consistency of the hue discrimination and the rapidity of learning indicated that the subjects were very adept at hue discrimination and, most likely, utilized this ability with frequency.

The form discrimination study was designed to assess one bear's abilities to differentiate and recognize patterns. It was found that the ability to choose the correct stimulus was not affected by size of the stimuli, configurational placement, or the introduction of novel negative stimuli. The reversal of backgrounds produced an initial but very short period of confusion.

The retention of the discrimination was found to be perfect after four and eight month delays. The rate

of learning the initial discrimination was also very rapid. It was concluded that the bear was very capable of making visual discriminations on the basis of pattern.

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CHAPTER I

INTRODUCTION

As one of the largest and most widely distributed carnivores, the American black bear (Ursus americanus) has had a full history of incorporation into the cultures of North America. Accounts of the black bear frequently appear in American literature. From Faulkner's (1942) tragedy, The Bear, to heroes of children's books, bears have always been a popular subject. Susceptibility to diverse anthropomorphism(e.g. carefree, cuddly, powerful, sinister) has also added to the black bear's popularity.

Economically, the black bear is quite important. This species has been viewed both as an important game animal and an agricultural pest. In many states the black bear is legally hunted and the revenues form an important part of various local economies. Conversely, a few accounts point to damage by the black bear. Fritz (1951) and Glover (1955) report the detrimental affects of black bears upon redwoods in California.

The major economic import, however, appears to be the bear's incorporation into the increasingly expanding tourist trade. Tourism in the areas surrounding the

Great Smoky Mountains National Park (GSMNP) is a major economic force. Copeland and Copeland (1973) report that the Knoxville market area (a 42 county area in which the GSMNP is located) contains 8,900 tourist related businesses that employ 37,482 area residents. Although many of these businesses also serve local residents, it was estimated that in 1972, 200 million dollars was brought into the market area from out of the state. Of the 17 million travelers into the Knoxville travel area, 8.4 million visited the GSMNP.

As indicated by a recent survey, visitors to the GSMNP want to see bears. The black bear was considered a major attraction by a large portion of the park visitors (Burghardt, et al., 1971). The popularity of the black bear is evident from the abundance of souvenirs and caricatures found in the tourist-related communities surrounding the GSMNP. As an attraction to area visitors the black bear is very influential and economically important.

The black bear is also a regular member of the zoo community. Along with other members of the genus Ursidae, the black bear is found in almost every zoo and often becomes a problem, not in maintenance in captivity, but by persistent fecundity

Considering the popularity, wide distribution, and

economic importance of the black bear, it is unusual that research on this adaptable animal is incomplete. Bray and Barnes (1968) present a fairly comprehensive review of the available literature. Research appears to have been confined to physiology, population dynamics, and management. Outside of anecdotal and gross qualitative observations, the behavior of the animal itself has not been studied. The extent and relative importance of the bear's sensory modalities has also not been reported.

Leyhausen (1948) reported observations of an American black bear kept as a pet while he was a prisoner of war in Canada. Although anecdotal, this was probably the first account of the black bear by an ethologist. Perceptual assessment has been totally ignored. The first and only systematic attempt at gathering perceptual information on any species of bear was done by Kuckuk (1937). In his work on two young European brown bears, Kuckuk reports that "all in all the coordination of the senses is excellent (p.20)." The bears were capable of visual recognition of Kuckuk at 30 m, and of hearing an auditory signal at 150-155 m whose human boundary lay at only 80 m. They were also quite capable of learning tasks to acquire food and finding "invisible" or hidden foods olfactorally.

Burghardt and Burghardt (1971) reported on the behavioral development of two female black bears in their first eight months of life. Observations on various behaviors such as exploration and curiosity, play, feeding, and communication were reported. Herrero (unpublished) studied the behavior of black bears in a mass feeding situation at a garbage dump in the Canadian Rockies. Pruitt (1973) accomplished a detailed study of social interactions and their development in captive black bears. Play and agonistic interactions, and establishment of dominance were important parts of the study. The accompanying communicative signals of the captive black bears were also described in detail.

Jonkel (1967) was the first wildlife biologist to include a serious and detailed discussion of the behaviors of black bears encountered in his research. Although brief, this discussion is indicative of the increasing recognition of the importance of behavior in the ecological study of a species.

The present study involved a variety of approaches to the study of the visual capacities and ingestive behaviors of the black bear. Ethological observations and experimental techniques designed for use in semi-natural field conditions were employed

during the study. The reported research is part of the author's research designed as a beginning toward the understanding of the behavior of the American black bear.

CHAPTER II

SUBJECTS AND RESEARCH FACILITY

Subjects

Description

The subjects used in this dissertation were two captive female black bears. These animals were obtained through the National Park Service after their mother had been driven away from her den site by dogs on April 18, 1970 in the Great Smoky Mountains National Park (GSMNP). The exact date of birth was unknown but on the basis of known birth dates was assumed to have occurred on February 1, 1970. The two young bears were from a litter of four. A detailed description of their history prior to acquisition by this author can be found in Burghardt and Burghardt (1971).

The two bears were named Kit and Kate, and shall be referred to by these names in the following chapters. Both animals were totally black except for a light brown area around the muzzles and within the ears. Kate had an extremely thin white "V" on her chest which disappeared with age. The black color is the only color phase present in the bear population of the GSMNP. A plastic cattle ear tag was placed in one ear of each bear to

aid in their identification by unfamiliar observers and from films and videotapes. Kit was given a blue tag and Kate a yellow tag. The tags were placed in opposite ears.

The population from which these animals were taken is centered around the GSMNP and extends into both eastern Tennessee and western North Carolina. Due to the increasing and expanding human population, this bear population may be considered restricted to the southeastern mountain ranges and genetically isolated from other, especially western, populations. As of 1973 no stocking programs for black bear by either the Tennessee or North Carolina state game agencies have included animals from outside this area. However, hunting clubs in western North Carolina have released yearly 18-20 bears some of which were the "brown" phase.

Weighing and Measuring

The two bears were weighed regularly throughout the study. At the beginning of the study Kit and Kate were 5-1/2 months of age and weighed 8.8 kg and 10.4 kg, respectively. Weighing for the first months was accomplished by using a set of bathroom scales. The bear was either gently lifted or grabbed under the front legs from behind. The author would then step on the scales. By subtracting the author's weight from the total shown

on the scales, the bear's weight was determined. This method, illustrated in Figure 1, was used until the animals were too large to handle.

The next method for weighing the subjects used a swing attached to spring scales which were suspended from a tree. Three, two cm water pipes were attached varying distances parallel to the wooden base of the swing for the bear to use as climbing aids. As shown in Figure 2, a bear could be lured onto the swing by attaching and holding food items above the top bar. Apples and raisins were used successfully. After the subject was off the ground, the swing was steadied as much as possible and a weight reading was taken. Two to three readings were taken for each bear to assure accuracy. The scales were also validated with known human weights. The weights are shown in Figure 3.

Measurements were taken of each bear throughout the study. This was done by one person feeding the bear through the fence while either a co-worker or the author measured the animal using a cloth tape measure. The measurements of the subjects are described and presented in Pruitt, 1973.

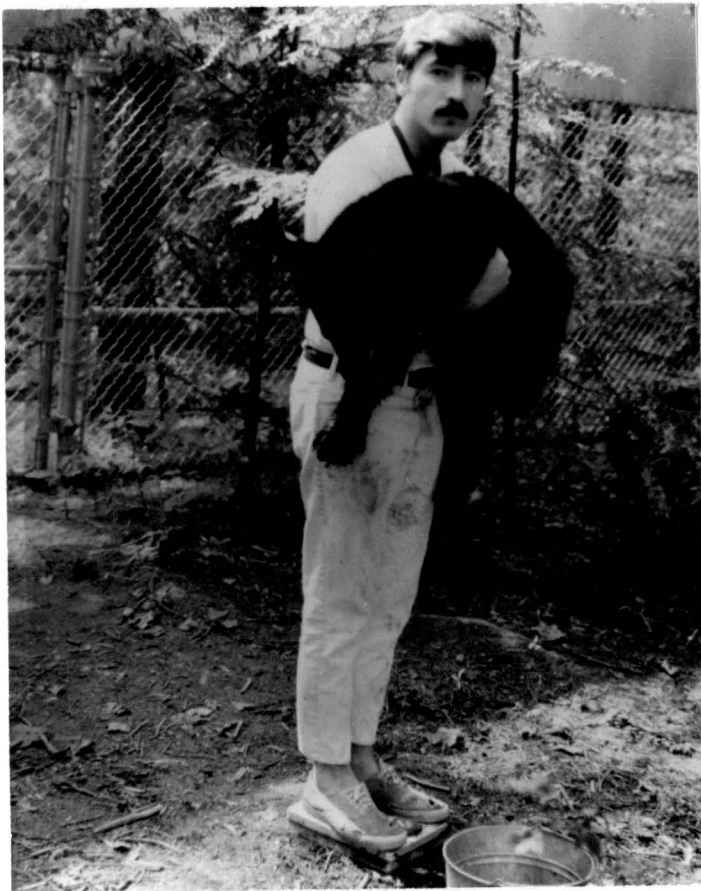


Figure 1. Method of weighing the subjects using bathroom scales.



Figure 2. Method of weighing the subjects using a swing attached to spring scales and suspended from a tree.

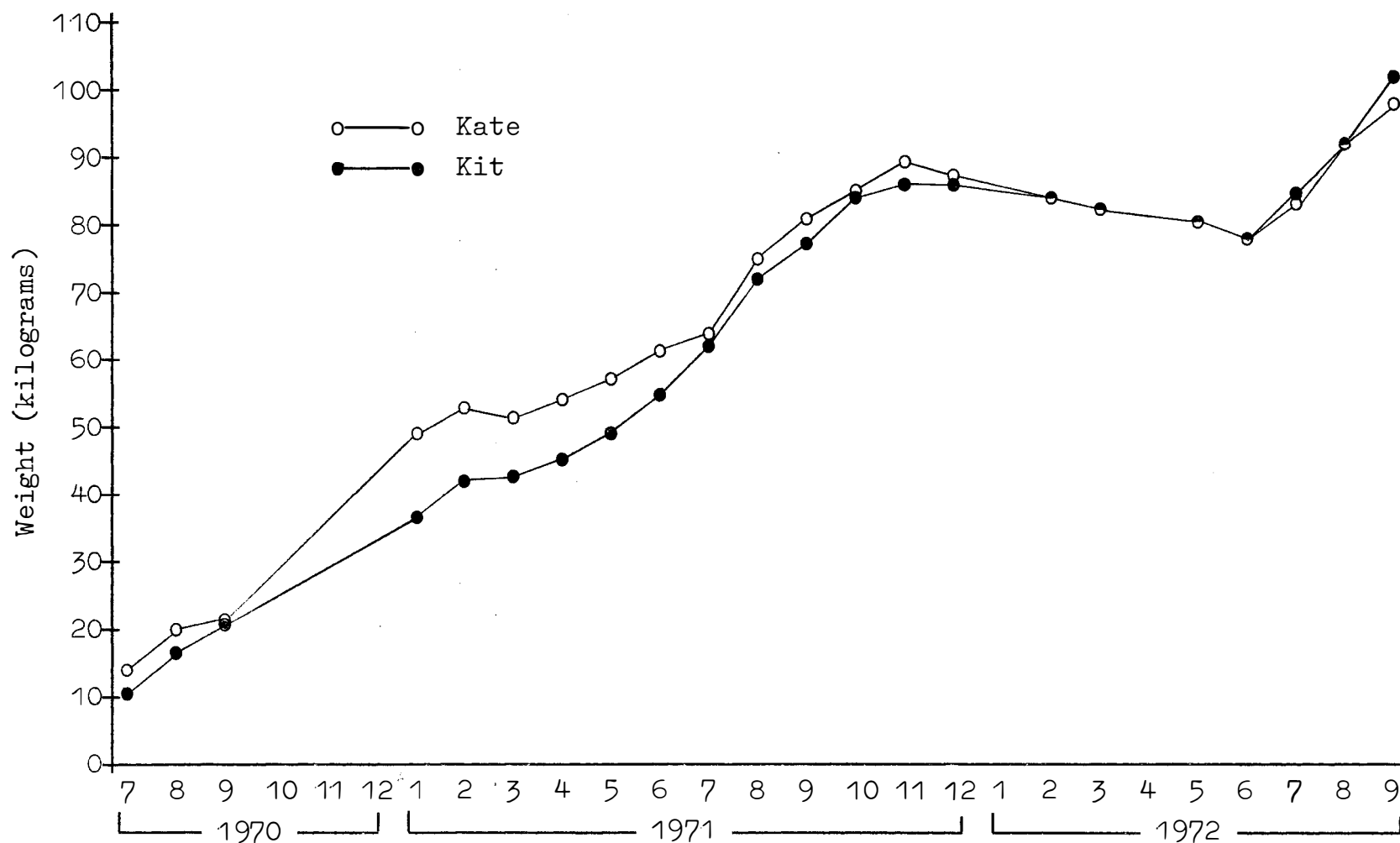


Figure 3. Weights of the two subjects from July 1970 to September 1972.

Medical Problems and Treatment

During the study only two illnesses aside from various endo-and ectoparasites required treatment.

In September, 1970 Kit was observed to become sluggish, exhibit a loss of appetite, and excrete blood in diarrhetic stools. Food poisoning was suspected, but no exact causal factors were isolated. She was given an injection of a penicillin and streptomycin combination, Di-Pen (Lamco), and an injection of vitamin B-12. Within three days the symptoms disappeared.

December 4, 1970, Kate became the first and only serious medical problem of the study. Both bears were accidentally deprived of water from the evening of December 3 until 11 a.m., December 4. The weather was clear and the afternoon temperatures were recorded at 11° C. When water was introduced, Kate took an unusually large draught. At noon she appeared healthy but at 5 p.m. was found semi-conscious and dehydrated. The prognosis by Dr. E.B. Jones, DVM, was an osmotic imbalance or shock.

She was immediately taken to the author's trailer and remained there approximately 24 hours. She was then transferred to an observation shed and remained there eight additional days under constant surveillance. The treatment was as follows:

December 4, evening - 1 liter lactated ringers
solution, subcutaneously
1.5 cc Azimycin (Sherring)

December 5, morning - 500 ml lactated ringers
solution, subcutaneously
1.5 cc Azimycin

December 6, morning - 500 ml lactated ringers
solution, subcutaneously

December 7,
1:45 p.m. - 2 cc Di-Pen (Lamco)
1.5 cc vitamin B-12

7:30 p.m. - 2 cc Di-Pen
1.5 cc vitamin B-12

December 9 and 10 - 1 cc Di-Pen

December 13 - release into enclosure

A semi-solid diet was initially given consisting mainly of apple sauce and wet dog chow. This was terminated December 9 because of the resulting diarrhea. By December 7 she was mobile but still weak. At that time it was decided to keep her inside the partially heated observation shed until full strength was recovered because of the danger of pneumonia.

The only endoparasite discovered was a cyclophylidean tapeworm (Taenia sp. L.). These occurred periodically after midsummer of 1971. November 14, 1972, both subjects were treated for worms. Yomesan (Wyeth) tablets were crushed, mixed with honey, and fed to the bears.

Both bears became infected with Listrophid mites during the summer of 1972. This was characterized by

loss of hair, dermatitis and persistent scratching. September 1972 the bears were tranquilized and treated with an oil of creosote and an oil of rotenone solution. The problem recurred with the introduction of several wild yearling bears into the enclosure. April 3, 1973 both subjects were again tranquilized and washed with the above solutions.

The only other ectoparasites observed were occasional ticks in the ears of the bears. These were removed by the author or C. Pruitt.

Enclosure

Study Site

The enclosure into which the two bears were placed July 1970 represents an example of confinement within a semi-natural habitat. The site selected for the enclosure was a second growth, mixed deciduous forest that contained several large Virginia pines. This site was near the Maryville College Environmental Education Center located in the GSMNP. The area in and around the enclosure is nearly level (0-2% slope). The soil is sandy with rock outcrops and natural drainage is adequate.

During construction of the enclosure no grading was done, and the only trees removed were those directly in the line of the fencing. All other trees and undergrowth within the enclosure were left intact. The trees found within the enclosure included black cherry (Prunus serotina), dogwood (Cornus florida), hemlock (Tsuga canadensis), eastern white pine (Pinus strobus), sassafras (Sassafras albidum), striped maple (Acer pensylvanicum), sweetgum (Liquidambar styraciflua), red maple (Acer rubrum), and Virginia pine (Pinus virginiana). All trees of base diameter larger than 38 cm were pine except one large sweetgum.

Design of Enclosure

An enclosure for bears must include precautions against an animal being able to climb over the barrier. Three known methods to prevent climbing are: use of aversive stimuli such as electric fencing, enclosing the top of the cage, and providing high walls without sufficient handholds. This enclosure was designed utilizing the third method.

Figure 4 illustrates the design of the fence. The total height above the ground is 3.05 m. The top 122 cm is #18 gauge sheet metal, welded upon the fence posts to form a solid, unbroken, vertical barrier. This has proven very effective in containing the subjects. The fencing below the sheet metal is #9 gauge industrial grade chain link embedded in 40-50 cm of concrete. Although the bears were proficient at digging and made holes as deep as 60 cm beside the fence, no attempt to dig under the concrete base was observed.

The enclosure itself is 18.3 m square bisected by a center fence (Figure 5). The center fence has 3.05 m gates at each end, one of which was generally left open, allowing the bears access to both sides of the enclosure. When necessary the enclosure could be completely divided. Each half of the cage has an entrance gate 1.22 x 1.83 m and side one has an additional entrance gate 3.6 m wide

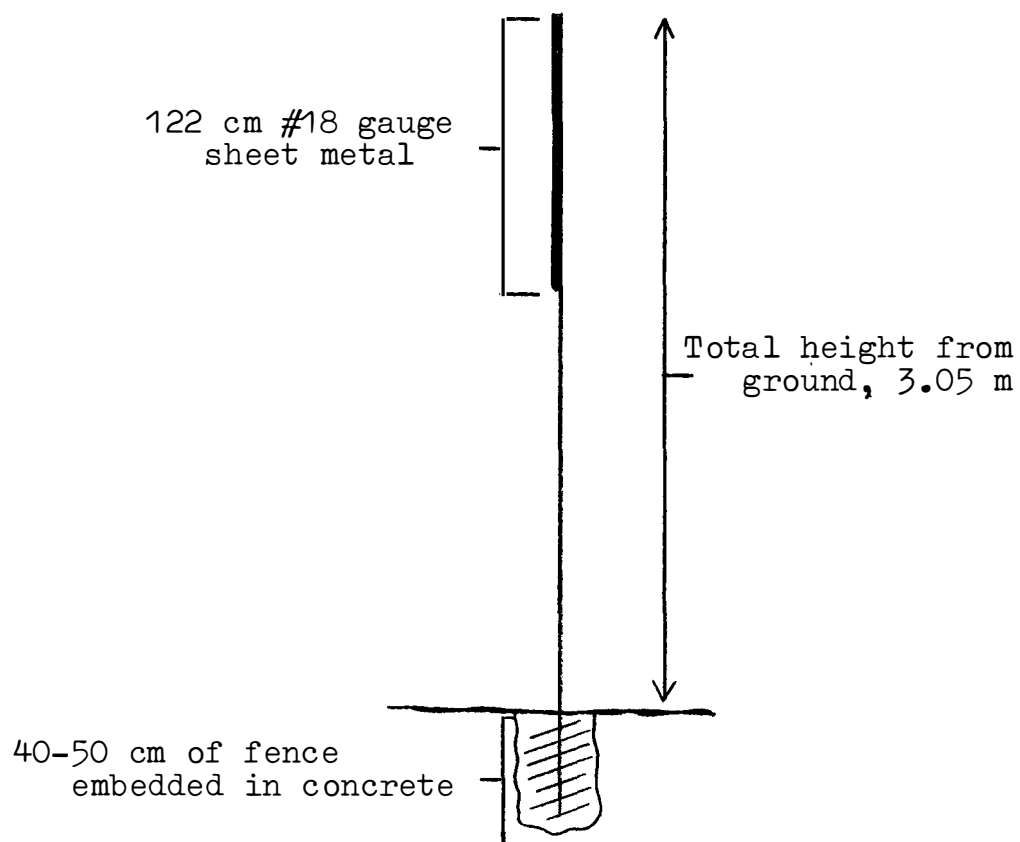


Figure 4. Fence design of the enclosure.

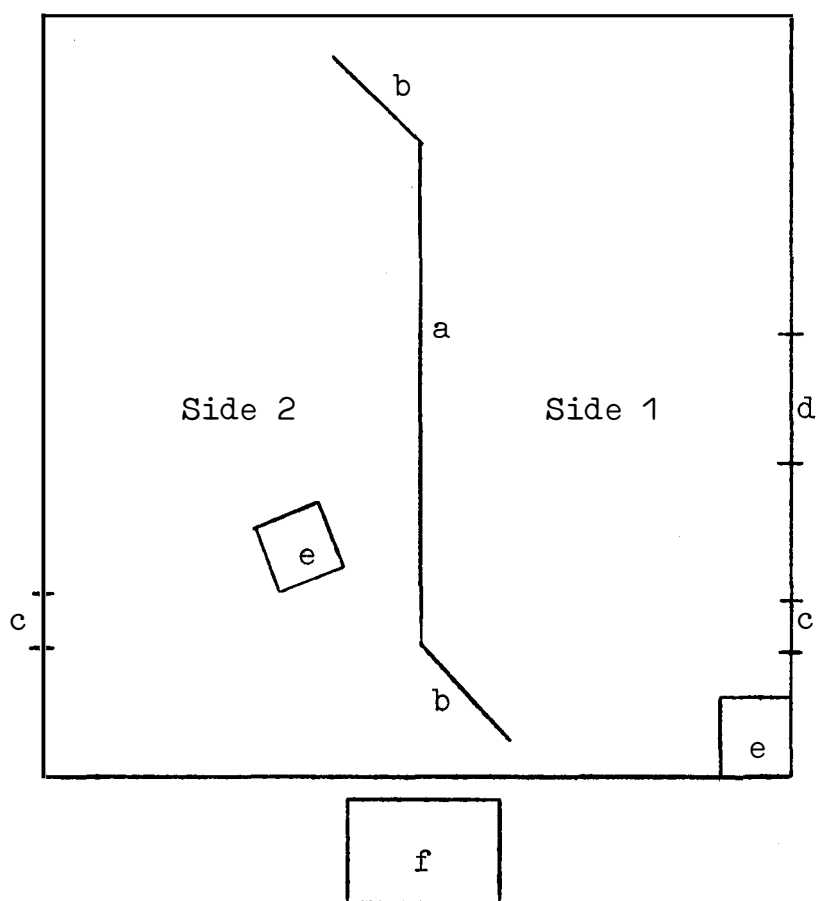


Figure 5. Design of the enclosure.

- a Center fence
- b Gate of center fence
- c Entrance gate
- d Vehicle entrance
- e Shelter
- f Observation and storage shed

for vehicle entry. The two gates of the center fence and the vehicle entrance of side one are constructed so that the sheet metal is part of the gate. This allows complete opening without vertical restrictions.

The erection of the fence and the sheet metal was contracted by the University of Tennessee to Caldwell Fence Erection Company. All other construction work was done by the author, G. Burghardt, other graduate students, and volunteers.

Collared Trees

It was observed that although the bears were very proficient climbers, they were extremely cautious. Seldom would either bear venture out on the high branches of the large trees. The bears were never observed to willingly free-fall from any height. However, both animals would freely move from a tree to the top of the fence, if the fence was within reach from the main bole of the tree. To prevent such excursions, sheet metal collars were placed on the trees near the fencing. Also the large sweet gum tree was collared to keep the bears from stripping all of its branches off. The first collars were .61 m in height and made of #24 gauge sheet metal. As the bears grew, larger collars and additions were necessary. The final collars were 1.22 m in height and were placed about 1.5 m from the ground.

Observation and Storage Shed

An observation shed was designed and constructed by the author in late summer and early fall 1970. This shed serves as a storage facility for apparatus and equipment, and as an observation tower. As illustrated in Figure 6, the observation shed is a small two-story structure with windows across the front of the second floor. These windows may be swung upward for clear viewing and filming of activities in the enclosure. A "moisture-proof" box was constructed on the first floor in which calcium chloride was kept. This container was used to store film, tapes, photographic and recording equipment.



Figure 6. Side view of the observation and storage shed.

Maintenance Apparatus

Food

During the summer of 1970 the bears were fed from a variety of portable containers that included plastic bowls, buckets and pans. By the end of the summer the major portion of the subjects' diet was transferred to dry dog chow. The dog chow remained as their major food during the study. Both Purina and Wayne bite size dog chow was used. At the time of transfer to dry dog chow, it was found that if the chow was allowed to become wet neither bear would eat it. A two-lid hog feeder was then placed along the center fence of side two in which the dog chow could be placed and remain relatively dry. Figure 7 shows Kate eating from the feeder. Both bears were immediately capable of opening the feeder by lifting the lids with either their front foot or nose to obtain food.

No problems arose from the immediate proximity of the available food. The two animals fed together for the length of the study and (outside of dominance testing, Pruitt, 1973) were not observed to fight over the dog chow once it was placed in the feeder. Conflicts over food did occur and pertained to favored food items and situations in which only one food item was available. All conflicts were quite brief and consisted mainly of vocalizations and



Figure 7. Kate eating from a two-lid hog feeder.

defensive posturing.

A variety of foods were given to the bears as a supplement to the dog chow. Several of the most frequently given included acorns, apples, applesauce, pears, blackberries, raisins, lettuce, grass, bread, and fish. These foods were given to the animals simply by throwing them into the enclosure. Almost all food additional to the dry chow was consumed immediately and, therefore, presented no storage or spoilage problems.

Drinking Water

Water was available to the animals at all times. Both buckets and a water tank were used to contain drinking water. Two three-gallon buckets were used for the first year of the study. Although adequate for smaller bears, these did not afford the safety of a constant water supply. Also an average of one bucket per two to three months was crushed beyond use. Both animals eventually ceased turning over the water buckets placed in the enclosure, but never stopped sitting in the water. Even though a bath was present, all fresh water was greeted by either stepping or sitting in the bucket (Figure 8). During this time water was carried at least twice daily from a ford in the Middle Prong of the Little River located approximately 175 m from the enclosure.

To insure a more constant, clean water supply



Figure 8. Kate sitting in a water bucket.

requiring less maintenance, a water tank was installed (Figure 9). A water regulator with a small trough was attached to the tank so that water upon demand was available to the bears. During the winter months an electric water heater was placed inside the tank to aid in preventing freezing of the water.

To obtain water the bear had to push a lever toward the tank. This was always done with the nose. Although the bears were observed to play with the small trough and lever, the paws were never used to push the lever to get water.

Bath Water

During the warmer months a bath was placed in the enclosure in which the bears could play and sit. The first bath was a children's plastic playpool approximately 150 cm in diameter. Within several weeks this was completely destroyed. Early spring 1971 an elongated stock watering tank 61 x 91.5 x 45.5 cm was introduced. Midsummer 1971 a 96 x 127 x 40 cm sheet metal tank with a drain reinforced with 5 x 10-cm boards was obtained. Water was kept in the tank at a depth of approximately 30 cm, and was changed every four to five days.

Shelter

Two shelters were provided for the subjects. These are illustrated in Figures 10 and 11. The shelter in side



Figure 9. Kate obtaining water from the water tank.

two of the enclosure (Figure 10) was open in front and back with an angled roof. The roof was 170 x 174 cm and the opening was 84 cm high. The roof was two layers of wood with a sheet of polyethylene between to reduce leaking. The polyethylene proved to be a mistake as the bears were quite attracted to it. The top layer of wood was pulled off and the plastic sheet partially consumed.

The two bears used this shelter predominately on which to play and rest. Until the fall of 1972, the animals rarely slept in the shelter. At this time and the winter of 1973, the shelter was consistently used for sleeping. Figure 10 shows both bears resting inside the shelter.

Another shelter was provided in the corner nearest the entrance to the enclosure area (corner two). This shelter was a single platform, 158 x 189 cm, constructed of 5 x 10-cm wooden boards and 2-cm plywood (Figure 11). This den was initially dug by both bears under a large half of a hollow log placed in corner two. The log was removed and the platform was placed over the digging so as to provide more "roof space". A 140 x 80 cm hole approximately 60 cm deep was dug under the platform by both bears. The author later enlarged the hole about twice the size of the original. Even with the additional space, only one bear consistently used the shelter. Only during extremely cold weather wer both bears observed to sleep in the den.



Figure 10. Both subjects resting in the shelter on side two of the enclosure.

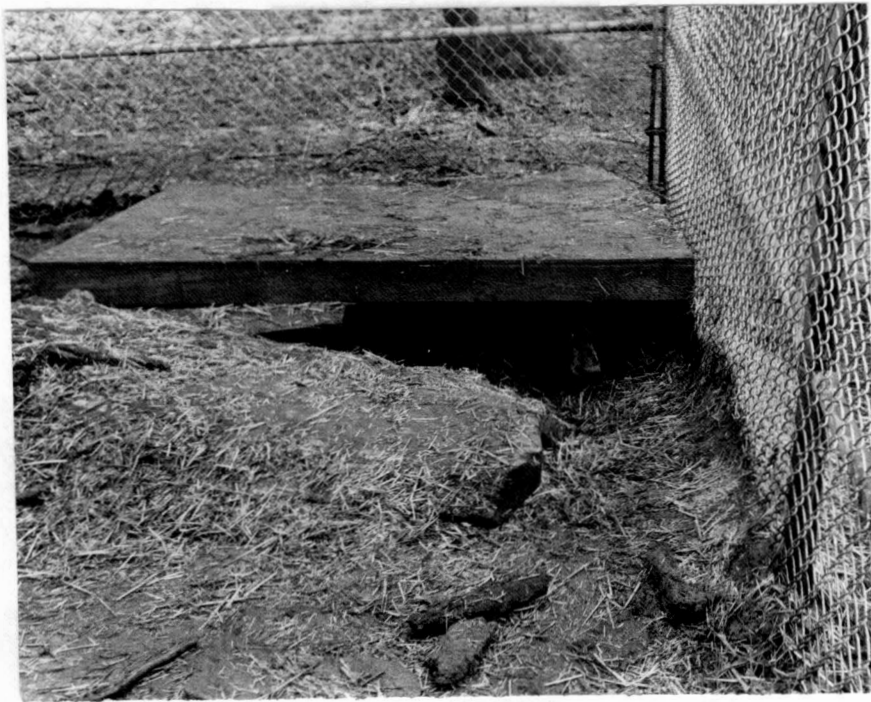


Figure 11. Kit inside the den located on side one of the enclosure

CHAPTER III

INGESTIVE BEHAVIORS

Behaviors associated with feeding are often considered to constitute a large portion of an animal's life, yet detailed descriptions of appetitive and consumatory behaviors are infrequently found. Research on ingestive behaviors of a species quite often consists of qualifying and/or quantifying the foods normally ingested, but little else. Such is the case with the American black bear.

From studies concerning the food habits of black bears, it appears that this species, although omnivorous and classified in the order Carnivora, relies primarily upon vegetative foods. In a recent study, Beeman and Pelton (1973) found vegetative material to comprise 83% of the diet of the black bear in the Smoky Mountains of Tennessee and North Carolina. Plant foods consumed by bears were divided into two categories: leaves and stems and fruit and twigs, the latter making up 66% of the total diet. The relative importance of vegetative materials in the diet did not significantly vary with the season, but the utilization of leaves and stems greatly diminished from early spring to late fall as the importance of fruits and twigs increased. Leaves and stems,

consisting mainly of grasses (Gramineae) and unknown herbs, comprised 76.5% by volume in the spring and only 11% in early fall. Fruits and twigs, consisting mainly of black cherry (Prunus serotina), acorns (Quercus sp.), blueberries (Vaccinium sp.), and squaw root (Conopholis americana), comprised only 13% by volume in the spring and 74% by early fall. Although availability may account for the small consumption of fruits and twigs in the spring, the dramatic shift to these foods by the summer as they become available indicates a strong preference away from leaves and stems toward the fruits and twigs.

Insects are found to be the major animal food consumed by black bears. Beeman and Pelton (1973) found insects in bear feces throughout the year, as did Cottam, et al. (1943) in Pennsylvania. In the study by Beeman and Pelton the relative volume of insects consumed ranged from 1% to 19% with an average volume of 8% from spring through fall. Murie (1937) reports, however, that in a situation of unusual abundance black bears in Yellowstone National Park may feed almost exclusively upon insects. Upon examination of 64 droppings in a year of cricket and grasshopper abundance, 58 consisted entirely of these insects.

Mammals appear to be infrequently utilized as food items. Beeman and Pelton reported that most mammal consumption in the Smoky Mountains consisted of carrion,

and that the occurrence by volume is generally less than 1%. Other studies have shown similar results indicating the black bear's herbivorous preference (Bennett et al., 1943; Cottam, et al., 1939; Harlow, 1961; and Tisch, 1961).

There appears to be little literature pertaining to the behaviors of ingestion in black bears. Several observations have been published, but these are, for the most part, included in discussion of the bears' "food habits" or diet. Murie (1937) gives a brief description of the foraging of an adult female for grasshoppers. He noted that the bear frequently overturned bison chips in search of the food. Cottam, et al. states that in Virginia "the black bear is much more of a clean feeder than might be expected" (p. 314). He reports finding little debris (leaves and twigs) of the plants from which fruits or seeds are consumed. Chatelain (1950), however, found that the black bears on the Kenai Peninsula of Alaska consume considerable debris. These accounts appear in research on the diet of the bear and reflect the dominant trend of food habit studies in American wildlife literature.

No literature was found pertaining to the behaviors related to the procurement and consumption of food of any North American Ursidae. This lack of knowledge concerning the bear's vegetative behaviors is typical of the

information on most mammalian species. Although some patterns are known pertaining to the finding and eating of food, such behavioral analysis is not commonplace. The present study, therefore, concluded a description of the behaviors associated with procurement and consumption of food by captive black bears. Both ethological descriptions of observed behaviors and a food preference test over a one year period were part of this facet of the research.

I. ETHOLOGICAL OBSERVATIONS OF PROCUREMENT AND CONSUMPTION OF FOOD

Foraging

Methods of Observation

Delineation of the foraging behaviors was accomplished by observations taken from November 11, 1971 to April 24, 1972. These observations consisted of 18, randomly-spaced, one-hour periods in which the bears were observed with a minimum of possible interruptions. Each observation period was broken down into 10-second time blocks. The behaviors were recorded on paper using a system of abbreviations and simple figures which are illustrated in Appendix 1. Various infrequent behaviors were not assigned abbreviations, but were written out. The behavior of the subjects in most instances was found to be very deliberate, especially those pertaining to feeding. Therefore, the 10-second intervals worked quite well in recording their behaviors as well as approaching the practical limit of note taking. The results of this set of observations were the appellation of the foraging behaviors observed, and their relative frequencies within the recorded time periods.

During the minimally-interrupted observations food was not placed in the enclosure. However, dog chow was

available in the feeder and naturally occurring edible items were also available, (e.g. grasses, insects, bark, and worms).

Food was introduced into the enclosure to verify observed behaviors and allow the author a closer examination of foraging behaviors. By scattering raisins throughout the enclosure foraging behaviors were artificially induced which aided in filming and close examination.

A Sony portable Videocorder, Model AV 3400, was also used to record and analyze foraging behavior patterns. Systematic recording with the videocorder was not done. This recording system was used to analyze such factors as speed of movements and frequencies of pattern repetitions.

Delineation of Foraging Behaviors

Analysis of the Observations

The appetitive categories were delineated by analysis of the minimally interrupted observations. Within these observation periods, 24 instances of eating various food items occurred. Prior to each instance of ingestion the behaviors within thirty 10-second time blocks, or five minutes, were listed. The behaviors associated with foraging were separated and the frequencies of occurrence of these behaviors were compared with the

frequency of occurrence of the same behavior in 24 randomly selected 5-minute time blocks.

Results and Discussion

The frequencies of the foraging behaviors prior to ingestion are shown in Table 1. The total number of time blocks in which foraging behaviors occurred is listed. Of the 720 possible time blocks prior to ingestion, foraging behaviors occurred in 508 (71%). The frequencies of the foraging behaviors in 24 randomly selected 5-minute time blocks are also listed in Table 1. Foraging occurred in only 214 (30%) of the 720 possible time blocks. This high frequency of a relatively small number of behaviors prior to ingestion and their lower random occurrence strongly supports the delineation of these behaviors as appetitive.

The major appetitive categories delineated by this analysis did not appear to be connected with the resting, playing and agonistic behaviors. Neither did they seem to be related to periods of high anxiety in which behaviors such as pacing and fright reactions may occur. The behavior patterns delineated as foraging did, however, correlate highly with ingestion. Whenever food items (either naturally occurring within the enclosure or present in the feeder) were eaten the foraging behaviors dominated the immediate, precursory patterns of

TABLE 1

COMPARISON OF THE FREQUENCY OF FORAGING BEHAVIORS
PRIOR TO INGESTION WITH THOSE OCCURRING
WITHIN A RANDOM SAMPLE

Foraging Behaviors	Prior to Ingestion	Random Sample
Smell closely objects in cage	77	11
Smell air	1	9
Smell closely the ground	33	
Apparently random walking	72	15
Direct movement	99	32
Apparent random walking and smell closely the ground	62	65
Smell closely and use front paws	105	6
Consumption of food or water	<u>59</u>	<u>76</u>
Total	508 (71%)	214 (30%)

behavior.

Three major behavior patterns were evident: olfactory scanning, ambulatory movements, and use of the front paws. These three general patterns occurred both separately and integrated.

The overt olfactory orientation consisted of sniffing the air, smelling objects within the enclosure, smelling the fence, and smelling the ground. Several of these olfactory behaviors quite frequently occurred in conjunction with the ambulatory movements. Two major ambulatory movements were observed. These were wandering around and direct movement toward a food object. The front paws were used to dig, uncover food items, and obtain food by raking it toward the animal. Digging and uncovering food was always paired with overt olfactory orientation. Detailed descriptions of the foraging behaviors observed are presented below.

Topography of Foraging Behaviors

Olfactory Scanning

The two general patterns of behavior delineated as olfactory scanning were sniffing the air and smelling objects within the enclosure, including the fence and the ground.

Sniffing the air, shown in field notes as S air, was considered a non-directional orientation toward a

relatively distant source of olfactory stimuli. As the bear is S air, it is generally not moving. Regardless of body position the head is raised and its nose extends upward. This type of orientation was observed when the bears were in a variety of body postures including sitting on the haunches, standing on all fours, and standing on the back legs resting against a tree or the fence. The mouth is either open or closed depending upon the intensity of the orientation. If the bear is S air rather intently, the mouth is open and exhalations may be heard from one to two m distance. The inhalation appears to be reasonably slow with higher rates associated with a greater intensity of orientation. The S air is illustrated in Figure 12.

Smelling objects within the enclosure involved varying intensity levels. Usually the bears oriented their noses closely to the ground or objects being smelled with little actual contact. Depending upon the distance, this was shown in the field notes as sniff medium, Sm, or sniff close, Sc. Figure 13 illustrates the Sc. With Sc the bear would place the upper lip within two cm of the object. Further distances, from approximately two to ten cm, were labeled as Sm. These two forms of scanning were considered of low intensity relative to the sniff mash, Smh. In the Smh the bear pushed the front of its nose firmly onto the object



Figure 12. Non-directional olfactory scanning, sniffing the air.



Figure 13. Olfactory orientation, sniff close (Sc).

being smelled. The Smh was observed as the bear smelled the ground, logs, and pockets of the investigator. The presence of food was generally associated with this olfactory behavior.

Smelling objects within the enclosure occurred along with a variety of body postures. In addition to the postures in which the S air occurred, Sc and Sm were observed as the bears were lying down. The mouth was usually closed. The inhalation rate during this orientation was more rapid than in the S air. Six to eight inhalations per five seconds appeared to be a consistent rate as the bears sniffed the author.

As the bear inhales, the lower portions of the upper lip extend. The lip is drawn back as the animal exhales. Contact with objects being smelled is frequently accomplished with the upper lip as it extends. During foraging the upper lip is often used to move forest litter. The ears seldom moved during the olfactory scanning and were maintained in an outward position known as the lateral 45° position (Pruitt, 1973).

Ambulatory Movements

Two major patterns of movement were observed: apparent random walking and direct movement toward a food object. The predominant pattern that differentiated appetitive ambulation from other forms of movement such

as pacing, running play, and fright reactions was the general orientation of the bear toward the ground.

As the bear wandered in search of food, the body line along the back and top of head formed an arc. The difference in angle of the head relative to the ground between food searching and walking not in search of food is subtle, but can be distinguished by the experienced observer. A pictorial difference is shown in Figures 14 and 15. The wild bear in Figure 14 is walking along a roadside in the GSMNP. The head is held more upward than that of the foraging bear in Figure 15. The head of the foraging bear is more toward the ground. A more obvious indication of foraging was the random breaking of stride to smell or orient toward the ground and various objects. In the apparent random walking the bears walked in a Left-front, Right-rear, Right-front, Left-rear pace frequently broken by olfactory orientation.

In the random walking the speed of forward movement varies greatly. In a fifteen minute video tape sequence of foraging behaviors the maximum speed recorded was one m per second. The frequency of orientation toward objects varies according to the food available. When raisins were scattered in the enclosure, the bears seldom oriented away from the ground.

The ear position during the apparent random walking was the lateral 45° position, and movement of the



Figure 14. Wild bear walking, not in search of food.



Figure 15. One of the subjects foraging in the enclosure.

ears was infrequent.

In the direct movement toward a food object the bear moved quite deliberately. The breaking of stride and olfactory orientation was not seen. The primary orientation appeared to be visual as the head was not oriented toward the ground, but was maintained toward the food being approached. Thus, the movement is quite similar to walking not in search of food. Although the direct movement sometimes involved running, the bear generally walked in a brisk pace slightly more rapid than the maximum speed of the apparent random walking. Again the ears were maintained in the lateral 45° position and did not move.

Use of the Front Paws

The front paws were used frequently during foraging. Several uses of the paws were observed: digging, raking, turning over objects, lifting, and pulling.

Digging resulted in actual movement of earth and occurred throughout the year. Limited digging in an area generally consisted of small, shallow holes which were often enlarged over a period of time. Digging tended to concentrate adjacent to rocks, root systems of trees, and the concrete in which the fence was embedded. Figure 16 illustrates the results of long-term digging around the roots of a large pine. This, of course,



Figure 16. Results of digging around the roots of a large pine tree.

would presumably never be as extensive under natural conditions.

Figure 17 illustrates Kit digging in the enclosure. As the bear digs, it stands on all fours with the nose near the ground. The back feet are together, and the paws are used one at a time. Overt olfactory orientation to the ground is always integrated with the digging behavior. The front claws are used as rakes with which to move the earth. A front leg is extended, lowered to the ground, and pulled back along the ground in a single motion. The front leg motion was always observed to be parallel to the body line, and the earth was always pulled toward the body. Pushing earth away from the body was never observed.

Video tape analysis of one subject illustrated that the speed approximated .8 seconds per digging movement. After three to four digging movements, the bear would stop and Sc or Smh the ground. Within a 10-minute recording the digging movements averaged 27 per minute.

The raking pattern was identical to the digging except that only the litter on the ground was moved. Raking was used to move the surface litter, draw objects toward the animal, or move specific objects such as rocks and branches. Figure 18 illustrates Kit raking straw toward the den for use as bedding material.

Both bears were quite adept at lifting and turning



Figure 17. Typical digging posture for the observed bears.



Figure 18. Kit raking straw toward the den in side 2 of the enclosure.

over rocks, logs, and other objects covering the ground. By bending the claws of the front foot downward the subjects could almost touch the front pad of the foot. With this mobility of the claws the animals could partially grasp varying objects. The lifting and turning over of objects was accomplished by grasping the side of the object farthest away, and pulling upward and back toward the body. Although the bottom of the front paws of the subjects may be turned so that they are perpendicular to the ground, flipping of objects by a rotation of the foreleg was never observed. Also, the bears never lifted an object with the pads of the front foot turned upward. All lifting was a continuation of the raking motion with the claws turned downward and back.

The front paws were also used to pull at objects such as the bark of a tree. In debarking logs the bears were observed to hook the claws of one paw under the bark and pull toward the body. The other front foot was used for support against the log.

Discussion

In the present study the foraging behaviors appeared to be relatively consistent and uncomplicated.

Foraging included searching for and orientation to selected food items, and was particularly stereotyped in the subjects studied. This may seem unusual

for a member of the order Carnivora due to the complexity of finding and attaining prey, but is not abnormal when the diet of this species is considered. Predation upon other than sessile invertebrates and social insects was seldom observed and was not considered a component of foraging.

Although particular behavioral sequences of foraging depended upon the situations encountered, the components of the observed behaviors were consistent. This consistency occurring in semi-natural conditions indicates that the behaviors described are representative of patterns involved in the attainment of food by black bears in natural conditions.

Predation

Methods of Analysis

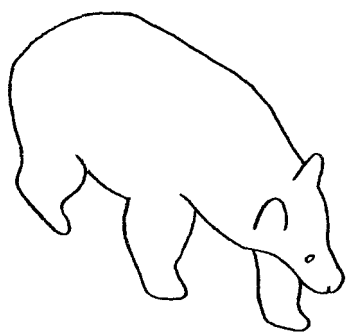
This type of behavior was so seldom observed that systematic study was impossible. Three film sequences of predation and several written observations were obtained. These included predation upon flying insects, a mouse, and a snake. Sessile and social invertebrates which comprise the majority of the black bears' animal food are not considered under this section of predation.

Topography and Discussion of Predatory Behaviors

Both bears were observed to use a forepaw for

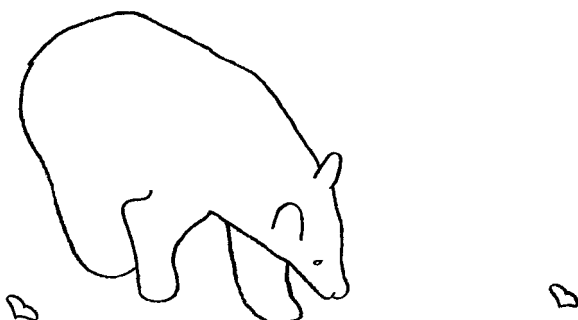
initial contact with prey animals. In the predatory behaviors observed, the prey was almost always approached by slapping the prey with a forepaw. The bears were observed to quickly snap up an insect in their mouth, but generally the procedure was to trap the insect beneath the paw. Often both front paws were used in what appeared to be attempts to cover and crush the prey. The reaction to an uninjured mouse was similar to that toward insects. When introduced, both bears chased the mouse with a series of slaps of the front paws. The bears' approach to a water snake (Natrix sp.) was also similar, in that the forepaws were used to initiate contact with the snake. However, unlike the insects and mouse, the snake exhibited an aggressive defense. During the interaction with the snake, the bears cautiously raked and pulled the animal toward them, but no crushing slap was administered. The sequence of approach and paw slap of a butterfly is shown in Figure 19. The sketches were traced from a super-8 movie sequence. The frame number and cumulative time elapsed are shown with each figure. The film speed was 18 frames per second. The orientation appears to be visual and the ears remain in the lateral 45° position throughout the sequence.

Eisenberg and Leyhausen (1972) state that the use of the forepaws to grasp prey may be considered a recent advance in prey capture that has evolved several times

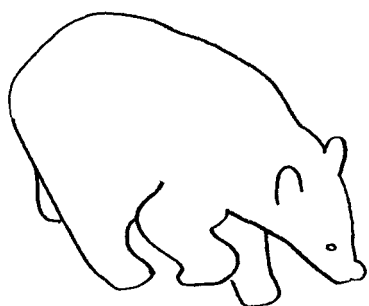


Frame 1

Apparent Random Movement

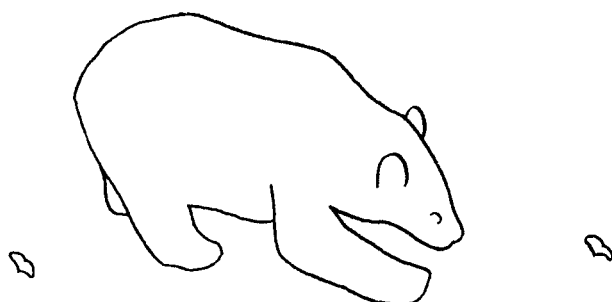


Frame 5 (.22 seconds)

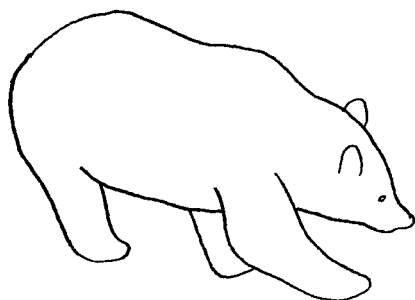


Frame 9 (.44 seconds)

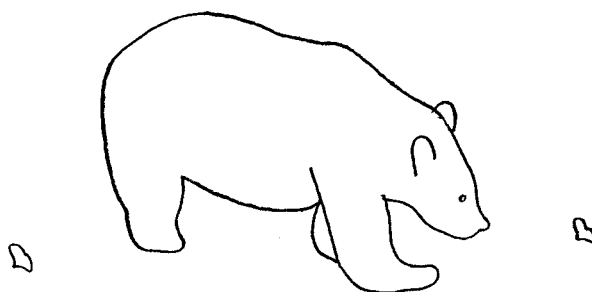
Initial Orientation



Frame 13 (.66 seconds)

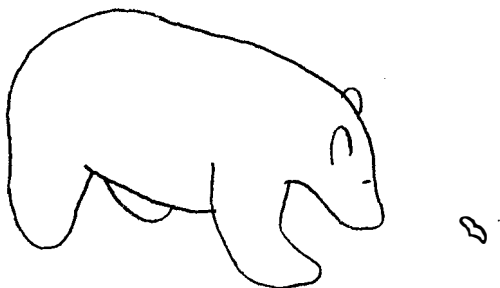


Frame 17 (.88 seconds)

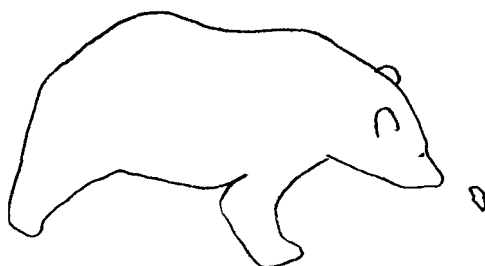


Frame 21 (1.1 seconds)

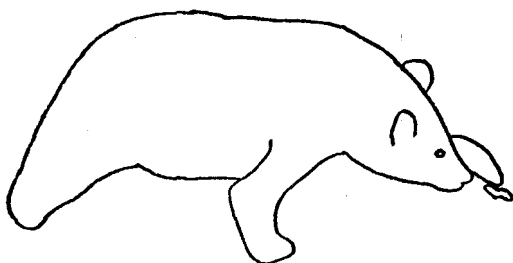
Figure 19. Sequence of butterfly catching activity by Kit.



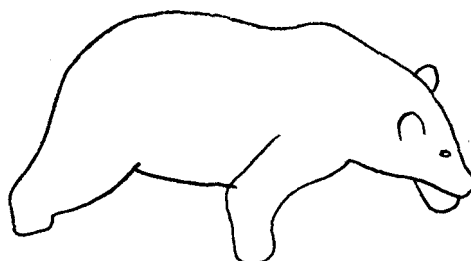
Frame 25 (1.33 seconds)
Beginning of Paw Slap



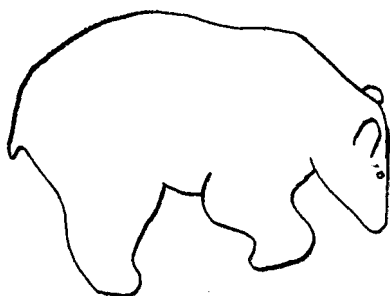
Frame 29 (1.55 seconds)



Frame 30 (1.61 seconds)



Frame 31 (1.66 seconds)
Paw Slap Complete



Frame 35 (1.88 seconds)
Investigation of Prey

Figure 19 (continued).

within various orders of mammals. With small prey objects, insectivores, dasyurid marsupials, and small carnivores may employ the forepaws to pin the prey animal to the ground before administering a killing bite or series of bites. However, only in the Felidae is found a definite selection favoring the use of the forepaws to clasp the prey prior to killing (Eisenberg and Leyhausen, 1972).

Ewer (1968) mentions another use of the forepaws considered unique to the Felidae. Both the serval cat (Felis serval) and the domestic cat (Felis catus) have been observed to crush prey with a downward, slapping blow of a forepaw, particularly those prey exhibiting offensive or defensive behavior patterns. It was intimated that the Felidae paw slap functioned to keep the head away from potentially hazardous prey. The bears' use of the forepaw with the snake appeared to serve this function but no paw slap was observed. However, when an injured mouse was introduced to one bear, she oriented to the mouse, smelled it, delivered a crushing paw slap with the right forepaw, smelled the mouse again, and delivered another rapid slap with the left paw prior to taking the mouse into her mouth. The use of the forepaws appeared to be to kill or greatly disable the prey prior to taking the animal into the mouth.

Procurement is also considered a function of the bears' use of the paw slap. With the uninjured mouse and the insects the behavior seemed to be primarily a facilitation of procurement.

Consumption

Methods of Analysis

Topography of consumatory behaviors for acorn, blackberry, and grass were analyzed using super-8 mm movie film and miscellaneous observations. A Braun N120 S80 (f 1:25, 10-80 zoom), super-8 mm movie camera was used. Kodak 4-x and Tri-x reversal films were found to be the best for filming at the enclosure. Thirty-five separate film sequences were used. All movie film was taken at 18 frames per second. The acorns were introduced into the enclosure by scattering 20-30 upon the ground. To film the bears eating blackberries, several stems of the plant containing fruit were stuck into the ground. Both of these methods were used to approximate as closely as possible the natural occurrence of the food items. The grass was placed in the enclosure in the form of 50 cm pieces of sod. The films were viewed using a Lafayette Super 8 Analyzer Projector which enabled a frame-by-frame view of the behaviors.

Topography of Consumatory Behaviors

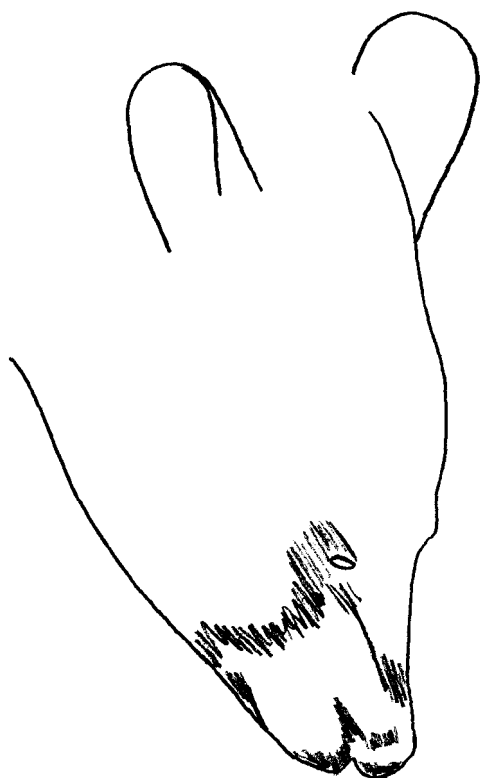
Analysis of the consumption of three important native food items are presented: acorns, blackberries, and grass. These items represent three major classes of vegetative foods consumed in the GSMNP: nuts, berries, and grasses.

Consumption of Acorns

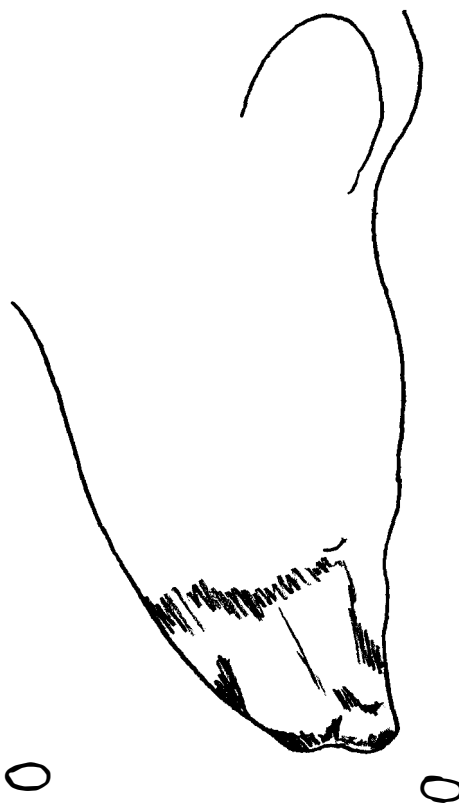
Orientation to the acorns appeared to contain both visual and olfactory elements. Although experimental evidence has not been obtained as to the exact procedure of orientation, the film analysis indicates that the initial orientation is visual. This, of course, assumes that the bear is already located in the general vicinity of available food.

Figure 20 illustrates a sequence of orientation and procurement of an acorn by Kit. These sketches are tracings from a super-8 mm film taken at 18 frames per second. The frame number and cumulative time elapsed are shown with each sketch. Frame 1 is the first obvious orientation toward the acorn. The distance is approximately 16 cm. Since other acorns are scattered nearby and no upper lip movement associated with sniffing occurred, this initial orientation was considered visual.

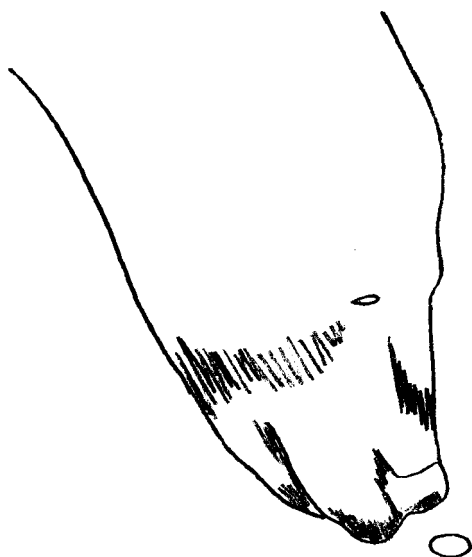
In frame 11 (.5 seconds later), the bear is



Frame 1



Frame 11 (0.55 seconds)



Frame 15 (0.77 seconds)



Frame 18 (0.94 seconds)

Figure 20. Orientation and procurement of an acorn.



Frame 24 (1.27 seconds)



Frame 26 (1.38 seconds)

Figure 20 (continued).

approximately 6 cm from the acorn. At this point the upper lip extension of the Smell Close (SC) begins. In frame 15 the upper lip is maximally extended and withdrawn three frames later (frame 18). This SC possibly serves as a reliability check for the object to which the bear is orienting.

Immediately succeeding the olfactory orientation (frame 18) the bear begins to obtain the acorn. Contact with the food occurs in frame 24. The tongue is extended and the acorn is picked up between the tongue and extended upper lip (frame 26). The extension of the upper lip often masks the role of the tongue in picking up the acorns. This is illustrated in Figure 21. This sketch of Kate is one frame prior to ingestion of the food. The upper lip is extended partially over the acorn and the tongue is not visible.

Details of the orientation and procurement vary with the specific situation, but the visual orientation, olfactory orientation and procurement via tongue and upper lip is quite consistent.

After the bear has obtained the acorn, it is transferred to the rear of the mouth and chewed. Most of the hull of the acorn is separated and the pieces of the hull are pushed out of the front and side of the mouth. In this manner little of the acorn hull was ingested.

An interesting use of the front paws and legs

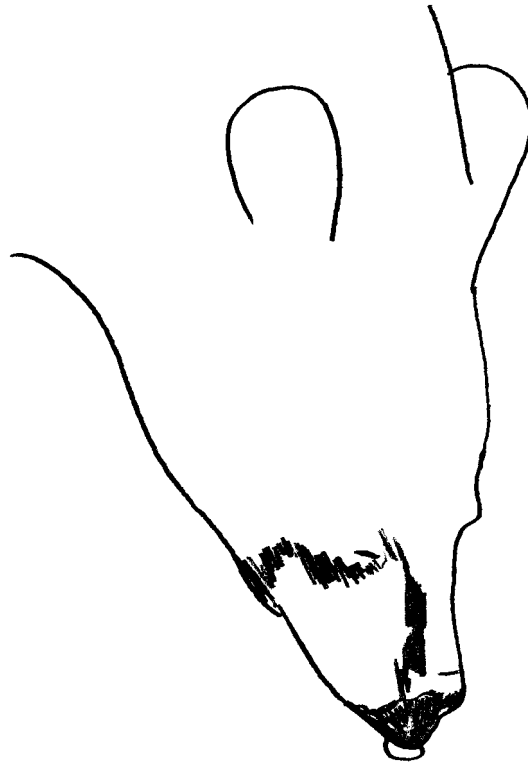


Figure 21. Extension of the upper lip in picking up an acorn.

frequently occurred. During the initial chewing of an acorn, pieces were often allowed to drop on the top of the front foot or on the leg. Later the bear would pick up the fallen pieces. However, debris was never observed falling on the foot. Using the front feet on which to rest uneaten food was frequently observed in the two subjects. This was also observed in another semi-naturalistically enclosed black bear (R. Jordon, personal communication). Figure 22 illustrates Kit using her front legs upon which to rest pieces of uneaten acorn.

After much of the hull was removed, the chewing rate was quite rapid. In eight sequences in the super-8 film the bears were observed to chew as fast as three times per second.

The body position appeared to be dependent on the situation. In the films the two bears usually were standing on all four feet. However, lying on the stomach and sitting were two other positions assumed. The ears were always at the lateral 45° as the bears were orienting to the food or eating. Frequently during the sequences both bears would orient away from the food to varying stimuli in and around the enclosure. At these times the ear position appeared to move forward toward the sound or object to which the subject was orienting.



Figure 22. Kit using forepaw upon which to rest uneaten pieces of acorn.

Consumption of Blackberries

The orientation to the blackberries appeared to be primarily visual. This may have been due to the lack of necessity to search for the food items. The acorns were scattered randomly on the ground. The blackberries were conveniently located on the bushes placed in the enclosure. Very few overt SC's were found in the film analysis. There was, however, obvious head nodding. This consisted of lowering the nose slightly prior to movement toward a berry or group of berries. This lowering of the head could possibly bring the food into a clearer field of vision. The head nodding is illustrated in frames 1 and 5 of Figure 23 which contains tracings of a typical procurement sequence. The cumulative time of the sequence is shown with each sketch. The film speed was 18 frames per second. The berry is approached, and grasped behind the incisors in frame 9. Frames 17 and 29 of Figure 23 are good examples of the incisor bite. The bear then pulls the head from the bush and the berry is removed from its stem (frame 35). In this manner very little of the stem becomes ingested. The bears used their tongues to guide the berries into the mouth, although berries were also obtained without the use of the tongue.

The rate of chewing was approximately the same as with the acorns. The front paws were used only to hold

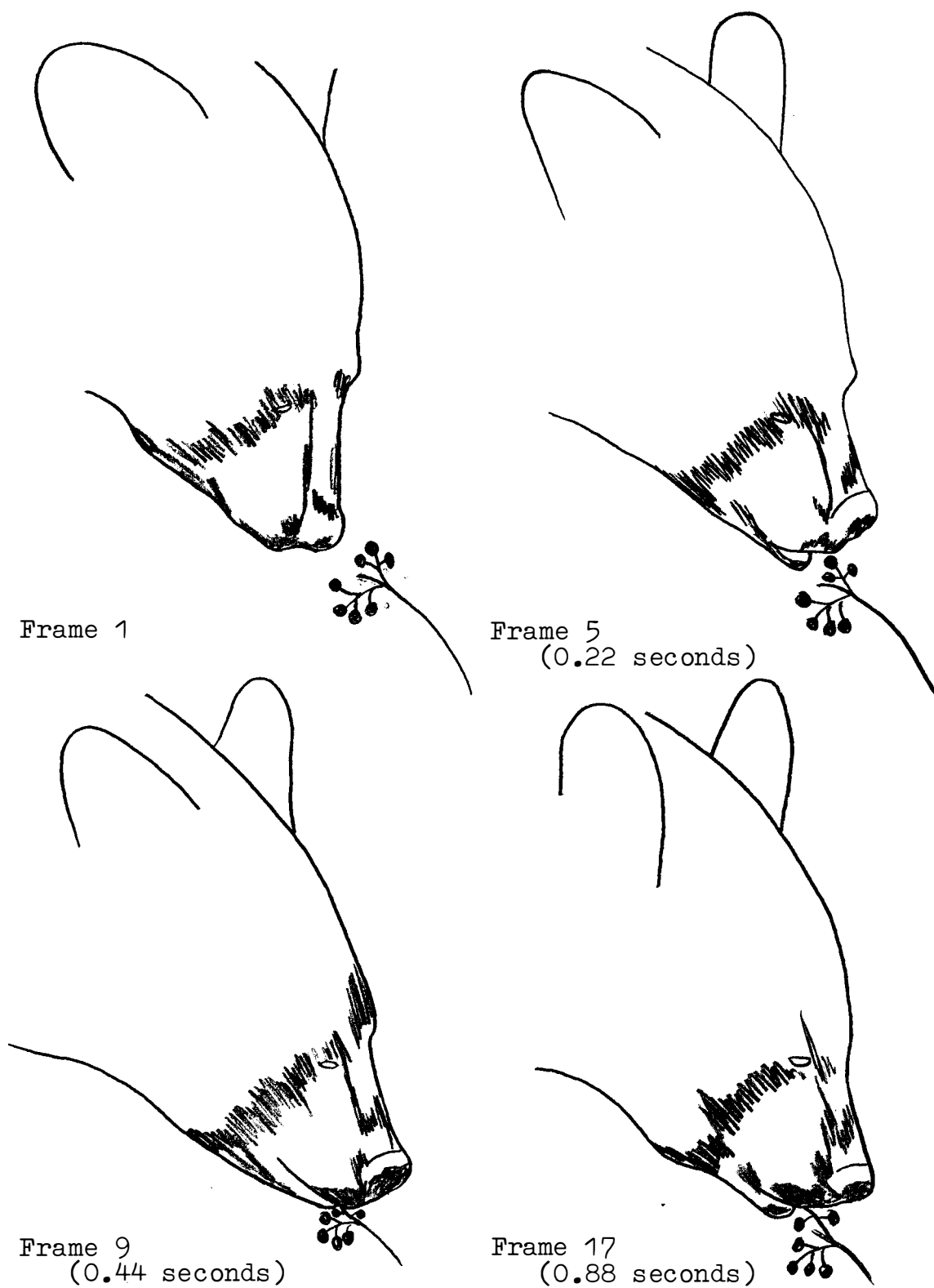


Figure 23. Procurement of blackberries.

Frame 29
(1.4 seconds)



Frame 35
(1.7 seconds)



Figure 23 (continued).

or manipulate the bush. Holding consisted of standing on the stems of the bush and appeared to be used to steady the plant. The lateral 45° ear position again occurred throughout the ingestion .

Consumption of Grass

Figure 24 illustrates the procurement of grass. The frame number (film speed of 18 frames per second) and cumulative time are shown with each sketch. The mouth is opened wide and the bear bites into grass, holding it with the incisors. By then lifting the head, the grass is pulled from the ground. In eating grass the mouth is opened much wider than in eating either acorns or blackberries. The tongue was used to procure loose blades, but intact grass was initially grasped by the front teeth without the use of the tongue.

The chewing was also more pronounced and slower in rate than in the consumption of acorns and blackberries. The bear very obviously manipulated the grass by the tongue during the chewing. The front paws were used much more while eating grass than during the consumption of the other two foods. Both bears used their paws to rake through the grass, hold it down, and lift the grass closer to their mouths. The body position varied from standing on all fours to lying on the stomach. The ears were again lateral 45° position during

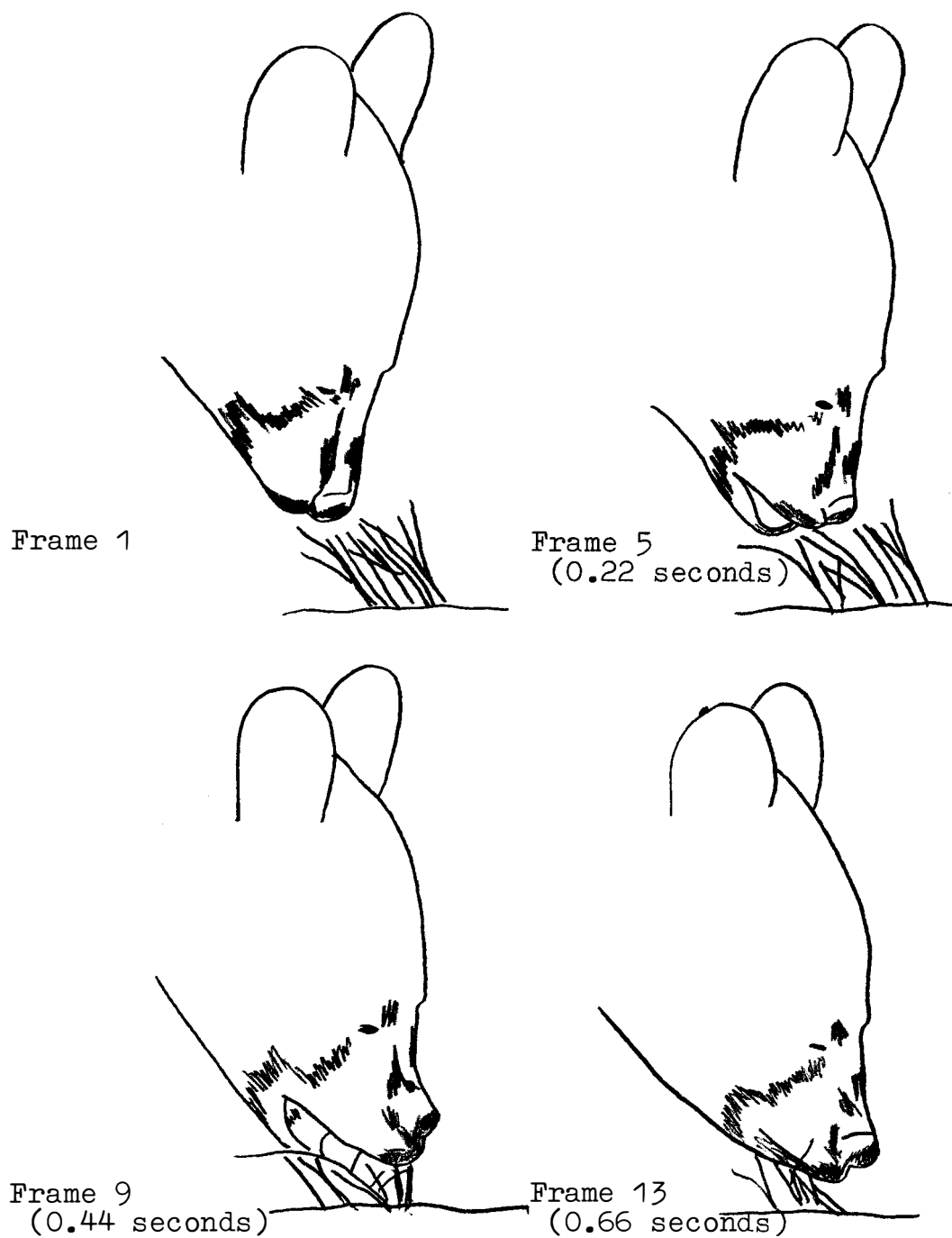


Figure 24. Procurement of grass.

Frame 17
(0.88 seconds)



Frame 21
(1.1 seconds)



Figure 24 (continued).

the ingestion.

Discussion

The subjects were found to be particularly clean feeders. Although many foods were eaten in entirety (e.g. apples, pears, whole fish) very little debris was ingested as they consumed the acorns, blackberries, and grass. Most debris was either spit out or avoided. These results agree with observations on the black bear in Virginia (Cottam, et al., 1939).

Orientation to food items appeared to contain both visual and olfactory sensory components. The observations indicated that the bears have well developed visual and olfactory systems, and that these systems are efficiently integrated. The apparently frequent use of the visual system also indicated the presence of a high degree of visual acuity and pattern discrimination.

II. FOOD PREFERENCE

Preferences of food items often may be attributed to the nutritional requirements and present nutritional state of the organism. It has been well documented that selection of foods closely approximates the nutritional requirements in various species, including rats, swine, mice and children (Cofer and Appley, 1964). One may assume that the preference for one food over another may be mediated via a presently undefined physiological-behavior mechanism. This mechanism translates the necessary information needed to maintain homeostasis within the organism to behaviors related to consumption. Here, preference or, in some cases, selective perception is considered part of gustation in that the end result is the channelization of behavior toward a drive reducing goal (consumption).

However, in many natural situations the food consumed may not be that which is most preferred. Availability is an important factor in the quantitative consumption of foods by many wild species. Availability is often seasonal in North America and is illustrated by quantitative seasonal changes in various species including black bear (Beeman and Pelton, 1973) and white-tailed deer (Cushwa, et al., 1970).

Seasonal variation of diet is well documented in

the black bear and availability of food items is considered the extrinsic mechanism through which this occurs. Couturier (1954) states that in general the bear prefers sweet plants and parts of plants (bulbs, fruits, and berries) which contain a large amount of carbohydrates. If relative food preferences are constant throughout the year, then availability can be definitely considered the determining factor of foods consumed. However, if changes in preference occur seasonally, the variance in diet may be due to intrinsic physiological needs which also, most likely, vary seasonally.

Two, one-year food preference tests were conducted using the two female bears previously described. One test consisted of native foods and the other of non-native foods. The tests were designed to quantify preferences for various foods and to study the seasonal effects upon relative preference.

Methods

Subjects

The subjects of the experiment were the two captive, female black bears described in Chapter II. Their ages during the testing were approximately 18 to 32 months.

Apparatus

The apparatus used in both preference tests was a modification of the Wisconsin General Testing Apparatus. The food preference apparatus is illustrated in Figures 25 and 26. The apparatus consisted of two major parts: a wooden door equipped with an opening through which a tray could be introduced, and the tray in which the food items were placed. The door was constructed of 2 cm plywood reinforced by 5 x 10 cm boards, and mounted on the gate post opposite to the entrance gate of side two. Being the same dimensions as the entrance gate, the food preference apparatus could be swung into place when the gate was open. This large wooden door was equipped with a platform upon which the food tray was placed, and a vertically-moving sliding door covering the opening through which the tray was introduced.

The food tray was 43 x 88 cm and was constructed of 1.3 cm plywood. The tray was designed so that each of two glass bowls, 9.7 cm in diameter, could be placed under movable screen covers. To obtain the food the bear could slide the screen covers either with the nose or one of the front paws. The food tray rested upon a platform attached to the door and could be completely withdrawn from the subject.

Figure 25. Food preference apparatus in operation from the side of the experimenter.

Figure 26. Kate eating a food item from the food preference apparatus.

Food Items

Native Food Items

Five native foods were tested. These were white oak acorns (Quercus alba), blackberries (Rubus, spp.), hickory nuts (Carya tomentosa), beech nuts (Fagus grandifolia), and grass (Gramineae spp.). All food items except the grass were collected late in the summer, 1971. The beechnuts, blackberries, and acorns were kept frozen. The hickory nuts were kept in a dark closet. Grass was available throughout the year and was collected prior to testing. For several tests grass grown inside with artificial lighting was used.

For presentation the food items were equated by total weight. The average presentation weighed approximately 3.4 grams. Three grams of the food tested consisted of one acorn, five beechnuts, three blackberries, 2/3 of a hickory nut, and a bowlful of grass.

Non-Native Food Items

The seven food items of the non-native preference test were: fish (Ictiobus sp.), hamburger, red delicious apples, canned pears, lettuce, cucumbers, whole wheat bread and dry dog chow. The fish, hamburger, and canned pears were obtained in quantity and kept frozen until use. The apples, lettuce, cucumber, and bread were obtained prior to testing. The dog chow was that which

the subjects were fed as a major part of their diet. These items were also equated by total weight. The foods were prepared so that each presentation approximated 10 grams.

Testing Procedure

The procedure for the native and non-native preference tests was the same. In each test a paired-comparisons procedure was used. That is, every food item within a set was paired twice with every other item. In each second pairing the positions of the choices were reversed to compensate for side preferences. The order of presentation of each choice was determined by randomly balancing the food pairs. Within the native food test 20 choices were presented each subject per session. The non-native food test consisted of 56 choices per session.

Prior to testing both bears were placed in the side opposite the apparatus. The apparatus was then assembled, properly positioned, and the food items were placed beside the experimenter. A plywood board was positioned beside the preference apparatus between the food items and the subjects. Figures 25 and 26 show both sides of the apparatus in operation. Kate was always tested first because of the relative ease in leading her away from the door at the termination of the test.

The native food sessions lasted approximately 30 minutes and the non-native sessions approximately one hour.

The experimenter used stainless steel forks to place the food items into separate glass bowls. Appropriate bowls were placed in the sliding tray of the apparatus and the screen covers placed over them. The vertically sliding door was lifted and the tray introduced. The bear was allowed to consume only one food item of the pair, and was required to noticeably attend to both choices. If the subject did not orient the nose to each screen prior to consumption, the tray was rapidly retracted and the sliding door shut. Several seconds later the tray was reintroduced. This procedure was repeated until the experimenter saw obvious head orientation toward both food items. Infrequently the bear held the tray and ate both food items. To avoid reinforcement of this behavior, the bear received a few sharp words and a rap on the knuckles with a stick, upon which she would quickly release the tray.

Discrimination of the foods was very good and seldom did the bear uncover an unwanted item. If a non-preferred item was uncovered, the subject would quickly move the head, uncover, and consume the opposite choice. This self-correction was allowed since preference and not discrimination was being tested. However, if the subject touched the food item with the lips, it was

considered a choice.

Training

The training was quite simple and proceeded rapidly. This consisted of introducing the tray and allowing the bear to eat both food items. Both bears initially rested their front feet on the tray to eat the food. By the third introduction Kate would take her feet off the tray immediately after the food was consumed allowing the experimenter to easily retract the tray. Kit was noted to be as cooperative, but exhibited a greater level of excitement about the procedure. This was evident by her frequent whining, pawing at the withdrawn tray, and digging at the base of the wooden door.

A preliminary preference test was given using six food items: apple, pear, bread, lettuce, cucumber, and dog chow. In the preliminary preference test the bears were allowed to eat both food items, and the order of consumption was recorded. Six test sessions presenting all possible combinations were done. Although this technique did not force the animals into a definite choice, the results approximated the final results of the preference testing for non-native foods. The results are shown in Table 2. After the preliminary tests, the paired-comparison preference test for the non-native foods was begun.

TABLE 2
PRELIMINARY FOOD TEST

Food Item	Results ^a	
	Kit	Kate
Pear	84%	94%
Bread	78%	75%
Apple	55%	67%
Cucumber	33%	32%
Lettuce	45%	23%
Dog Chow	7%	10%

^aThe scores indicate the percentage of times each food item was chosen first.

Number and Occurrence of Tests

Native Food Tests

The native food test sessions began November 21, 1971 and ended November 25, 1972. During these 12 months thirty sessions were run with each bear. The dates of testing are shown in Table 3. As is evident, seasons have adequate representation for comparative purposes.

Non-Native Food Tests

The non-native food test sessions began September 25, 1971 and terminated September 1, 1972. Twenty-two tests were run during this time period. As in the native food test, adequate representation of each season is present for comparative purposes (Table 3).

Results

The cumulative results of the native food test are shown in Figures 27 and 28. The bars of the figures represent the percentage of times each food item was chosen from the total times presented. During the native food test each food item was presented a total of 308 times. The estimated scale values (s'_k) from a least-squares solution of paired data (Torgerson, 1958) are shown for each food item. The average absolute deviation from the projected model of the rankings is also shown. From the cumulative results it is clear that

TABLE 3

DATES OF FOOD PREFERENCE SESSIONS

<u>Native Food Test</u>			<u>Non-Native Food Test</u>		
3	September	1972	1	September	1972
3	October	1972	25	September	1971
13	October	1972	27	September	1971
6	November	1972	11	October	1971
25	November	1972	13	October	1971
21	November	1971			
21	November	1971	15	December	1971
			18	January	1972
9	December	1971	8	February	1972
10	December	1971	26	February	1972
20	December	1971			
7	January	1972	7	March	1972
14	January	1972	26	March	1972
26	January	1972	12	April	1972
10	February	1972	23	April	1972
			1	May	1972
4	March	1972	10	May	1972
20	March	1972	13	May	1972
29	March	1972			
5	April	1972	2	June	1972
19	April	1972	18	June	1972
27	April	1972	23	June	1972
6	May	1972	20	July	1972
11	May	1972	1	August	1972
17	May	1972	14	August	1972
29	May	1972			
11	June	1972			
24	June	1972			
3	July	1972			
26	July	1972			
8	August	1972			
21	August	1972			

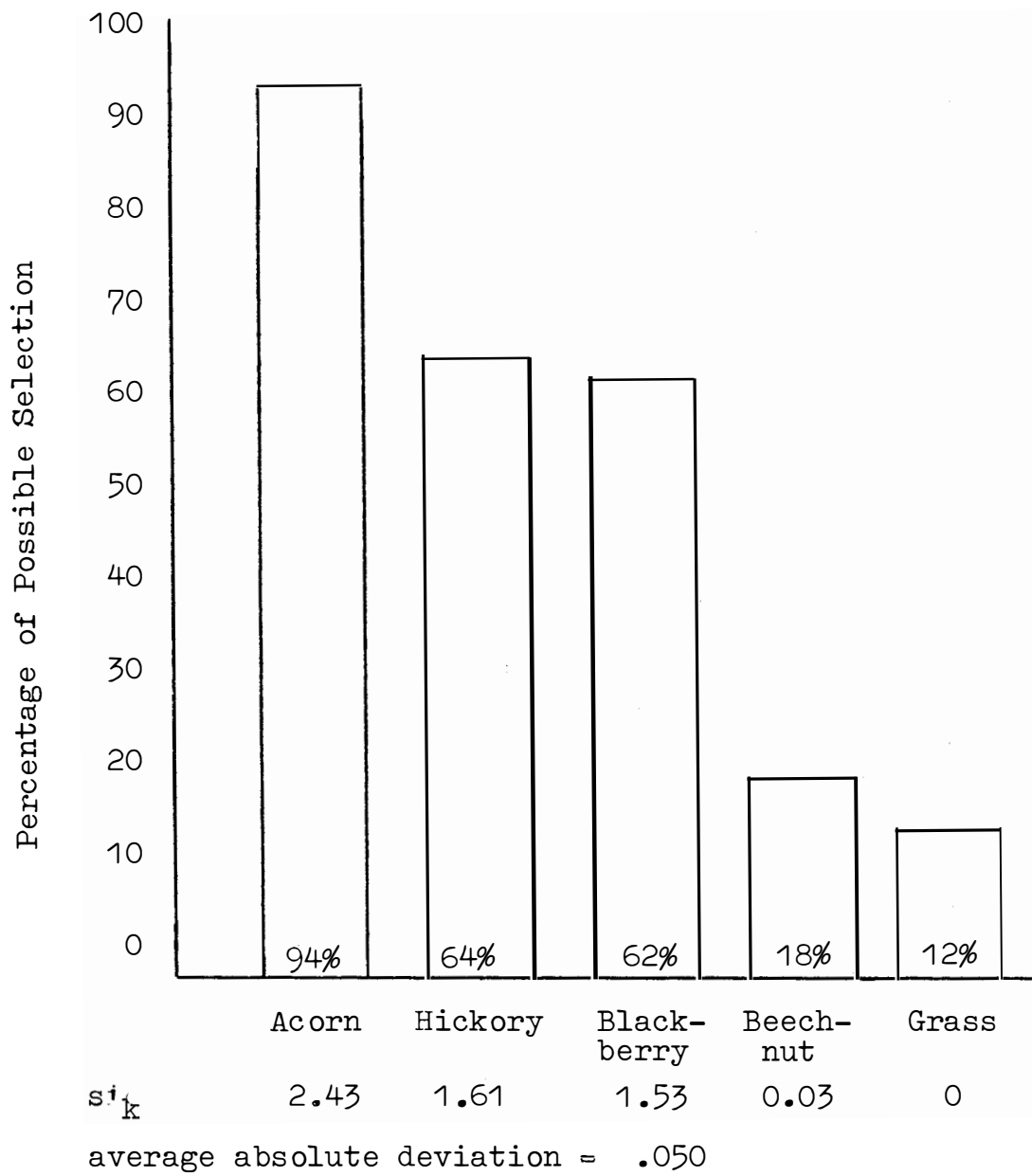


Figure 27. Results of the native food test for Kate.

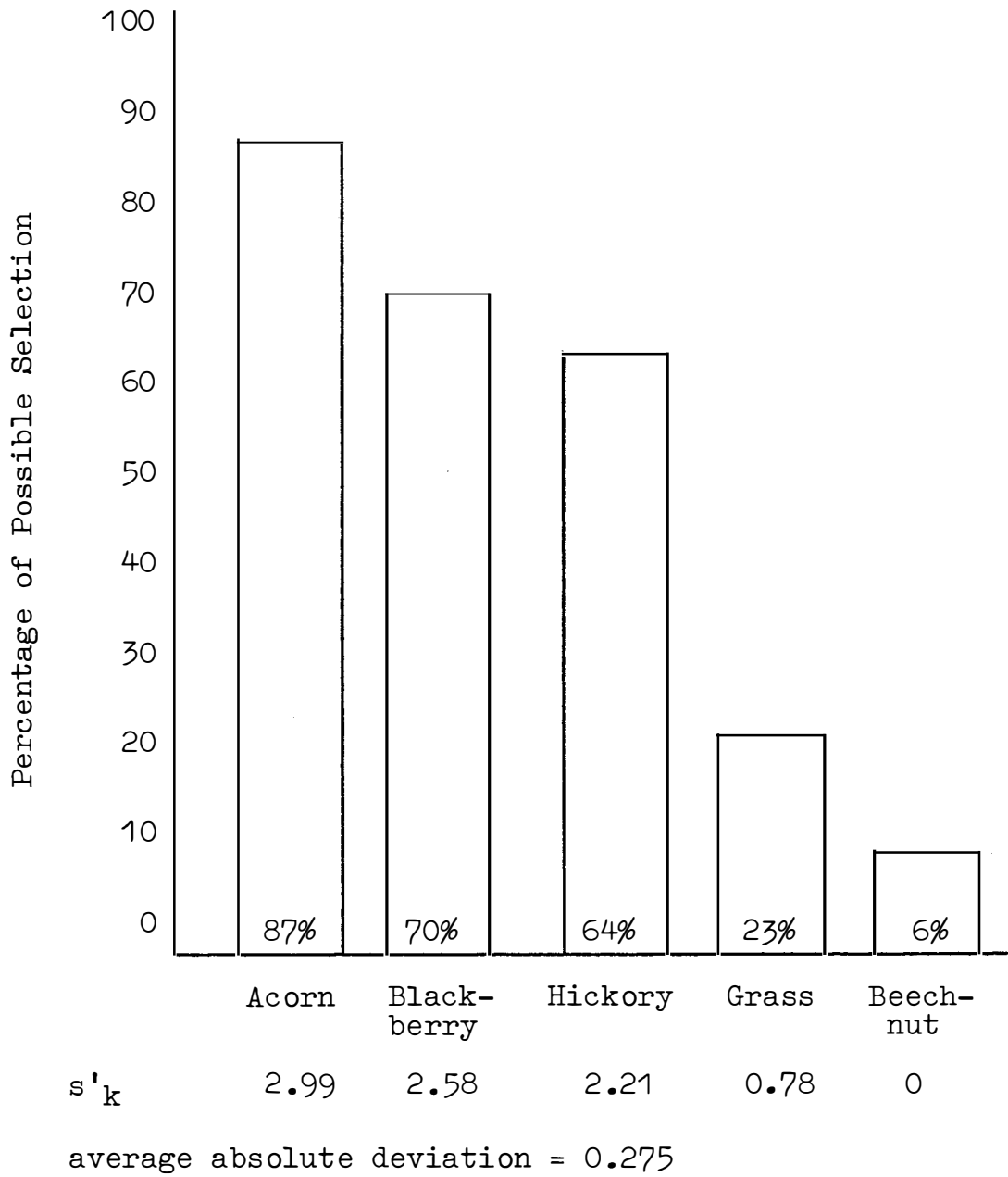


Figure 28. Results of the native food test for Kit.

distinct preferences are present among the foods tested. Also, the average absolute deviation for both bears is sufficiently small to conclude that the food items may be ranked, and the intransitivities occurring among the rankings are minor. In fact, of the ten food item pairs in the native food test, significant preference for one item over another occurred in nine of ten combinations. Both subjects failed to significantly choose between hickory and blackberry.

With Kate the preferences were separated into three distinct groups: acorns, hickory nuts and blackberries, beechnuts and grass. Both the cumulative percentages of selection and the s'_k values illustrate the three categories. Kit's preferences were similar in that beechnut and grass were obviously less preferred than the other three foods. However, the s'_k values separating the acorn, blackberry, and hickory preferences varied only slightly, therefore, no distinct division separated the acorns from the blackberries and hickory nuts.

The results of the native food test are similar between the two subjects. A Pearson product-moment correlation coefficient (Siegel, 1956) yielded a correlation of .96 between the subjects cumulative preference scores.

The choices among seasons remained very consistent. Visual analysis of Table 4 reveals that seasonal discrepancies are infrequent and that the two major preference

TABLE 4

SEASONAL RANKINGS OF NATIVE FOOD ITEMS
BY THE TWO SUBJECTS

	<u>Kate</u>					<u>Kit</u>				
	Fall	Winter	Spring	Summer	R _j	Fall	Winter	Spring	Summer	R _j
Acorn	1	1	1	1	4	2	1	1	1	5
Hickory	2	2	2	3	9	3	2	3	3	11
Black- berry	3	3	3	2	11	1	2	2	2	8
Beech- nut	5	4	4	4	17	5	5	5	5	20
Grass	4	5	5	5	19	4	4	4	4	16

categories (i.e. acorns, blackberry, and hickory vs. beechnut and grass) remained unchanged. A Kendall coefficient of concordance (Siegel, 1956) for each subject indicates that agreement among seasons is significantly higher than it would be by chance ($p < .01$). The results for each food item pair are shown in Appendix B.

Non-Native Food Test

The percentage of times selected from the total presentations, the estimated scale values (s'_k), and the average absolute deviation are illustrated in Figures 29 and 30. Again, distinct preferences occurred and the absolute deviations from the projected models indicate that the preferences of both bears were stable.

Of the 26 possible food pairs Kate significantly chose one food over another in 23 of the pairs. She made no significant choice between fish and hamburger, bread and apple, and cucumber and lettuce. Kit chose significantly 22 of the 26 food item pairs. Those not showing significant preference were fish and hamburger, pear and hamburger, hamburger and bread, and cucumber and lettuce.

The responses of the two subjects were very similar. A Pearson product-moment correlation coefficient of the cumulative results yielded a correlation of .99 between the choices of the subjects.

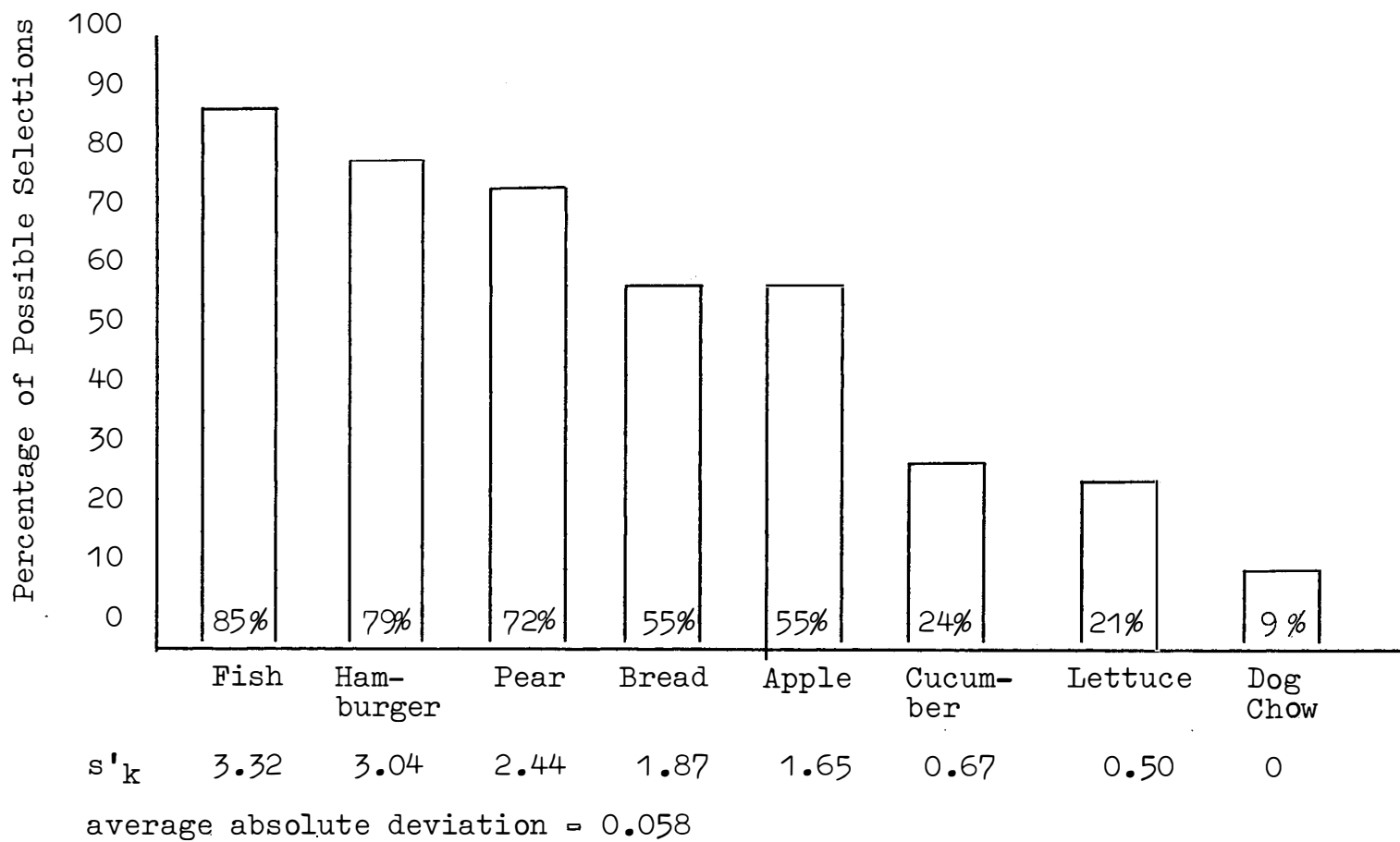


Figure 29. Results of the non-native food test for Kate.

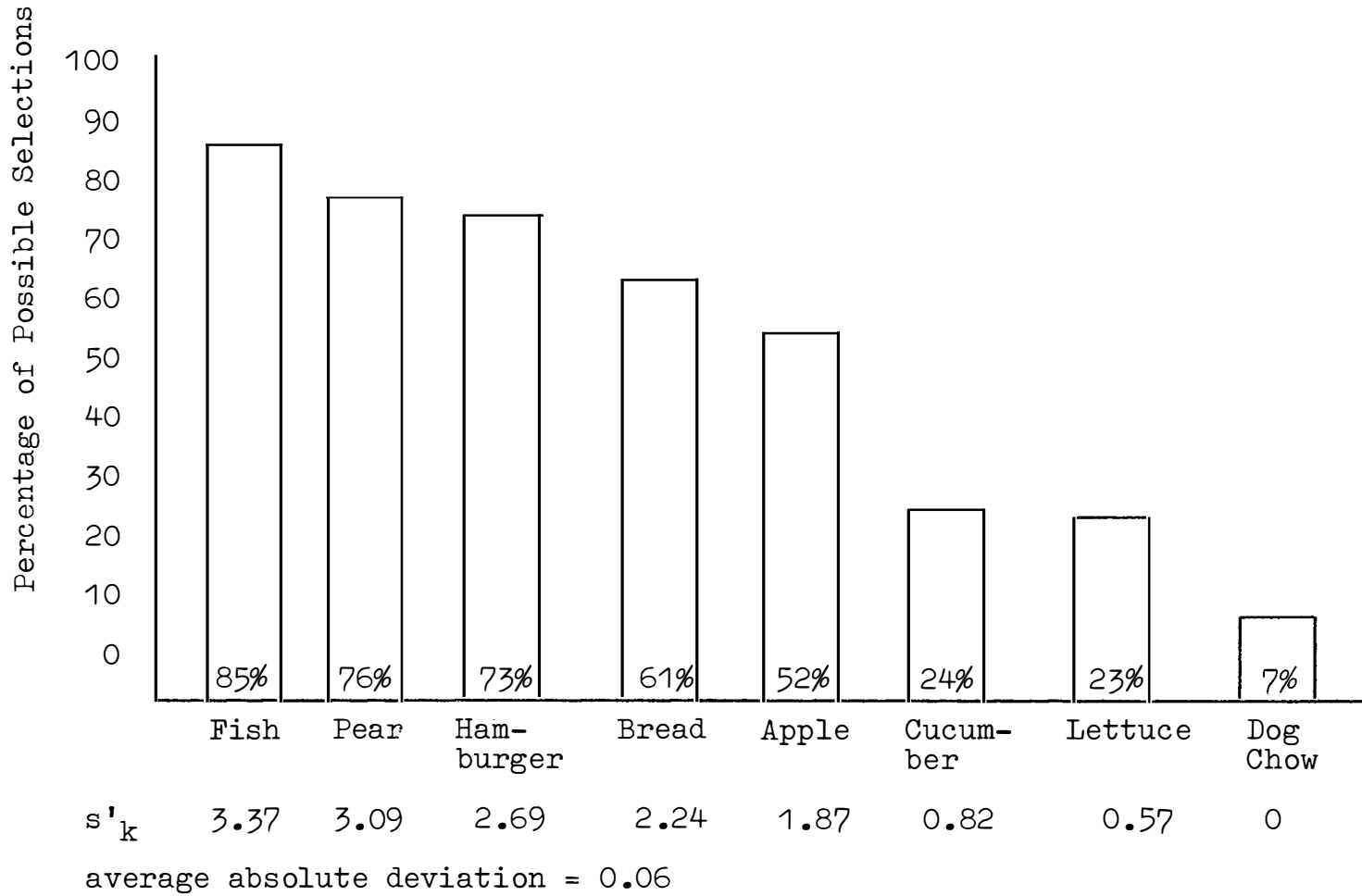


Figure 30. Results of the non-native food test for Kit.

The choices among seasons for the non-native foods remained consistent, but did not exhibit the high degree of stability of the native food preferences. A Kendall coefficient of concordance for each subject indicates that agreement among seasons is significantly high ($p < .01$). The only dramatic preference shift occurred during the summer in the hamburger preference. In three consecutive sessions of the eight sessions during the summer, preference for hamburger dramatically decreased. The decrease in hamburger preference was associated with a change from the frozen hamburger used in previous sessions to freshly ground hamburger. The resulting decrease in relative ranking due to these three tests can be seen in Table 5. As soon as the frozen hamburger was reintroduced in place of the freshly ground meat the preference was again consistently higher. The results for each food item pair are shown in Appendix C.

Discussion

The two captive bears exhibited a very structured relative preference among two differing sets of food items. These preferences were well correlated between the subjects. Seasonal variability was small, and no trends toward seasonal preference changes were indicated.

In the native food test acorns were significantly preferred over all other foods. This finding integrates

TABLE 5

SEASONAL RANKINGS OF THE NON-NATIVE FOOD
ITEMS BY THE TWO SUBJECTS

	<u>Kate</u>					<u>Kit</u>				
	Fall	Winter	Spring	Summer	R _j	Fall	Winter	Spring	Summer	R _j
Fish	1	3	2	1	7	2	1	1	1	5
Ham- burger	2	1	1	5	9	1	2.5	3	4	10.5
Pear	3	2	3	2	10	3	2.5	2	2	9.5
Bread	4	4	5	3	16	4	4.5	4	3	15.5
Apple	5	5	4	4	18	5	4.5	5	5	19.5
Cucumber	8	6	6	6	26	7	7	6	6	26
Lettuce	6.5	7	7	7	27.5	6	6	7	7	26
Dog Chow	6.5	8	8	8	30.5	8	8	8	8	32

well with the food habits of the bears in the GSMNP. When available in the fall, acorns become a major part of the diet. Berries, an important summer food item, were also highly preferred.

Although beechnuts comprise a minor portion of the diet of the black bear in the GSMNP, they are a major item in various bear populations of the northeastern United States and Canada (Pelton, personal communication), and may be a highly preferred food in those populations. Unfortunately, the rejection of the beechnuts by the subjects was, most likely, an artifact of the experiment. The beechnuts used in the food test were found to contain very little flesh. This discovery was made after the testing had begun. By that time no other beechnuts were available. The small amount of ingestible material relative to that of the acorns, hickory nuts, and blackberries may well have influenced the selections.

The storage methods and length of time stored of the food items did not appear to influence the selections. The stability of the preferences among seasons, especially from fall when the foods were collected through the following summer of testing, tends to indicate that the foods themselves did not differ significantly during the test.

Grass, available almost the entire year, is a major early spring food item. With emergence of other

native foods the importance of grass quickly decreases. From the food habits of the wild population in the GSMNP, and from the results of this study, it appears that grass is a utilized, but truly unpreferred food. Although the relative preferences remained stable, the absolute preference for grass did not. Both bears were observed to eat and forage for grass as early as mid-May and continued to consume small quantities of this food throughout the summer. By late fall and through the winter, grass was refused by both animals. This occurred for two consecutive years. Similar phenomenon was not observed with the non-native vegetative food items.

In the non-native food test the two meats and the canned pears were the most preferred. A very sharp division separated the lettuce, cucumber, and dog chow from the other foods. The rejection of cucumber and lettuce is analogous to the rejection of grass in the native food test. The dog chow was never a favorite food. Constant exposure to the dog chow most likely affected its position in the relative preference.

The lack of seasonal trends and inter-seasonal variability in the results of both preference tests indicates that volume consumption within this species is controlled by availability of the food items. Seasonal differences of nutritional needs may be intimated from native food studies (e.g. consumption of acorns in

preparation for the winter), but are not supported by the present study. The preference ranking of the food items was so strong and temporally stable, the availability of food items is considered the major temporal environmental force directing the gustatory behaviors of the black bear.

The nutritional constituents of the food items also appear to be related to the relative preference. In the native food test the acorns contained the highest percentage of starches and sugars (carbohydrates) (Table 6). Preference for such a food would be advantageous for weight gain in preparation for winter dormancy. In the non-native food test the sharp separation of cucumber and lettuce from the other foods is also related to the total nutritive value of the food items. The lettuce and cucumber contain the least total nutrients (Table 7).

The volume and distribution of black bear foods (Beeman and Pelton, 1973) indicates that the bears of the GSMNP primarily consume foods high in starches and sugars. A preference for such foods was substantiated by the two food preference tests. However, such a diet is greatly deficient in protein. Fruits and seeds contain relatively little protein as does other vegetative materials consumed by bears. Insects appear to be the major source of protein. Considering the available information, the natural diet of black bears may be

TABLE 6

NUTRITIONAL CONSTITUENTS OF 100 G INGESTIBLE
MATERIALS - NATIVE FOODS

Food Item	Protein (g)	Fat (g)	Ash (g)	Carbohydrates (g)	Crude Fibers (g)
Acorn (White Oak) ^a	3.2	10.7	1.2	25.0	9.9
Pecan b,d	9.4	73.0	1.6	13.0	2.2
Blackberries ^b	1.2	1.0	.5	12.5	4.2
Grass (fresh fescue) ^c	4.4	1.4	2.8	12.7	7.7

^a Source: Morrison, Frank B. 1954. Feed and Feeding 21st Ed. Morrison Publishing Co. Ithaca, N.C.

^b Source: Heinz International Research Center. 1964. Heinz Nutritional Data 5th Ed. Heinz International Research Center and Heinz Research Fellowship of Mellon Institute. H.J. Heinz Co. Pittsburgh, Pa.

^c Source: National Research Council. 1964. Joint US-Canadian Tables of Feed Composition. National Academy of Science, National Research Council Publication 1232.

^d No values for beechnut or hickory could be found. Pecan is listed as a substitute for hickory and can only be considered a rough approximation.

TABLE 7

NUTRITIONAL CONSTITUENTS OF 100 G INGESTIBLE MATERIALS
NON-NATIVE FOODS

Food Item	Protein (g)	Fat (g)	Ash (g)	Carbohydrates (g)	Crude Fibers (g)
Shed, raw	13.7	9.8	1.4	Negligible	0
Hamburger, ^a cooked	23	27	1.1	0	0
Pears, canned	.4	.1	.4	18.2	.4
Bread, whole wheat	9.3	2.6	2.5	49.0	1.5
Apple, raw	.3	.4	.3	14.9	1.0
Cucumber, raw	.7	.1	.4	2.7	.5
Lettuce	1.2	.2	.9	2.9	.6

Source: Heinz International Research Center. 1964. Heinz Nutritional Data 5th Ed. Heinz International Research Center and Heinz Research Fellowship of Mellon Institute. H.J. Heinz Co. Pittsburgh, Pa.

^a No value for raw hamburger could be found.

considered protein deficient. Data presented by Jonkel (1969) supports this assumption. Captive animals and those obtaining supplementary feeding greatly outgrow their wild counterparts. This growth differential is most likely due to nutritional (specifically, protein) differences of the diets. Accelerated growth also occurred with the two bears of this study which were maintained on a protein-rich diet.

In the non-native food test the high protein, zero starches-and-sugar foods (fish and hamburger) were preferred over the low protein, high starches-and-sugar foods (bread and apples) by both subjects. The subjects differed in their preference of pears. The pears, canned in a sweet syrup, were less preferred to both meats by Kate, but only less preferred to fish by Kit. However, in comparison with the naturally ingested foods, one would expect a higher preference for the high starch and sugar items. The striking preference for the meats indicates that the protein preference necessary for a carnivore is still extant. The high carbohydrate preference is unusual for a carnivore, but possibly evolved as the black bear moved into the forest and became omnivorous. The evolution of a primarily vegetative diet along with the inability to assimilate cellulose necessitated a strong preference for high starch and sugar foods.

In conclusion, it appears that the diet of the black bear is mediated by intrinsic preferences, but controlled by the extrinsic factor of availability. The highly structured and correlated relative preferences indicate that food selection may be controlled by specific hungers associated with nutritional requirements. These preferences, are realized as the food becomes available. In natural situations this availability is seasonal.

CHAPTER IV

VISUAL DISCRIMINATION

The black bear has long been considered an animal of limited visual abilities, especially relative to its purposed olfactory prowess. The American literature reviewed has indicated that eyesight in the bear is poor (Skinner, 1925; Seton, 1909). The above is still maintained as evidenced by Wormser (1966). Unfortunately, this information has been accumulated anecdotally without experimentation or controlled observation. The perceptual abilities of the American black bear are virtually unknown aside from gross generalizations.

Two European sources consider the role of vision in the life of the European brown bear. Couturier (1953) regards vision in the bear as a secondary sense. However, he does state that brown bears are capable of discriminating bright colors but not the more tonal pastels.

Kuckuk (1937) states that the brown bear has quite adequate visual capacities. He found that he could be recognized by the two young bears being studied in a crowd of strangers at a distance of 15 m. Although the bears could recognize Kuckuk olfactorally, the behaviors of the animals indicated that the visual image played

the principle role in recognition. The bears also had a very rich visual image of a species member. At 10-15 m one bear gave definite signs of recognition of a stuffed bear when the following were visible: the head alone, the neck and forelegs, and the hind legs alone.

The present research was designed to assess the abilities of two captive black bears to perform visual discriminations on the basis of hue and pattern. Development of a learning task amenable to use with this species was also a goal of the study. The procedures were basically experimental with varying modifications to adapt the tasks to the semi-natural conditions present during the study.

I. COLOR VISION TESTING

Color vision in the higher mammals is still assumed to be weak, if present at all. As recently as Viaud (1960) and Gregory (1966), hue perception, aside from primates, was considered rudimentary or non-existent.

Unfortunately, such considerations have been generated by assumptions taken from inadequate, often poorly controlled experimentation on a relatively few species. As Rosengren (1969) points out, results obtained from predatory animals are not consistent. She lists studies on only four species: the domestic dog and cat, the raccoon (Procyon sp.), and the red fox (Vulpes sp.). Walls (1942), in his compendium on the eye, mentions color vision research on only ten non-primate species. All of the research Walls reviewed yielded questionable or conflicting results. In fact, the primates appear to be the only group of mammals in which both behavioral and physiological data convincingly establish hue perception (Grether, 1940; Rosengren, 1969; and Walls, 1942).

Aside from the present study, little recent research has been devoted to non-primate mammals. Behavioral research strongly indicates that both swine (Klopfer, 1966) and dogs (Rosengren, 1969) have a well developed ability to discriminate on the basis of hue. Color vision in the domestic cat has been well studied

with conflicting results. However, Daw and Perimann (1970) were able to behaviorally demonstrate hue discrimination. They also found lateral geniculate units showing opponent properties and postulated the cat to be dichromatic.

The present research was a behavioral assessment of the abilities of two captive black bears to perform visual discriminations on the basis of hue. The experiments were designed to test for the existence of hue discrimination by the subjects and did not include methods of precisely quantifying the discriminatory capacities.

Methods

Subjects

The subjects for the experiment were the two captive female black bears previously described. Kate was 19-31 months of age during testing. Kit was 28-31 months of age during testing.

Apparatus

Stimulus Items

The major components of the apparatus were the stimulus items which consisted of 8 oz. (.24 l) translucent, polyethylene cups. The cups were painted with a flat gloss latex paint. Each cup was painted at least

twice to insure a homogeneous appearance of the varied hues. The paints were manufactured by Foy-Johnson. Varying shades were produced by adding differing amounts of pigment to either a latex paint base or white latex paint. The shades, or saturations, ranged from dark to light for each hue. Forty shades were used in the study. These were: blue - seven shades, green - five shades, red - five shades, yellow - five shades, and gray - 18 shades.

Spectrographic Analysis

The intensity of transmission within the visible spectra was obtained for each paint. The 40 shades, each painted upon a 5 x 5 cm polyethylene square, were analyzed by a Bausch and Lomb 505 spectrometer. Light transmission relative to a barium carbonate standard was obtained at every two nanometers between 400 and 700 nanometers. The transmission spectra are illustrated in Figures 31 through 36. The hues of the blue, green, red, and yellow remained remarkably stable, varying only in saturation (expressed as relative transmission). The shades of gray also exhibited an excellent homogeneity of transmission.

Olfactory Control Boards

Control of olfactory cues was accomplished by use of olfactory control boards upon which stimulus items

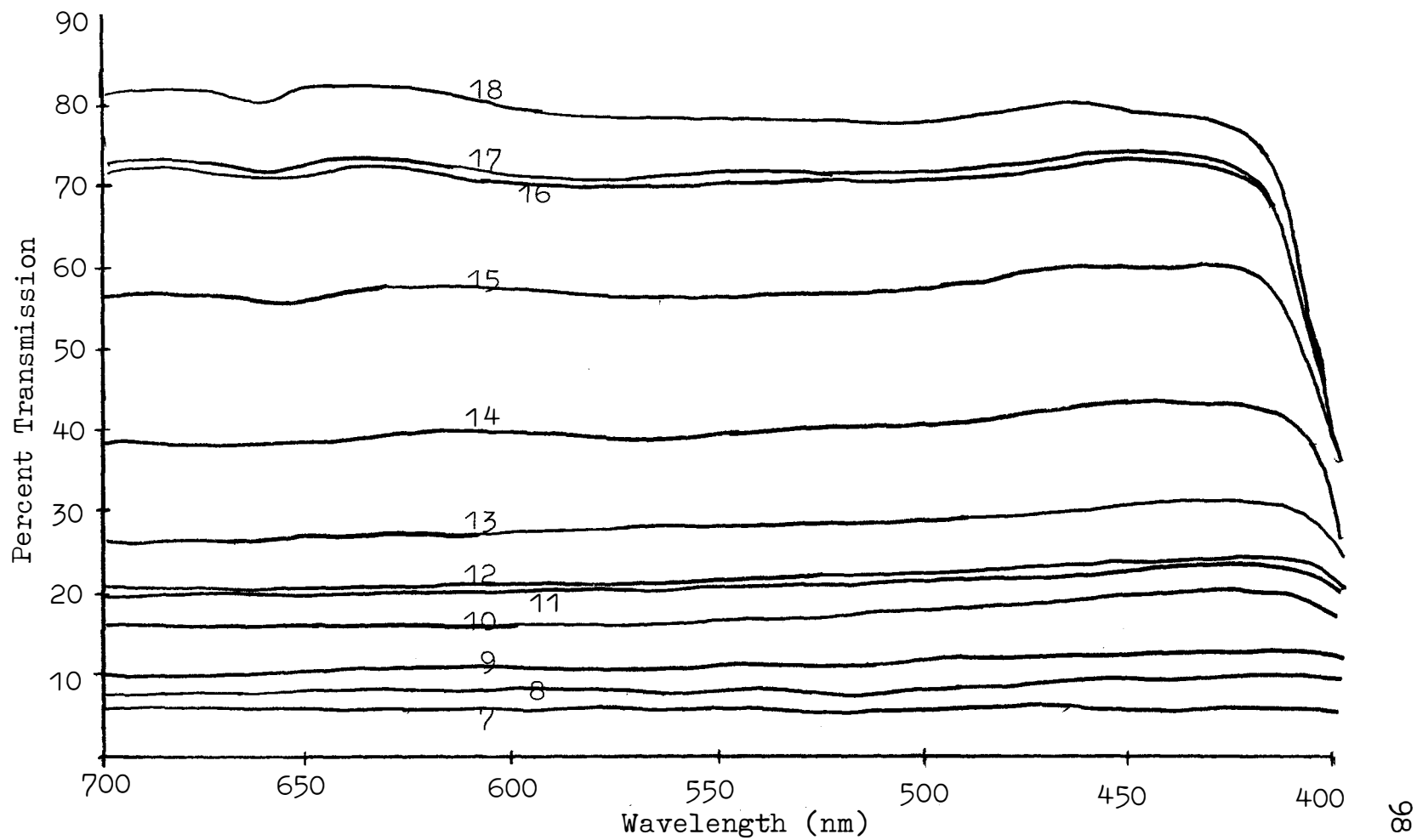


Figure 31. Transmission spectra of gray paints (#7 - #18).

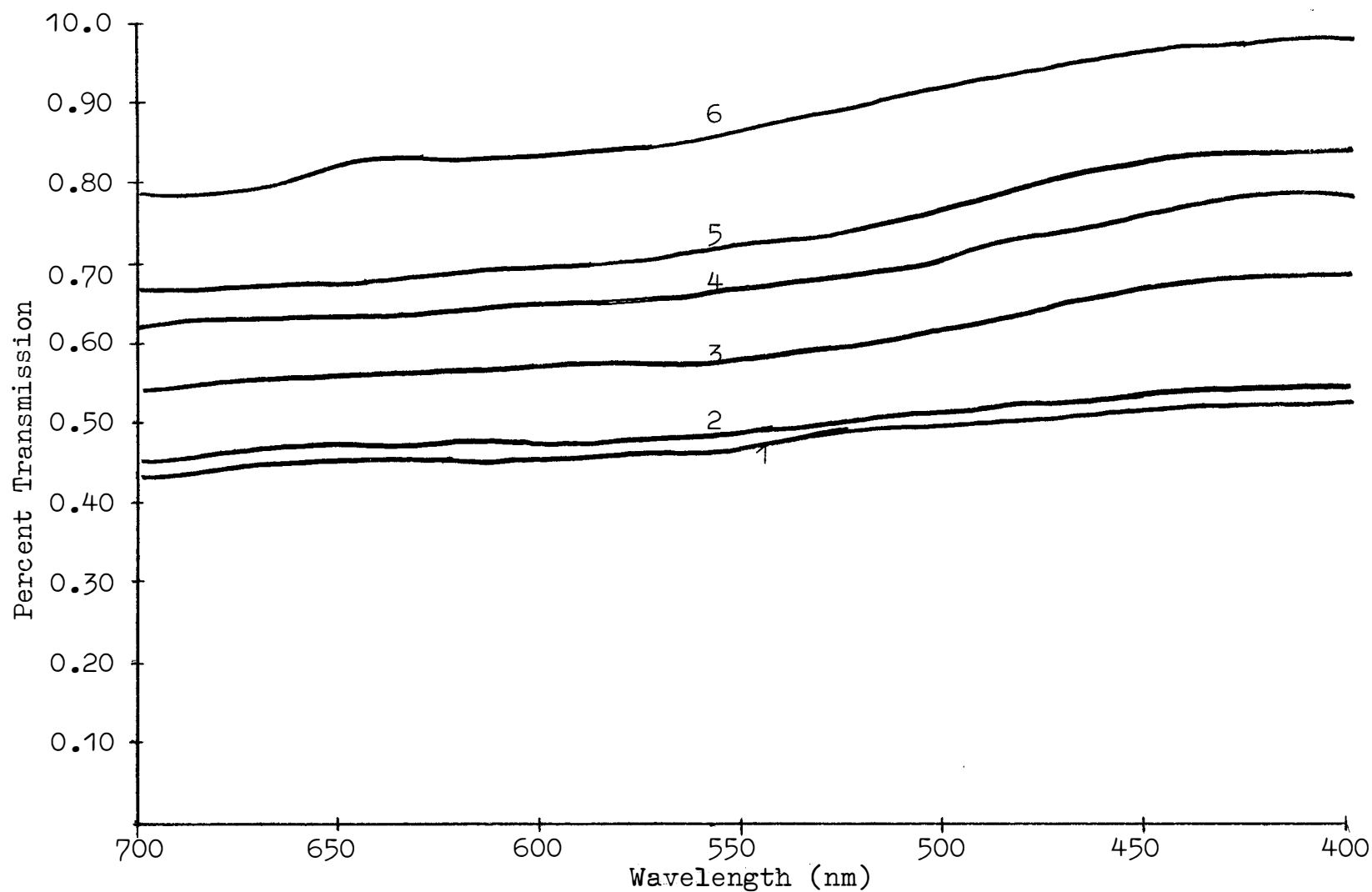


Figure 32. Transmission spectra of gray paints (#1 - #6).

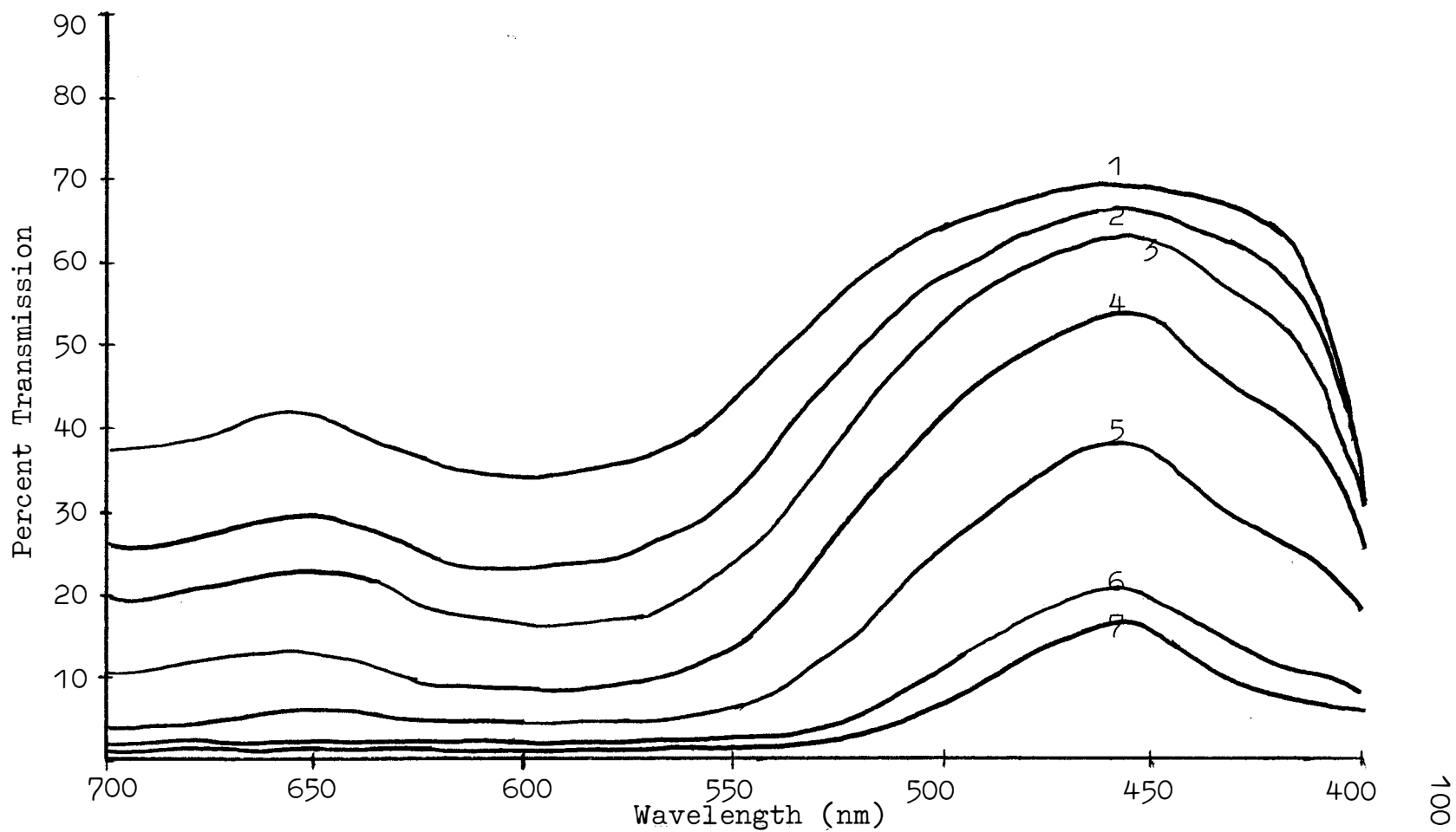


Figure 33. Transmission spectra for the blue paints.

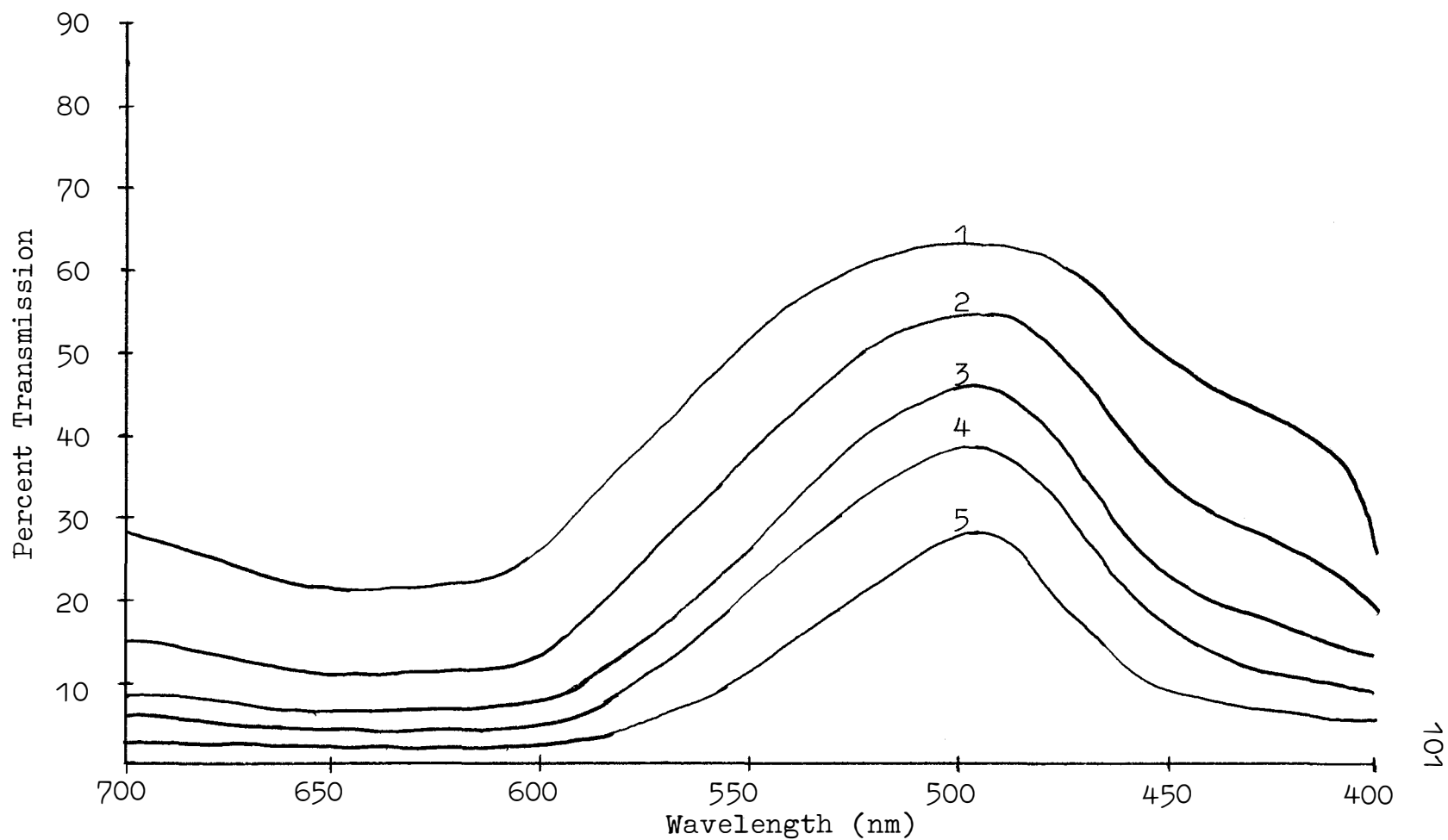


Figure 34. Transmission spectra for the green paints.

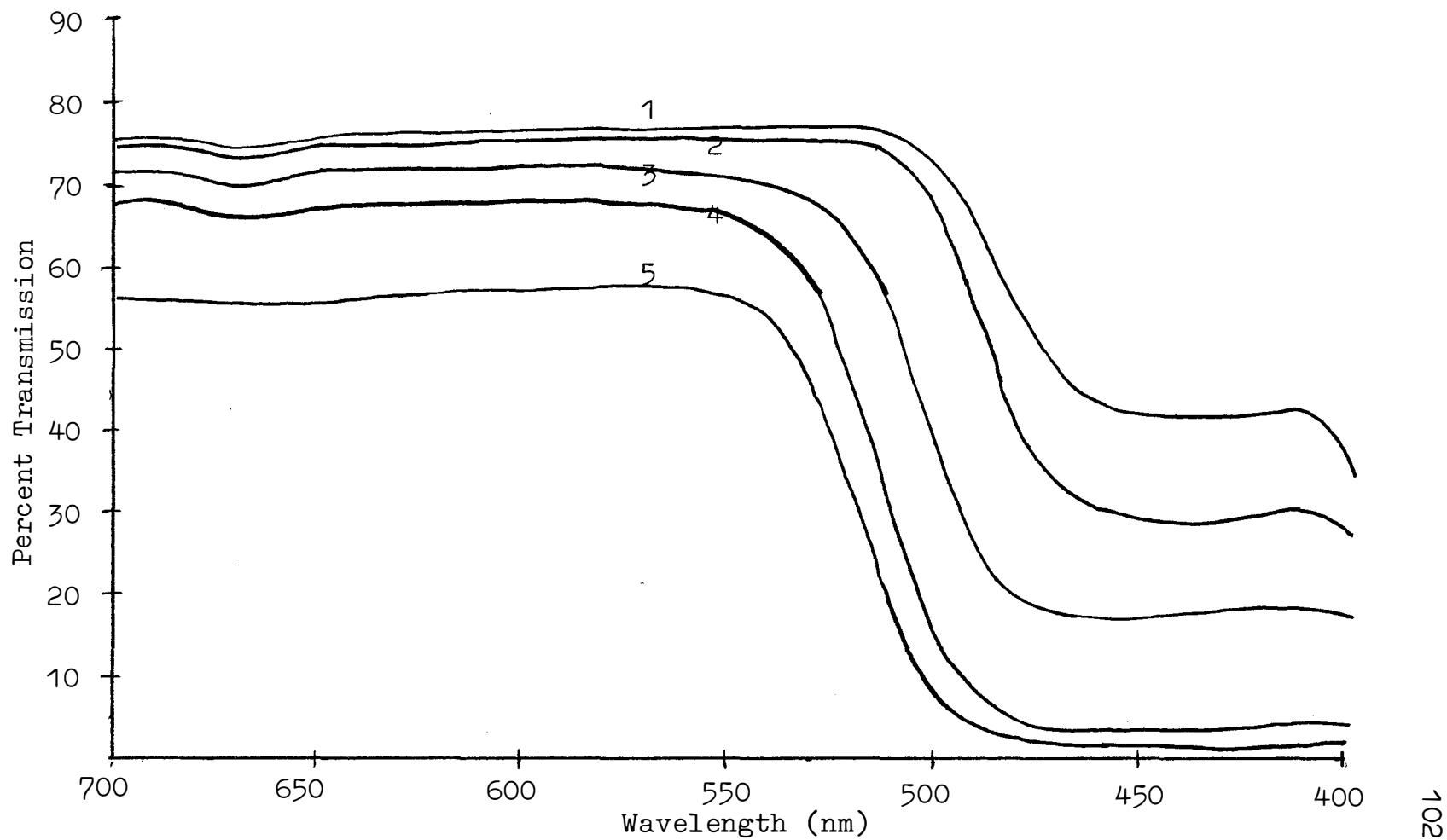


Figure 35. Transmission spectra for the yellow paints.

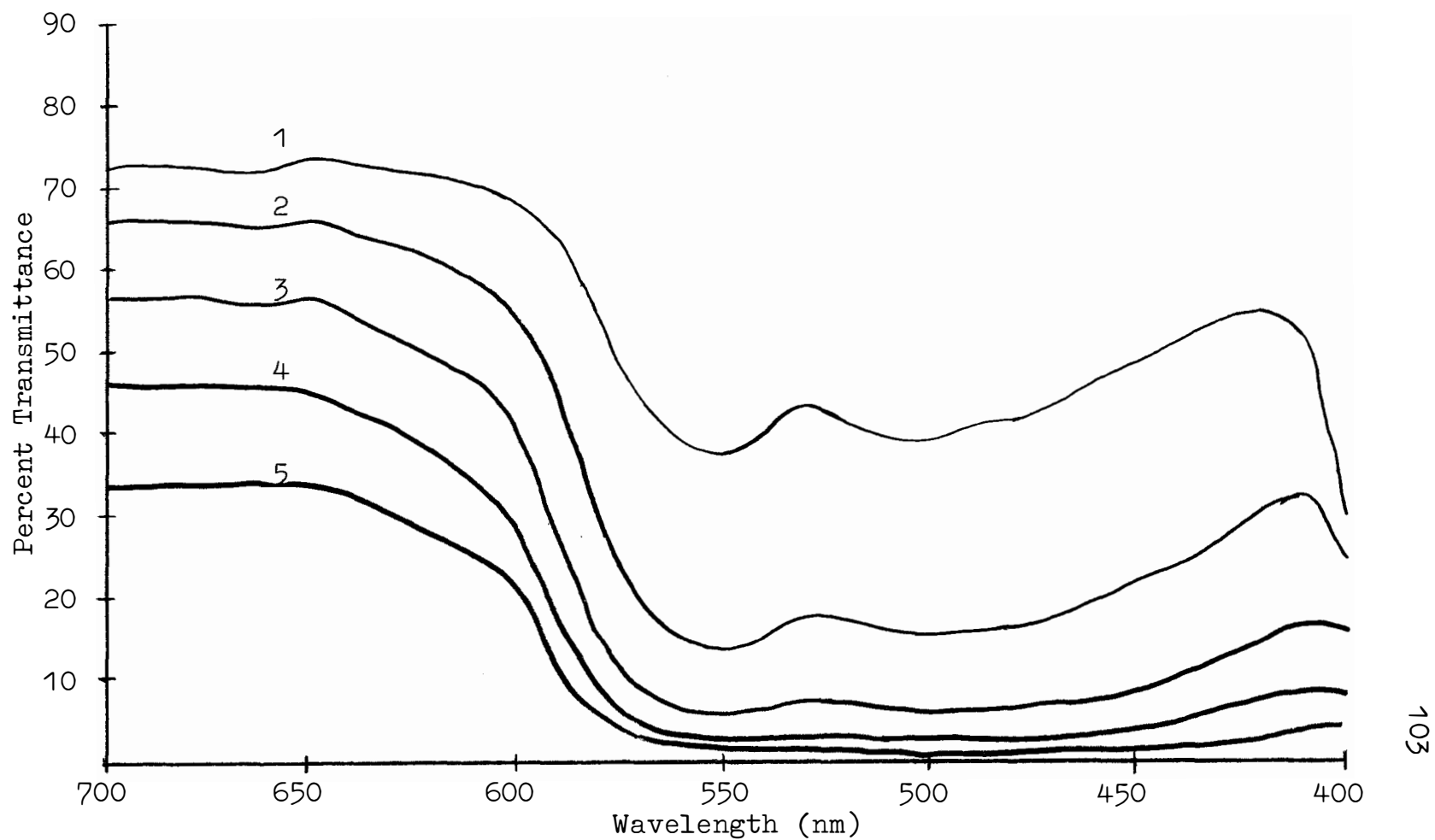


Figure 36. Transmission spectra for the red paints.

were placed. Each olfactory control board was two 30 x 30 x .63 cm plywood squares bolted one upon another. A hole the size of the stimulus item was cut in the top board, and a shallow well was hollowed out in the bottom piece of plywood. Two squares of copper window screen were placed between the boards. During testing, raisins were placed in the small hollow under the copper screen. These raisins were not available to the subject unless it chose to tear the boards apart. A stimulus item was placed on each olfactory control board covering the copper screen, and additional raisins were placed under the positive stimulus. By using the olfactory control boards, raisins were directly beneath each stimulus item, but available only under the positive stimulus. Figure 37 illustrates the olfactory control board.

Procedure

Stimulus Arrays

Seven combinations of the five colors described previously were presented as two-choice discriminations during the final testing. The two stimuli were placed one to four m apart, and, when possible, equidistant from the avenue of approach of the subject. Three - and five-choice arrays were used during the training of the subjects and the modification of the final procedures. The training and procedure modification is



Figure 37. Olfactory Control Board.

discussed in Appendix B.

Kate was trained positively to blue and was tested with four color pairs. These were blue-gray, blue-green, blue-red, and blue-yellow. Kit was trained positively to green and was tested with three color combinations. These were green-gray, green-blue, and green-red. The four remaining possible color pairs (red-gray, yellow-gray, green-yellow, and yellow-red) were not presented to either subject.

Hypothesis testing, such as perserverence and alternation, was corrected by the use of chance stimulus sequences developed by Fellows (1965).

Reward

For each trial a reinforcement consisting of two raisins was placed under the appropriate stimulus item. The subject could obtain the reward by turning over the correct cup. This was accomplished by the bear pushing over the cup with the side of her nose or, more infrequently, with a forepaw.

Testing Routine

The testing was done in the enclosure previously described. Before each trial the subject was placed on the side of the enclosure away from the apparatus. Two olfactory control boards were placed on the ground near the center of the testing side of the enclosure.

The experimenter would exit the enclosure, obtain two stimulus items, and return to place the stimuli on the proper olfactory control board. The stimulus item to the left of the bear's path of approach was always positioned first. Irregardless of the location of the reinforcement attempts were made to equate all motions pertaining to placement of the two stimuli on the olfactory control boards. A clipboard was also used to shield placement of the stimuli from the field of view of the subject. After the placement of the stimulus items, the experimenter opened one of the center gates of the enclosure and allowed the subject to enter. The experimenter walked along the center fence while the bear approached the stimuli. Care was taken by the author to remain behind the subject and not to present extraneous cues as to the correct choice. After the bear obtained the reinforcement, the author walked to the other center gate. The bear approached the experimenter. If the subject made a correct discrimination, she was given another raisin. Regardless she was again placed on the side opposite the stimulus items. The entire trial formed a circular pattern of movement for the animal.

Each subject was tested in a different half of the enclosure. Since this procedure was used in all of the experimental work, both bears became well adjusted

as to which side of the cage they would be allowed to enter during any particular test. As the subject was performing the discrimination, the other bear generally oriented toward the gate through which the subject would return. Both bears were given a raisin on the re-entry of the subject.

Length of Session

The average testing time per session was 37 minutes. This represents the time from the start of trial one to the end of the session. The sessions varied from 16 to 19 trials. Approximately $1/3$ of the time was devoted to preparing the stimulus arrays.

Criteria

A discrimination was considered correct when the subject turned over the positive stimulus item before touching or turning over the other (incorrect) stimulus. The bear was allowed to correct her response to obtain the reward (i.e. after initial incorrect response the animal could turn over the correct stimulus item for the reward). The bear was considered to be discriminating at a significant level when she responded correctly in nine of ten consecutive trials.

Control of Brightness Cues - Stimulus Bracketing

Since the testing occurred in modified field

conditions, precise equation of brightnesses was impossible. Such precision, however, was rendered unnecessary by utilizing the procedure of bracketing the positive stimulus. From the transmission spectra of the paints one could predict which colors would appear lighter or darker, under constant lighting, to a monochromatic animal. Figure 38 illustrates the spectral transmissions of several of the blues and grays used in the testing. Irregardless of the spectral sensitivity of the retina of a monochromatic animal, blue 1 and blue 2 would always appear brighter than gray 12. All points within the visible spectrum the two blues reflect more light than the gray. Conversely, gray 17 and 15 will always appear lighter than blue 4. The shades with intersecting curves would appear lighter or darker depending on the spectral sensitivity of the visual system of the monochromatic animal.

Selected spectral transmission curves for blue, red, and green appear in Figure 39. The principle of

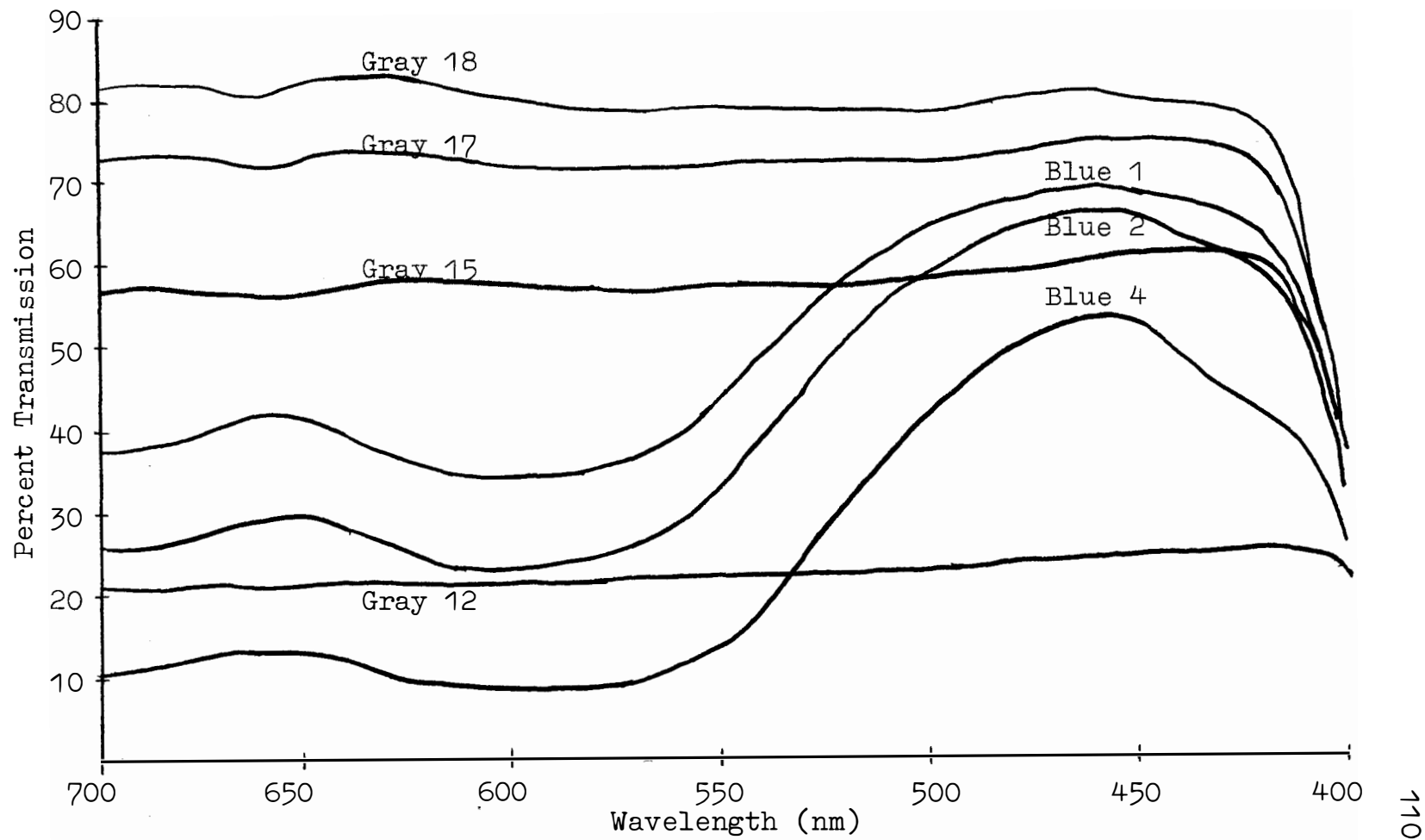


Figure 38. Transmission spectra for selected blue and gray paints.

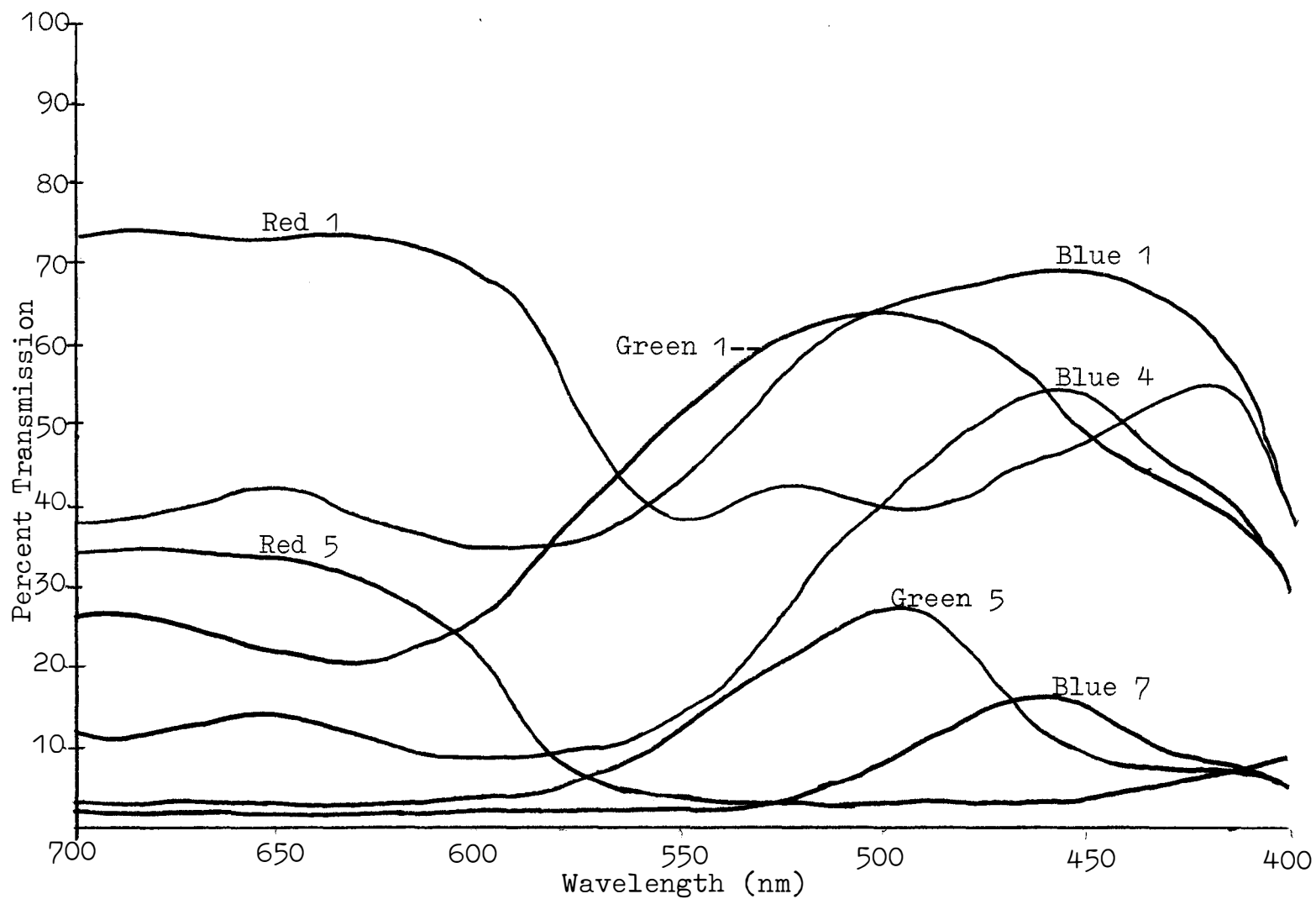


Figure 39. Selected transmission spectra for blue, green, and red paints.

bracketing the positive stimulus is again illustrated. Since certain colors will always appear lighter or darker to a monochromatic subject, any consistent, correct discrimination cannot be made utilizing brightness cues when the colors are presented randomly.

Control of Brightness Cues - Variable Illumination

Stimulus bracketing of the positive stimulus is dependent upon constant illumination of both stimuli. Because of the shifting light patterns in a field situation, an additional control technique was used. In addition to bracketing the positive stimulus, an attempt was made to systematically vary the illumination of the stimulus items. Three lighting conditions were used: both stimuli in the sun, both stimuli in the shade, and one stimulus in the sun and the other in the shade. Two controls were introduced by varying the illumination. First, the relative brightnesses of the positive stimuli were further compounded, making it more difficult for the subject to respond to brightness cues. Secondly, with one stimulus item in the sun and the other in the shade, the relative brightnesses according to the spectral curves may be reversed. A slightly darker cup resting in the sun will transmit more light than the lighter cup resting in the shade. By varying the illumination consistent discrimination utilizing brightness was

further hindered.

Training of the Subjects

The apparatus and procedures evolved during a one year testing period prior to the final testing presented in this chapter. During this time the procedures were being modified to produce an efficient and workable task. Kate was used for all of the preliminary testing. A total of 31 sessions comprised the training of Kate. Kit was trained over 12 sessions. No procedural modifications were being made during her training. Kit had previously been trained in a form discrimination task of similar procedure which facilitated acquisition of the new task. The results of the training sessions for both subjects are presented in Appendix 2.

Results

The seven discriminations and their results are illustrated in Tables 8 through 14. The blue-gray, blue-green, blue-red, blue-yellow, green-gray, and green-blue discriminations were all consistently positive. Only in the green-red discrimination by Kit did the results not yield a positive response according to the criteria. In 17 sessions of the green-red discrimination, only eight satisfied the criterion. However, the cumulative correct response was 225 of 312 total presentations of the green-red task. The cumulative probability of

TABLE 8

RESULTS OF THE BLUE-GRAY, TWO-CHOICE DISCRIMINATION
FOR KATE

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Blue (positive)	Gray	Left	Right		
5 May 1972	1,2	10-18	Shade	Shade	12 of 18	no
11 May 1972	1-5	12-15,17	Shade	Shade	24 of 25	yes
12 May 1972	1,3-6	11,12,14-16	Sun	Sun	25 of 27	yes
15 May 1972	3-5, 7	11,13,14,16	Shade	Shade	16 of 17	yes
24 May 1972	2-5	9,13,15,18	Shade	Shade	10 of 16	yes
25 May 1972	2-5	9,13,15,18	Sun	Shade	16 of 18	yes
26 May 1972	1,3,4,5	12,14,15,17	Sun	Sun	16 of 19	yes
27 May 1972	1,3,5,6	10,13,15,18	Shade	Sun	17 of 18	yes
30 May 1972	2,4,6,7	5,11,13,17	Sun	Shade	17 of 18	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 9

RESULTS OF THE BLUE-GREEN, TWO-CHOICE DISCRIMINATION
FOR KATE

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Blue (pos.)	Green	Left	Right		
14 May 1972	1,3,4-6	1-5	Shade	Shade	25 of 27	yes
16 May 1972	1,3,4-6	1-5	Shade	Shade	25 of 25	yes
17 May 1972	1,3,5,7	2-5	Sun	Sun	16 of 18	yes
26 May 1972	1,2,5,7	1-4	Sun	Sun	16 of 16	yes
1 June 1972	1,3,5,6	2-5	Sun	Shade	17 of 18	yes
1 June 1972	2,4,5,6	2-5	Shade	Sun	16 of 16	yes
2 June 1972	1,2,5,7	1-4	Sun	Sun	17 of 18	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 10

RESULTS OF THE BLUE-RED, TWO-CHOICE DISCRIMINATION
FOR KATE

Date of Test	<u>Stimulus Items</u>		<u>Illumination</u> ^a		Results	Criterion Reached
	Blue (pos.)	Red	Left	Right		
7 May 1972	1,3,5,7	1-5	Shade	Shade	18 of 21	yes
11 May 1972	1,2,4,5,7	1-5	Shade	Shade	18 of 21	yes
12 May 1972	1,3,4,5,7	1-5	Shade	Shade	25 of 25	yes
1 June 1972	1,3,5,7	1-4	Sun	Sun	16 of 16	yes
2 June 1972	2,4-6	1-3,5	Sun	Shade	17 of 18	yes
2 June 1972	1,2,6,7	1,2,4,5	Shade	Sun	16 of 16	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 11

RESULTS OF THE BLUE-YELLOW, TWO-CHOICE DISCRIMINATION
FOR KATE

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Blue (pos.)	Yellow	Left	Right		
15 June 1972	1-4	1-4	Shade	Sun	17 of 18	yes
24 June 1972	1,3,5,7	1-3,5	Sun	Sun	16 of 16	yes
1 August 1972	1,3,4,5	2-5	Shade	Shade	16 of 16	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 12

RESULTS OF THE GREEN-GRAY, TWO-CHOICE DISCRIMINATION
FOR KIT

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Green (pos.)	Gray	Left	Right		
13 June 1972	1-4	1,12,14,17	Shade	Shade	16 of 19	yes
13 June 1972	1,3,4,5	12,14-16	Shade	Shade	12 of 16	no
14 June 1972	2-5	5,7,13,15	Shade	Shade	16 of 16	yes
24 June 1972	2-5	5,7,13,15	Shade	Shade	16 of 20	yes
6 August 1972	1-4	8,10,12,14	Shade	Shade	16 of 16	yes
7 August 1972	2-5	8,12,15,17	Sun	Shade	19 of 20	yes
15 August 1972	1-4	7,12,15,17	Sun	Shade	11 of 14	yes
16 August 1972	1-4	7,12,15,17	Sun	Sun	16 of 19	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 13

RESULTS OF THE GREEN-BLUE, TWO-CHOICE DISCRIMINATION
FOR KIT

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Green (pos.)	Blue	Left	Right		
4 August 1972	1,2,4,5	2-4,5	Shade	Shade	16 of 16	yes
6 August 1972	1-4	1,3-5	Shade	Shade	16 of 16	yes

^a Illumination of the stimuli is relative to the path of approach of the subject.

TABLE 14

RESULTS OF THE GREEN-RED, TWO-CHOICE DISCRIMINATION
FOR KIT

Date of Test	Stimulus Items		Illumination ^a		Results	Criterion Reached
	Green (pos.)	Red	Left	Right		
5 August 1972	1-4	1-4	Shade	Shade	10 of 16	no
5 August 1972	1-4	1-4	Shade	Shade	12 of 22	no
16 August 1972	1-4	1-4	Sun	Sun	9 of 16	no
21 August 1972	2-5	1,2,4,5	Shade	Shade	15 of 20	yes
22 August 1972	1,2,4,5	1-4	Shade	Shade	15 of 24	no
23 August 1972	1,2,4,5	1-4	Shade	Shade	14 of 16	yes
24 August 1972	1-3,5	1,2,4,5	Shade	Shade	10 of 16	no
25 August 1972	1-3,5	1,2,4,5	Sun	Shade	15 of 20	yes
26 August 1972	1-3,5	1-4	Sun	Sun	10 of 16	no
26 August 1972	1-3,5	1-4	Shade	Shade	16 of 20	yes
27 August 1972	1-3,5	1-4	Shade	Shade	15 of 20	yes
29 August 1972	2-5	1,3-5	Sun	Shade	10 of 16	no
30 August 1972	1-3,5	1-4	Varied	Varied	18 of 21	yes
1 September 1972	1-3,5	2-5	Varied	Varied	7 of 12	no
2 September 1972	1-3,5	2-5	Shade	Shade	15 of 18	yes
2 September 1972	1-4	1-4	Varied	Varied	17 of 19	yes
3 September 1972	2-5	1-4	Varied	Varied	15 of 20	no

^a Illumination of the stimuli is relative to the path of approach of the subject.

this response is less than .0001 which indicates that the bear was making a correct, but not consistent choice.

Discussion

The results indicate that the subjects were capable of visual discriminations on the basis of hue. The blue-gray and green-gray discriminations by themselves illustrate the presence of more than a monochromatic system. The exact type of chromatic mechanisms unfortunately cannot be postulated with the available data. Muntz, et al. (1966) trained goldfish (Carrasius avratus) to successfully discriminate red-green, green-red, blue-green, green-blue, blue-red, and red-blue color pairs. They concluded the fish were trichromatic since at least three types of photoreceptors with different spectral sensitivities were required for successful discrimination of the six color pairs. Yager and Jameson (1968), however, argue that with Muntz's data, a deuteranope could make similar discriminations. The success of the discriminations did not necessarily require a trichromatic system. The critique by Yager and Jameson appears to be applicable to the present study, and, therefore, no assumptions were made concerning trichromaticity in the black bear.

The color discrimination, however, was quite strong,

and contrary to Courtier did not depend on "bright" colors. The task acquisition was very rapid and the discriminations were consistently correct. The bears learned more rapidly than Grether's (1940) chimpanzees, and at a similar rate as the dogs used by Rosengren (1969). This positive performance by the bears indicates that the color sense is most likely a strong and greatly utilized component of the bear's visual perception.

The existence of color vision in the black bear does not correspond with the unfortunate generalizations still in the literature concerning mammalian visual capacities. It does, however, fit with various observations of this species. It has been noted by the author and others (e.g. Wormser, 1966) that roadside bears in the national parks are capable of rapid recognition of a park ranger. This is especially true if the rangers are in the habit of delivering punishment to the bears to induce them to stay away from the roads and camping areas. Aside from the blue light on the top of the ranger vehicles in the GSMNP, the only other "obvious" feature is the light green color of the car.

Analysis of the foraging behaviors also correlates with the findings concerning color vision in the bears. The black bear appears to use its eyesight during ingestive behaviors much more than has previously been supposed. The food items consumed indicate that the

bear simply does not just smell these objects out. Consumption of small insects, berries, and scattered ground foods such as acorns requires visual expertise and acuity. The presence of a highly developed color sense would be adaptive for such discriminations.

The black bear has also been assumed to be primarily a nocturnal animal. Physiological evidence for nocturnality of the bear is the well developed tapetum lucidum of the eye. However, the observed feeding behaviors indicate that the bear, in natural situations, may feed during the light or crepuscular hours of the day, and relies greatly on eyesight to locate and obtain food. A monochromatic retina would appear to be insufficient to cope with the needs of an animal that feeds by day on often small, scattered objects.

II. FORM DISCRIMINATION

Introduction

Form discrimination research in animals has been limited to a relatively few species. The white rat and various primates have been extensively studied, but work with other mammals is limited. In an extensive review of form-perception literature Zusne (1970) lists research on only five carnivores: the dog, cat, raccoon, weasel, and ferret. Fifteen studies with intact animals were listed as the bulk of the form-perception literature on the five species.

Only one study concerning visual perception in bears has been found. This article by Kuckuk (1937) has previously been discussed. Various observations indicate that acuity and pattern discrimination are well developed in the black bear. The bears' visual orientation to small food items, and the manipulative abilities exhibited substantiate the existence of a highly developed visual system.

The present research was designed to add experimental evidence concerning the bear's ability to discriminate form, and the transfer of this discrimination to various contexts. Zusne (1970) points out that form-perception experiments where the positive stimulus is presented among unfamiliar stimuli after a period of

delay have not been recorded in the literature.

Therefore, along with the discrimination tasks a form-recognition experiment was conducted. Also included in the study was an experiment pertaining to the retentive abilities of the subject.

Methods

Subject

The subject of this experiment was Kit, one of the two captive bears previously described. Her age at the beginning of testing was 27 months.

Apparatus

Stimulus Items

The stimulus items were hollow, wooden cubes measuring ten centimeters per side. Thses cubes were constructed of 1.2 cm plywood, and each was painted either white or black using a flat luster latex paint. The forms to be discriminated were painted upon one side of the cube so that the open end of each cube formed the base of the stimulus item. Twelve forms were used during the testing. Eight of these were black patterns painted upon a white background, each subtending an area of 9cm^2 . Two stimulus items were black patterns of 36 cm^2 upon a white background. The remaining two stimulus items had

white patterns of 9 cm² painted upon a black background (Figure 40).

Olfactory Control

The olfactory control boards and procedures described earlier in this chapter (p. 91) were used in this experiment.

Procedure

Testing Routine

The testing procedure was identical to that described previously (p. 106).

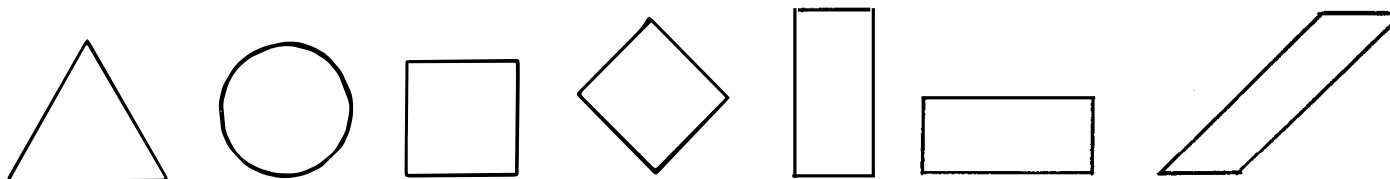
Stimulus Arrays

Two-choice and three-choice arrays were used in the testing. The three-choice array was used during the training of the subject. The stimuli were placed approximately 60 cm apart on an arc of a circle whose radius was 2 m. The avenue of approach was directly toward the center stimulus item.

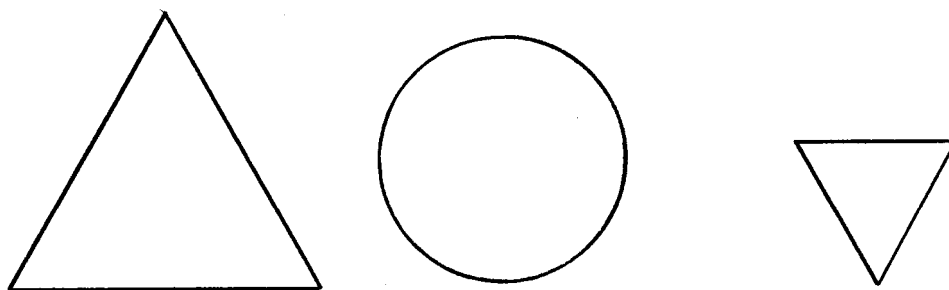
The two-choice array was used during the training and final testing. Here the stimuli were placed approximately 90 cm apart.

Criteria

A response was considered correct when the subject turned over the positive stimulus before touching or



Object Recognition - 1/2 scale



Size Constancy - 1/2 scale

Rotation -
1/2 scale

Figure 40. Illustrations of the patterns used for the form discrimination testing.

turning over any other (incorrect) stimulus items. As in the color vision experiment, the subject was allowed to correct her response. The behavior of the subject during each trial was also recorded.

The criterion for the two-choice tasks was nine correct responses in ten consecutive trials. Cumulative binomial probability tables were also used to ascertain probability of response in the discriminations. Hypothesis testing was corrected by the use of chance stimulus sequences (Fellows, 1965).

Training

Training the subject involved five sessions with a total of 87 trials. During these sessions the stimulus arrays were changed, building upon the conceptual sets formed by the bear. This was done to facilitate task acquisition by the subject and worked quite adequately. The first session involved choosing a cube with a black triangle upon it from two cubes without forms painted upon them. After significant response in this task, the array was decreased to two stimulus items, and finally a circle was introduced as a negative stimulus. The various tasks and Kit's scores are illustrated in Table 15 .

Final Testing

All final testing involved two-choice arrays with

TABLE 15

RESULTS OF FORM DISCRIMINATION
TRAINING FOR KIT

Date of Test	Task	Score	p ^a
24 April 1972	Three-choice, black triangle vs. two blanks	15 correct of 23 trials	.002
25 April 1972	Three-choice, black triangle vs. two blanks	10 correct of 10 trials	.00002
28 April 1972	Three-choice, black triangle vs. two blanks	6 correct of 6 trials	.001
	Two-choice, black triangle vs. one blank	4 correct of 4 trials	.062
	Two-choice, black triangle vs. black circle	2 correct of 10 trials	.999
28 April 1972	Two-choice, black triangle vs. black circle	17 correct of 20 trials	.001
11 May 1972	Two-choice, black triangle vs. black circle	11 correct of 14 trials	.029

^a p = cumulative binomial probability of the subject's responses occurring by chance

the black triangle as the positive stimulus. Six different tests were included in this experiment:

1) Simple Discrimination. The triangle was tested against a 9 cm² black circle.

2) Size Constancy. This test consisted of four stimulus arrays: black 9 cm² triangle versus a black 9 cm² circle, black 36 cm² triangle versus a 9 cm² circle, the 9 cm² triangle versus a 36 cm² circle and finally a 36 cm² triangle versus a 36 cm² circle.

3) Rotation of the Positive Stimulus. This consisted of two stimulus arrays: the 9 cm² triangle versus the 9 cm² circle, and a 9 cm² triangle rotated 90° versus the 9 cm² circle.

4) Background Reversal. Two stimulus arrays were also used in this test. The black 9 cm² triangle and circle were first presented and then a white 9 cm² triangle and a white 9 cm² circle painted upon black backgrounds were presented.

5) Object Recognition. This involved presenting the black triangle with seven other forms, six of which were novel stimuli. The forms in order of their presentation were: circle, diagonal block, vertical rectangle, inverted T, diamond, horizontal rectangle, and square. All forms were 9 cm² in area.

6) Retention. This involved testing the subject

at varying times following the initial testing. The black 9 cm² triangle and circle were used as the stimulus items. One test occurred three months after the initial testing and the other 11-1/2 months.

Results

The subject's scores are shown in Table 16 . Of the 211 trials in these six tests only 13 incorrect responses were made.

Discrimination

This first test of the final testing was to further establish the significance of the original triangle versus circle discrimination learned in the training phases. Twenty-four trials were run of which the bear correctly discriminated 23.

Size Constancy

This next test was to find if the discrimination depended upon the object size. Only two incorrect responses were made of the 40 trials in this test. The criterion was attained within 10 trials in each of the four variations. These results indicate that the ability of the subject to discriminate a figure remains constant within at least gross variations in object size.

TABLE 16

RESULTS OF FORM DISCRIMINATION TESTING

Date	Task	Score	Significant Positive Discrimination $p \leq .05$
<u>Discrimination</u>			
12 May 1972	▲ vs ●	23 correct of 24 trials	yes
<u>Size Constancy</u>			
15 May 1972	▲ vs ●	10 correct of 10 trials	yes
	▲ vs ●	9 correct of 10 trials	yes
	▲ vs ●	9 correct of 10 trials	yes
	▲ vs ●	10 correct of 10 trials	yes
<u>Rotation</u>			
16 May 1972	▲ vs ●	10 correct of 10 trials	yes
	▼ vs ●	10 correct of 10 trials	yes
<u>Background Reversal</u>			
17 May 1972	▲ vs ●	10 correct of 10 trials	yes
	△ vs ○	14 correct of 20 trials	no
18 May 1972	▲ vs ●	10 correct of 10 trials	yes
	△ vs ○	9 correct of 10 trials	yes
<u>Object Recognition and Retention</u>			
7 September 1972	vs ●	9 correct of 9 trials	yes
	vs ▽	9 correct of 10 trials	yes
	vs ■	9 correct of 10 trials	yes
	vs ▴	9 correct of 9 trials	yes
	▲ vs ◆	9 correct of 9 trials	yes
	vs —	9 correct of 9 trials	yes
	vs ■	9 correct of 9 trials	yes
2 May 1972	vs ●	11 correct of 12 trials	yes

Rotation

The 9 cm² black triangle and circle were presented in the first ten trials. After the ten correct responses the rotated triangle and the circle were presented. Kit responded correctly in each of the next ten trials. Rotation, therefore, apparently has no effect upon simple object recognition.

Background Reversal

After the 9 cm² black triangle and circle were presented for ten trials, both were substituted with the reversed stimulus items. Kit chose incorrectly five times in the first ten trials with the reversed figures, but responded correctly nine times within the following ten presentations. This procedure was repeated the following day. The reversal resulted in only one incorrect response in ten trials. Correct response to the figure-ground reversal was rapidly learned, but did not exhibit the immediate generalization shown in the previous tests.

Object Recognition

This test was designed to investigate the ability of the subject to recognize the positive stimulus among an array of novel stimuli. Seven two-choice arrays were presented of which six contained a novel stimulus. The subject responded correctly in 63 of the 65 trials indicating strong recognition of the positive figure.

Retention

The object recognition test formed part of the retention testing. This test was given 112 days, almost four months, after the figure-ground reversal test. The retention within this time span is obvious as shown by the results of the Object Recognition test. The second retention test given 349 days after the figure-ground test (237 days following the first retention test) was also significant. In neither test did the subject exhibit any trouble in making the correct choice.

Discussion

The results show a very rapid task acquisition, and a remarkable consistency of recognition of the positive stimulus item. In the final testing the subject exhibited ability to generalize readily with changes in stimulus size, stimulus position, and figure-ground. This is consistent with findings for other mammals such as the dog, cat, and macaques (Sutherland, 1961). The subject was definitely responding to the triangular form as illustrated by the highly positive results of the object recognition test.

These results also indicate that the bear has a well developed visual system. Although the task was relatively simple the great consistency of response among varying situations and the high speed of task acquisition

illustrates that the subject can make rapid and sophisticated visual responses. The results of this experiment correlate with the observed behaviors of the two subjects. The use of the visual system is not obscured by the olfactory sense as popular literature has indicated. Feeding behaviors and aboreal capabilities exhibited by the bears necessitates a well developed and coordinated, and frequently used visual system.

The long term retention of the subject was excellent. With minimal experience she was able to retain the discrimination over a three-month and an eight-month time lapse. This ability to retain information may possibly be significant in the ontogeny of social, territorial, and ingestive behaviors of free-roaming black bears. Unfortunately, both field observations and experimental data are too incomplete to do more than speculate about the effects of highly efficient, long term memory upon the ethology of this species.

Also of interest was the rapidity with which Kit acquired the discriminations. In the first test of her training, Kit chose incorrectly eight of eleven consecutive trials. Then from trial twelve to the final trial twenty-three she did not err. Almost the same response occurred in the initial triangle versus circle discrimination. Eleven of thirteen trials (unfortunately part of these thirteen trials occurred at the last of one day's

testing, and part occurred at the very beginning of the next day's session) were incorrect, then the subject missed only two of the following 16 presentations. The task acquisition was very rapid. Similar results were obtained with Kate in the color vision testing (Re: Appendix D). In the initial oddity discrimination of Kate's color vision training, only 14 consecutive trials (over two sessions) were presented until she was responding without error.

The author acknowledges that generalization of learning data from two subjects is seldom viewed with accolations. However, even if these subjects are responding significantly deviant from the norm for black bears (i.e. superior to the general population) the learning ability in simple situations can still be considered very good.

In the color and form discrimination testing similar procedures were employed. The procedures relied on the assumption that extraneous cues were minimized, and the subjects were attending strictly to the cues being purposefully varied. The success of the olfactory masking of the reinforcement, and the presence of unintentional cueing by the experimenter were considered as two possible sources of experimental error. Both sources of error were considered during the study, and the influence of their extraneous cues were considered minimal.

CHAPTER V

CONCLUSION

Several conclusions may be drawn from the present study. Because of the diversity of the presentation of the data, the conclusions shall be enumerated.

1. The foraging behavior of the black bear appears to be uncomplicated and to contain several components that are reliably consistent. The complexity of the appetitive behaviors exhibited by other carnivores was not present in the observed bears. Although feeding behaviors are situation specific, the natural foods of the black bear do not necessitate particularly complex sequences of procurement.

2. Orientation to food items is a well coordinated function of the olfactory and visual systems. The use of smell by bears was observed as an integral part of the foraging behaviors. However, vision plays a greater role than may have been assumed from the anecdotal literature. When food is located, the bears cease much of the overt olfactory behavior. Final localization of food items was observed to be primarily visual even with very small food items.

3. Predation in the black bear is not a substantial method of food procurement. Orientation to small prey is visual and the catching of prey involves

primarily the forepaws. In respect to observed predation, the black bear exhibits behaviors closely aligned with the behaviors observed only in various members of the Felidae.

4. The black bear is a very clean feeder. Behaviors surrounding consumption allow for minimum ingestion of debris. Consumption of native foods was observed to be very deliberate with the majority of debris excluded.

5. Food preferences do exist in the bear and can be successfully ranked using a modified Wisconsin General Test Apparatus. The preferences do not vary seasonally indicating that availability controls consumption in the natural habitat, and not intrinsic preference changes among seasons.

6. The most highly preferred foods in both tests were rich in either protein or carbohydrates. A high protein preference would be expected from a member of the Carnivora, but the carbohydrate preference is somewhat unusual. This carbohydrate preference is probably a function of the change from a carnivorous to basically herbivorous diet in the bear. The carbohydrate preference also integrates well with the protein-deficient naturally occurring diet of the black bear.

7. Black bears are capable of making complex visual discrimination. Both hue and pattern

discrimination are well developed in this species. The rapid rate of learning the tasks and the consistency of the performance indicate that the bears possess a well developed visual system. The exhibited ingestive behaviors indicate that vision plays an important role, as supported by the visual discrimination studies.

8. Retention in the black bear is excellent. Not only are the animals capable of making rapid visual discrimination, they are capable of long term memory of the task. The retentive powers may be related to the high degree of persistence exhibited by the subjects during the experimental work.

Throughout the study the subjects were maintained in a semi-naturalistic enclosure. In this enclosure the sensory experiences for the captive bears closely approximated that of wild members of the species. Although the basic goal of the research is the understanding of the behavior of free-roaming bears, field observations on this socially solitary and naturally secretive animal are very difficult to accomplish. The detailed analysis of various behaviors accomplished in the study would have been greatly restricted in a completely natural situation. The detailed analysis of behavior and perception in captive bears is a useful precursor and reference for research of wild black bears.

As previously indicated within this text, behavioral and perceptual research on the black bear has been extremely limited. The present study has considered several aspects of the bear's behavior. It is clear that the black bear is an intelligent animal with well developed sensory abilities. The results also indicate that the bear has been greatly affected by the transition to an omnivorous diet.

This study incorporated several approaches to the study of behavior. Research on a little studied species benefits from the use of both observational and experimental methods.

BIBLIOGRAPHY

BIBLIOGRAPHY

- Beeman, L.E. & Pelton, M.R. Seasonal food habits of the black bear in the Smoky Mountains of Tennessee and North Carolina. Journal of Wildlife Management, (in press) 1973.
- Bennett, L.J., English, P.F. & Watts, P.L. The food habits of the black bear in Pennsylvania. Journal of Mammalogy, 1943, 24 (1), 25-31.
- Bray, O.E. & Barnes, V.G. Jr. A literature review on black bear populations and activities. Ft. Collins: Colorado Cooperative Wildlife Research Unit, Colorado State University, 1967.
- Burghardt, G.M. & Burghardt, L.S. Notes on behavioral development of two female black bear cubs: the first eight months. In S. Herrero (Ed.), Bears - Their Biology and Management. Morges, Switzerland: IUCN Publications, new series, No. 23, 1971. Pp. 207-220.
- Burghardt, G.M., Hietala, R.O. & Pelton, M.R. Knowledge and attitudes concerning black bears by users of the Great Smoky Mountains National Park. In S. Herero (Ed.), Bears - Their Biology and Management. Morges, Switzerland: IUCN Publications, new series, No. 23, 1971. Pp. 255-273.
- Chatelain, E.F. Bear-moose relationships on the Kenai Peninsula. Transactions of the North American Wildlife Conference, 1950, 22, 145-151.
- Cofer, C.N. & Appley, M.H. Motivation: Theory and Research. New York: John Wiley and Sons, 1967.
- Copeland, L. & Copeland, L. 25th Annual Travel Survey Knoxville: Knoxville Tourist Bureau, 1973.
- Cottam, C.A., Nelson, A.J. & Clarke, T.E. Notes on early winter food habits of the black bear in George Washington National Forest. Journal of Mammalogy, 1939, 20 (3), 310-314.
- Couturier, M.A.J. L'Ours Brun. Grenoble: L'imprimerie Allier, 1954.

- Cushwa, C.T., Downing, R.L., Harlow, R.F. & Urbston, D.F. The importance of woody twig ends to deer in the Southeast. USDA Forest Service Research Paper SE-67, Asheville: USDA Forest Service Southeast Forest Experiment Station, 1970.
- Daw, N.W. & Perlman, A.L. Cat colour vision: evidence for more than one cone process. Journal of Physiology, 1970, 211, 125-137.
- Ewer, R.F. Ethology of Mammals. London: Logos Press Limited, 1968.
- Faulkner, W. The bear. In Bradley, S., Beatty, R.C., & Long, E.H. (Eds.), The American Tradition in Literature. New York: W.W. Norton, 1962.
- Fellows, B.J. Chance stimulus sequences for discrimination tasks. Psychological Bulletin, 1967, 67, (2), 87-92.
- Fritz, E. Bear and squirrel damage to young redwood. Journal of Forestry, 1951, 49 (9), 651-652.
- Glover, F.A. Black bear damage to redwood reproduction. Journal of Wildlife Management, 1955, 19 (4), 437-443.
- Gregory, R.L. Eye and Brain. New York: McGraw-Hill, 1966.
- Grether, W.F. Chimpanzee color vision. I. Hue discrimination at three spectral points. Journal of Comparative Psychology, 1940, 29, 157-165.
- Harlow, R.F. Characteristics and status of Florida black bear. Transactions of the North American Wildlife Conference, 1961, 26, 481-495.
- Heinz International Research Center. Heinz Nutritional Data, 5th ed. Pittsburg: H.J. Heinz Co., 1964.
- Herrero, S. Black bear behavior. Unpublished manuscript, University of Calgary.

- Jonkel, C.J. The ecology, population dynamics, and management of the black bear in the spruce-fir forest of northwestern Montana. Ph.D. dissertation, University of British Columbia, 1967.
- Jordon, R. Personal communication, Psychology Department, University of Tennessee, 1972.
- Klopfer, F.D. Visual learning in swine. In Bustad, L.K., & McClellan, R.O. (Eds.), Swine in Biomedical Research. Richland, Wash.: Frayn Printing Co., 1966.
- Kuckuk, E. Tierpsychologische beobachtungen an zwei jungen braunbaren. A. Vergl. Physiol., 1937, 24, 14-41.
- Leyhausen, P. Beobachtungen an einem jungen schwarzbaren. Z. Tierpsychologie, 6, 433-444.
- Morrison, F.B. Feeds and Feeding. 21st ed. Ithaca: Morrison Publishing Co., 1954.
- Muntz, W.R.A. & Cronly-Dillon, J.R. Colour discrimination in goldfish. Animal Behaviour, 1966, 14 (2-3), 351-355.
- Murie, A. Some food habits of the black bear. Journal of Mammalogy, 1937, 18 (2), 238-240.
- National Research Council. Joint United States - Canadian Tables of Feed Composition. National Research Council Publication 1232. Washington: National Academy of Science.
- Pelton, M.R. Personal communication. Forestry Department, University of Tennessee, 1973.
- Pruitt, C.H. An observational analysis of the behavior and social development in captive black bears (Ursus americanus). Unpublished Ph.D dissertation, University of Tennessee, 1973.
- Rosengren, A. Experiments in colour discrimination in dogs. Acta Zoologica Fennica, 1969, 121, 3-19.
- Seton, E.T. The black bear. In Lives of Game Animals, vol. 2 (1), Boston: Charles T. Branford Co., 1929.

- Siegel, S. Nonparametric Statistics For The Behavioral Sciences. New York: McGraw-Hill Book Company, 1956.
- Skinner, M.P. Bears in the Yellowstone. Chicago: A.C. McClurg and Co., 1925.
- Sutherland, N.S. The Methods and Findings of Experiments on the Visual Discrimination of Shape by Animals. Oxford: Experimental Psychology Society, 1961.
- Tisch, E.L. Seasonal food habits of the black bear in the Whitefish Range of northwestern Montana. M.S. thesis, Montana State University, 1961.
- Torgerson, W.S. Theory and Methods of Scaling. New York: John Wiley & Sons, Inc., 1958.
- Viaud, G. La vision chromatique chez les animaux (sauf les insectes). In Mechanism of Color Discrimination. New York, 1960.
- Walls, G.L. The Vertebrate Eye and its Adaptive Radiation. New York: Hafner Publishing Co., 1942.
- Wormser, J. Van. The World of the Black Bear. Philadelphia: J.B. Lippincott co., 1966.
- Yager, D. & Jameson, D. On criteria for assessing type of color vision in animals. Animal Behaviour, 1968, 16 (1), 65-66.
- Zusne, L. Visual Perception of Form. New York: Academic Press, 1970.

APPENDIXES

APPENDIX A

ABBREVIATIONS AND SYMBOLS USED IN UNINTERRUPTED OBSERVATIONS

Ambulatory Movements

	movement toward an apparent goal
	random movement
	running
P	pacing
	climb tree
	enter den
	exit den

Body Postures

	standing on all four feet
	standing on back feet
	sitting up
	resting with stomach on ground and legs under body
	leaning back from a sitting position
	lying on back
	lying on side

Olfactory

Sc	smell closely
Sm	smell medium
Sf	smell far
S air	smell air

Play

p	play
ip	initiate play
•j	jaw play - involves primarily muzzle contact
pp	paw play - involves primarily pawing at each other
pw	wrestling
sfb	side face bite - holding the other bear by the side of the face, often mutual

Use of Paws

rake	raking objects in enclosure
dig	digging
TO	turning over objects with the front feet
scratch	scratching self

Visual

O →	orient to an object
LID	look in den

Miscellaneous

g	ground
C	corner of enclosure, always suffixed with the number or letter of the corner referenced

TABLE B - 1

RESULTS OF NATIVE FOOD PREFERENCE TEST

Food Item Pairs	Ratio of Times ^a		Ratio of Times ^a	
	Chosen - Kate	p .05 ^b	Chosen - Kit	p .05 ^b
Acorn-Hickory	54/6	yes	48/12	yes
Acorn-Blackberry	56/4	yes	41/19	yes
Acorn-Beechnut	59/1	yes	60/0	yes
Acorn-Grass	57/3	yes	59/1	yes
Hickory - Blackberry ^c	32/28	no	27/33	no
Hickory- Beechnut	58/2	yes	59/1	yes
Hickory-Grass	58/2	yes	55/5	yes
Blackberry- Beechnut	58/2	yes	57/3	yes
Blackberry- Grass	58/2	yes	59/1	yes
Beechnut-Grass	38/22	yes	11/49	yes

^a Total number of presentations of each food item pair was 60.

^b Probability of selection was obtained by use of cumulative binomial probability tables.

^c Preference reversal between the two subjects.

TABLE C - 1

RESULTS OF NON-NATIVE FOOD PREFERENCE TEST

Food Item Pairs	Ratio of Times ^a Chosen - Kate		Ratio of Times Chosen - Kit	
	p	.05	p	.05
Fish-Hamburger ^c	20/24	no	27/17	no
Fish-Pear	33/11	yes	33/11	yes
Fish-Bread	38/6	yes	39/5	yes
Fish-Apple	39/5	yes	38/6	yes
Fish-Cucumber	43/1	yes	42/2	yes
Fish-Lettuce	44/0	yes	43/1	yes
Fish-Dog Chow	44/0	yes	44/0	yes
Hamburger-Pear ^c	33/11	yes	21/23	no
Hamburger-Bread	35/9	yes	28/16	no
Hamburger-Apple	37/7	yes	33/11	yes
Hamburger-Cucumber	37/7	yes	40/4	yes
Hamburger-Lettuce	39/5	yes	39/5	yes
Hamburger-Dog Chow	38/6	yes	40/4	yes
Pear-Bread	39/5	yes	36/8	yes
Pear-Apple	33/11	yes	37/7	yes

APPENDIX C (continued)

Food Item Pairs	Ratio of Times ^a Chosen - Kate		p	.05	Ratio of Times ^a Chosen - Kit		p	.05
Pear-Cucumber	42/2		yes		42/2		yes	
Pear-Lettuce	43/1		yes		43/1		yes	
Pear-Dog Chow	44/0		yes		43/1		yes	
Bread-Apple ^c	21/23		no		33/11		yes	
Bread-Cucumber	42/2		yes		42/2		yes	
Bread-Lettuce	41/3		yes		40/4		yes	
Bread-Dog Chow	44/0		yes		43/1		yes	
Apple-Cucumber	38/6		yes		43/1		yes	
Apple-Lettuce	40/4		yes		41/3		yes	
Apple-Dog Chow	44/0		yes		40/4		yes	
Cucumber-Lettuce	23/21		no		24/20		no	
Cucumber-Dog Chow	34/10		yes		39/5		yes	
Lettuce-Dog Chow	32/12		yes		37/7		yes	

^a Total number of presentations of each food item pair

^b Probability of selection was obtained by use of cumulative binomial probability tables.

^c Preference reversal between the two subjects.

APPENDIX D

TRAINING OF THE SUBJECTS AND PROCEDURAL MODIFICATIONS OF THE COLOR VISION TESTING

Subject One - Kate

Thirty-one sessions extending from August 21, 1971 to April 23, 1972, comprised the training of subject one and the procedural modifications of the color vision test. During the training four phases of testing occurred. Phases one, two, and three were primarily concerned with establishing the existence of hue discrimination, and training the subject to the experimental task. Phase four was primarily concerned with the introduction of olfactory and brightness controls. The results are presented and discussed below.

Phase One - Oddity Discrimination

Six sessions were administered during this section. The first two sessions were three-choice discriminations. The positive stimulus was a cup painted blue. The negative stimuli were unpainted cups of the same size and shape. As is shown in Table D-1, the bear learned very quickly to choose the painted cup. The oddity concept was apparently learned by the second session. The negative results from the second part of the second test are most likely due to both the change in procedure (i.e. from

TABLE D-1

PHASE ONE - ODDITY DISCRIMINATION

Date	Stimulus ^a Array	Results Correct/Total	Signif- icance
21 August 1971	Three Choice	8 of 18	-
25 August 1971	Three Choice	10 of 12	+
	Five Choice	2 of 5	-
25 September 1971	Five Choice	10 of 15	-
26 September 1971	Five Choice	12 of 15	+
27 September 1971	Five Choice	13 of 15	+
29 September 1971	Five Choice	10 of 10	+

^a Positive stimulus was a blue polyethylene cup placed in arrays of unpainted polyethylene cups.

three-choice to five-choice arrays) and the lack of sufficient trials.

Phase Two - Oddity Discrimination Varying the Negative Stimuli

In this phase each trial matched the same blue against four grays of the same shade in a five-choice array. The shades of the grays were varied among sessions but not within the same testing session. Seven shades of gray were used ranging from very light to very dark. The results of this testing indicated that the bear had little difficulty in choosing the blue stimulus item from arrays varying with each test. Table D-2 contains the results and the arrangement of presentation of the various shades of grays. Here, gray #1 was white and gray #11 was black with nine intermediate shades.

Phase Three - Hue Discrimination

The following tests matched the blue stimulus item against four grays differing in shade in a five-choice array. Thus, in this situation, the discrimination must be made solely on the basis of hue. As in all previous testing the paints used were from the first set of paint mixes discussed previously. The consistent display of significant discriminations strongly indicated that the subject had chosen the hue to which to

TABLE D-2

PHASE TWO - ODDITY DISCRIMINATION
VARYING THE NEGATIVE STIMULI

Date	Unrewarded ^a Stimulus Items	Results Correct/Total	Signif- icance
30 September 1971	Unpainted Cups	3 of 3	
	Cups painted Gray #1	6 of 12	-
2 October 1971	Gray #1	6 of 8	+
	Gray #3	7 of 9	+
5 October 1971	Gray #1	9 of 12	+
5 October 1971	Gray #3	9 of 10	+
6 October 1971	Gray #5	11 of 20	-
6 October 1971	Gray #5	13 of 15	+
7 October 1971	Gray #7	13 of 19	+
11 October 1971	Gray #9	12 of 15	+
12 October 1971	Gray #11	13 of 15	+
12 October 1971	Gray #2	10 of 15	+

^a All stimulus arrays were five-choice. The positive stimulus was one shade of blue.

respond and was not utilizing brightness cues. The results are shown in Table D-3.

This section of testing terminated the experiments for the winter. The great drop in food consumption associated with the time of year, made it impossible to motivate the subject adequately for testing.

Phase Four - Final Testing

This phase was begun three months following Phase Three in early March. The testing involved all new stimulus items painted with the second set of paint mixes, introduction of the olfactory control boards, and, for the first time, variation of the shade of the positive stimulus. The food reward was also changed from apple slices to raisins. The stimulus items for each five-choice array or trial were selected randomly from the seven shades of blue and 18 shades of gray.

Unlike most of the earlier testing, the majority of the sessions in this phase did not show significant discrimination. Of the eleven tests only four illustrated that the bear was significantly choosing the correct stimulus item. Although the response was well above chance level for a five-choice discrimination (60% correct response), it did not meet the criteria, and was definitely inferior to the earlier tests. The various modifications in apparatus and procedure, and

TABLE D-3

PHASE THREE - HUE DISCRIMINATION

Date	Unrewarded ^a	Results	Signif- icance
	Stimulus Items	Correct/Total	
13 October 1971	Grays #2,#3,#5,#7	13 of 15	+
13 October 1971	Grays #4,#6,#8,#11	12 of 14	+
20 October 1971	Grays #1 through #11	15 of 20	+
11 December 1971	Grays #1,#3,#5,#6	13 of 15	+

^a All stimulus arrays were five-choice with one shade of blue as a positive stimulus.

the time span from the last testing may have contributed to these results (Table D-4).

TABLE D-4

PHASE FOUR - FINAL TRAINING

Date	Results ^a Correct/Total	Signif- icance	Testing Modifications
11 March 1972	9 of 14	-	
12 March 1972	2 of 5	-	
12 March 1972	8 of 15	-	Change reward from apple slices to raisins
13 March 1972	11 of 15	+	Introduction of olfactory control boards
14 March 1972	12 of 15	+	
14 March 1972	10 of 20	-	
22 March 1972	4 of 10	-	Introduction of raisins under screen of olfac- tory control boards
23 March 1972	3 of 10	-	
19 April 1972	13 of 18	+	
21 April 1972	19 of 27	-	
23 April 1972	18 of 23	+	

^a Positive stimulus was selected randomly from seven shades of blue and the unrewarded stimuli were selected randomly from 18 shades of gray. All stimulus arrays were five-choice.

Subject Two - Kit

Kit was tested over a four month period coinciding with the end of the sessions with Kate. No procedural modifications were involved in the testing with Kit. Also, subject two had previously been trained in a form discrimination task of similar procedure, and, therefore, the training consisted of only 12 sessions.

Kit was trained to respond positively to green from an array of grays. Two- , three- , and five-choice discrimination tasks were used. Five shades of green and 18 shades of gray were used during the training. As soon as significant discrimination was obtained in three consecutive two-choice discrimination sessions, the training phase was concluded. The results are illustrated in Table D-5.

TABLE D-5

RESULTS OF THE TRAINING PHASE FOR KIT

Date	Stimulus Array	Results Correct/Total	Significance	Stimulus Positive	Items Unrewarded
26 May 1972	Three-choice	0 of 3	-	Green #4	Gray #8,#9
27 May 1972	Three-choice	5 of 15	-	Green #4	Gray #8,#10
27 May 1972	Three-choice	8 of 11	-	Green #5	Gray #16,#17
28 May 1972	Two-choice	32 of 42	+	Green #5	Gray #2,#5,#10,#16
1 June 1972	Two-choice	9 of 18	-	Green #1,#4,#5	Gray #2,#10,#17
8 June 1972	Two-choice	5 of 11	-	Green #1,#4,#5	Gray #2,#10,#17
8 June 1972	Five-choice	12 of 20	-	Green #3	Gray #4,#7,#13,#18
8 June 1972	Five-choice	19 of 25	+	Green #3	Gray #4,#7,#13,#18
9 June 1972	Five-choice	14 of 20	+	Green #2,#3	Gray #3,#4,#5,#7,#12 #13,#15, #18
9 June 1972	Three-choice	21 of 24	+	Green #2	Gray #12, #15
11 June 1972	Three-choice	4 of 5	-	Green #2,#3	Gray #3,#5,#12,#15
	Two-choice	23 of 28	+	Green #2,#3	Gray #3,#5,#12,#15
11 June 1972	Two-choice	17 of 20	+	Green #1,#4	Gray #10,#12,#13, #15
12 June 1972	Two-choice	12 of 14	+	Green #2,#4	

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