SPECIFIC CONCEPT FORMATION IN HORSES:

YOU SURE LOOK FAMILIAR

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PREFACE

Animals have played a significant role in the lives of humans throughout history. Archeological finds such as skeletal remains and cave drawings indicate that animals have co-existed with humans for thousands of years. The first species to make the transition towards domestication with humans was the wolf (Canis lupus), the predecessor of the modern domestic dog. Sheep, goats, cattle and pigs soon followed. More recently horses, asses, camels, water buffalo, alpaca, llama, turkey, guinea pig, and domestic fowl became animals of choice.

From an evolutionary perspective animals pose a reduced risk of survival to the human (Archer, 1997) and, therefore, human-animal contact should not occur. When a human becomes attached to an animal, they expend time, energy, and resources on it that could otherwise be spent on their human offspring. Research has shown, however, that pets fulfill physical and psychological needs not met by other humans (e.g. Beck & Katcher, 1996). Additionally, animals enhance the daily living of humans by providing companionship. These fulfilled psychological needs translate into increased health benefits such as reduced stress (e.g. Allen, Blascovich, Tomaka, & Kelsey, 1991; DeSchriver & Riddick, 1990).

Various animals are increasingly used for their therapeutic nature for numerous human disabilities. Animals that have served as interventions include dogs, cats, monkeys, horses, birds, hamsters or gerbils, and rabbits. Even aquaria filled with fish and exotic organisms have resulted in tremendous therapeutic benefits when used by therapists to alleviate emotional and psychosocial disabilities of their human clientele (Beck & Katcher, 1996). Additionally, it has been shown that equine-assisted therapy has helped to rehabilitate various disorders ranging from language and physical disabilities to emotional and social disadvantages (DePauw, 1992; Netting, Wilson, & New, 1987). However, despite all of the findings supporting the benefits of animals to humans there remains much debate regarding training methods. This is due, in part, from the differences of opinion about animals' cognitive abilities.

Reinforcement, at the appropriate time, can strengthen responses of organisms, human and non-human alike (Skinner, 1951). This principle is evident in human-animal interactions and is the basis for the relationship that develops between humans and animals. Additionally, when properly applied in training sessions, reinforcement can be used to shape the behavior of animals used for therapeutic purposes (Levinson, 1969, 1972). Whereas few would deny that behavior is guided by its consequences (Skinner, 1951), there is debate over the role of cognitive functions in learning. What theoretically diverse researchers readily accept, however, is the role of reinforcement in conceptual learning. Concept formation, the process of forming internal representations of stimuli based on similarly shared characteristics, has been successfully demonstrated in various species. For example, Herrnstein and Loveland (1964) found support for conceptualization in pigeons while D'Amato and Van Sant (1988) found it in primates. Only one study, however, has suggested that horses are capable of concept learning (Sappington & Goldman, 1994), therefore, their cognitive capacity for conceptualization remains unclear.

According to the learning hierarchy proposed by Thomas (1986), animals that are capable of performing concept learning tasks use classical and operant conditioning because they are fundamental parts of forming concepts of stimuli. Most of the horse research has concentrated on simple discrimination learning, observational learning, avoidance learning, maze learning and the effects of handling or experience on future learning. In contrast to the numerous behavioral studies, only Sappington and Goldman (1994) examined the cognitive ability of discrimination learning and concept formation in Arabian geldings. The results suggested that horses are capable of learning at level 6 of Thomas' (1986) learning hierarchy.

The purpose of this study was twofold. First, this study attempted to determine if horses formed concepts of specific stimuli by using discrimination training of an arbitrary stimulus (5-pointed star) and a natural stimulus (photograph of a woman, Ahna). Secondly, after successful completion of discrimination training, the horses were given a one-trial transfer test to determine whether they formed a mental representation of the specific 2D stimuli and transferred the representation to the actual 3D stimuli as suggested by Herrnstein and his colleagues (1976). If the horses spent more time in proximity, measured in seconds, to the large replica of the Star and to Ahna, it was assumed that they had formed a concept of the specific discriminative stimuli based on the positive reinforcement they represented. Therefore, the dependent measure was the amount of time spent in proximity to the testing stimuli.

It was hypothesized that the horses would easily learn to discriminate 2D photographs containing the target stimuli. Furthermore, it was also predicted that during the 30-minute field test the horses would spend more time in or near the sector containing the actual stimulus than in any other sector. Specifically, this study (a) used operant techniques and concept formation tasks to determine if horses could form 2D representations of the Star and Ahna and (b) used a field test to determine if the horses transferred this 2D learning to a 3D, real world situation.

The results of the current experiment indicated that (a) the horses learned to discriminate during the training trials, (b) the horses learned to discriminate in fewer trials as the training progressed, a phenomenon termed as learning to learn and found in various species including horses (Hanggi, 1999), and (c) the horses demonstrated specific transfer of discriminative learning by spending more time with the Star and Ahna rather than to the novel Cross and Stranger stimuli. Additionally, four prominent stimulus wall approach behaviors were identified during the discrimination phase of the study; (a) Direct, (b) Veer, (c) Veer after Looking, and (d) Contemplate.

The results of this study also provided support to previous findings that horses can learn to discriminate arbitrary (e.g. Giebel, 1958; Rensch, 1967; Sappington & Goldman, 1994) and natural (Herrnstein, 1990) stimuli. According to Thomas's (1986) hierarchy of learning abilities, this type of discrimination operated on Level 3, simple operant conditioning to obtain reinforcement. In addition, the results of the Ahna discrimination training suggests that horses are capable of Level 5 learning (concurrent discrimination) when natural stimuli are presented. More importantly, this study has shown that a method using photographs of human companions or riders to reduce the amount of time necessary to train horses is successful. Finally, the current results suggest that photographs may be used to enhance the human-horse bond, a critical finding for all industries dependent on human and horse interactions.

The completion of this project would not have been possible without the assistance of many people. From the design phase to the construction phase and the running of subjects to writing the final draft, many supportive people have been invaluable. Specifically, thanks to my dad, Jim Stone, and Ray Warren for helping Marty design and construct the stimulus wall. Next, many thanks to Mike Moore for the use of his head set walkie-talkies. They were invaluable to the success of the study by allowing communication between the assistants and leaders. Also, thanks go to the City of Edmond street department for allowing me to borrow the orange construction cones for the study. Additionally, I am grateful for Rae Reese and Brandy Gilles, the volunteers who served as the Stranger, during the pilot and preliminary field tests.

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Rachel, you were very critical to my study and one of my most important helpers.

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He was there from the very beginning of this project. Not only did he help build the stimulus wall, he also dug the holes to bury the posts into the ground, he trudged through the mud to get the horses from the pasture, hung on for dear life when he was being drug around by the younger horses, took time off work to help me run the horses, cared for Peaches when she got hurt, and too many other chores to even mention. I thank him for pushing me on when I was so tired and sore I did not think I could continue. Likewise, when I was unable to continue due to my damaged ankle, he took over so there would not be a break in the training. He was essential to this project and the completion of my Ph.D. and I am forever grateful.

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CHAPTER I

Animals have played a significant role in the lives of humans throughout history. Archeological evidence such as skeletal remains and cave drawings indicate that animals have co-existed with humans for thousands of years (Serpell, 1996). For instance, artifacts from approximately 20,000 years ago reveal that the first species to make the transition towards domestication was the wolf (*Canis lupus*), the predecessor of the modern domestic dog (Clutton-Brock, 1981). Nearly 14,000 years ago the people of the Near East began to domesticate sheep and goats (Davis, 1982). Around 9,000 years ago various Asian cultures began to farm cattle and pigs (Serpell, 1996). Horses, asses, camels, water buffalo, alpaca and domestic fowl became the animals of choice (Serpell, 1996) about 5,000 years later. During the same time, farmers in the New World began to domesticate animals such as llama, turkey and guinea pigs (Harris, 1969; Zeuner, 1963). Finally, emerging 4,000 years ago in Egyptian civilizations was the predecessor of the modern domestic cat (Malek, 1993).

Egyptians first domesticated wildcats to keep as house pets. In addition, they soon elevated dogs to the same sacred category as the dog-headed god, Anubis (Serpell, 1996). The Egyptians were not alone in their fondness for animals. The early Greeks were also noted for their love of pets (Halliday, 1922). They preferred the longhaired Maltese lap dogs and carried them around everywhere they went. Most dog owners not only allowed but also encouraged the dogs to share the owner's bed at night (Serpell, 1996). Just as Maltese dogs, monkeys were also greatly admired and kept as pets by the early Greeks. Greek pet owners often purchased play toys for their pets and it was also a common practice for the Greeks to embalm their pets and bury them in their own elaborate tombstones or later with the owner (Halliday, 1922).

The upper class Romans kept birds, monkeys, Maltese dogs, and fish not only as pets but also as status symbols (Campbell, 1984). They were very affectionate towards their pets and went to great extremes to honor them upon their death. For example, Emperor Hadrian erected monumental tombstones for his favorite dogs (Serpell, 1996). The Romans were even more overtly affectionate with their pets than the Greeks or Egyptians. Serpell (1996) reported, for instance, that the Romans routinely adorned their pets with gold jewelry and expensive clothing. It was also common practice for songs, poems, paintings, and other artistic works to be inspired by the owner's love for a pet (Pond, 1983).

The Britains were very fond of their pets as well. For example, during the Middle Ages many noble ladies not only kept lap dogs, but also fed them and carried them about in their arms. Szasz (1968) reported that Mary Queen of Scots was quite indulgent with her pet dogs, at times dressing them in blue velvet suits during the winter. The men, however, preferred pets that symbolized masculinity and strength (Larbarge, 1980). The majority of English monarchs, including James I, Charles I, Charles II, and James II all were avid dog keepers. The King Charles Spaniel, because it was his favorite pet, was named after Charles II (Ritchie, 1981). Soon, English, Scottish, and Irish commoners adopted the same fondness for dogs as their royalty and they treated their pets as part of their family (Ritvo, 1987).

Many tribal societies also kept animals as pets. For instance, when Hernandez arrived in the land known as Mexico, he found domesticated raccoons living in the citizens' houses (Hernandez, 1651). The raccoon was a favorite pet of the Indians of California (Elmendorf & Kroeber, 1960) and pioneer Americans (Beck, 1983) as well. In addition to raccoons, the North American Indians kept large animals such as moose, bison, calves, wolves, and bears for pets (Galton, 1883). Early century travelers documented many instances of tame moose following Indians along the banks of rivers as they canoed and meeting them when they came ashore (Serpell, 1996). Likewise, Osgood (1975) reported that it was common for the Indians to raise young bear cubs as their own offspring. The women often nursed the cubs and allowed them to play with their children.

The Indians of South American were even more indulgent with their animals than the North American Indians. For example, Roth (1970) recounted numerous accounts of travelers who observed young mammals such as dogs, monkeys, opposum-rats, labba, acouri, and deer suckling from the women. The Spanish explorers Juan and Ulloa reported that the natives they encountered never ate their pets and exhibited intense grief when they died or were killed by others (Juan & Ulloa, 1760).

Tribal communities of the West Indies and Jamaica also kept pets. Fernandez (1937) described the pets as being similar to the Maltese lap dogs. The dogs were particularly noted for never barking. However, they exhibited exuberant affection towards their owners by such behaviors as wagging their tails and playfully frisking around them. Rarely were they without their dogs. For example, it was a widespread practice for the owners to carry their dogs on their shoulders and take them everywhere they went.

Finally, Galton (1883) wrote of animals such as fruit bats, lizards, and parrots in Fiji and pigeons and eels in Somoa as the favored pets. Likewise, the anthropologist

Luomala (1960) documented ardent pet keeping customs of Polynesians in the Hawaiian Islands. He found that men, women, and children of all social ranks pampered, played with, talked to, and named their pets. They also displayed deep grief when the pet died and elaborate burial rituals were very typical among the Polynesian societies.

CHAPTER II

Benefits of Human-Animal Relationships

From an evolutionary perspective animals pose a reduced risk of survival (Archer, 1997) to the human and, therefore, human-animal relationships should not occur. Specifically, when a human becomes attached to an animal, they expend time, energy, and resources on it that could otherwise be spent on their human offspring. Research has shown, however, that pets fulfill physical and psychological needs not met by other humans (e.g. Beck & Katcher, 1996). Physically (Table 1), the presence of animals has been shown to reduce stress, heart disease, and blood pressure (Allen, Blascovich, Tomaka, & Kelsey, 1991), lower blood fat, cholesterol, and triglycerides (Anderson, Reid, & Jennings, 1992), and increase survival rates after serious sickness or injuries (e.g. DeSchriver & Riddick, 1990; Friedmann, Katcher, Lynch, & Thomas, 1980).

Table 1

Physical Benefit	Study	Results
Heart patients survival	Friedmann, Katcher, Lynch, and Thomas (1980)	Pet owners showed greater survival rate and overall health
Blood pressure	Friedmann, Katcher, Thomas, Lynch, and Messent (1983)	Lower systolic and diastolic blood pressure when petting animals
Recovery from heart disease	Beck and Katcher (1984)	Pet owners had greater probability of full recovery
Various health benefits	Anderson, Reid, and Jennings (1992)	Pet owners had lower blood fat, lower cholesterol, lower triglycerides, and lower blood pressure
Longevity	Friedmann, Katcher, Lynch, and Thomas (1980).	Pet owners had greater longevity after heart disease
Stress and women	Allen, Blascovich, Tomaka, and Kelsey (1991)	Pets reduced arousal, blood pressure, and pulse rate
Anxiety and stress	Katcher, Beck, and Levine (1984)	Watching fish reduced anxiety, stress, and blood pressure
Stress in elderly	DeSchriver and Riddick (1990)	Watching fish reduced pulse rate, skin temperature, and muscle tension
Cardiovascular risk factors	Serpell (1991)	Acquiring a pet after cardiovascular problems led to improved health and cardiovascular risk factors of pet owners were found to be lower than those of patients without pets

Note. Table only presents a fraction of those studies that have been conducted.

Just as animals significantly benefit human physical health, research has indicated that they are very important deterrents of psychological distress in humans. For instance, animals have been used as therapeutic tools for many emotional disorders (Levinson, 1969, 1972) and have served as teachers for children. Kidd and Kidd (1985) found that pets were used to teach life skills such as responsibility and patience to children. Classroom pets are often used to increase knowledge about animals and instruct children on their proper care (Serpell, 1996). Bryant (1985) found that 10-year-old children who reported having intimate talks with pets exhibited higher empathy and acceptance of others than children without pets. Animal husbandry programs have also been found to be of great benefit in teaching reproduction principles to children because they provide a safe and interactive teaching tool for very sensitive issues (Beck & Katcher, 1996). Caring for pets before, during, and after breeding provide first hand information of reproductive methods along with animal health and maintenance knowledge.

Children are not the only group of individuals who benefit from the presence of animals. Kidd and Kidd (1990) found that pets served to reduce loneliness experienced by homeless individuals. Other researchers have shown that animals reduced loneliness in the elderly (e.g. Zasloff & Kidd, 1994) and strengthened the elderly person's social interactions with other people (Brasic, 1998; Brown, Shaw, & Kirkland, 1972). Animals also serve in therapeutic capacities and enhance psychological functioning of the human companion or therapy client (e.g. Corson & Corson, 1981; Levinson, 1969, 1972). Table 2 presents a representative sample of studies that found therapeutic and psychological benefits of human-animal interactions.

Table 2

Psychological Benefit	Study	Results
Trust	Levinson (1969, 1972),	Dog eased psychological transfer of trust to a human
Social Interaction	Corson and Corson (1981)	Pets reduced withdrawal and increased communication
Psychiatric behaviors	Thompson, Kennedy, and Igou (1983)	Dog, kitten, cat, guinea pig, or parakeet reduced psychological behavior problems
Loneliness	Zasloff and Kidd (1994)	Both dogs and cats provided emotional benefits to the women and alleviated lonely feelings
Enhance Relationships Reduce Stress	Allen, Blascovich, Tomaka, and Kelsey (1991)	Pets complemented human relationships, reduced stress-effects more than the presence of a good friend
Identity	Beck and Katcher, (1984).	People tended to name their pets after something or someone important to them. Livestock kept for 4-H and FFA projects often named.
Confidant	Beck and Katcher (1996)	Farm children confided in livestock raised as pets.
Social companion Emotional bonds	Beck and Katcher (1989)	Pets, dogs and cats, provided listening ear and great psychological benefits to the young and elderly.
Communication skills Social companion	Beck and Katcher (1996)	Scottish children talked to their pet and believed the pets comprehended. Swedish elderly considered pet their most significant social contact
Homelessness Loneliness	Kidd and Kidd (1994)	Pets reduced loneliness and enhanced psychological well-being of homeless

Note. Table only presents a fraction of those studies that have been conducted.

As evidenced by the long history of human and animal relationships, it is no wonder that animals continue to play a pivotal role in the lives of humans. It is this rich and satisfying relationship that underlies the curiosity that humans currently possess about animals. This curiosity extends from the biological and neurological sciences to the philosophical and psychological sciences. One of the underlying themes of all the sciences is the ability of animals to learn and adapt to their environment .

Darwin (1872) proposed that animals are guided by their evolutionary history in both structure and function. Therefore, unraveling the mysteries of animal behavior must begin with an understanding of evolutionary concepts, specifically, natural selection and adaptive behavior. To this end, psychologists, ethologists, and zoologists, for instance, have conducted countless studies in an effort to understand the mechanisms that animals use to learn and to adapt to their environment (e.g. Lorenz, 1965; Pavlov, 1927; Skinner, 1951; Watson, 1914).

According to Darwin's (1872) rule of natural selection, adaptive behavior is defined as that which promotes an animal's survival and eventual reproduction. Adaptive behavior is, consequently, dependent on both genetic and environmental influences. Specifically, those individuals who fail to learn the appropriate response to their environmental stimuli do not survive to procreate. Therefore, their genetic pool becomes extinct. On the other hand, individuals who possess genetic influences that enhance survival of the environment have an advantage over less genetically endowed individuals. This advantage culminates in sexual selection and a new generation of adaptive individuals.

Understanding the environmental reinforcers that promote animal learning is the essence of psychological studies of behavior. However, learning capabilities differ as one progresses up the taxonomic hierarchy. Staddon (1983), for instance, acknowledged that the modes of behavior differ tremendously between paramecia, pigeons, and primates. Whereas few would deny that behavior is guided by its consequences (Skinner, 1951), others debate the role of cognitive functions in learning. What is readily accepted by theoretically diverse researchers, however, is the role of reinforcement in conceptual learning, Concept formation, or the process of forming internal representations of stimuli based on characteristics they share with other stimuli, has been successfully demonstrated, for example, in pigeons (Herrnstein & Loveland, 1964) and primates (D'Amato & Van Sant, 1988). Although one study suggested that horses (Sappington & Goldman, 1994) are capable of concept learning, it remains unclear the extent of their cognitive capacity for conceptualization.

Know the Animal

Hebb (1949) insisted that researchers must know their animal prior to beginning any type of animal research or training program. Schwartz (1978), therefore, proposed three questions for animal researchers: (a) what are the animals' sensory limitations and what stimuli are they capable of detecting, (b) how does the internal state of the animal determine detectable stimuli, and (c) can animals learn to perceive relations among objects or differences between them, and how does such learning occur?

Timney and Keil (1996) found that horses see red and blue better than other colors. In addition, they found that horses are sensitive to pictorial depth cues. To assess the ability to detect pictorial depth cues, two stimulus cards were constructed that consisted of different scenes. One stimulus card had a picture of railroad tracks while the other stimulus card had a picture of a pastoral scene with a pond and stream. Two 10 cm lines were imposed onto the pictures. On the railroad track picture, the lines were placed between the tracks to give the Ponzo illusion, an illusion that occurs when two horizontal lines of equal length look unequal by the presence of two lines that tilt inwards. To a human observer, the upper line in the railroad track picture appeared longer. However, the lines on the pastoral scene picture did not appear to differ in length. The results indicated that the horses were able to detect pictorial depth cues and suggested perceptive ability similar to that of humans. In addition, previous experiments by Timney and Keil (1992) showed that horses also have very good resolution acuity.

The internal state and body condition of horses has been found to affect their discriminative learning ability. McCall (1989), for example, obtained fifteen malnourished Thoroughbred and Standardbred horses from a local slaughterhouse. The horses were dewormed and assigned to one of three conditions: (a) thin, (b) moderate, and (c) fat. The horses were then fed low quality grass hay to control hunger as a motivational factor of responding. The feed concentration ration for moderate and fat rated horses was increased to rehabilitate them to appropriate body conditions. After a 2-week adjustment period, discrimination training began. Two buckets were used during the testing phase. The black bucket contained the reward (S+) and a white bucket did not contain the reward (S-). The results indicated that the fat horses had higher error scores than the thin or moderate horses suggesting that food did not serve as motivator when body condition was not in jeopardy.

The early experiences of horses have also been studied for its affects on learning ability, training aptitude, and emotionality. Mal, McCall, Cummins, and Newland (1994) randomly assigned twenty-three foals (14 Arabian, 7 Quarter horse, 2 Thoroughbred) to three treatment groups: (a) non-handled, (b) intermediately handled, (c) and extensively handled. The non-handled foals were not handled except for routine and emergency care from birth to weaning. The intermediately handled foals received two 10-minute handling sessions daily from birth to seven days and were not handled again except for routing and emergency veterinary care. The extensively handled foals received two 10-minute handling sessions daily from birth to seven days and one weekly 10-minute session until weaning. After weaning, a one-trial test for learning was conducted on Days 1, 3, and 15. The foal was placed in a familiar pen and observed for five minutes. Next, a small amount of feed was placed in a target bin and the foal's attention was directed to the feed bin. After eating the feed, the foal's behavior was observed for another five minutes and the number and location of visits to the bin was recorded. On Day 16, each foal was tested to determine how closely a human could approach it as an indication of manageability. Flight distance, number of flight steps, and gait of steps was recorded as the human walked with her arms to her side, towards the foal. Next, a novel volleyball was placed in the pen. The time required to approach the ball served as the dependent measure. The results indicated no significant differences between treatment groups for either of the manageability tests. These results, however, differ from those found by Heird, Lennon, and Bell (1981) and Heird, Whitaker, Bell, Ramsey, and Lokey (1986). Both of these studies found that handling of young horses improved their performance on learning tasks when compared to non-handled young horses. Mal and colleagues (1994) suggested these differences were due to the precocial nature of foals, therefore, the critical period and handling time needed to be determined.

Handling has been found to enhance manageability and learning in other species as well. Rabbits (Anderson, Denenberg, & Zarrow, 1972), silver foxes (Pedersen & Jeppesen, 1990), and dogs (Fox & Stelzner, 1966) have all shown reduced fear and enhanced learning ability as a result of human handling. The dogs, for example, showed less fear reactions to humans and novel environments when handled immediately after birth. Puppies, when handled from birth to five weeks of age, were found to approach novel stimuli more readily than non-handled puppies (Wright, 1983).

Lastly, the limits and boundaries of learning for the species under study determines what an animal *can* learn not what an animal *will* learn. Hanggi (1997a) determined that horses not only could, but do, learn to categorize shapes according to predetermined criteria. Her study suggested that horses are capable of concept learning and she called for more extensive studies to examine this as a possible training procedure.

Discrimination Learning

Discrimination training is the first step towards experimentally testing the degree of stimulus control. During discrimination training, animals are reinforced only when they respond to stimuli that contain specific characteristics. The stimulus that results in reinforcement is the positive (S+), whereas responding to the other stimulus produces no reinforcement and is termed negative (S-). Once the animal reaches the criterion, defined as exhibiting a predetermined number of correct responses to the S+, or a training stimulus, it is presented with a novel stimulus. If the novel stimulus resembles the S+, it is assumed to result in a decrease in discrimination behavior on subsequent trials. In contrast, if the novel stimulus does not possess similar characteristics as the S+, the individual should exhibit inhibitory behavior that yields no response, or an increase in discrimination behavior on subsequent trials. To test the acquisition of discrimination, researchers conduct one or more tests following the training. These are referred to as stimulus generalization or transfer tests.

Generalization

Spence (1936) declared that generalization learning is the opposite of discrimination learning. Generalization, therefore, is the undifferentiated behavioral response exhibited to similar stimuli after successful discrimination training. It is easily tested with a generalization test, sometimes referred to as transfer test. Stimulus generalization behavior is tested after successful discrimination training. The underlying assumption of stimulus generalization is that a novel stimulus possessing similar or common properties as the discriminative stimulus will elicit increased responding. Therefore, the more disparate the novel stimulus is from the training stimulus, the less likely the animal is to respond. Similarly, the more similar the novel and training stimulus are to each other, the greater the probability that the animal will respond to the novel stimulus in the same manner as the training stimulus (Schwartz, 1978). Thus, when similar responses are observed to disparate stimuli, stimulus generalization is assumed to have occurred.

Stimulus generalization has been investigated and demonstrated along various sensory dimensions using both classical and operant conditioning procedures. For example, Pavlov (1927) used stimulus generalization techniques in his dog studies and Herrnstein and Loveland (1964) used operant conditioning procedures, including discrimination training, in their pigeon studies. The degree of similarity between controlling and novel stimuli is thus very important. For instance, the more similar the stimuli, the more characteristics they share. This similarity factor decreases the probability of discrimination learning, the differential responding towards stimuli, while dissimilar stimuli have been shown to increase the probability of discrimination learning. This has been demonstrated in various species of animals such as pigeons (Bhatt, Wasserman, Reynolds, & Knauss, 1988; Herrnstein & Loveland, 1964), primates (Schrier, Angarella, & Povar, 1984), and horses (Hanggi, 1997a, 1999).

Several researchers have debated whether experience is necessary for generalization to occur. Pavlov (1927), for example, insisted that generalization gradients were produced by innate properties of activation in neurons of the cerebral cortex and the stimuli most effective are those that are the best predictors of the unconditioned stimulus. As applied to operant conditioning, Lashley and Wade (1946) argued, instead, that generalization gradients are dependent upon prior learning experience. They suggested that stimuli that are the best predictors of reinforcement exert the strongest control over the individual's responding. Generalization gradients, according to them, arise because of an inadequate opportunity for the individual to compare relationships between stimuli.

Jenkins and Harrison (1960, 1962) provided support for Lashley and Wade's hypothesis that generalization gradients were dependent on experience. Their results indicated that when two pigeons received discrimination training to a 1000-Hz (S+) tone and a 950-Hz (S-) tone they responded to the reinforced 1000-Hz tone more than to the non-reinforced 950-Hz tone. Therefore, the generalization gradients were dependent on the previous experience with the tones and the reinforcement they provided.

Lastly, the dependent measure is important in determining which type of learning has occurred. If the dependent measure is the occurrence of the conditioned response, then Pavlovian conditioning is considered to be the mechanism controlling the individual's behavior. If the dependent measure is a voluntary action exhibited by the individual, then operant conditioning is deemed the mechanism guiding the behavior. However, both types of learning may interact and occur simultaneously. Additionally, Pavlovian conditioning may be the precursor to the success of operant conditioning when the reward of the voluntary behavior is biologically significant to the individual. For instance, lever pressing to receive the reward of food may also elicit salivation in the individual. The dependent measure of salivation is Pavlovian conditioning and the dependent measure of the lever pressing is operant conditioning.

Cognitive Models of Learning

Cognitive models assume that animals possess cognitive capacities and they use these abilities to form mental representations of environmental stimuli. They further predict that animals use these mental representations to solve problems imposed by the various stimuli in their environment. Problem solving abilities are considered strategies and are the mechanisms used to enhance survival. The use of the term "strategy" to explain animal behavior implies that animals engage in the most compensatory behavior for each environmental condition. In other words, animals employ different strategies for different environmental stimuli. Categorization is one such strategy used by animals to form concepts of environmental stimuli.

Categorization.

Animals develop concepts of stimuli by grouping them into categories by the similar characteristics they possess much like humans group fruits, automobiles, and animals. Characteristics include, for instance, such concrete properties as color, shape, and texture while abstract properties include such properties as sameness and difference. Researchers have used various arbitrary and natural stimuli to examine categorization learning in animals. For example, natural objects such as trees, water, people, cats, and flowers (e.g. Bhatt, Wasserman, Reynolds, & Knauss, 1988; D'Amato & VanSant, 1988; Schrier, Angarella, Povar, 1984) and human-made stimuli including cars, chairs, the letter A, and the cartoon character Charlie Brown (e.g. Bhatt et al., 1988; Morgan, Fitch, Holman, & Lea, 1976; Schrier et al., 1984) have been used to examine categorization. Additionally, experimenters have used auditory stimuli such as phonemes and music (Burdick & Miller, 1975; Kluender, Diehl, & Killeen, 1987; Porter & Neuringer, 1984). Tools have also been employed to examine categorization in animals (Oden, Thompson, & Premack, 1988; Pepperberg, 1987; Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980).

Hanggi (1999) found support for categorization learning for arbitrary geometric shapes in horses. She demonstrated that the horses responded to geometric shapes possessing white centers, as opposed to ones containing blackened centers, when they had previously received a food reward for doing the latter. Pigeon studies have shown similar results. For example, pigeons were shown to respond preferentially to pictures of trees when previous responses to trees resulted in access to food pellets (Herrnstein & Loveland, 1964; Herrnstein. Loveland, & Cable, 1976).

The results of these and other studies have indicated that animals sort stimuli into categories. It is hypothesized that animals categorize stimuli based upon their common characteristics. Additionally, it is presumed that animals respond to stimuli when the response results in positive reinforcements such as access to preferred foods. However, it remains unclear what characteristic animals use to classify various stimuli, an area that is in need of further research. Regardless of the method used, Huber (1995) stressed that the ability to assign stimuli to distinctive categories is vital to adaptation. Because survival depends on the appropriate response to stimuli, he suggested that categorization is biologically dispersed throughout the animal world. Additionally, he asserted that categorization is a higher form of learning than classical conditioning and operant conditioning (Vauclair, 1996). However, both classical and operant conditioning techniques, because of their reinforcing properties, promote the cognitive ability of forming concepts.

Concept Formation. Concepts are defined as mental representations of stimuli that are clustered by similar abstract exemplars as Herrnstein and Loveland (1964) proposed. Simple discrimination learning occurred when organisms distinguished stimuli according to physical exemplars. In contrast, concepts are formed as a result of discrimination between stimuli based upon abstract exemplars or complex combinations of exemplars. Thus, concept formation is the process by which the stimuli are categorized. Just as humans form concepts by learning to sort stimuli into clusters (Rosch, 1973, 1975, 1977), research has indicated that animals also are capable of conceptualizing stimuli (e.g. Blough, 1982; Herrnstein & Loveland, 1964; Schrier & Brady, 1987) according to their similar characteristics.

Herrnstein and Loveland (1964) proposed that animals compare all novel stimuli to conceptualized representations of past stimuli. by comparing them with internal representations of previously encountered stimuli. For instance, when similarities exist between the conceptualized representation of a previously encountered stimulus and a novel stimulus, animals responded according to the reinforcement contingency provided in past encounters (Herrnstein, 1979; 1990; Herrnstein & Loveland, 1964). Simply stated, animals respond to novel stimuli in the same manner they previously responded to stimuli that possessed similar exemplars.

Generalization or Concept Formation

Although the distinction between concept formation and stimulus generalization is at times ambiguous (Pearce, 1994), the main distinction may better be understood as a function of the sequencing of events. Specifically, generalization occurs when organisms respond to the stimulus that most represents the discriminative stimulus, whereas concept learning involves mentally categorizing numerous stimuli that contain both positive and negative characteristics of the discriminative stimulus. Generalization is, therefore, the behavioral manifestation of the internal process of forming conceptual representations. Simply state, before an animal can exhibit generalization, it must first have formed a concept of the stimulus. Without a concept, the animal has no mental representation to compare to the presenting stimulus.

Function of Discrimination in Concept Formation

An important requirement of concept formation is successful discrimination learning. Once discriminative behavior has been successfully learned it is assumed that the animal has formed a concept of the positive stimuli. At this point, generalization tests, sometimes referred to as transfer tests, examine the extent that novel stimuli result in similar responses as the discriminative stimulus.

It must be emphasized that the role of reinforcement to concept learning is vitally important. As Skinner (1951) so successfully demonstrated, consequences of past behavior underlie the expression of future behavior. Hence, conceptualization builds upon both of the lower levels of classical and operant learning (Herrnstein et al., 1976; Thomas, 1996). Likewise, conceptualization requires that the animal distinguish stimuli based on the consequences they represent. Positive consequences enhance discriminative learning while negative consequences discourage discriminative learning. Therefore, discrete concepts are formed based upon the reinforcement value of varying stimuli.

Concept Formation Findings

Research on concept formation has been designed to analyze the way individuals learn to discriminate between complex stimuli. Concept formation experiments have been conducted on both human and non-human animals using both natural and unnatural stimuli. For example, Rosch (1973, 1975, 1977) studied how humans responded to stimuli such as birds, vegetables, and vehicle while non-human studies have been conducted with natural stimuli such as trees (Herrnstein, 1979), fish (Herrnstein & de Villiers, 1980), and water (Herrnstein et al., 1976). Animal studies of concept formation for unnatural stimuli include artificial objects (Lubow, 1974), letters of the alphabet (Blough, 1982; Schrier et al., 1984), and geometric figures such as triangles and squares (Towe, 1954; Sappington & Goldman, 1994). Although pigeons have been the subjects of choice for most concept formation research, other species have also been observed for their ability to form concepts or categories of stimuli. For instance, studies have been conducted with a parrot (Pepperberg, 1987), horses (Hanggi, 1999; Sappington &

Goldman, 1994), and monkeys (D'Amato & VanSant, 1988; Schrier & Brady, 1987; Schrier et al., 1984; Yoshikubo, 1985).

A classic study by Herrnstein and Loveland (1964) used operant procedures to train pigeons to peck at a key when a slide contained a picture of a person. When the pigeons responded correctly to the slide that had a person they received a food reward. However, the pigeons did not receive a reward when they pecked at the slides that did not contain images of people. The results revealed that the pigeons rapidly learned the discrimination task. This discriminatory learning was also evident in pictures presented for the first time.

Herrnstein and his colleagues (1976) expanded their operant procedure to include trees, water, and a particular woman as the reinforcing stimuli. The *tree* experiment included 1,840 pictures with varying aspects such as species, distance from tree, and amount of tree that was obscured from view. The pigeons were reinforced when they responded to pictures that contained any portion or aspect of tree. The *water* experiment used 1,760 different pictures of water. The water stimuli included an array of pictures from an aerial view of the Atlantic Ocean to pictures of small puddles, snow or ice. The pigeons were reinforced for responding to pictures containing water but not reinforced for responding to pictures that contained no liquid form of water. The *person* experiment used 1,600 different pictures of a particular woman. The woman was photographed in a variety of settings including indoors, outdoors, near, far, front, rear, clear, obscured, alone, or with other people. For all the experiments, the pictures were in color but varied in brightness. Each experiment lasted from 120-131 trials per day. Eighty pictures were randomly selected from 500-700 pictures with half being the reinforced (S+) stimuli and half composing the non reinforced (S-) stimuli. Some of the pictures were seen for the first time during the testing while others were repeated.

The results indicated that two levels of discrimination had been presented to the pigeons. The first level of discrimination was based on the inclusion of common features in the pictures. For instance, trees have certain characteristics in common such as shape, texture, color, or any combination of these. If the pigeons responded to these common features then single exemplars would be assumed to determine the correct pictures as Blough (1975) and Rescorla (1976) suggested. However, no single exemplar was found to exist across either the trees or bodies of water. The second level of discrimination classified the properties that distinguish the reinforced stimuli from non-reinforced stimuli. Herrnstein and his colleagues (1976) suggested that the pigeons were, therefore, categorizing the stimuli by clusters of features similar to the way humans respond to stimuli. A prototype of tree, water, and person was constructed and the pigeons generalized their responses to additional stimuli that also shared characteristics of the reinforced stimuli. Although this explanation applies to the pigeons' response to the tree and water stimuli, the response to the particular woman was not understood. Additionally, the pigeons never saw the photographed woman in person. Therefore, it is unknown if the pigeons would have responded to her specifically or because they had formed a generic category for *human*. The current study addressed this issue by including a transfer test to examine the degree of discrimination between the actual woman featured in the discriminative photographs, Ahna, and a Stranger, a woman previously unseen by any of the horses.

Herrnstein and his colleagues (1976) concluded that the pigeons responded not to common elements in the positive and negative slides, but to complex visual features present in the two-dimensional (2D) slides as if they represented the three-dimensional (3D) world. This allowed the pigeons to sort the patterns contained in the positive and negative slides into categories experienced in their real world environment. Not all psychologists, however, agreed with this conclusion. Cerella (1980), for instance, doubted that the animals treated the 2D pictures as representations of 3D objects. Two plausible alternatives have been offered for the pigeons' ability to discriminate the pictures of trees. D'Amato and Van Sant (1988) suggested that the novel slides contained some absolute features such as color, shape, or patterns with the training slides. Another explanation, provided by Kendrick, Wright, and Cook (1990), claimed that the pigeons memorized individual positive and negative pictures and responded to the novel slides if they were similar to the memorized slides.

On the other hand, several studies support Herrnstein's and his colleagues (1976) hypothesis that the animals recognized 3D objects based on their similarity to the 2D pictures, slides, or photographs. Delius (1992), for instance, found that pigeons who were presented with spherical objects during discrimination training subsequently chose pictorial drawings of spherical objects such as marbles, peas, and ball bearings over drawings of non-spherical objects including dice, buttons, nuts, and flowers. Additionally, Honig and Stewart (1988) found that pigeons that were presented with 2D photographs of locations responded to the actual location depicted in the picture. This latter finding further supports Herrnstein's hypothesis that animals, particularly pigeons, possess the cognitive mechanism of concept formation.

In summary, the acquisition of discriminative behavior is believed to be a prerequisite of concept learning (Thomas, 1996). Categorization allows the animal to correctly respond to novel stimuli without depending entirely on memorizing each exemplar and its significance to the S+ (Bhatt et al., 1988; Schrier & Brady, 1987). Thus, when presented with novel environmental or abstract stimuli that resemble the S+, the categorization mechanism is triggered and the animals respond adaptively. Several theories have been proposed to explain how animals transfer the significant information learned during discrimination training to novel stimuli. Lea (1984), for example, suggested that if categories of stimuli are formed during discrimination training then the animals had formed a concept of the discriminative stimuli and thus possess the cognitive ability of concept formation.

Thomas' Hierarchy of Animal Learning

Morgan (1896) denied that animals possess cognitive ability. In contrast, Romanes (1969; 1977) was an advocate for the mental abilities of animals. Recent evidence seems to support Romanes view that many species of animals process external stimuli using a classification system. For example, Vauclair (1996) provided data from several studies that suggested many species use abstract information to classify stimuli. For instance, discrimination learning has been shown in fish, reptiles, birds, and mammals such as mice, rats, zebras, donkeys, and horses (e.g. Thomas, 1996; Rensch, 1967). Wasserman (1993) stated, unfortunately, that beyond rats, pigeons, monkeys, and apes, researchers know very little about cognition in non-human animals. Hanggi (1999), in her research on categorization in horses, also echoed this sentiment.

Thomas (1986) was one of many researchers who developed a hierarchy of animal learning-intelligence. This hierarchy, as depicted in Table 3, is composed of eight levels. Levels 1-5 constitute Pavlovian and operant conditioning. Levels 6-8 involve concept learning that occurs after discrimination learning. If stimulus generalization is going to occur, it will be seen during these higher-order levels. Thomas further hypothesized that squirrel monkeys, rhesus monkeys, and chimpanzees could perform conjunctive and conditional-reasoning tasks involved in levels 7 and 8 of relational concept learning.

Table 3

Level	Category
8	**Relational Concepts II:** Uses class concepts in biconditional relationships
7	**Relational Concepts I:** Uses class concepts in conjunctive, disjunctive, or conditional relationships
6	**Absolute and Relative Class Concepts**
5	**Concurrent Discrimination Learning:** Learning S-R units in parallel
4	**Chaining:** Learning S-R units in series
3	**Stimulus-Response Learning:** Simple Operant conditioning
2	**Signal Learning:** Pavlovian conditioning
1	**Habituation and Sensitization**

Note. The hierarchy of basic cognitive processes associated with learning and intelligence. Levels 1-5 constitute Pavlovian and operant conditioning. Levels 6-8 constitute concept learning.

According to Thomas' (1986) hierarchy, Level 1 describes habituation, or learning not to respond to stimuli. Level 2 assumes that classical conditioning occurs when the individual responds to a new stimulus (CS) that has been repeatedly paired with an original innate eliciting stimulus (US). For instance, Pavlov (1927) found that dogs salivated to a tone (CS) after it was repeatedly paired with food (US). Level 3 of the hierarchy determines that simple operant conditioning has occurred when the individual repeats a voluntary response to obtain a reward. Level 4 encompasses a higher level of operant conditioning. That is, at this level, learning is assumed to have occurred when an animal makes a connected sequence of voluntary responses to obtain reinforcement. Level 5 consists of concurrent discrimination learning. It describes learning to make voluntary, operant responses to more than one set of stimuli presented in parallel. For example, when presented with *n* number of different discrimination problems (e.g. triangle vs. square, circle vs. pentagon, diamond vs. cross) level 5 is the measure of the animal's ability to learn randomly presented problems. Horses and elephants have shown the ability to learn as many as 20 problems whereas rats have learned eight problems (Rensch, 1967).

Levels 1-5 address Pavlovian and operant conditioning. In contrast, Levels 6-8 incorporate cognition as part of the learning process. Specifically, Level 6 describes concept learning. The animal learns to discriminate a large number of stimuli based on some common characteristic shared by all of them. Level 7 includes conjunctive, disjunctive, and conditional relationships in the learning process. For instance, conjunctive reasoning would include decisions regarding *if-and* choices while disjunctive reasoning would be responses based on *if-then* alternatives. In other words, the animal learns a relationship between stimuli. Researchers have designed oddity and matching to sample studies to test this level of reasoning in animals. Thomas and Noble (1988) found that rats, for example, were capable of learning sets of olfactory oddity sets. Level 8 learning consists of biconditional concepts. This level requires the animal to make complex logical reasoning processes involving the relationship between stimuli. Simply, one stimulus may or may not exist when another stimulus exists. However, Thomas (1986) points out that no one has investigated the possibility of Level 8 learning ability in animals, only humans have been tested at this level. Table 4 presents a summary of the learning studies for each of the species described below.

Table 4

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6	Level 7	Level 8
Fish	X	X	X					
Marine Animals	X	X	X					
Newt	X	X	X					
Turtle	X	X	X					
Birds	X	X	X	X				
Chickens	X	X	X	X	X			
Swine	X	X	X	X	X	X		
Horses	X	X	X	X	X	X		
Dolphins	X	X	X	X	X	X	X	
Sea Lions	X	X	X	X	X	X	X	
Elephants	X	X	X	X	X	X	X	
Primates	X	X	X	X	X	X	X	
Humans	X	X	X	X	X	X	X	X

Notes. X = indicates learning studies support this type of learning capacity in the species.

Fish

Rensch (1967) found that teleost fish such as perch (small-brain) appeared to learn four concurrent discrimination problems while trout (large-brain) learned six concurrent discrimination tasks. Subsequent studies of goldfish showed that a memory trace of visual patterns was interrupted when followed by a different visual pattern, a behavior referred to as latent learning (Ducker, Rensch, & Stascheit, 1980). The goldfish were first examined to determine which of three patterns were preferred. Two stimuli were presented and the preferred pattern became the negative cue. The two remaining patterns were then presented and the preferred pattern served as the S+. After the goldfish were trained to discriminate the stimuli they were divided into groups. During the retention phase of the experiment, a similar pattern was presented to the experimental group of goldfish whereas the control group was presented with a solid white stimulus. The testing phase indicated that the experimental group responded significantly more to the most recent stimulus pattern. The control group, in contrast, showed a preference to the originally rewarded pattern. These results suggested that the goldfish were capable of Level 3 learning, discrimination, memory, and latent learning.

Marine Animals

Operant procedures have been used to examine the learning capacity of the octopus (*octopus vulgaris*) (Dews, 1959) and their memory abilities have been tested with reversal learning (Boycott & Young, 1959). Dews (1959), for example, demonstrated that shaping was effective in differentiating responses. The octopus worked for rewards of fish by lever pressing. Extinction occurred when the lever-pressing behavior was no longer reinforced.

Boycott and Young (1959) trained octopus to attack a plastic figure and reinforced it with a crab when the behavior occurred within 15 seconds. However, if the octopus attacked the negative figure, a 6-8 volt shock was given. After being shocked all of them returned to the "home" section of the tank. If they continued to inhibit attack responses while the negative figure remained in the tank no more shocks were administered. After criterion was met, reversal training began. The positive figure became the negative figure and the negative figure became the positive figure. The results indicated that they were able to learn not to attack crabs that resulted in shock. The ability of the octopus to relearn the criteria after each reversal suggested that well-established memories were formed of the figure associated with shock and the figure associated with food. All of these operant procedures demonstrate Level 3 of the animal intelligence proposed by Thomas (1986).

Reptiles

Several studies have been conducted on the reptilian species in an effort to understand their learning capacity and processes. For instance, Tinklepaugh (1932) found that the wood turtle learned to maneuver in a maze and was compared to the learning exhibited by rats in similar mazes. Other studies have revealed spatial learning abilities in reptiles (Burghardt, 1977) and discrimination learning in lizards. For instance, Rensch (1967) found that lizards (small-brain) learned two concurrent discrimination problems while lizards (large-brain) learned three concurrent discrimination tasks. Additionally, he demonstrated that the iguana learned five concurrent discrimination tasks.

No experimental learning tests with amphibians have been conducted beyond Level 3 of Thomas' hierarchy of animal learning (1986). However, the amphibian newt and the reptilian terrapin were trained in a simple T-maze, and they successively exhibited reversal learning (Seidman, 1949). Although both animals showed evidence of a learning set (Harlow, 1949), the terrapin clearly showed learning superiority over the newt. This was attributable to its larger brain size and greater plasticity.

Birds

Pigeons. In a classic study of categorization, Herrnstein (1964) found that pigeons responded to stimuli that resembled those used in discrimination training. That is, the pigeons were trained on stimuli that contained pictures of people as the rewarded or positive stimulus. During generalization testing, the pigeons successfully responded to pictures that only contained people. Herrnstein and colleagues (1976) further tested concept formation using natural categories. The pigeons were first trained to respond to pictures containing trees. Generalization tests indicated that pigeons correctly responded to pictures that presented novel trees, portions of trees, and trees with and without leaves, green leaves, and colored leaves.

Morgan and colleagues (1976) tested the feature theory of categorization using pigeons. The pigeons were first trained to discriminate between the letter A and the numeral 2. The letter A served as the positive stimulus and the 2 served as the negative stimulus. They were then tested using a transfer of training procedure. To determine whether the learned information transferred to other similar stimuli. All of the other letters of the alphabet, rather than just the letter A, were presented to the pigeons. The results indicated that the pigeons pecked at letters that consisted of a top apex point and two bottom legs, whereas, rounded and curved letters did not produce a response.

Pigeons were found to differentiate four categories of stimuli (cats, flowers, cars, chairs) (Bhatt et al., 1988). They were tested in an operant chamber to peck at a key signifying the correct category. The pigeon was required to peck 30 times to ensure the pigeon observed the stimulus. After the pecking, the food reward was delivered if the pigeon had pecked the correct key. The results indicated that over 30 sessions, the pigeons achieved a 75 percent accuracy level.

Various Fowl Species. Pastore (1954) used a black chess pawn and an aspirin tablet to investigate discrimination learning in canaries. He found that the canaries learned oddity problems easily even when the absolute stimulus values were reversed from trial to trial.

Ryan (1982) found evidence of concept formation and individual recognition in domestic chickens (*Gallus gallus*). Adult cock bantam chickens were trained to discriminate slides depicting two conspecies. After learning to criteria, the chickens were tested using a transfer experiment. The S+ contained the familiar conspecies whereas the S- slides were of an unfamiliar bird. The results supported the hypothesis that the chickens formed concepts of the specific individuals presented in the discriminative stimuli.

Pietreivicz and Kamil (1977) studied Blue jays (*Cyanocitta cristata*) to determine if they could differentiate the presence or absence of *Catocala* moths in slides. The blue jays were trained to discriminate slides that contained moths from those that did not contain moths. Following the discrimination training, the birds were tested with slides that differed in various ways, for instance, the orientation of a slide. If the slide contained a moth, the bird received reinforcement after a 10-peck response. Following reinforcement, a 10-second intertrial interval was provided to allow ingestion of the reward. On negative trials, the tenth peck on the incorrect key was followed by a 60-second intertrial interval but a correct 10-peck response was followed by a 4-second intertrial interval. The results indicated that the background of the picture decreased the blue jays accuracy of moth detection. Orientation also reduced the proper response and suggested that body placement was an important component of discrimination learning of prey detection.

The majority of discrimination studies involving non-human animals have examined visual stimuli. However, experiments with non-human animals have revealed much regarding the human processes required for distinguishing speech sounds and thus challenged theories that assert only humans possess sound classification abilities. For instance, Japanese Quail (*Coturnix coturnix*) have been shown to form categories of phonemes (Kluender et al., 1987). The quail learned categories for the syllables d, b, and g. Each of these was followed by the presentation of four novel vowels. The quail correctly categorized syllables in which the same consonants preceded eight novel vowels. These results suggested that quail use a complex mapping system rather than simple generalization for syllable identification. That is, no single feature or pattern was identifiable in the syllables.

<u>Parrots</u>. Many animal behaviorists have assumed that birds were limited in their conceptual abilities. However, studies have shown that some birds are able to solve concept formation problems. For example, Pepperberg (1987) examined an African Grey parrot named Alex. He was trained to respond to same and different stimuli using 80 discrete objects that differed in shape and color. When presented with two novel objects

that differed in either shape or color and asked what was the same, his responses fulfilled the criterion of concept formation. He responded correctly by saying the object was "same color" or "same shape" and his answers were correct. Additionally, Alex could answer questions about objects that contained two categories. For example, when presented with materials of the same color but of different sizes and made of different materials, he correctly responded when asked "what is bigger?" or "what is smaller?" To ensure Alex did not respond simply due to the color of the stimulus, different colors were used. Additionally, different materials such as wood and plastic were incorporated into other tests. Alex successfully learned to discriminate and the results suggested that he was capable of generalizing various concepts such as size, color, and material.

Altevogt (1951) found a difference in the amount of visual discrimination learning between dwarf and large birds. The large birds, for instance ravens and parrots, learned seven concurrent visual discrimination tasks, whereas small birds such as jackdaws and parakeets learned up to five visual discrimination tasks. Additionally, the larger birds were better at learning more complicated and difficult discriminations. The larger birds were also better at memorizing the stimuli. Rensch (1967) suggested that larger body sized species had better learning, memory, and abstracting abilities than small body sized species. He attributed this to larger brain size.

Mammals

A variety of mammals are capable of learning multiple-choice problems. For example, Hamilton (1911) showed that in a five-choice test, animals learn to choose the alley that has not been previously tried. Thus, they avoided repetitions until all choices had been exhausted. This is similar to the learning to learn phenomenon except that the animal must learn not to repeat rather than repeat the response. Other evidence of the learning to learn phenomenon used discrimination problems in a study with rats (Wodinsky & Bitterman, 1953). Rats were shown to learn oddity problems if stimuli were not vertically or horizontally striped panels or black and white figures. The rats performed better on later problems than on earlier problems. In other words, the rats acquired the correct responses sooner when they had previous experience with the problems. Numerous other studies have revealed learning capabilities in mammals also. These include, but are not limited to, primates, dolphins, horses, elephants, and humans.

Primates. Rhesus monkeys successfully discriminated between regular and irregular geometric shapes (Warren, 1953). The monkeys' ability to discriminate increased with more geometric area. However, this enhanced ability was only demonstrated between regular and irregular shapes. When both shapes were regular or both shapes were irregular, no significance discrimination was demonstrated.

Roberts and Mazmanian (1988) tested the prototype effect in squirrel monkeys. They found that the monkeys learned to choose pictures that contained animals when positively reinforced. Although the results demonstrated discrimination learning, they do not support the prototype theory because the animals included very diverse species such as insects, fish, amphibians, reptiles, and mammals (human and non-human). As the authors emphasized, no prototypical characteristic is common to this disparate cross-section of animals.

Macaque monkeys, stumptail monkeys, baboons, and chimpanzees have also been studied by numerous researchers (e. g. Oden et al., 1988; Schrier et al., 1984; Harlow, 1949; D'Amato, Salmon, & Colombo, 1985; Gardner & Gardner, 1984; Vauclair, 1996).

Infant chimpanzees, for example, were trained using a match-to-sample experiment with two stimuli, a lock and a cup (Oden et al., 1988). The infant was handed one of the stimuli, for instance a cup, and this represented the sample. Next, the infant was offered a matching, another cup, and a non-matching stimulus, a lock. The cup was paired with food and social reinforcement. Once the 80% accuracy rate was achieved, the infant was tested with six new problems with different stimuli, two objects, two clothes, and two food items. On the transfer tests the infants were given 12 trials with each of the different stimuli. The results indicated that the infant chimpanzees chose the matching items, those that were reinforced, on 81% of the test trials. This suggested that chimpanzees are able to transfer matching concepts to novel stimuli.

One of the groundbreaking studies of primate cognitive learning ability involved teaching sign language to Washoe, a female chimpanzee (Gardner & Gardner, 1984). Washoe was taught American Sign Language. After learning basic signs for food items, persons, and objects, she began to chain the signs to obtain desired items. Subsequent studies revealed that Washoe taught other chimpanzees the signs and evidence of communication between chimpanzees was documented.

Sea lions. Sea lions have been shown to master concept formation problems involving the essentials of Aristotelian logic. For example, Schusterman and Kastak (1998) rewarded California sea lions for learning that X = Y and Y = Z. When they were tested for the concept of X = Z they correctly responded. Another study used operant conditioning techniques to teach sea lions to choose the letter B over other alternatives when A had been presented earlier. Next, the sea lions were rewarded for selecting A when B had been previously presented. They were then rewarded for selecting C when B had been presented or B when C had been presented. Finally, when the sea lions were shown the letter A, they immediately selected C over other alternatives.

California sea lions are also capable of semantic comprehension. Schusterman and Krieger (1984) taught two sea lions, Rocky and Bucky, to respond to human gestures. The distinct signals referred to objects, modifiers, and actions. Rocky's modifiers consisted of size and color attributes while Bucky's consisted of locations of the objects. After 24 months of training, Rocky had a vocabulary of 20 signs consisting of 5 modifiers, 10 objects, and 5 actions. Bucky, after 20 months of training, learned 16 signs consisting of 2 modifiers, 8 objects, and 6 actions. Rocky eventually learned 190 three-sign combinations and Bucky learned 64 three-sign combinations. Their ability to comprehend and respond correctly to gestural language further suggested that they possessed logical reasoning capacity. In comparison to bottlenosed dolphins, California sea lions learn semanitic comprehension equally as well (Herman, 1980).

Schusterman, Gisiner, and Hanggi (1992) offered evidence of human-sea lion imprinting on a human attachment figure. In the first experiment they observed sea lions in their home pool while two to three humans were present. In the second experiment the experimenters took the sea lion pup at birth and hand raised it in the laboratory. The last experiment consisted of eliminating the olfaction and visual signals from the attachment figure. The results indicated that the early social interactions with humans changed the sea lions' behavior and enhanced their working relationship.

<u>Dolphins</u>. Bottle-nosed dolphins have been examined for their ability to learn language as a consequence of auditory categorization (Herman & Gordon, 1974). For example, Herman (1987) trained Phoenix, a female bottle-nosed dolphin, to respond to

compute-generated acousitc signals. The signals were broadcast in a tank of seawater and were whistlelike to simulate the natural sounds of dolphins. Ake, another female dolphin, was trained to respond to gestural movements of the trainer's arms and hands. To prevent any inadvertently cueing to the dolphins, as was found to occur during the Clever Hans phenomenon, the trainer wore opaque goggles. The dolphins were instructed to gather objects in their tank with instructions such as *fetch, toss, go under*. For example, "Ake Phoenix under" meant that Ake was supposed to swim under Phoenix to obtain the object. The results indicated that Ake and Phoenix successfully applied labels to five objects (Herman, 1987).

Gisiner and Schusterman (1992) extended the experimental method used by Herman (1987) to train dolphins and test their ability to categorize instructions to California sea lions. Two female sea lions were trained to respond to objects on land and in the water. When they responded correctly they were given a food reward. The results indicated that Rocky learned to follow commands that involved one or more exemplars, for instance, "Go over the *large gray ball*." She further demonstrated an understanding of simple syntax. These studies suggested that conceptualization of language and the language-learning potential is present in mammals other than humans and apes.

Swine. A measure of learning abilities in swine was tested using an avoidance procedure. Karas, Williams, and Cox (1962) chose this design due to the previous results with dogs (Solomon, 1953) and rats (Mowrer, 1946) that indicated few trials were required for avoidance learning to occur. The pigs were tested in 40 trials using three different temporal spacings. The different spacing was performed to determine the optimal one for avoidance learning. For instance, some pigs received 40 consecutive trials for one day, 20 trials per day for two days, and 10 trials per day for four days. During the training trials each pig received 6-seconds of the buzzer (CS) and 10-seconds of shock (US) on both sides of the hurdle box to produce habituation response. The intertrial interval was approximately eight seconds. The testing trials consisted of a six-second CS following by the US unless the pig made an avoidance movement of crossing the hurdle. An attempt to avoid the shock resulted in the absence of the US. The results revealed that the spacing of the trials facilitated learned avoidance behavior. That is, the pigs learned to avoid an aversive shock when they received 10 trials per day for four days rather than either 20 trials per day for two days or 40 trials in one day.

Elephants. Rensch (1967) suggested that larger animals have more developed cerebral cortex areas and therefore have greater learning abilities. To test this prediction, he observed Indian elephants in India. The results of the naturalistic observation indicated that the elephants could respond correctly to 21-24 vocal commands. Subsequent research at the Munster, Germany zoo was conducted with a five-year-old Indian elephant. First, she was trained to discriminate among visual pair patterns. A preference test indicated that she chose a circle over a cross therefore the circle was made the S-. After achieving criteria in the discrimination training she was presented with different pairs. The results indicated that she was able to learn discrimination more rapidly in successive tests, as suggested by the learning to learn phenomenon. In a final multiple-choice task, she was presented with 20 stimulus pairs 30 times. The results of this test revealed that she retained 20 concurrent visual discrimination pairs. Interestingly, she showed no signs of fatigue over 600 test trials lasting several hours.

Equine

Zebras. Rensch (1967) extended the elephant discrimination tasks to donkeys, zebras, and horses. He found that zebras learned 10 concurrent discrimination tasks and donkeys learned 13 concurrent discrimination tasks. The discrimination learning exhibited by horses, on the other hand, more closely matched the learning ability of elephants. That is, the horses learned 20 concurrent discrimination tasks, the same as the number exhibited by the elephants. McCall (1993) concluded that horses are equipped with good memory capacity and are able to assimilate new information with previously learned information. Additional studies have also shown and confirmed the finding that horses can correctly learn to discriminate 20 pairs of visual patterns (Giebel, 1958).

Horses. How horses learn is vitally important information for the horse industry professionals, amateurs, and enthusiasts. These include horses trained for: (a) ranch work to herd cattle, (b) racetrack work, (c) farming work such as plowing fields for agriculture, (d) therapeutic riding programs for disabled humans, and (e) pets or companions. It is advantageous, therefore, for the trainers to know the least time-consuming and efficient training method (Rubin, Oppegard, & Hintz, 1980).

Haag, Rudman, and Houpt (1980) conducted avoidance learning procedures with ponies. A handler controlled the pony by a halter and lead rope. The conditioned stimulus (CS) was an electric buzzer that sounded for 10 seconds. If the pony jumped a .4-m hurdler with the 10-second time period the pony was not shocked. The jump constituted the conditioned response (CR). However, if the jump did not occur within the 10-second time period an electric shock (US) was administered for 1.5 seconds. During the shock the handler led the pony over the hurdle. The results indicated that the ponies learned the avoidance response faster when one session rather than daily or twice-weekly sessions were conducted. Bolles (1970) stated that quicker learning of avoidance behavior is due to innate defense reactions. Defensive responses are acquired more rapidly as avoidance responses than non-innate responses due to their survival importance.

Houpt, Zahorik, and Swartzman-Andert (1990) conducted avoidance learning studies in Shetland ponies. In contrast to shock avoidance learning, however, taste aversion learning was studied. Because horses spend approximately 60% of their time eating (Waring, 1983) and consume a large variety of plants (Marinier, 1980), this study was conducted to determine if Shetland ponies could learn to avoid plants that resulted in illness. The first experiment was designed to determine the avoidance of food that produced immediate illness. The US was a 3-mg dose of apomorphine injected intramuscularly into half of the ponies after 15 minutes of exposure to a novel food. The other half of the ponies received an equivalent amount of saline injected intramuscularly. Two days later the ponies were offered the same foods again. The results indicated that an aversion to the illness food was formed as measured by the reduced intake of the food.

The second experiment was designed to measure the avoidance behavior to food that produced a delayed illness. Rather than being injected with the US after a 15-minute feeding, the ponies were injected after 45 minutes. All of the other specifics were the same as the first experiment. In contrast to studies of rats that learned to avoid foods that produced illness up to four hours after consumption (Garcia, Hankins, & Rusiniak, 1974), the results indicated that the ponies did not learn to avoid a food that produced a delayed illness. The results of both studies indicated that horses learned to avoid food associated with illness only if it produced illness soon after consumption but not if the illness occurred 30 minutes after ingestion. These results were similar to those found in rodents, carnivores, cattle (Olsen & Ralphs, 1986) and sheep (Thorhallsdottir, Provenza, & Balph, 1987), which also indicated learned taste aversion when illness occurred soon after ingestion.

Discrimination learning in horses has been tested using various stimuli. For instance, Gardner (1937) was one of the first researchers to reveal that horses were capable of discrimination learning. Her studies indicated that horses learned to choose a feed box containing food that was covered with a black cloth over feed boxes that did not contain food. When tested a year later, the horses demonstrated they retained the learned information. However, when the cloth was repositioned the horses had a more difficult time choosing the correct feed box.

Hagerbaumer (1995) used visual and auditory stimuli as the CS in an effort to develop an effective discrimination task. The US consisted of sweet feed, a preferred feed of the horses. The visual signals consisted of two small appliance light bulbs. A steady light signaled left was the correct choice, and a blinking light signaled that right was the correct choice. A buzzer signaled left as the correct choice while a doorbell signaled right. Punishment for choosing the incorrect side was a fine mist of water sprayed on the horses' muzzles. The CR was choosing the correct gate after presentation of the light or sound. When the cue was presented for either left or right gate, the horse had to press the appropriate flap to open the gate and gain access to the feed. The results indicated that auditory signals worked better than visual signals for discrimination learning. It was hypothesized that the sounds were better at getting the horses' attention. Punishment, however, made the horses give up and hindered their learning.

Houpt (1995) has used various procedures to study the learning ability of horses. For instance, she used habituation training to desensitize horse to sounds such as crowds at horse shows and traffic noise near their pasture. After repeated exposure to the loud stimuli the horses exhibited less responding and habituated to the noise. This is also seen when horses are desensitized to the feel of a halter and saddle.

Horses are also capable of both classical learning and operant learning. Houpt (1995), for example, demonstrated classical conditioning. Her horses exhibited escape behavior at the sight of a syringe after it had been paired with penicillin injections. The injections produced pain and the horses soon associated the syringe with the pain and the escape response occurred. Houpt (1995) also successfully demonstrated operant learning in horses. She found that horses controlled their environment using operant techniques such as nuzzle pressing a lever for positive consequences. The horses turned on lights when the barn was dark and turned on heat lamps when they were exposed to cold temperatures.

Various researchers have used mazes to test the memory abilities of horses (Marineier & Alexander, 1994; McCall, Potter, Friend, & Ingram, 1981). For example, the Hebb-Williams closed field maze, a maze consisting of a start box and a goal box and no other escape, was used to study the learning ability of yearling horses. This was done because prior research indicated that horses learned rapidly and used learning sets to solve problems (e.g. Fiske & Potter, 1979; Gardner, 1937; Warren & Warren, 1962). During days 1-3 of the study, each horse was allowed to roam freely in the maze for five minutes each day. On days 4-13 feed was placed in the goal box and served as the reinforcer. Six training problems were introduced to the horses with the learning criterion set at completion of eight of nine trials within seven minutes each. During the testing period the horses were presented with one of the six problems with a new problem each day. The results indicated that the horses adapted quickly to the procedure. All the yearling horses reached criterion on the last two training problems. However, more errors were made on the non-visual cues than on the visual cues. These results agree with studies that suggest other species also use visual cues more efficiently for problem solving than non-visual cues (Pollard & Lysons, 1967; Pollard & Lewis, 1969; Preston & Kirkby, 1973).

More recently, Marinier and Alexander (1994) used mazes to test learning and memory in horses. Maze A was a continuation of Maze B. Both contained five turns and two blind pockets. Two months after reaching criterion on Maze A the horses were retested on Maze A as they trained on Maze B. The results indicated successful maze learning as determined by decreased median running time and number of runs to criterion on successive maze tests.

As noted, most of the equine research has concentrated on simple discrimination learning, observational learning, avoidance learning, maze learning and the effects of handling or experience on future learning. In contrast, very few studies have been conducted to examine concept formation in horses. Sappington and Goldman (1994), for instance, examined discrimination learning and concept formation in Arabian geldings (castrated males). They hypothesized that the horses were capable of learning at Level 6 of Thomas' (1986) learning hierarchy. To test this hypothesis they constructed a wall containing two stimulus panels. Six discrimination problems were presented to the horses. The correct stimulus was randomly alternated between panels. Problems 1-2 consisted of two geometric shapes. The correct shape was the one not chosen by the horse on the first trial. Problems 3-6 tested the horses' ability to form a concept of triangularity by pairing different triangle shapes with non-triangle shapes. The results indicated that the horses' performance increased during the discrimination training. This suggested that the horses were *learning to learn* (Harlow, 1949). Additionally, the results suggested that some horses are capable of learning at Level 6, that is, they have the capacity for concept formation. Subsequent research has found that horses can form concepts and can learn to discriminate other geometric shapes, such as rectangles and half circles, in addition to triangles (Houpt, 1995).

Hanggi (1999) examined categorization learning in horses. She used sixteen geometric stimulus pairs served as the discriminative stimuli. The pairs differed only in the middle. The open-center stimuli were always the correct choice while the filled center stimuli were always the incorrect choice. The handler took the horse to the starting point and released it. When the horse chose the correct stimulus, it was rewarded with sweet feed. When the horse chose the incorrect stimulus, it was told "no" by the experimenter and not rewarded. After the criterion was met, 100% correct responses on two consecutive sessions, the stimuli were mixed. The mixed pairs did not match in shape or rotation. The results indicated that some horses are able to categorically sort stimuli. Additionally, following the first discrimination training with similar shapes, the horses learned new stimulus pairs rapidly. This finding coincides with other research that suggests horses, like other species, learn to learn.

General Summary

Animals must be able to respond to novel stimuli and modify their behavioral responses accordingly. Reinforcement (Skinner, 1951) predicts that previously experienced stimuli that provided positive rewards are more likely to result in similar behavior on future encounters. Likewise, aversive consequences would decrease the rate of response on future confrontations. However, it is highly unlikely in a continually changing environment that animals have previously experienced all stimuli. Therefore, the most efficient way for an animal to survive in its environment is to form a representation of stimuli and categorize them based on similar characteristics they possess. Otherwise, the animal would expend all of its energy in processing the information and would have no metabolic energy left to respond to the stimuli.

Categorization is the process of classifying stimuli by grouping them according to similarities in their physical or functional characteristics. Stimuli may also be categorized according to differences that exist between them. When an animal subsequently responds to similar stimuli it is assumed that it has formed a conceptualization of them. This is behavior termed as stimulus generalization (Watson, 1913). Implicitly, this assumes that the animal has a past history with stimuli possessing similar characteristics as the present stimuli. However, this does not address the issue of responding to novel stimuli. In ever changing environments, survival would not be possible if animals were required to have experience with every type of stimuli. Simply stated, environments are constantly changing and no animal has encountered every possible stimulus. In contrast, conceptualization allows the animal to compare existing mental representations to novel stimuli and respond to them based on their sameness/difference characteristics.

Concept Formation in Horses

Horses have evolved from open land range roamers with their main predator threat being ground animals. They have extremely keen sensory perceptions (Waring, 1983) and use their sensory abilities to enhance survival. The visual system, for example, is vital to their ability to detect danger from all sides, watch where their hoofs are placed, and find appropriate food. Thus, evolution has equipped horses with visual fields that point sideways and downward. The eyes are laterally positioned on the head and they move in unison. Additionally, the horse has one of the largest eyes of any living animal (Waring, 1983). Research has shown that horses have color vision (Grzimek, 1952; Timney & Keil, 1992) and they rely on facial characteristics and clothing to recognize humans Grzimek (1944b). Dixon (1966) demonstrated that horses have good pattern discrimination skills as evidenced by their ability to detect triangles from dots of the same size. Finally, Grzimek (1943a) found 2D and 3D imitation horses were approached and investigated around the nose and flanks as done when approaching conspecies. Visual acuity of horses is also quite advanced (Timney & Keil, 1992).

The purpose of this study was twofold. First, this study attempted to determine if horses formed concepts of specific stimuli by using discrimination training of an arbitrary stimulus (Star) and a natural stimulus (Ahna). Secondly, after successful completion of discrimination training, the horses were given a one-trial generalization field test to determine whether they had formed a mental representation of the 2D stimuli and transferred the representation to the 3D stimuli as suggested by Herrnstein and his colleagues (1976). It was hypothesized that the horses would easily learn to discriminate 2D photographs containing the S+ stimuli and would therefore spend more time in or near the sector containing the 3D replica of the S+ stimuli than the replica of the S- stimuli.

It was further hypothesized that during the 30-minute field test the horses would attempt to avoid the S- stimuli. This, it was expected, would be exhibited by the horses spending more time, measured in seconds, in the sectors containing the Star and Ahna than in the Cross and Stranger or Empty sectors. This timed behavior would support the assumption that the horses had formed a concept of the specific S+ stimuli based on the positive reinforcement they represented. Similarly, if the horses spent more time in the Empty or Star and Ahna sector than in the Cross or Stranger sector, it was hypothesized that the latter stimuli held a negative value to the horses and, therefore, they would avoid them. In contrast, the hypothesis was considered to be unsupported if the horses spent more time in the Cross and Stranger sectors than they spent in either the Star and Ahna or Empty sectors. Thus, the dependent measure of the field test was the amount of time spent in proximity to the testing stimuli.

In summary, this study: (a) used operant techniques and concept formation tasks to determine if horses could form 2D representations of a specific geometric shape, Star, and a particular woman, Ahna, and (b) used a field test to determine if the horses transferred the 2D learning to a 3D, real world situation.

CHAPTER III

Method

Subjects

Thirteen horses were included in the study. The demographics are presented in Table 5. All horses were feed-maintained by their owners. They were fed their normal feed of prairie hay, grass pasture, and grain feed no higher than 14% crude protein and met the National Research Council (1989) nutritional requirements. All horses were discrimination trained and tested in their home quarters to reduce any bias from environmental changes. Additionally, all owners signed an informed consent for the use of their horse(s) and were fully briefed about the procedures used in the study.

Table 5

Horse	**Age (in years)**	**Breed**	**Sex**	**Completed Study (Yes/No)**
Pearl	19	Quarter	F	Yes
Peso	21	Quarter-Palomino	M	Yes
Sam	12	Quarter	M	Yes
Steppin Annie	29	Quarter	F	Yes
Jimmie Anne	18	Quarter	F	Yes
Peaches	1	Quarter-Percheron	F	Yes
Teddy	5 wks	Quarter-Palomino	M	Yes
Pye (control)	10	Thoroughbred	M	Yes
Amigo	18	Arabian-Quarter	M	No
Buckshot	1	Appaloosa-Quarter	M	No
Snowfire	1	Appaloosa-Quarter	F	No
Hot Rod	4	Quarter	M	No
Babe	6	Quarter	F	No

Note. Amigo, Hot Rod, and Babe did not complete the study because they would not stay in the testing area. Buckshot and Snowfire were not halter trained and were only caught twice. Pearl was used to run the pilot study, however she was exposed to each stimulus pair only once. This allowed her to be used in the experimental phase. The remaining horses, excluding Pye, were used for the discrimination training and field tests. Pye was the control for the discrimination training effect.

Materials and Apparatus

Stimuli

Survival is enhanced by the ability to respond appropriately to various types of stimuli. Natural stimuli (Herrnstein & de Villiers, 1980) and arbitrary stimuli (Herrnstein, 1990; Morgan et. al, 1976) both hold adaptive significance to animals. Therefore, this study presented an arbitrary, living and a non-arbitrary, nonliving material stimulus to the horses. A photograph of a woman in the discrimination training and the actual woman along with a stranger in the field test was presented to each horse. During the discrimination training, the arbitrary stimulus was the computer-generated printout of a geometric 5-point star. For the field test, a large wooden replication of the star was constructed and used. It was painted black to resemble the photograph. The field test was conducted to determine if the horses had formed a concept of the specific stimuli, the star and the woman.

The computer-generated 5-point star was chosen based on the objectives outlined by Hanggi (1999). For example, this stimulus was one that had not been previously encountered by any of the horses in their environment (Huber, 1995) and the Star avoided redundancy caused by pictures of natural scenery available in the horses' environments. The computer-generated black star was printed on a 33 x 37 cm white sheet of drafting paper.

During the discrimination trials, the presence of the Star stimulus served as the S+. The star was photographed with three dogs, on wooden steps, and atop of a bale of hay. The Star was then removed and the three dogs, wooden steps, and bale of hay were photographed without it. If the photograph did not include the Star stimulus then the picture served as the S- and the horse was not rewarded for responding to it.

The pictures were photographed using color exposure film and a 35mm Minolta camera, developed at Wal-Mart film developing center, and enlarged to approximately 33 x 37 cm. All of the photographic stimuli were laminated to prevent damage by moisture or tearing by the horses. The stimuli were held in place by a piece of Plexiglas mounted to the hinged door on the panel. The stimuli were placed behind the Plexiglas prior to each discrimination trial. Figures 1-4 present the Star stimulus photographs. All photographs that contained the star always served as the S+ whereas the pictures without the star served as the S-.

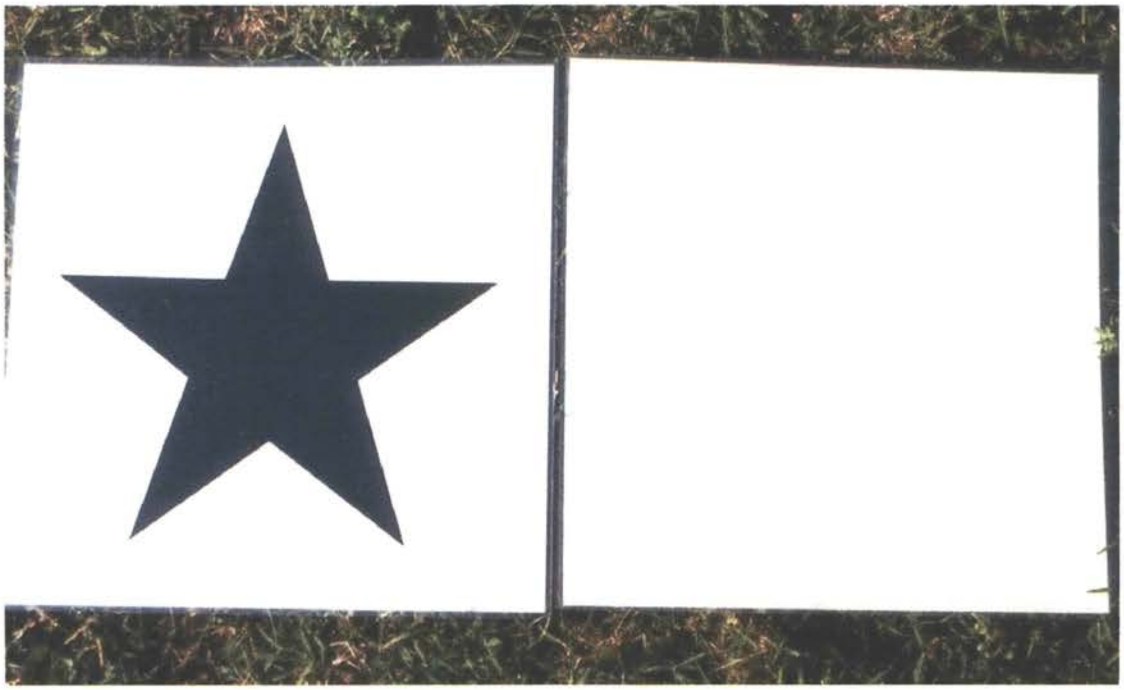


Figure 1. The Star/No Star discriminative stimulus cards.

Figure 2. The Star/Dogs discriminative stimulus cards.

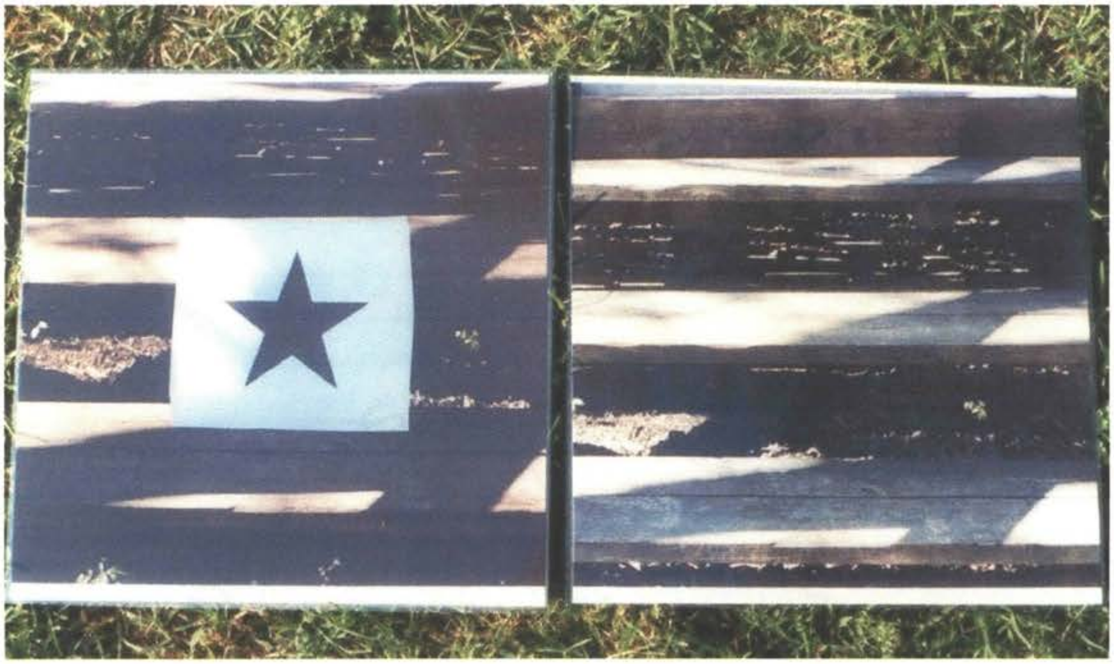


Figure 3. The Star/Steps discriminative stimulus cards.

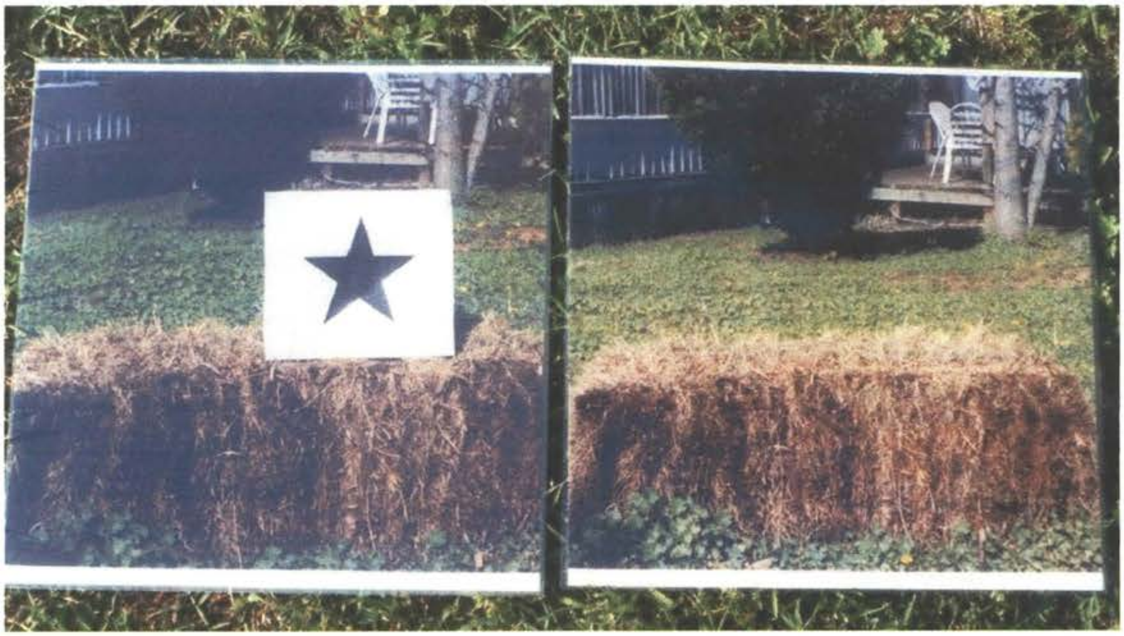


Figure 4. The Star/Hay discriminative stimulus cards.

Figures 5-7 presents the Ahna stimulus photographs. Ahna was unknown by all the horses. All photographs that contained Ahna always served as the S+ whereas the pictures without Ahna served as the S-. She was photographed standing in the middle of a grassy lawn and this served as the Ahna/No Ahna stimulus card (Figure 5). She was also photographed sitting on a wooden park bench, Ahna/Bench (Figure 6), and sitting on a bale of hay, Ahna/Hay (Figure 7). The grassy lawn, wooden park bench, and bale of hay were also photographed without her present.

Color exposure film and a 35mm Minolta camera were used for all photographs. The film was developed and enlarged to match the size of the computer-generated star stimulus (33 x 37 cm). During the discrimination trials, the presence of Ahna in the photographs served as the S+ and the horse was rewarded for responding to it. If the photographic stimuli did not include Ahna, then the photograph served as the S- and the horse was not rewarded. All of the photographic stimuli were laminated to prevent damage by moisture or tearing by the horses.

Figure 5. The Ahna/No Ahna discriminative stimulus cards for the adult horses.

Figure 6. The Ahna/Bench discriminative stimulus cards for the five adult horses.

Figure 7. The Ahna/Hay discriminative stimulus cards.

Apparatus

Two identical stimulus walls were constructed because of the different locations of the horses. Five of the horses were located at one ranch and two horses were located at another. A picture of one of the apparatus stimulus walls is presented in Figure 8 and 9. Because Teddy was shorter than all of the other horses he could not reach the panel or feed bowl placed behind it. Therefore, during his training sessions, duct tape was used to tape the stimuli low enough on the wall so that he could easily touch them with his muzzle. Additionally, a feed bowl was placed on the ground in the center of the stimulus wall (Figure 10 and 11). The stimulus wall was constructed from a 1.2 m x 2.4 m wooden panel and a 1.0 m x 2.0 m wooden panel. Both panels were painted with white latex (water-based) paint.

Figure 8. The apparatus used during discrimination trials for Pearl and Peaches.

Figure 9. The apparatus used during discrimination trials for Sam, Peso, Jimmie Anne, and Steppin Annie.

Figure 10. The apparatus used during discrimination training for Teddy.

Figure 11. Teddy touching the Star stimulus card with his muzzle.

On each test panel a 40 x 45 cm door was hinged at the top and swung inward when the horse pressed its muzzle against the door (Figure 12). An eyehook and clasp were placed at the bottom of both doors and were used to lock the door in place when it concealed the S-. A feed tray was placed behind each door and contained 17 g of food reinforcer. The measuring spoon was obtained from the experimenter's veterinarian to ensure an accurate measurement of food. A review of the literature indicated that the food reinforcers ranged between 60 ml (Dougherty & Lewis, 1991) and 15 g (Hanggi, 1999). Because a nursing foal and mare were included in this study the food reinforcer was increased to 17 g in the feed bowls. Also, this small amount lessened the probability of satiation occurring during the discrimination trials.

Figure 12. Pearl correctly choosing the Star stimulus card and pushing panel door open to obtain food reinforcement.

Mader and Price (1980) found that individual differences in feed preference influenced the horses' motivation. Therefore, the horse owner alerted the experimenter to the food treat most preferred by each horse. This was done to ensure each horse had the same amount of motivation to work for the reward. Without this control, physiological difficulties would have been added to the results, and any learning could have been contributed to the preference of the reinforcer. To control for olfactory cues, the tray behind both the S+ and S- contained each horse's food treat reward.

Two of the paddocks were composed of metal pipe and the other paddock was composed of metal t-posts and barbless cable wire. An assistant stood behind the panels and changed the stimuli at the leader's instruction. The assistant and leader communicated with each other using headset walkie-talkies. Two cones, orange road construction type, were placed 5m from the panels and served as the starting point. The leader brought the horse to the cones and held the bottom strap of the halter. The leader then lowered her/his eyes and remained quiet after releasing the horse to avoid any inadvertent cueing. The leader was blind to the location of the S+ and S- stimuli.

In an effort to determine if the horses formed shape-specific concepts of the computer-generated Star, a large sized replica of the Star and of a Cross was created. Andrew and Harlow (1948) found that rhesus monkeys were able to form a concept of triangularity. However, two of the horses used in this study had been familiarized with a triangle as a call for feeding time. Therefore, the Star was used because of its novelty to all the horses in the study. In addition to discrimination training, a field test of both stimuli was conducted to examine concept formation of specific stimuli. For the geometric shape field test, the Star and a computer generated Cross were replicated using plywood. The plywood was cut and painted black using water based latex paint. The water-based paint was chosen to control for odor left by oil-based paints. The stimuli resembled the computer-generated stimuli. The plywood Star and Cross were approximately five times larger (165 cm x 185 cm) than the computer-generated image.

The person field test was conducted to determine if the horses formed a concept of a specific person. In the latter test, Ahna was accompanied by an additional woman, the Stranger, who was unknown by each horse. To control for confounding environmental conditions, the daytime illumination, time of day, and other conditions were similar in the photograph of Ahna and the actual field test. Ahna wore different clothing during the field test than she wore in the photograph to control for responses solely to clothing color or type. She displayed the same facial expression as exhibited in the photograph. Additionally, the field test was conducted on a day when the weather was similar to the day the photograph was taken. This was done to control the amount of sunlight, brightness, and weather conditions. Three different people participated as leaders during the study to control for cueing by any specific leader. The leaders followed the same procedure.

Procedure

Pre-training Trials – Stage 1

A 5-day pre-training period was conducted to acquaint the horses with the panels and their operation. The horses were allowed to habituate to the training paddock and were trained to push the doors to obtain the food reinforcement. On Day one of the pre-training period, both panel doors were locked in the open position. The leader led the horse to the doors and allowed the horse to eat for approximately five seconds. This procedure continued for five trials for a total time of 15 minutes. On Day two of the pre-training period, both doors were closed. The leader led the horse to a door (ABAB or BABA pattern) and opened it. The horse was allowed to eat for approximately 5 seconds.

On Days 3 and 4, the leader brought the horse to the cones. To ensure the horse had ample time to see the stimuli, a 5-second observation period began each trial. After the observation period the leader led the horse to the doors (ABBA or BAAB). If the horse did not open the door on its own the leader opened the door for it. During the 5-second eating period, the leader gently placed the door on the horse's muzzle. This training continued for five trials on both days. Trials 6-10 were conducted in the same manner as trials 1-5 except that the leader released the horse at the cones. If the horse did not proceed to the doors after the 5-second observation period, the leader led the horse to the door, opened it, and gently placed the door on the muzzle while it ate. On Day five the leader released the horse at the starting cones on all 10 trials and allowed it to choose its own door.

Stimulus Training Trials – Stage 2

On Day one both doors were closed and the cones were placed five meters (16 feet) from the stimulus wall. The leader allowed a 5-second observation period from cones. For Trials 1-12, the leader led the horse to the S+ (Star photographs or Ahna photographs) door in an ABBA BAAB sequence (Table 6). The Ahna stimulus training did not begin until after completion of the Star field test. For Trials 13-24, the leader released the halter at the cones while keeping head bowed to control for any subtle cueing. If the horse correctly responded by choosing the S+ door it was allowed to eat the reward. However, an incorrect response resulted in an immediate return to the cones.

During the 1-minute intertrial interval, the horse and leader faced away from the stimulus wall while the assistant changed the photographic stimuli.

On Day two both doors were closed and the horse was released at the cones after a 5-second observation period. If the horse correctly responded by choosing the S+ door it was allowed to eat the reward. However, an incorrect response resulted in an immediate return to the cones. During the 1-minute intertrial interval, the horse and leader were turned facing away from the stimulus wall while the assistant changed the photographic stimuli.

Discrimination Training Trials – Stage 3

Criteria for Stage 3 of the training was for the horse to correctly respond on 80% (Hanggi, 1997a) of the trials, or 19 of 24 trials, for three consecutive days. All discrimination training was done in a section of the horses' home paddocks. The sections measured approximately 14.5 x 14.5 meters. The horse's home paddock was taped off to ensure all training areas were the same dimensions. The tape was measured to specifics using a metric tape employed by trainers in setting up dressage courses. Orange cones were used as the starting point for each horse. All data were recorded with paper and pencil. An Excel spreadsheet was used to record the horses' responses. When the horse responded correctly to the S+, a "1" was recorded for that trial. In contrast, if the horses responded incorrectly, a "0" was recorded for that trial.

Each session of the training period consisted of 24 trials. Although Hanggi (1999) used 30 trials in her categorization study of horses, 24 trials were selected for this study to accommodate the ABBA BAAB schedule (8 trials x 3 repetitions). The intertrial interval was one minute. This interval was chosen for two reasons: (a) intervals that are too short often lead to over-stimulation, animals tend to shut down and stop responding, and (b) satiation may occur when food is concentrated within a short amount of time. Each horse was tested with one session (24 trials) per day. The approximate training time was 30 minutes per horse. If more than one horse was training at each paddock, the other horses were tied out of view of the training horse until it was their turn to participate.

Table 6

Trial	Schedule	Left Door	Right Door
1	A	Food	No Food
2	B	No Food	Food
3	B	No Food	Food
4	A	Food	No Food
5	B	No Food	Food
6	A	Food	No Food
7	A	Food	No Food
8	B	No Food	Food
9-24	Repeat 1-8 Sequence		

Note. The ABBA BAAB stimulus schedule. Trials 9-24 are repetitions of trials 1-8.

The stimulus training periods began after the last day of pre-training. Twenty-four trials were conducted using the ABBA BAAB sequencing schedule. The leader led the horse to the starting cones and allowed a 5-second observation period after the photographic stimuli were slid behind both doors. The leader then released the halter. When a photograph contained the Star, the horse obtained a food reward by pushing the door open. When a picture did not contain the Star, the door was locked from behind with the eyehook. If the horse responded to the stimuli on the locked door, it was not granted access to the food reward. After an incorrect response or five seconds of feeding, the experimenter immediately led the horse back to the cones. The leader faced the horse in the opposite direction until the photographic stimuli were changed and the 1-minute intertrial interval had elapsed. The same procedure was followed during all 24 trials.

Field Test

To determine if the horses formed stimuli-specific concepts of the Star and Ahna, concept formation tasks were conducted. The tests indicated if the horses transferred the discriminative learning to a real world situation. A one-trial generalization test was conducted in the field. It was hypothesized that the horses would respond more positively to the S+ stimuli by remaining in the corresponding sector longer than the S- sector. Likewise, an Empty sector was included in the field test and it was hypothesized that the horses would prefer it to the S- sector. The experimenter brought each horse into a 100 x 100 cm round pen composed of metal pipe fencing. The round pen was mapped into equal sectors by counting the number of metal posts and dividing equally into thirds.

Star Field Test. For the Star field test, the plywood replica was placed at differing sectors of the round pen for each horse. This was done to control for position bias. A plywood replica of a Cross was placed in an opposing sector of the round pen. The remaining sector stayed Empty (Figure 13). The experimenter then walked the horse to the center of the round pen, released the horse's lead rope from its halter, walked out of the pen, and remained out of sight for the remainder of the test. The field test was conducted for approximately 35 minutes. Five minutes were provided at the beginning of the 30-minute observation period to allow the horse to habituate to the round pen and the experimenter's absence. An 8-mm video camera was set up out of sight of the horse and recorded the field test. The amount of time (in seconds) the horse remained in each sector during the next 35 minutes and all behaviors the horses exhibited during the field test were later coded and analyzed.

<u>Ahna Field Test</u>. The Ahna field test was conducted in a manner similar to the Star test. However, Ahna replaced the Star stimulus and the Stranger replaced the Cross. Once again, the sectors differed to control for position bias. The 8-mm video camera recorded the amount of time (in seconds) and behaviors of each horse (Figure 14). Five minutes were provided at the beginning of the 30-minute observation period to allow the horse to habituate to the round pen and the experimenter's absence.

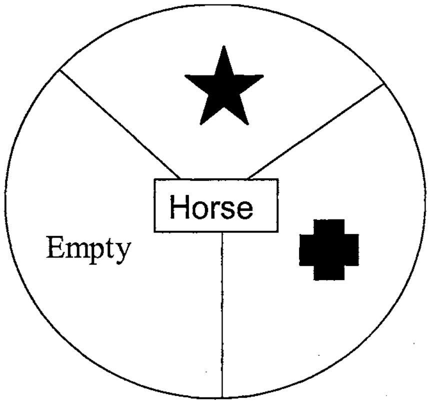


Figure 13. Location of Star and Cross stimuli during a representative field test.

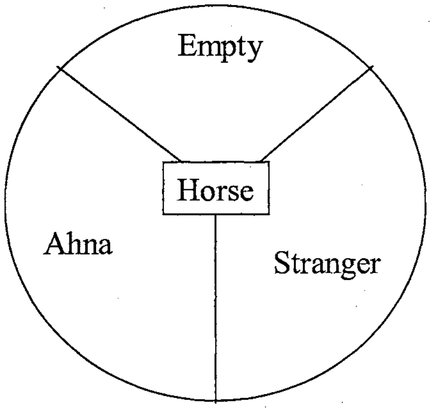


Figure 14. Location of Ahna and Stranger stimuli during a representative field test.

CHAPTER IV

Results

Two outcomes were anticipated from this study: (a) that the horses would demonstrate discrimination between stimuli, and (b) the horses would form a concept or mental representation of the specific geometric shape, the 5-pointed star stimulus, and the specific person, Ahna, stimulus. It was assumed that the concept would be formed due to the physical parameters of the Star stimulus or on abstract similarities or differences between the Star stimulus and the non-Star stimulus. This process was also assumed to underlie the conceptualization of the Ahna stimulus. It was predicted that the horses would transfer the conceptualization from the 2D photographic stimuli to the 3D actual stimuli. To test both of these assumptions regarding the stimuli, a field test was conducted. It was further predicted that the horses would respond by spending more time in the sector of the Star replica and the Ahna sector.

Three hypotheses were offered: (a) the horses would learn discrimination during the training trials, (b) the horses would learn discriminative behavior in fewer trials as the training progressed, a phenomenon termed as learning to learn and found in various species including horses (Hanggi, 1999), and (c) the horses would demonstrate specific transfer of learning behavior by spending more time with the Star and Ahna than to the Cross and Stranger.

Discrimination Training

Star discrimination photographs

The criterion for the adult horses was 80% correct (19 of 24 trials) for three consecutive days on all the photographic stimuli. Likewise, the criteria for the yearling

(Peaches) and the foal (Teddy) were 80% correct (9 of 12 trials) for three consecutive days on their photographic stimuli.

Star stimulus training. The presence of the Star served as the S+ for all of the Star photographic stimuli. The first and second day of the Star stimulus training consisted of leading each horse to the S+ on Trials 1-12. This was done to train the horse to the correct stimulus, that is, the stimulus that led to reinforcement. No response data were recorded for these two days. Beginning on Day three the horse's response data were videotaped, recorded into SPSS, analyzed, and subsequently graphed. The photographs were presently in the same order to all of the horses. Specifically, the order of presentation was: (a) Star/No Star, (b) Star/Dogs, (c) Star/Steps, and (d) Star/Hay. Additionally, each horse was required to meet criteria on each pair of photographic stimuli before they were moved to the next pair of photographs.

Finally, the ABBA BAAB presentation schedule was alternated between each pair of photographs in an effort to control for position bias. That is, the Star/No Star was presented ABBA BAAB, the Star/Dogs was presented BAAB ABBA, the Star/Steps was presented ABBA BAAB, and the Star/Hay was presented BAAB ABBA. However, individual differences in position bias was observed in each horse; Pearl exhibited a right bias, Peso exhibited a left bias, Sam exhibited a left bias, Steppin Annie exhibited a right bias, Jimmie Anne exhibited a left bias, Peaches exhibited a right bias, and Teddy exhibited a right bias.

Pearl

Figure 15 presents the results of Pearl's discrimination training for all of the Star photographic stimuli. Pearl's responses supported the learning to learn phenomenon.

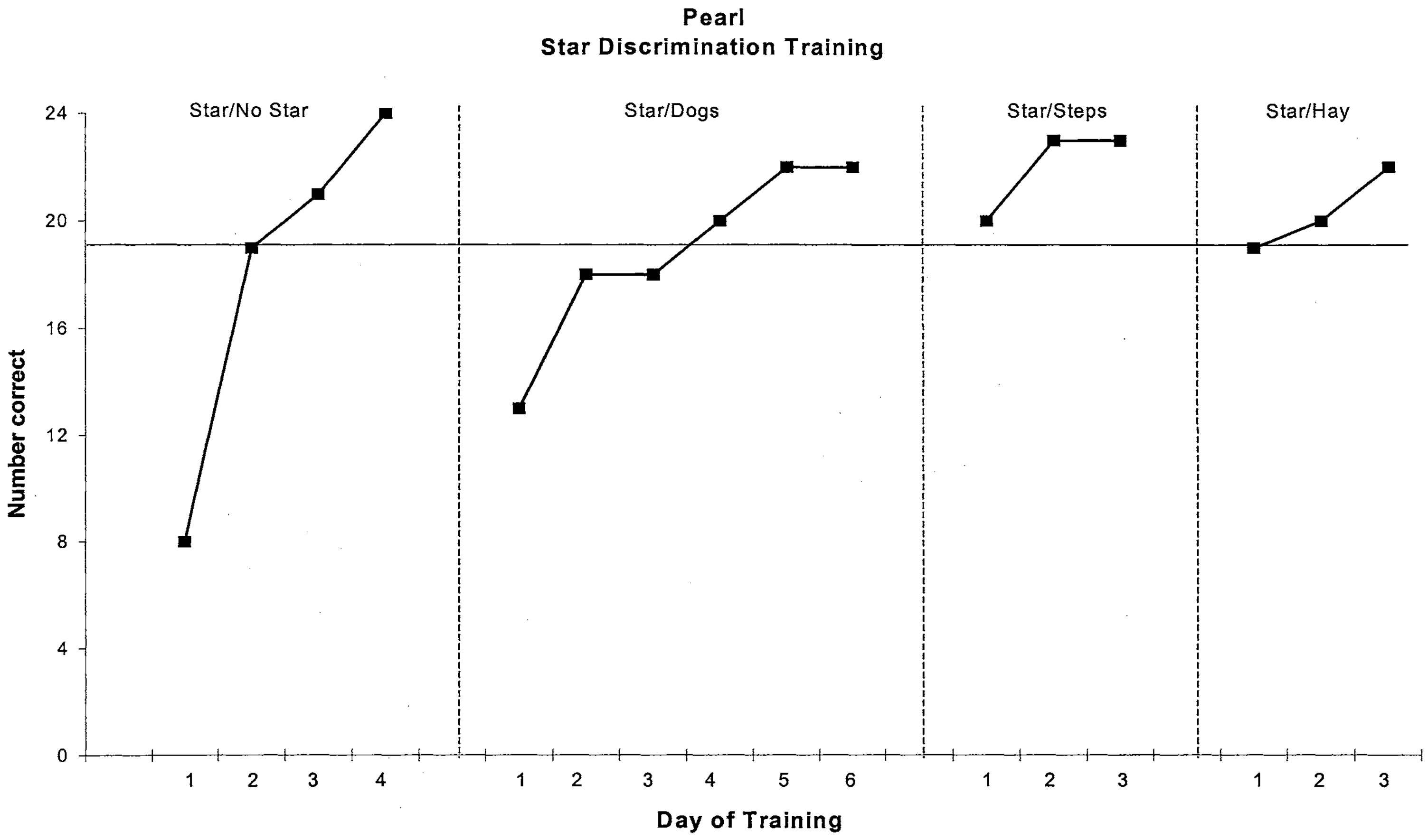
Specifically, she exhibited more correct responses to each succeeding pair of photographs than to the previously presented photographic pairs.

Star/No Star. The majority of Pearl's response errors occurred in the first 16 trials on Day one. However, Pearl correctly responded to 19 of the 24 trials on Day two, 21 of 24 trials on Day three, and 24 of 24 trials on Day four. Having met criteria on the fourth day of training, Pearl was moved to the next pair of photographs, the Star/Dogs.

Star/Dogs. This pair of photographs required the most number of days for Pearl to meet criteria. Specifically, Pearl did not meet criteria on Day one, 13 of 24 trials, on Day two, 18 of 24 trials, or on Day three, 18 of 24 trials. However, once she met criteria on Day four, 20 of 24 trials, she succeeded in meeting it on Day five, 22 of 24 trials, and 22 of 24 trials on Day six.

Star/Steps. Pearl correctly met criteria on the first three days of the Star/Steps discrimination training. She responded correctly on 20 of 24 trials on Day one, 23 of 24 trials on Day two, and 23 of 24 trials on Day three.

Star/Hay. Just as she exhibited in the previous pair of photographs, the Star/Steps, Pearl correctly met criteria on the first three days of the Star/Hay discrimination training. She responded correctly on 19 of 24 trials on Day one, 20 of 24 trials on Day two, and 22 of 24 trials on Day three.



<u>Figure 15</u>. Discrimination training days for Star photographs for Pearl.

Peso

Figure 16 presents the results of Peso's discrimination training for all of the Star photographic stimuli. Peso's responses also supported the learning to learn phenomenon. Specifically, he exhibited more correct responses to each succeeding pair of photographs than to the previously presented photographic pairs.

Star/No Star. The majority of Peso's response errors occurred in the first 12 trials on Day one and Day two. However, Peso responded perfectly on all 24 trials on Day three, Day four, and Day five. Having met criteria on the fifth day of training, Peso was moved to the next pair of photographs, the Star/Dogs.

Star/Dogs. This pair of photographs appeared to be more difficult for Peso than the Star/No Star photographs. Specifically, Peso did not meet criteria on Day one, 12 of 24 trials, or on Day two, 11 of 24 trials. It was also noted that he only responded correctly when the S+ was on the left side. As mentioned previously, he showed a left bias during the course of the discrimination training trials. However, he met criteria by correctly responding to 23 of 24 trials on Day three, 20 of 24 trials on Day four, and 21 of 24 trials on Day five.

Star/Steps. Peso correctly met criteria on the first three days of the Star/Steps discrimination training. He responded correctly on 19 of 24 trials on Day one, 21 of 24 trials on Day two, and 21 of 24 trials on Day three.

Star/Hay. Just as he exhibited in the previous pair of photographs, the Star/Steps, Peso correctly met criteria on the first three days of the Star/Hay discrimination training. He responded correctly on 22 of 24 trials on Day one, 20 of 24 trials on Day two, and 19 of 24 trials on Day three.

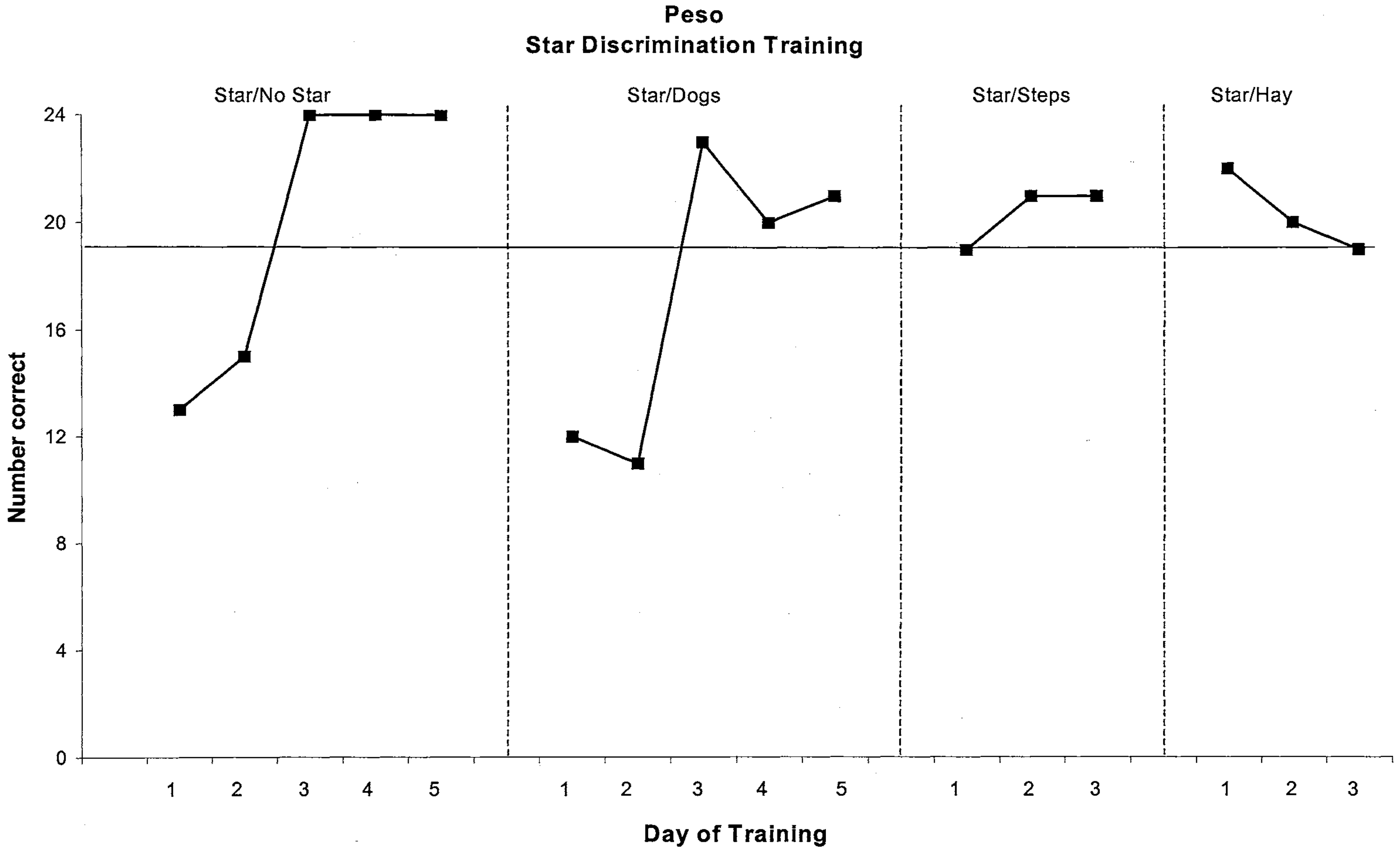


Figure 16. Discrimination training days for Star photographs for Peso.

Sam

Figure 17 presents the results of Sam's discrimination training for all of the Star photographic stimuli. Sam's responses also supported the learning to learn phenomenon. Specifically, he exhibited more correct responses to each succeeding pair of photographs than to the previously presented photographic pairs. However, Sam's training may have been affected by health reasons. He had an impacted tooth and jaw infection that required antibiotic medication.

Star/No Star. The majority of Sam's response errors occurred in the first 12 trials on Day one, Day two, and Day three. However, Peso responded correctly on 23 of 24 trials on Day four, 20 of 24 trials Day five, and 22 of 24 trials on Day six. Having met criteria on the sixth day of training, Sam was moved to the next pair of photographs, the Star/Dogs.

Star/Dogs. This pair of photographs appeared to be more difficult for Sam than the Star/No Star photographs. Specifically, Sam did not meet criteria on Day one, 14 of 24 trials, or on Day two, 16 of 24 trials. Day three resulted in a noticeable drop in correct responses, 11 of 24 trials, over Day two. It must be noted that this was when he began exhibiting nasal discharge and irritability from the impacted tooth. It is unknown if this negatively affected his performance. For instance, the task required pushing the door panel with the muzzle to gain the food reinforcement. It may have been that the impacted tooth caused pushing the panel to be extremely painful on Day three. However, he met criteria by correctly responding on 19 of 24 trials, on Day four, 21 of 24 trials on Day five, and 20 of 24 trials on Day six.

Star/Steps. Sam had been given a penicillin injection prior to beginning the Star/Steps training. Although his infection seemed to improve, he did not completely heal during the Star/Steps discrimination training. Sam did not meet criteria on Day one of the Star/Steps training, 16 of 24 trials, or on Day two, 17 of 24 trials. He responded correctly, however, on Day three, 20 of 24 trials, on Day four, 21 of 24 trials, and on Day five, 23 of 24 trials.

Star/Hay. Although Sam did not meet criteria on Day one, 15 of 24 trials, he did respond correctly on the next three days. Specifically, he responded correctly on 19 of 24 trials for Day two, Day three, and Day four.

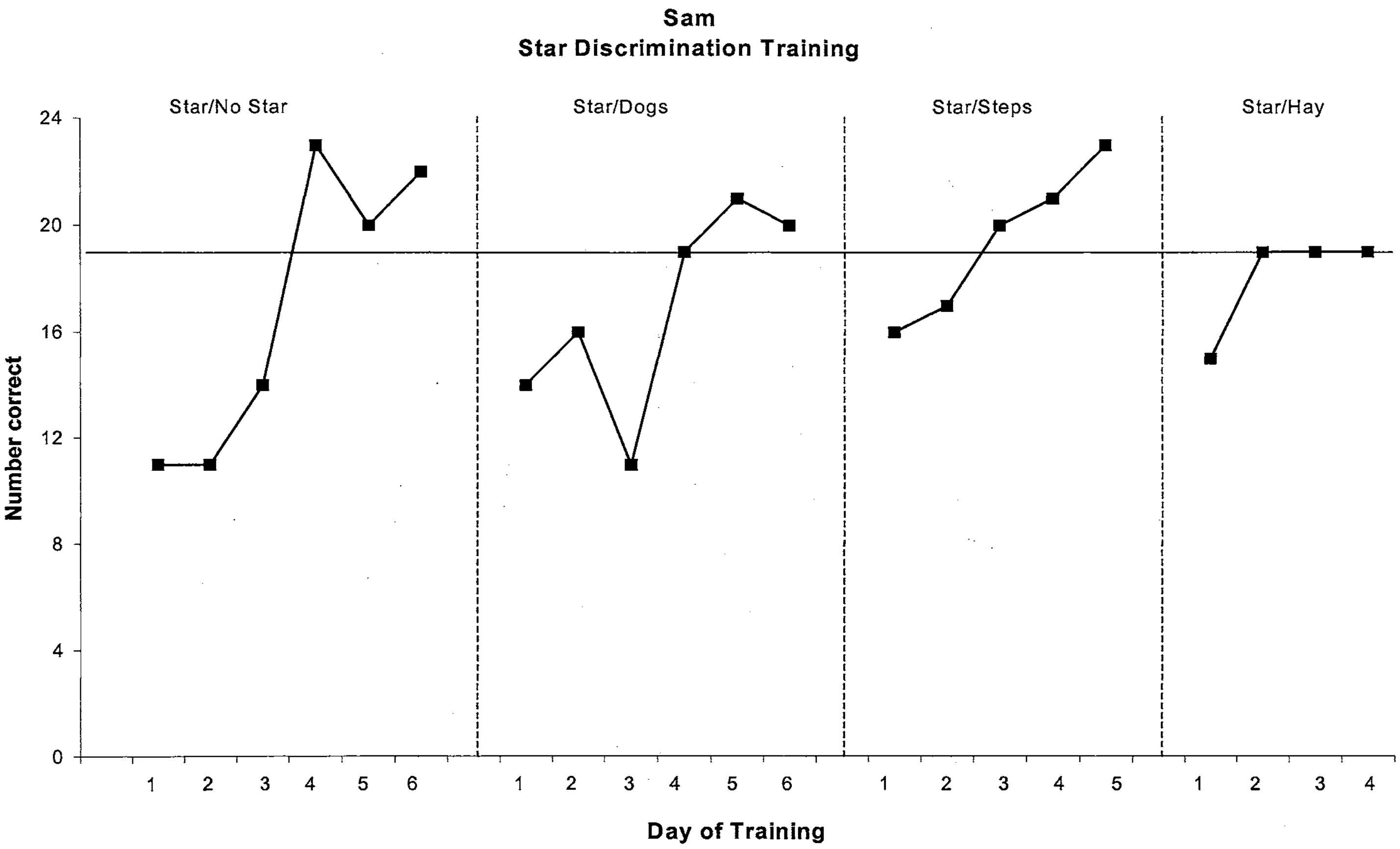


Figure 17. Discrimination training days for Star photographs for Sam.

Steppin Annie

Figure 18 presents the results of Steppin Annie's discrimination training for all of the Star photographic stimuli. Her responses, although more variable than the responses of Pearl, Peso, and Sam, supported the learning to learn phenomenon. Specifically, she exhibited more correct responses to each succeeding pair of photographs than to the previously presented photographic pairs. It must be noted that Steppin Annie had to be stimulated often during the intertrial intervals. If not, she tended to go to sleep or become very lethargic. This, most likely, was due to her age, 29 years, which is considered a senior horse.

Star/No Star. The majority of Steppin Annie's response errors occurred in the first 12 trials on Day one and Day two. Steppin Annie responded correctly on 19 of 24 trials on Day three, 21 of 24 trials Day four, and 19 of 24 trials on Day five. Having met criteria on the fifth day of training, Steppin Annie was moved to the next pair of photographs, the Star/Dogs.

Star/Dogs. Just as they had for all of the preceding horses, this pair of photographs appeared to be most difficult for Steppin Annie than the Star/No Star photographs. Specifically, it required eight days for her to meet criteria and move to the Star/Steps photographs. Steppin Annie did not meet criteria on Day one, 12 of 24 trials, on Day two, 14 of 24 trials, on Day three, 14 of 24 trials, on Day four, 13 of 24 trials, or on Day five, 13 of 24 trials. However, she showed a tremendous increase in correct responses beginning on Day six. That is, she met criteria by correctly responding on 21 of 24 trials, on Day six, 19 of 24 trials on Day seven, and 19 of 24 trials on Day eight.

Star/Steps. Steppin Annie responded correctly on the first three days of the Star/Steps discrimination training. She met criteria on Day one, 19 of 24 trials, on Day two, 19 of 24 trials, and on Day three, 21 of 24 trials.

Star/Hay. Steppin Annie did not respond as well as she had in Star/Steps during the Star/Hay discrimination training. She was very lethargic during the week and had to be constantly stimulated to stay alert and awake. She did not meet criteria on Day one, 17 of 24 trials, on Day two, 16 of 24 trials, on Day three, 14 of 24 trials, or on Day four, 16 of 24 trials. However, she responded correctly on 19 of 24 trials on Day five, Day six, and Day seven.

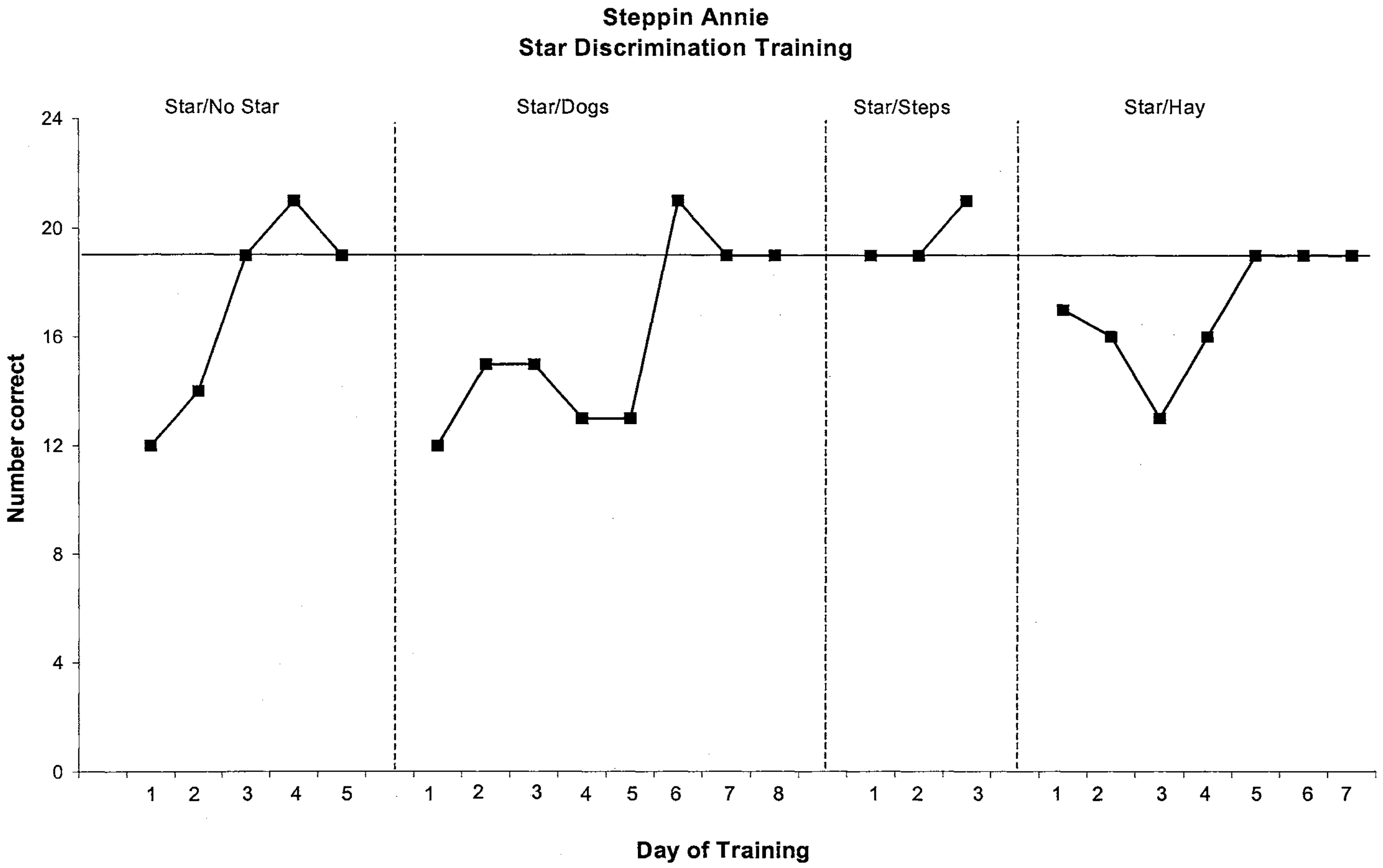


Figure 18. Discrimination training days for Star photographs for Steppin Annie.

Jimmie Anne

Figure 19 presents the results of Jimmie Anne's discrimination training for all of the Star photographic stimuli. Her responses showed the greatest variability of all of the adult horses. Likewise, although she met criteria on three of the photographic pairs, her responses tended not to support the learning to learn phenomenon.

The most significant difference between Jimmie Anne and the other adult horses was the fact that she had a nursing 5-week-old foal. At the beginning of training the foal was left in the arena but held at the opposite end. Jimmie Anne was very agitated during the first few days of training. It was not until the author visited the zoo to see a new baby dolphin did the reason behind Jimmie Anne's behavior become apparent. The dolphin trainers related that they allowed the baby to stay with the mother during the performance. By doing so, the mother appeared to perform the stunts without hesitation. However, separating the baby from the mother would have resulted in undue stress to the mother. After hearing this, Jimmie Anne's foal (Teddy) was allowed to stand next to the stimulus wall during her training trials. She did not exhibit any irritable behavior thereafter.

Star/No Star. Jimmie Anne did not meet criteria on Day one, 10 of 24 trials, Day two, 13 of 24 trials, or Day three 12 of 24 trials. She did meet criteria by correctly responding on 21 of 24 trials on Day four, 22 of 24 trials on Day five, and 23 of 24 trials on Day six. Having met criteria on the sixth day of training, Jimmie Anne was moved to the next pair of photographs, the Star/Dogs.

Star/Dogs. Just as they had for all of the preceding horses, this pair of photographs appeared to be most difficult for Jimmie Anne than the Star/No Star photographs. Specifically, after eight days she had only met criteria on Day seven. Additionally, she tended to only respond correctly when the S+ was on the left side. Because Teddy was standing on the left side of the stimulus wall, it was hypothesized this was affecting her performance so he was moved to the right side. However, she continued to respond to the left side so he was moved back for filming purposes.

Jimmie Anne did not meet criteria on Day one, 13 of 24 trials, on Day two, 14 of 24 trials, on Day three, 12 of 24 trials, on Day four, 14 of 24 trials, on Day five, 11 of 24 trials, on Day six, 12 of 24 trials, or Day eight, 13 of 24 trials. She did meet criteria by responding correctly on 19 of 24 trials on Day seven. However, she failed to meet criteria on the next day, Day eight.

Star/Steps. Jimmie Anne only responded correctly on 8 of 24 trials on Day one, 13 of 24 trials on Day two, and 15 of 24 trials on Day three. She successfully met criteria on Day four, 19 of 24 trials, Day five 21 of 24 trials, and Day six, 19 of 21 trials.

Star/Hay. Jimmie Anne appeared to have the least amount of trouble on the Star/Hay discrimination. It is unknown if the hay served any positive function in this since hay represents a food source to horses. In contrast to the preceding photographs, Jimme Anne responded correctly on 19 of 24 trials on the first three days of training.

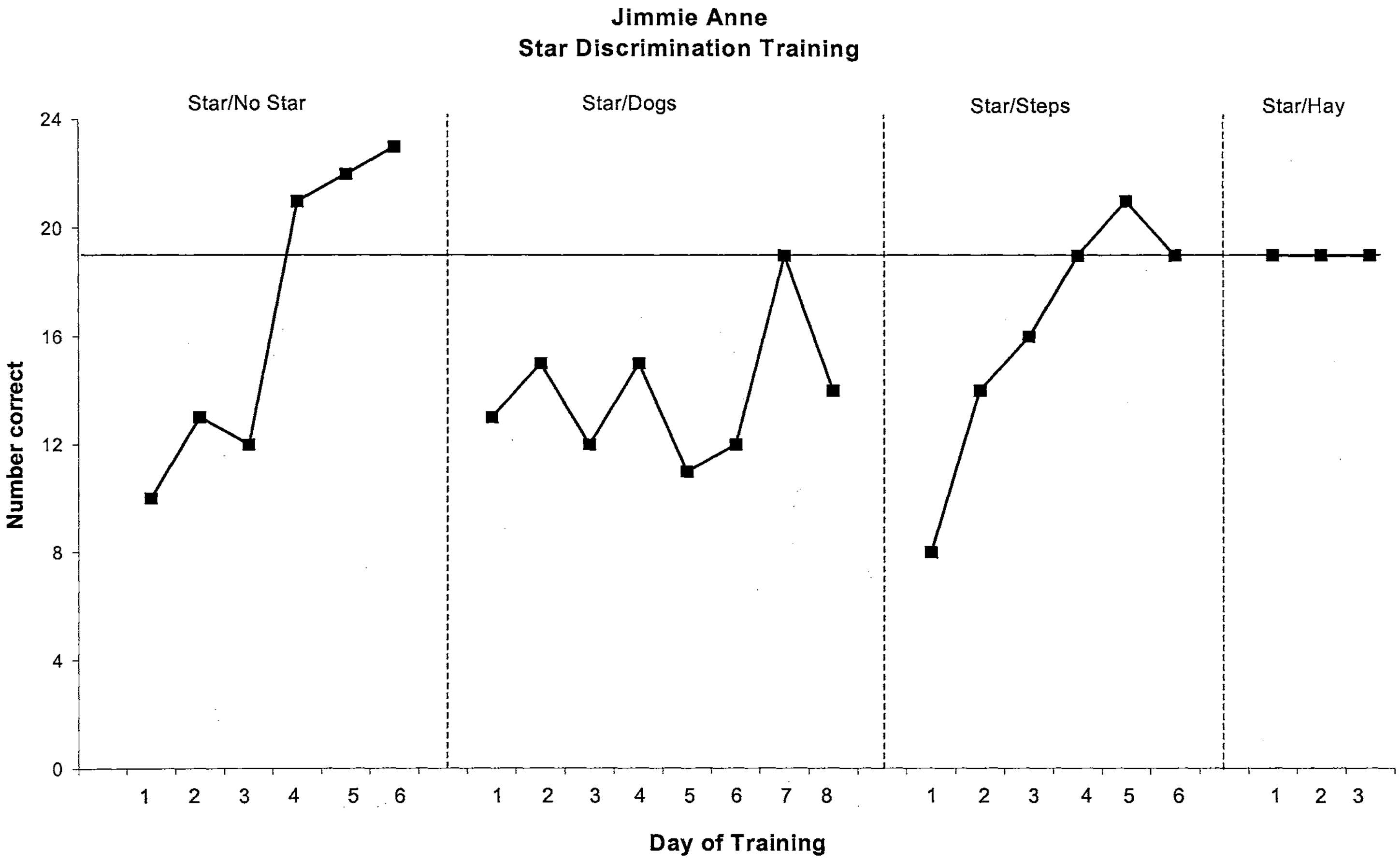


Figure 19. Discrimination training days for Star photographs for Jimmie Anne.

Peaches

Figure 20 presents the results of Peaches' discrimination training for the Star/No Star and Star/Steps photographic stimuli. Because of the difficulty the adult horses had with the Star/Dogs discrimination, this photographic pair was excluded from Peaches' training. Additionally, she dislocated her right rear pastern during the Star/No Star discrimination training and had to stop training for two weeks. When she returned she was trained on the Star/No Star and the Star/Steps only.

Yearlings have a difficult time attending to tasks for long periods of time (Heird et al., 1981; Heird et al., 1986) and tire more easily than adult horses (Roberts, 1997). Therefore, the number of trials for Peaches was reduced from 24, the number for the adult horses, to 16 trials. Additionally, the intertrial interval was shortened from 1-minute, as the adult horses, to 45 seconds. However, due to the difficulty she had in walking on her lame leg, her number of training trials was reduced from 16 to 12. The criteria, with 12 training trials, remained at 80% correct (9 of 12 trials) for three consecutive days. Although she met criteria on both pairs of photographic stimuli, her responses tended not to support the learning to learn phenomenon. That is, she did not exhibit an increase in correct responses from day to day within each pair of photographic stimuli pair or between each pair of photographic stimuli. It is unknown if this was due to her young age or her lameness.

Star/No Star. Peaches had only completed the stimulus-training portion of the study when she was hurt. Therefore, when she returned to the study, she was started at the beginning. Peaches did not meet criteria on Day one, 8 of 12 trials, on Day two, 7 of 12 trials, on Day three, 7 of 12 trials, or on Day four, 7 of 12 trials. Peaches correctly responded to 12 of the 12 trials on Day five, 11 of 12 trials on Day six, and 12 of 12 trials on Day seven. Having met criteria on the seventh day of training, Peaches was moved to the next pair of photographs, Star/Steps.

Star/Steps. Peaches did not meet criteria on Day one, 8 of 12 trials, on Day two, 3 of 12 trials, or on Day three, 5 of 12 trials. It is unknown if her lameness contributed to her low rate of correct responses. However, she met criteria by responding correctly to 9 of 12 trials on Day four, Day five, and Day six.

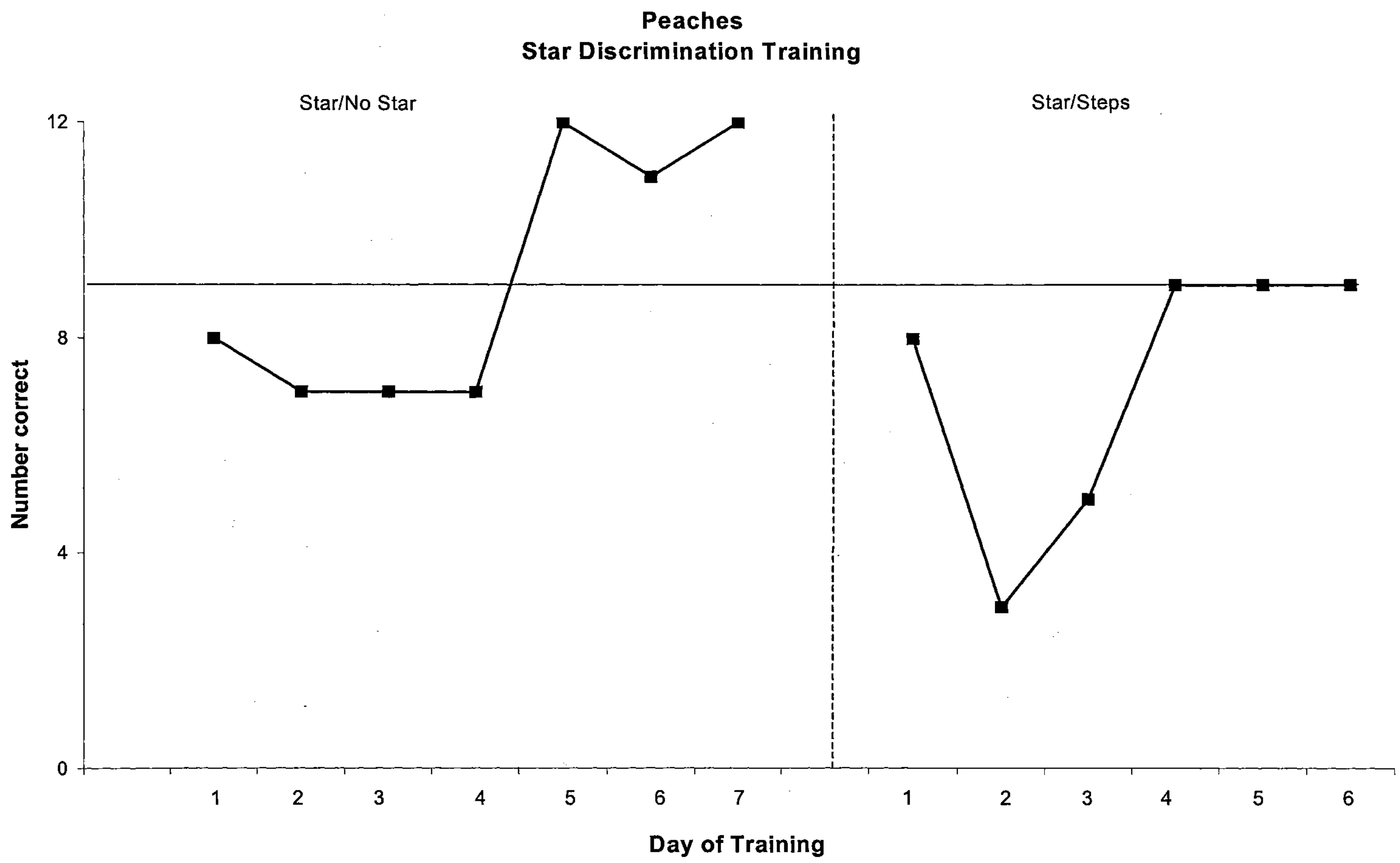


Figure 20. Discrimination training days for Star photographs for Peaches.

Teddy

Figure 21 presents the results of Teddy's discrimination training for the Star/No Star photographic stimuli. Foals have even more of a difficult time attending to tasks for long periods of time than yearlings (Heird et al., 1981; Heird et al., 1986). Also, they tire sooner than yearlings and take frequent rests (Roberts, 1997). Therefore, the number of trials for Teddy was reduced from 24, the number for the adult horses, to 12 trials. Additionally, the intertrial interval was shortened from 1-minute to 30 seconds. The criteria, with 12 training trials, remained at 80% correct (9 of 12 trials) for three consecutive days.

Star/No Star. Teddy did not meet criteria on the Star/No Star discrimination training photograph. He never showed any indication of learning. For instance, his responses were more chance than attempts to gain the reinforcer. Also, he tended to go directly to the feed bowl without attempting to make a response.

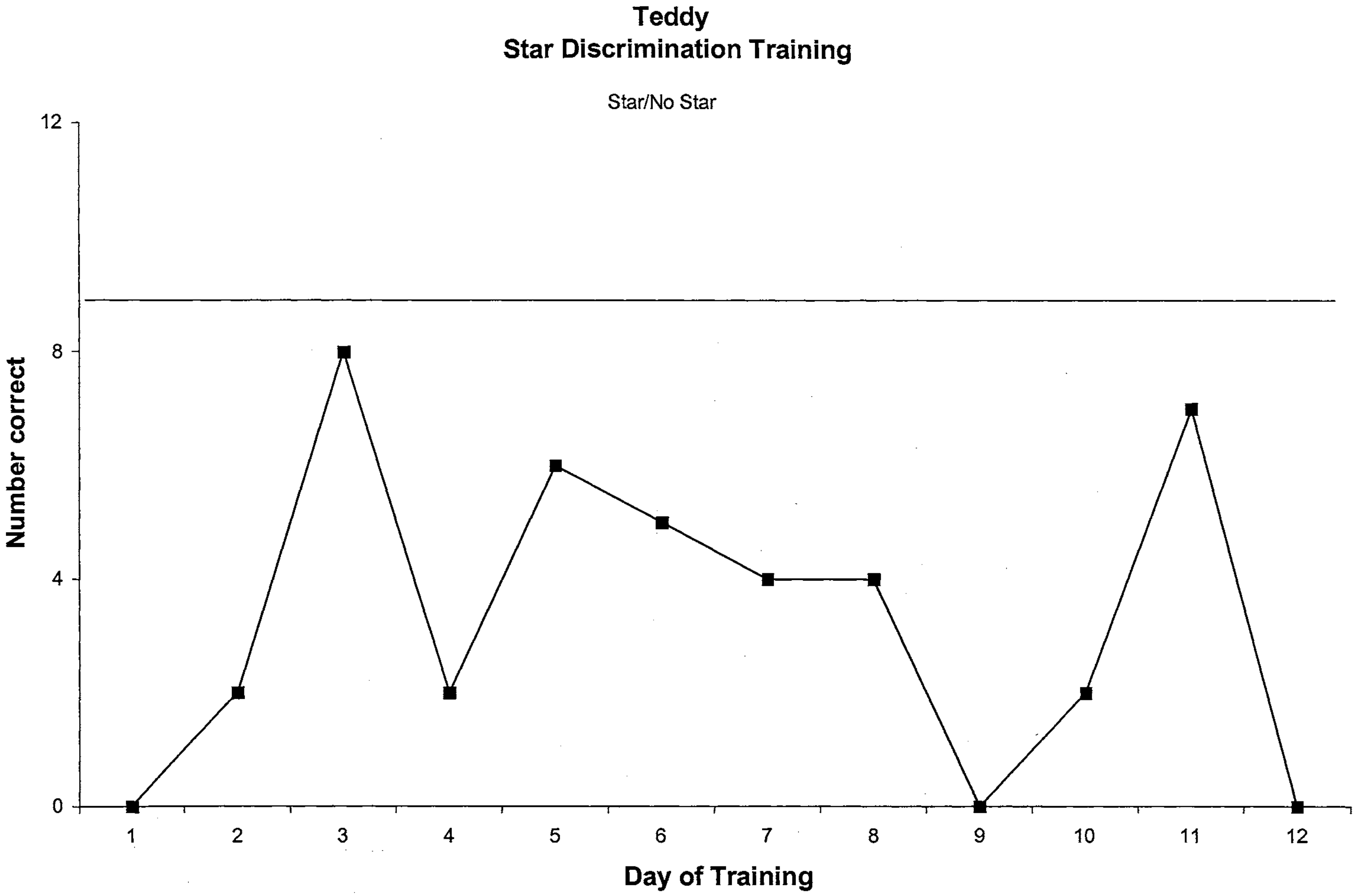


Figure 21. Discrimination training days for Star photographs for Teddy.

Overall Star statistics

In comparison to the other photographs, the Star/Dogs appeared to several human observers to be quite complex. Not only did it contain the star but it also contained three dogs, a chain link fence, and numerous shadows. It is unknown if the horses would have done better on this photograph, according to the learning to learn phenomenon, if it had been presented later in the experiment.

The Star/Hay photograph was presented last in the series. Because hay is a major food source for horses, it was hypothesized that the horses would respond to it rather than the star. It is unknown if this was the case because the horses responded similarly to it as they did the previously presented Star/No Star and Star/Steps photographs. Table 7 presents the statistical analyses of the Star photographic stimuli.

Table 7

Photograph	Number of horses trained	Number of horses meeting criteria	Mean number of days to criteria	SD
Star/No Star	7	6	5.3	.98
Star/Dogs	5	4	6.1	1.10
Star/Steps	6	6	4.2	1.38
Star/Hay	5	5	4.3	1.81

Note. Data from horses who did not meet criteria were not included in the statistical analysis for that photograph.

Ahna discrimination photographs

The criteria for all photographs was 80% correct or 19 of 24 trials correct for the adult horses and 9 of 12 trials correct for Peaches and Teddy for three consecutive days. Because all of the horses appeared to have a difficult time learning the Star/Dogs photograph, the corresponding Ahna/Geese photograph was eliminated. This photograph contained three geese, numerous trees, a sidewalk, and various shadows. Human observers suggested that it would be just as complex as the Star/Dogs photograph. Therefore, the Ahna discrimination training consisted of three rather than four photographs.

Peaches and Teddy were trained on the Ahna/Bench photograph only. This was due to the close facial view of Ahna sitting on the bench versus the farther distance and less facial view of Ahna in the Ahna/No Ahna and Ahna/Hay photographs. Additionally, Sam's training was interrupted during the Ahna/No Ahna photograph due to an unexpected surgery. Because he had not met criteria before he left, when he returned he resumed training on the Ahna/No Ahna photographs.

Ahna stimulus training. The presence of Ahna served as the S+ for all of the Ahna photographic stimuli. The first and second day of the Ahna stimulus training consisted of leading each horse to the S+ on Trials 1-12. This was done to train the horse to the correct stimulus, that is, the stimulus that led to reinforcement. No response data were recorded for these two days. Beginning on Day three the horse's response data were videotaped, recorded into SPSS, analyzed, and subsequently graphed. The photographs were presently in the same order to all of the horses. Specifically, the order of presentation was: (a) Ahna/No Ahna, (b) Ahna/Bench, and (c) Ahna/Hay. Additionally, each horse was required to meet criteria on each pair of photographic stimuli before they were moved to the next pair of photographs.

Finally, the ABBA BAAB presentation schedule was alternated between each pair of photographs in an effort to control for position bias. That is, the Ahna/No Ahna was presented BAAB ABBA, the Ahna/Bench was presented ABBA BAAB, and the Ahna/Hay was presented BAAB ABBA. As with the Star photographic stimuli, each horse maintained their position bias; Pearl exhibited a right bias, Peso exhibited a left bias, Sam exhibited a left bias, Steppin Annie exhibited a right bias, Jimmie Anne exhibited a left bias, Peaches exhibited a right bias, and Teddy exhibited a right bias.

Pearl

Figure 22 presents the results of Pearl's discrimination training for all of the Ahna photographic stimuli. Pearl's responses supported the learning to learn phenomenon.

Ahna/No Ahna. Pearl did not meet criteria on only one day, Day one, 13 of 24 trials correct. Pearl correctly responded to 19 of the 24 trials on Day two, 19 of 24 trials on Day three, and 21 of 24 trials on Day four. Having met criteria on the fourth day of training, Pearl was moved to the next pair of photographs, the Ahna/Bench.

Ahna/Bench. Pearl correctly met criteria on the first three days of the Ahna/Bench discrimination training. She responded correctly on 21 of 24 trials on Day one, 20 of 24 trials on Day two, and 20 of 24 trials on Day three.

Ahna/Hay. Just as she exhibited in the previous pair of photographs, the Ahna/Bench, Pearl correctly met criteria on the first three days of the Ahna/Hay discrimination training. She responded correctly on 20 of 24 trials on Day one and 23 of 24 trials on Day two and Day three.

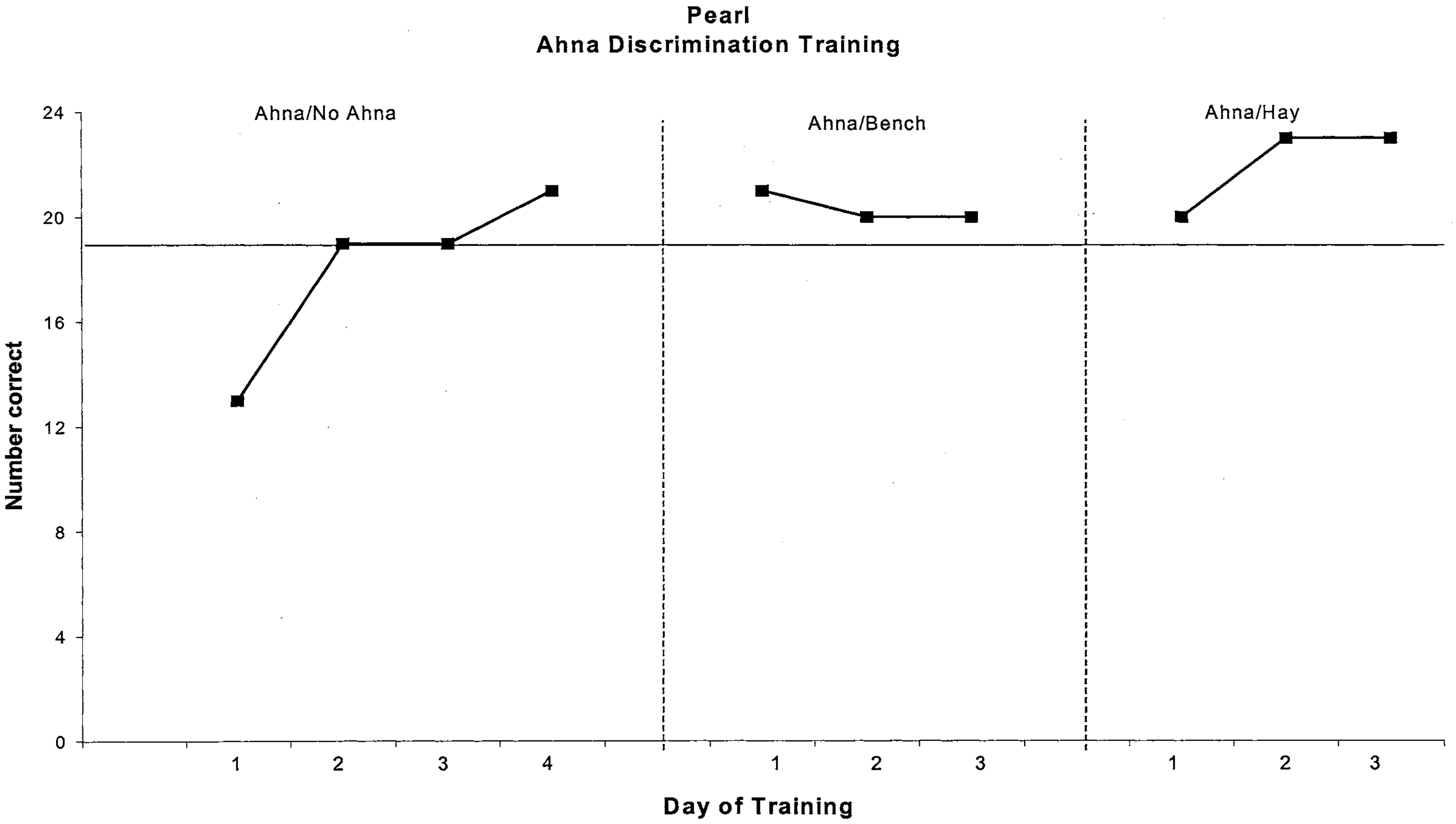


Figure 22. Discrimination training days for Ahna photographs for Pearl.

Peso

Figure 23 presents the results of Peso's discrimination training for all of the Ahna photographic stimuli. Peso's responses supported the learning to learn phenomenon.

Ahna/No Ahna. Peso met criteria on the first three days of the Ahna/No Ahna training. He correctly responded to 19 of the 24 trials on Day one, 21 of 24 trials on Day two, and 19 of 24 trials on Day three. Having met criteria on the third day of training, Peso was moved to the next pair of photographs, the Ahna/Bench.

Ahna/Bench. Peso correctly met criteria on the first three days of the Ahna/Bench discrimination training. He responded correctly on 19 of 24 trials on Day one, 21 of 24 trials on Day two, and 23 of 24 trials on Day three.

Ahna/Hay. Just as he exhibited in the previous pairs of photographs, the Ahna/No Ahna and the Ahna/Bench, Peso correctly met criteria on the first three days of the Ahna/Hay discrimination training. He responded correctly on 21 of 24 trials on Day one, 22 of 24 trials on Day two, and 24 of 24 trials on Day three.

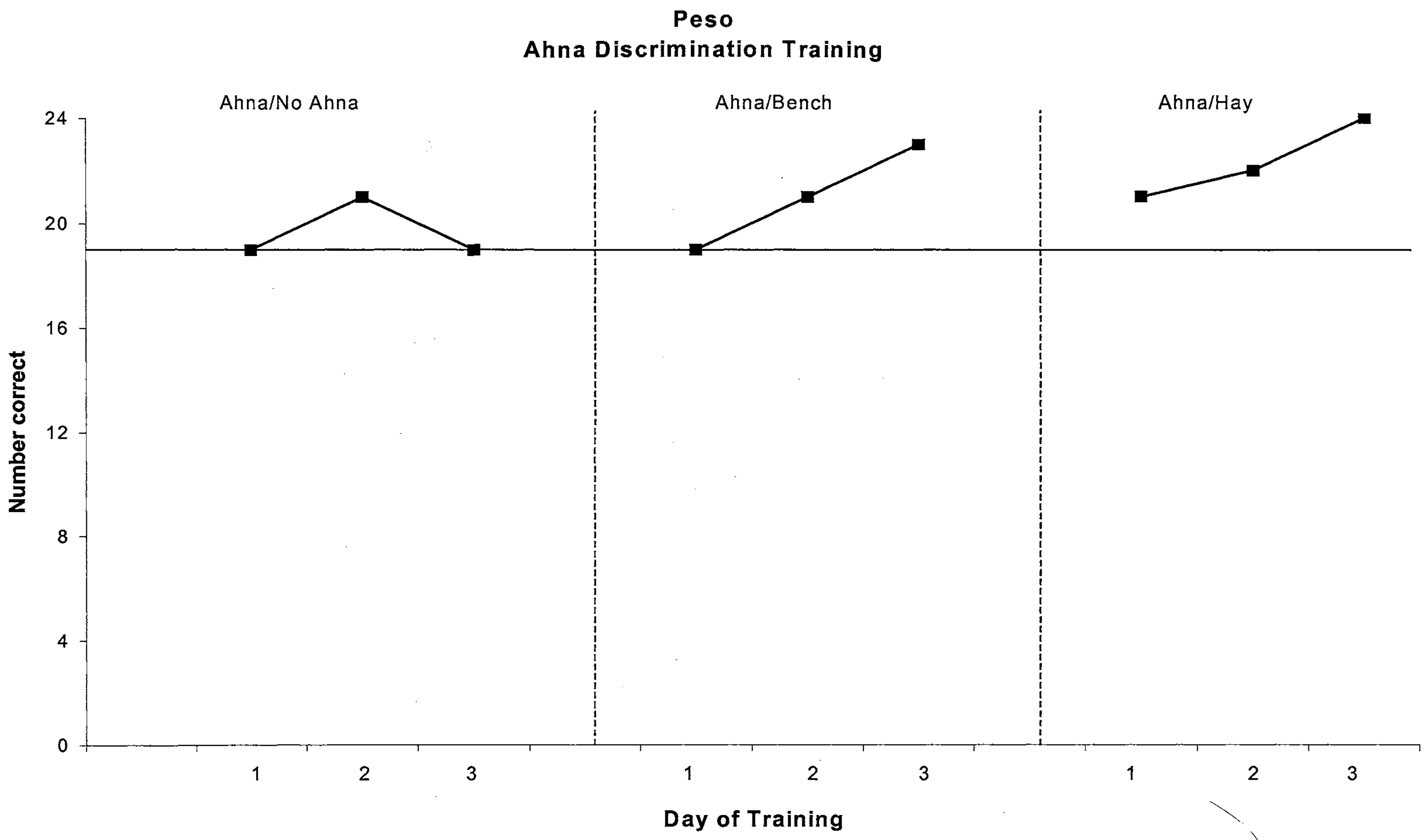


Figure 23. Discrimination training days for Ahna photographs for Peso.

Sam

Figure 24 presents the results of Sam's discrimination training for all of the Ahna photographic stimuli. Sam's responses supported the learning to learn phenomenon.

Ahna/No Ahna. Sam did not meet criteria on Day one, 14 of 24 trials correct, Day two, 14 of 24 trials correct, and Day three, 14 of 24 trials correct. It must be noted that he had unexpected surgery after Day three. When he returned he resumed training at the same point, that is, Day four. Sam correctly responded to 19 of the 24 trials on Day four, 21 of 24 trials on Day five, and 19 of 24 trials on Day six. It is unknown if he did well because he felt better or if the week off positively affected his memory. However, having met criteria on the Ahna/No Ahna stimuli, Sam was moved to the next pair of photographs, the Ahna/Bench.

Ahna/Bench. Sam correctly met criteria on the first three days of the Ahna/Bench discrimination training. He responded correctly on 22 of 24 trials on Day one, 22 of 24 trials on Day two, and 22 of 24 trials on Day three.

Ahna/Hay. Just as he exhibited in the previous pair of photographs, the Ahna/Bench, Sam correctly met criteria on the first three days of the Ahna/Hay discrimination training. He responded correctly on 22 of 24 trials on Day one and 23 of 24 trials on Day two and Day three.

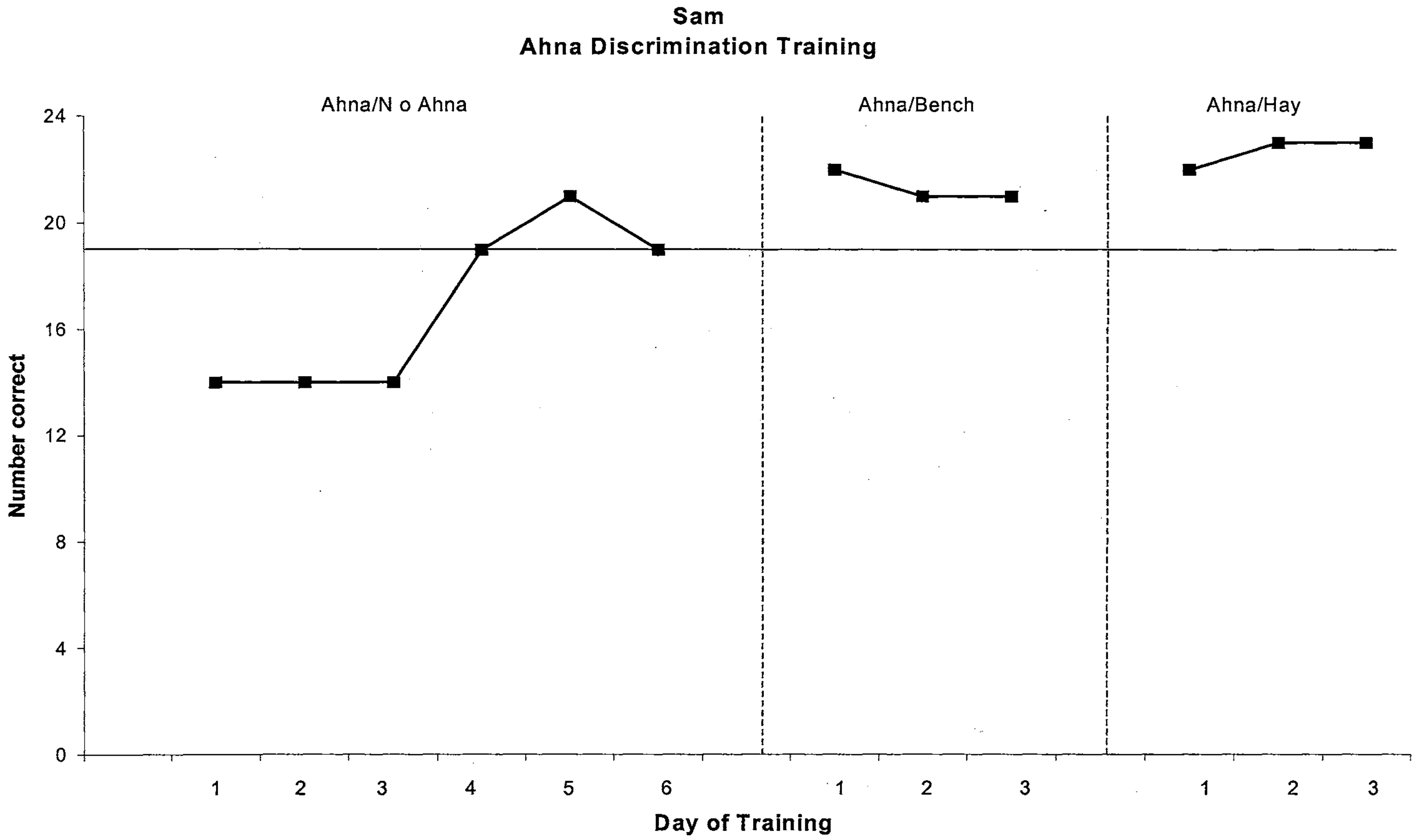


Figure 24. Discrimination training days for Ahna photographs for Sam.

Steppin Annie

Figure 25 presents the results of Steppin Annie's discrimination training for all of the Ahna photographic stimuli. Her responses on Day one did not support the learning to learn phenomenon but they did on Day two and Day three.

Ahna/No Ahna. Steppin Annie, as mentioned previously in the Star discrimination training, had to be constantly stimulated during the Ahna/No Ahna training trials. If not, she fell asleep and was very lethargic. Her lack of responsiveness was exhibited through incorrect responses. She only met criteria on one day, Day three, 19 of 24 correct responses. She exhibited fewer correct responses on each succeeding day of the Ahna/No Ahna training. Specifically, she only responded to 17 of 24 trials on Day one, 16 of 24 trials on Day two, 13 of 24 trials on Day four, 12 of 24 trials on Day five, 11 of 24 trials on Day six, 12 of 24 trials on Day seven, and 10 of 24 trials on Day eight. Although Steppin Annie did not meet criteria for three consecutive days she was moved to the Ahna/Bench photographs in an attempt to improve her responses.

Ahna/Bench. Steppin Annie began the Ahna/Bench training at the level she left the Ahna/No Ahna training, at 12 of 24 trials correct. However, she showed an improvement on the remaining training days. She did not meet criteria on Day two, 16 of 24 trials correct, but she met criteria by responding correctly on 19 of 24 trials on Day three, Day four, and Day five. Therefore, she was moved to the Ahna/Hay stimuli.

Ahna/Hay. Steppin Annie did not meet criteria on Day one, 18 of 24 trials correct, but she met criteria on Day two, Day three, and Day four by responding correctly to 19 of 24 trials each day.

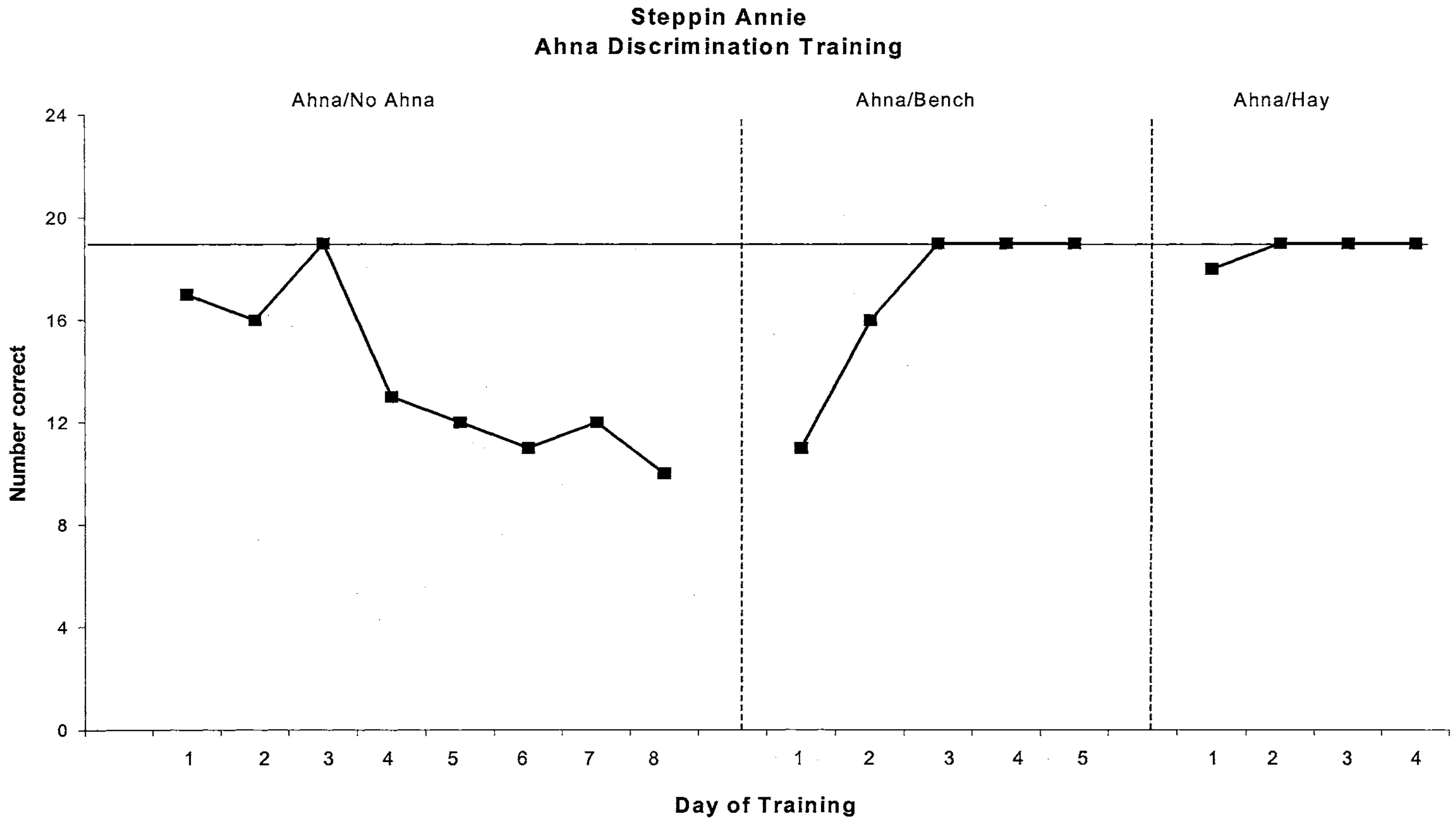


Figure 25. Discrimination training days for Ahna photographs for Steppin Annie.

Jimmie Anne

Figure 26 presents the results of Jimmie Anne's discrimination training for all of the Ahna photographic stimuli. Her responses showed the lowest rate of correct responses of all of the adult horses. This was expected due to her responses on the Star discrimination training. As previously mentioned, Jimmie Anne was nursing a 5-week-old foal and this may have impacted her learning ability. As before, Teddy, her foal, was allowed to stand next to the stimulus wall during her training trials.

Ahna/No Ahna. Jimmie Anne did not meet criteria on any of the Ahna/No Ahna discrimination training. After eight days, she was moved to the next pair of photographic stimuli. Jimmie Anne's correct responses were 18 of 24 trials on Day one, 10 of 24 trials, Day two, 13 of 24 trials, 15 of 24 trials on Days four, five, and six, 14 of 24 trials on Day seven, and 12 of 24 trials on Day eight.

Ahna/Bench. After eight days of training, Jimmie Anne never met criteria. Her correct responses were 16 of 24 trials on Day one and two, 13 of 24 trials on Day three, 16 of 24 trials on Day four, 18 of 24 trials on Days five, six, and seven, and 16 of 24 trials on Day eight.

Ahna/Hay. Jimmie Anne exhibited less variability on the Ahna/Hay photographs but, again, failed to meet criteria. She responded correctly on 17 of 24 trials on Day one, 18 of 24 trials on Days two, three, four, five, and six, and 17 of 24 trials on Day seven and eight. Her training was therefore halted.

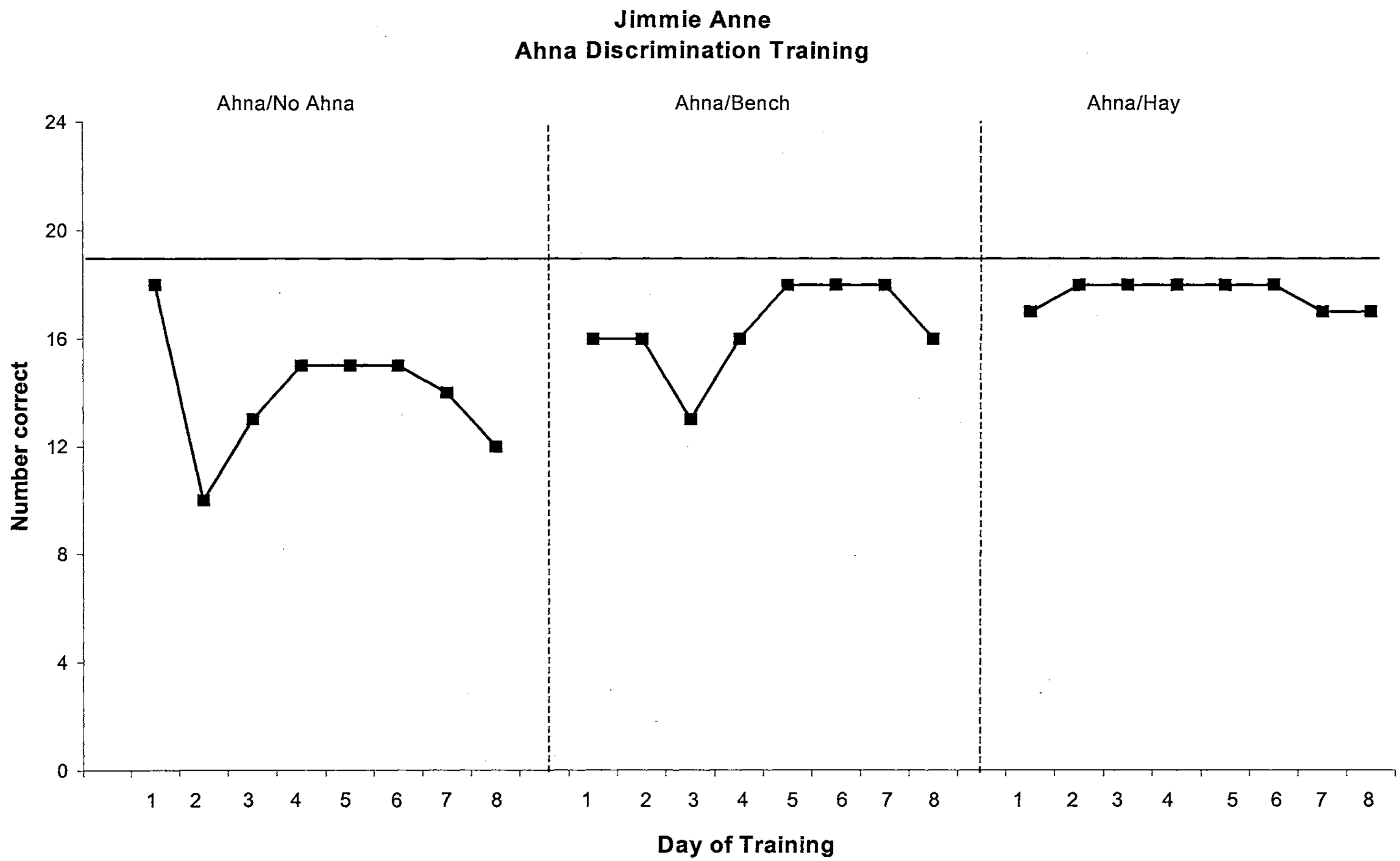


Figure 26. Discrimination training days for Ahna photographs for Jimmie Anne.

Peaches

Figure 27 presents the results of Peaches' discrimination training for the Ahna/Bench photographic stimuli. Due to her young age, she was only trained on the Ahna/Bench photographs because they had a closer view of Ahna's face than the other photographs.

Ahna/Bench. Peaches did not meet criteria on Days one and two, 7 of 12 trials correct, Day three, 5 of 12 trials correct, or Day four, 8 of 12 trials correct. Peaches correctly responded to 9 of the 12 trials on Days five, six, and seven.

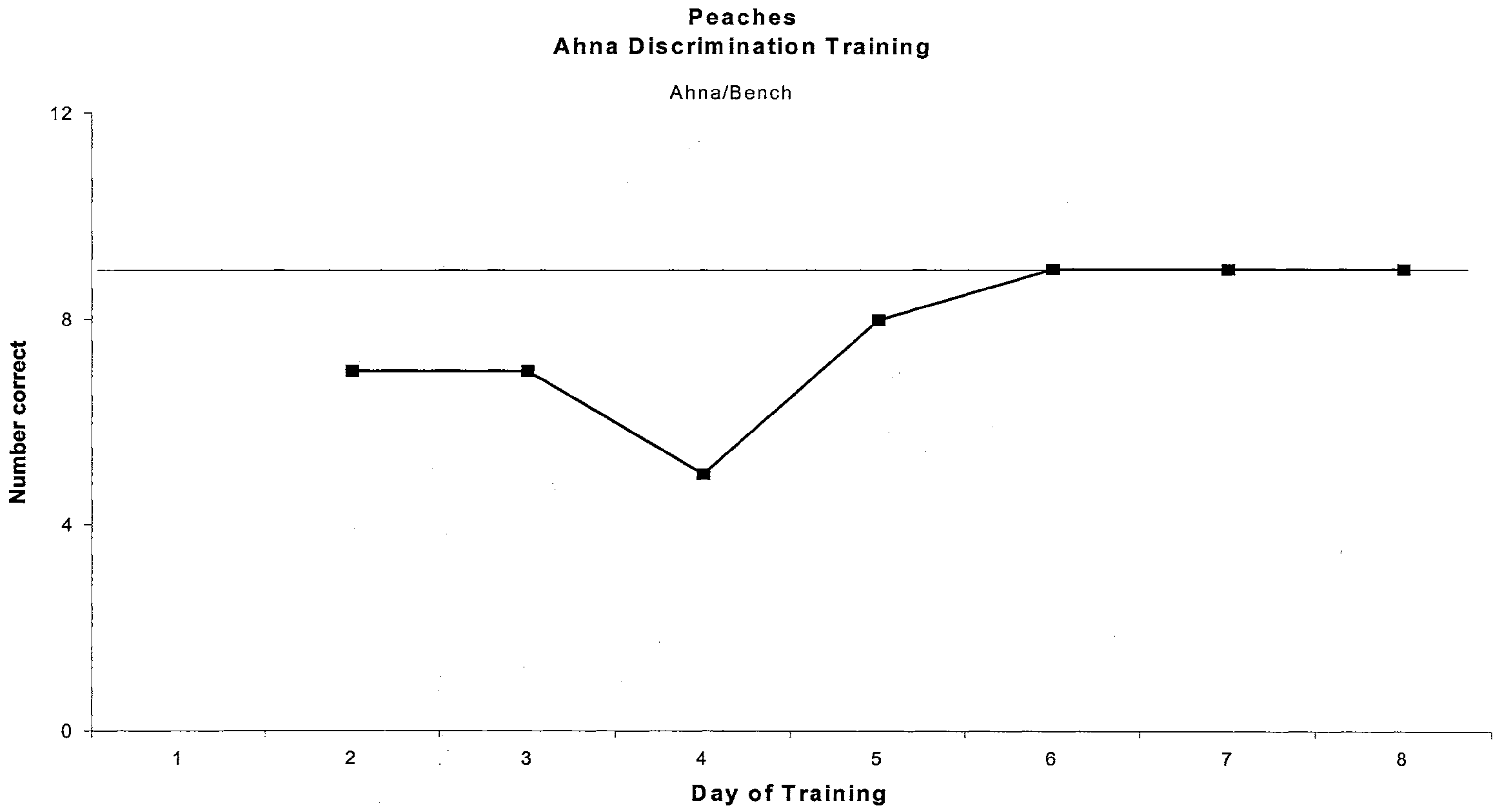


Figure 27. Discrimination training days for Ahna photographs for Peaches.

Teddy

Ahna/Bench. Just as he failed to meet criteria in the Star photographs, Teddy also failed to meet criteria for three consecutive days in the Ahna photographs. He met criteria on Day five of training, however, this may have been chance responding because he never met criteria over the next seven days of training. His results are present in Figure 28. He responded correctly to 5 of 12 trials on Day one, 7 of 12 trials on Day two, 5 of 12 trials on Day three, 5 of 12 trials on Day four, 9 of 12 trials on Day five, 5 of 12 trials on Day six, 4 of 12 trials on Days seven and eight, 5 of 12 trials on Day nine, 6 of 12 trials on Days 10 and 11, and 5 of 12 trials on Day 12.

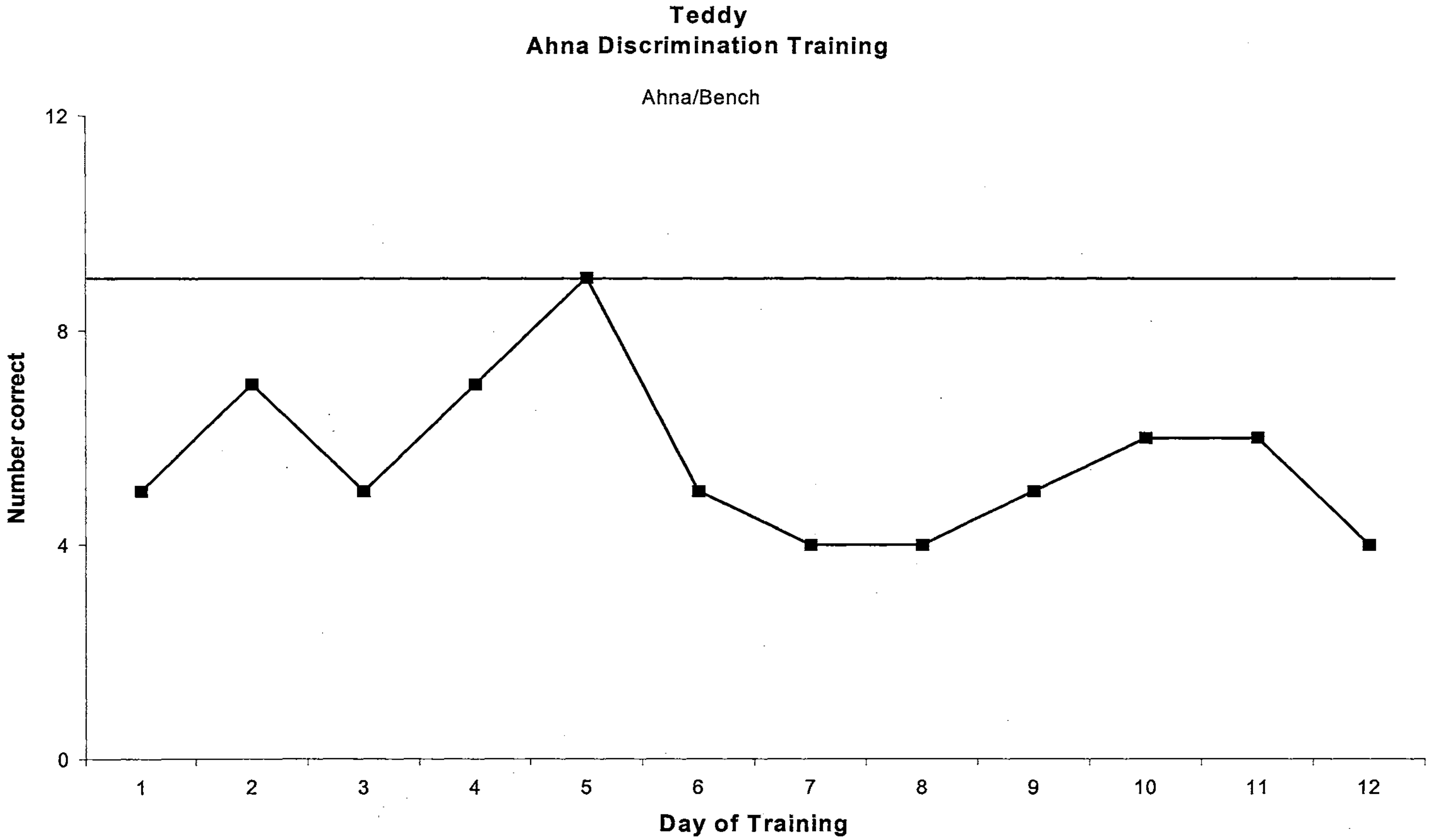


Figure 28. Discrimination training days for Ahna photographs for Teddy.

Overall Ahna statistics

The Ahna/Hay photograph was presented last in the series. Because hay is a major food source for horses, it was hypothesized that the horses would respond to it rather than to Ahna. It is unknown if this was the case because the horses responded similarly to it as they did the previously presented Ahna/No Ahna and Ahna/Bench photographs. Table 8 presents the statistical analyses of the Ahna photographic stimuli.

Table 8

Photograph	Number of horses trained	Number of horses meeting criteria	Mean number of days to criteria	SD
Ahna/No Ahna	5	3	4.1	2.20
Ahna/Bench	7	5	4.0	1.34
Ahna/Hay	4	3	3.0	0.00

Note. Data from horses who did not meet criteria were not included in the statistical analysis for that photograph.

Discrimination Training Behaviors

During the discrimination training phase of the experiment all of the horses were observed to exhibit similar behaviors when approaching the stimulus wall. These behaviors were displayed regardless of gender or age. Four prominent behaviors were identified and coded along with the response to the S+ and S- (Table 9). Specifically, if the horse proceeded directly from the cones to the stimulus and pushed on either S+ or S- door they were coded as a D for direct. The letter V for veer was coded if, after leaving the cones, the horse veered left or right prior to reaching the stimulus wall to push on a door. Similar to the V behavior was the V-L behavior. This was defined as the horse leaving the cones, approaching the stimulus wall, stopping at either the S+ or S- door, then veering to the other door without first pushing on the door she/he was standing in front of.

The most interesting and curious behavior was the one that suggested the horses were using some type of cognitive strategy to determine which door to push. This behavior was defined as contemplate and coded as a C. This behavior was identified when the horse proceeded from the cones and walked to either the S+ or the S- door. Once at the stimulus wall the horse would look at the other door, either S+ or S-, look back at the door she/he was standing at, and either push the door standing at or look back and forth again then push a door. This behavior always resulted in the horse making the correct response; that is, choosing the S+ over the S-.

Table 9

Code	Behavior
D	Horse proceeded directly from the cones to the stimulus and pushed on either S+ or S- door
V	Horse, after leaving the cones, veered left or right prior to reaching the stimulus wall to push on a door
V-L	Horse left the cones, approached the stimulus wall, stopped at either the S+ or S- door, then veered to the other door without first pushing on the door she/he was standing in front of
C	Horse proceeded from the cones to either the S+ or the S- door. Once at the stimulus wall the horse looked at the other door, either S+ or S-, looked back at the door she/he was standing at, and either pushed the door standing at or looked back and forth again then pushed a door. This behavior always resulted in the horse making the correct response

Note. The four types of behaviors exhibited during the discrimination training trials.

Field Tests

Geometric Stimuli Field Tests

Research has not been conducted to establish the transfer of discrimination training to an actual real world situation by horses. Therefore, a field test of both discriminative stimuli was conducted to determine if the horses formed a concept of the Star. Additionally, a control horse, Pye, was also used in this phase of the study. Pye was observed in the Star and Cross field test. Because he had not been included in the discriminative phase of the study, his performance in the field test was expected to add support to the concept formation hypothesis. For instance, Pye was expected to initially inspect all of the stimuli at the onset of the field test then ignore them for the remainder of the time. If this occurred as anticipated, his behavior would provide support to any discriminative behavior that the other horses showed to the S+ stimuli. Furthermore, if Pye demonstrated non-discriminatory behavior towards the stimuli, his behavior would suggest that the other horses, if they showed discriminatory behavior towards the S+ stimuli, had formed a *Star* concept.

Star and Cross Field Test

The horses appeared to display two types of time behaviors while in each of the stimuli sectors. For instance, while in the Star sector the horses either stood within touching distance of the Star or they remained in the sector out of reach of the star. Therefore, two separate times were recorded for each horse: (a) Time In each sector and (b) time Stand By each stimuli. Additionally, the horses exhibited two overt behaviors during this field test: (a) Look At stimulus, and (b) Sniff/Nuzzle stimulus.

Table 10 presents the criteria for the field test variables and coding definitions. All variables except the Time In sector were mutually exclusive. For instance, the Time In variable was recorded throughout the field test. In contrast, the other timed variable, Stand By, was only recorded when the horse was standing close enough to the stimuli that it could physically touch it. However, the moment when the horse initiated contact with the stimulus, the Stand By time recording ceased and frequency counts of the specific behavior was recorded. This was done due to the explicit nature of the variables. Horses are social animals and will remain in reachable presence of any number of stimuli in the environment. However, once a horse interacts with a stimulus by touching it, it has gone from a passive participant to an active participant of its environment.

Table 10

Field Variable	**Type of Variable**	**Coding Definition**	**Inclusive or Exclusive of other Variables**
Time In	Timed	Horse stood within the sector boundaries but out of reach of the stimulus	Inclusive
Stand By	Timed	Horse stood close enough to stimulus to touch it	Exclusive
Look At	Frequency	Horse looked at a stimulus without physically interacting with it a) in the same sector as the stimulus and turned its head to look at the stimulus b) in a different sector and turned to look at the stimulus	Exclusive
Sniff/Nuzzle	Frequency	Horse physically interacted with the stimulus a) sniffed b) nuzzled	Exclusive

Note. Inclusive indicates that one of the other variables may have been recorded at the same time. Exclusive indicates that no other variable other than Time In was recorded at the same time.

Group statistics. Both sets of nursing mothers and offspring were tested together. That is, Pearl was tested with Peaches and Jimmie Anne was tested with Teddy. Although Pearl was a nursemaid for Peaches and not the biological mother, this did not make a difference in either of the horses' behavior. Both younger horses, Peaches and Teddy refused to leave the mares for the Star and Cross field test. Likewise, when the experimenter attempted to remove the younger horses from the mares, the mares became agitated, broke free from the experimenter, and ran to their foal.

Figure 28 presents the Time In each sector for all of the horses while Figure 29 presents the Stand By time for each of the horses. Figure 30 depicts the number of times each horse Looked At the Star and Cross stimuli while Figure 31 presents the graph for Sniff/Nuzzle behaviors towards them. Finally, Table 11 presents the descriptive statistics for the Star and Cross field test.

Table 11

Sector	Behavior	N	Total Frequency /Seconds	Mean	SD
Star	Look At	7	44	6.29	5.02
	Sniff/Nuzzle	7	31	4.43	4.47
	Stand By	7	1792secs	256.00	221.73
	Time In sec	7	4070secs	581.43	343.00
Cross	Look At	7	14	2.00	2.08
	Sniff/Nuzzle	7	10	1.43	1.81
	Stand By	7	412secs	58.86	68.34
	Time In	7	2009secs	287.00	244.55
Empty	Time In	7	5601secs	800.14	218.33

Note. Number = total number of occurrences for all the horses, Seconds = total number of seconds for all the horses. Pye's data were excluded from analyses.

Individual statistics. Table 12 presents the Star and Cross field test statistics for the timed variables for each of the horses. The amount of time in each sector was also analyzed as a function of time for the entire field test. These statistics are presented as percentages of time. Table 13 presents the frequency variables for each of the horses. The frequency variables were only analyzed as a total number of occurrences rather than a function of time.

Table 12

Horse	Time In						Stand By			
	*		›		E		*		›	
	Secs	%	Secs	%	Secs	%	Secs	%	Secs	%
Pearl	490	27	613	34	717	39	157	37	176	28
Peaches	464	25	0	0	1082	75	393	85	0	0
Peso	543	39	163	12	698	50	224	32	128	31
Sam	1090	69	88	5	407	26	696	64	39	9
Steppin Annie	993	51	139	7	834	42	48	4	12	8
Jimmie Anne	127	8	503	32	944	60	127	100	57	11
Teddy	363	23	503	32	919	58	147	40	0	0
Pye	559	32	601	35	570	33	0	0	0	0

Note. Pearl and Peaches were tested together. Jimmie Anne and Teddy were tested together. * = Star, › = Cross, E = empty sector. No Stand By data could be recorded for the Empty sector because a stimulus was required. Secs = total number of sectors, % = percentage of time. Pye was the control horse.

Table 13

Horse	Look At		Sniff/Nuzzle	
	✻	›	✻	›
Pearl	3	0	2	0
Peaches	0	0	0	0
Peso	11	4	11	4
Sam	5	0	5	0
Steppin Annie	10	3	10	3
Jimmie Anne	13	5	4	3
Teddy	2	2	0	0
Pye	0	0	3	2

Note. Pearl and Peaches were tested together. Jimmie Anne and Teddy were tested together. ✻ = Star, › = Cross, E = empty sector. No behavioral data could be recorded for the Empty sector because a stimulus was required. Pye was the control horse.

Pearl and Peaches. At no time did Peaches approach or enter into the Cross sector. Also, Pearl stayed in a sector not being occupied by Peaches. For instance, when Peaches was in the Empty sector, Pearl was in the Star or Cross sector. Likewise, when Peaches went to the Star sector, Pearl went to the Empty sector. It is unknown if this was a strategy used by them to consciously refrain from occupying the same space. This deserves further testing.

Peso. Peso was the most interactive and aggressive with the Star and Cross out of all the horses. He knocked the Star stimulus over twice but never knocked the Cross over.

Sam. Sam only crossed into the Cross sector while he circled the round pen.

Steppin Annie. Steppin Annie slept most of the time she was in the Empty sector.

Jimmie Annie and Teddy. Jimmie Anne followed Teddy for most of the field test. She seemed to let him make the movements but she stayed by his side. Additionally, 15 minutes into the field test Teddy laid down in the Empty sector and Jimmie Anne stood over him, facing away from the Star and Cross.

Pye (control horse). Pye provided the most support for the conceptualization hypothesis during the field test. Pye had not participated in either of the discrimination training stages and, therefore, had no prior experience with the stimuli. As hypothesized, Pye spent almost equal amount of time in each of the three sectors. Additionally, while in the S+ and S- sectors, he did not stand in close proximity to either of them. After his initial inspection of the stimuli, he never again approached near enough to touch them. Both of his interactions occurred within the first 10 seconds of entering the sector. He did not interact with either stimulus thereafter.

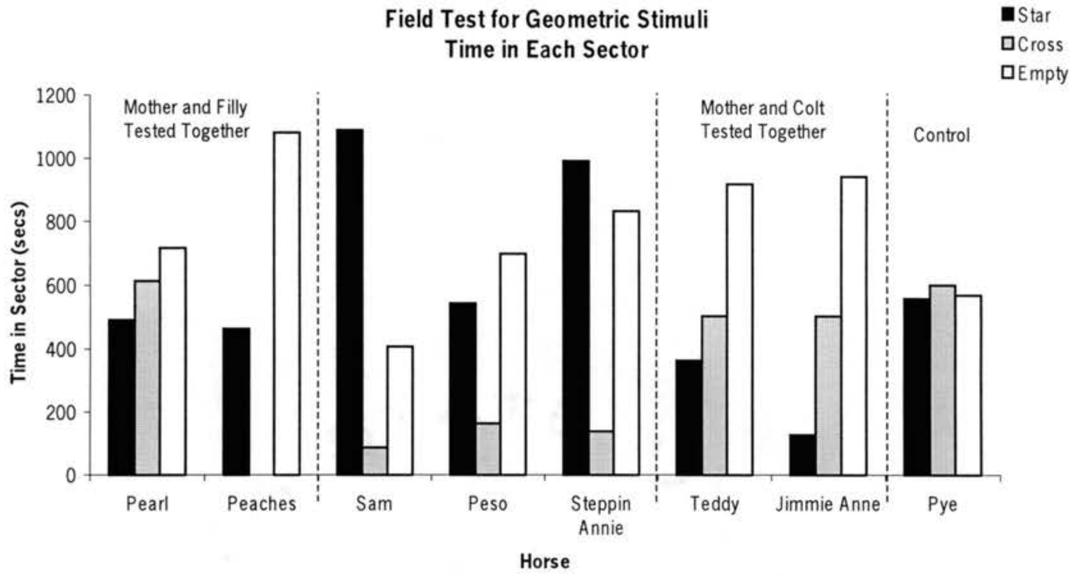


Figure 29. Amount of Time each horse remained in the Star sector, Cross sector, and Empty sector during the geometric stimuli field test.

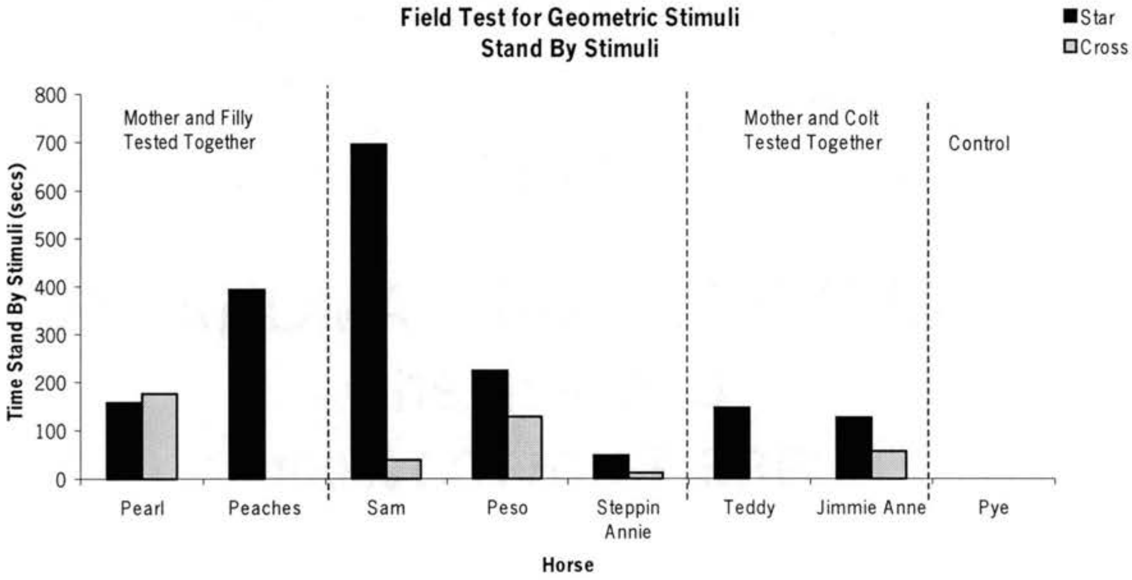


Figure 30. Amount of time each horse spent Standing By the Star and Cross during the geometric stimuli field test.

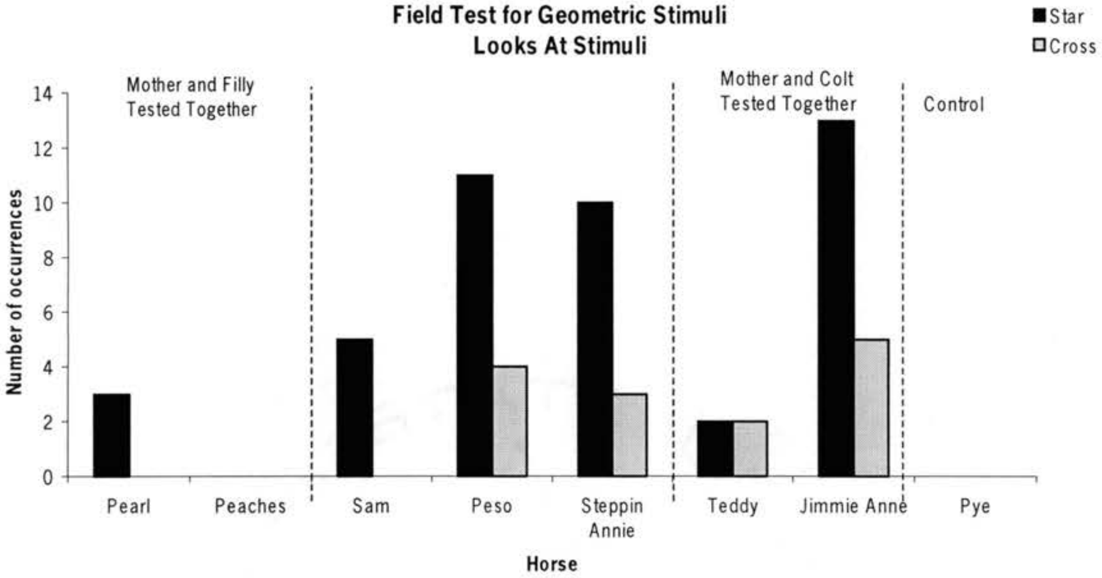


Figure 31. Number of times each horse Looked At the Star and Cross during the geometric stimuli field test.

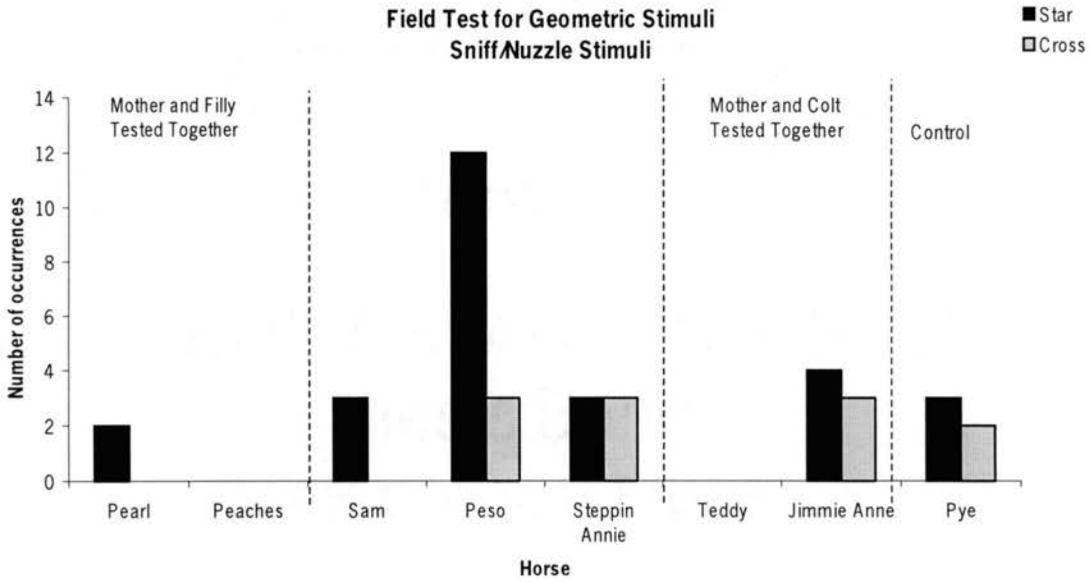


Figure 32. Number of times each horse Sniffed/Nuzzled the Star and Cross during the geometric stimuli field test.

Field Support of Geometric Concept Hypothesis

The data used for Figures 29-33 was further analyzed to determine the degree of support for the hypotheses. It was hypothesized that the horses would spend more time in proximity to the Star than to the Cross. However, the inclusion of an Empty sector necessitated additional interpretation of the data. Therefore, three degrees of support were identified for the Time In variable: (a) Total Support, (b) Partial Support, and (c) No Support. However, only two degrees of support were possible for the behavior categories Stand By, Look At, and Sniff/Nuzzle due to the existence of only two stimuli, the Star and the Cross. The degrees of support were identified as: (a) Total Support and (b) No Support. These data are presented in Table 14. The data represents the number of horses whose behavior supported the hypothesis.

Time In Sector

Total Support was defined as the horses spending more Time In the Star sector than in either the Cross sector or the Empty sector. Partial Support was defined as the horses spending more Time In the Empty sector than the Cross sector. Finally, No Support resulted from the horses spending more Time In the Cross sector than either the Star or the Empty sectors.

Stand By Stimulus

Total Support of the hypothesis was defined as the horses spending more time Standing By the Star stimulus than the Cross stimulus. No Support resulted from the horses spending more time Standing By the Cross stimulus than the Star stimulus.

Look At Stimulus

Total Support of the hypothesis was defined as the horses Looking At the Star stimulus more often than Looking At the Cross stimulus. No Support resulted when the horses Looked At the Cross stimulus than they Looked At Star stimulus.

Sniff/Nuzzle Stimulus

Total Support of the hypothesis was defined as the horses Sniff/Nuzzled the Star stimulus more times than they Sniff/Nuzzled the Cross stimulus. No Support resulted when the horses Sniff/Nuzzled the Cross stimulus more than they Sniff/Nuzzled the Star stimulus.

Table 14

Star, Cross, and Empty Variable				
	Time In	Stand By	Look At	Sniff/Nuzzle
Total Support	2	6	5	5
Partial Support	2	N/A	N/A	N/A
No Support	3	1	0	0

Note. No partial support possible for the Stand By, Look At, or Sniff/Nuzzle behavior categories due to the existence of only two stimuli. Sums below seven occurred when all the horses did not exhibit the behavior.

Human Stimuli Field Tests

Research has not been conducted to establish the transfer of discrimination training to an actual real world situation by horses. Therefore, a field test of both discriminative stimuli was conducted to determine if the horses formed a concept of Ahna. Additionally, a control horse, Pye, was also used in this phase of the study. Pye was observed in the field test with Ahna and the Stranger. Because he had not been included in the discriminative phase of the study, his performance in the field test was expected to add support to the concept formation hypothesis. For instance, Pye was expected to initially inspect all of the stimuli at the onset of the field test then ignore them for the remainder of the time. If this occurred as anticipated, his behavior would provide support to any discriminative behavior that the other horses showed to the S+ stimuli. Furthermore, if Pye demonstrated non-discriminatory behavior towards the stimuli, his behavior would suggest that the other horses, if they showed discriminatory behavior towards the S+ stimuli, had formed an *Ahna* concept.

Ahna and Stranger Field Test

The horses appeared to display two types of time behaviors while in each of the stimuli sectors. For instance, while in the Ahna sector the horses either stood within touching distance of her or they remained in the sector out of reach of her. Therefore, two separate times were recorded for each horse: (a) Time In each sector and (b) time Stand By each stimuli. Additionally, the horses exhibited four overt behaviors during this field test: (a) Look At stimulus, (b) Lick/Sniff/Nuzzle stimulus, (c) Rub Against stimulus, and (d) Butt/Kick/Bite stimulus.

Table 15 presents the criteria for the field test variables and coding definitions. All variables except the Time In sector were mutually exclusive. For instance, the Time In variable was recorded throughout the field test. In contrast, the other timed variable, Stand By, was only recorded when the horse was standing close enough to the stimuli that it could physically touch it. However, the moment that the horse initiated contact with the stimulus, the Stand By time recording ceased and frequency counts of the specific behavior was recorded. This was done due to the explicit nature of the variables. Horses are social animals and will remain in reachable presence of any number of stimuli in the environment. However, once a horse interacts with a stimulus by touching it, it has gone from a passive participant to an active participant of its environment.

Table 15

Field Variable	**Type of Variable**	**Coding Definition**	**Inclusive or Exclusive of other Variables**
Time In	Timed	Horse stood within the sector boundaries but out of reach of the stimulus	Inclusive
Stand By	Timed	Horse stood close enough to stimulus to touch it	Exclusive
Look At	Frequency	Horse looked at a stimulus without physically interacting with it c) in the same sector as the stimulus and turned its head to look at the stimulus d) in a different sector and turned to look at the stimulus	Exclusive
Lick/Sniff/Nuzzle	Frequency	Horse physically interacted with the stimulus c) sniffed d) nuzzled	Exclusive
Rub Against	Frequency	Horse physically rubbed against the stimulus with its head, neck, or torso but not its butt	Exclusive
Butt/Kick/Bite	Frequency	Horse physically butted, kicked, or bit the stimulus	Exclusive
Non-Aggressive	Frequency	Lick/Sniff/Nuzzle Rub Against	Inclusive (additive)
Aggressive	Frequency	Butt/Kick/Bite	Exclusive

Note. Inclusive indicates that one of the other variables may have been recorded at the same time. Exclusive indicates that no other variable other than Time In was recorded at the same time. The Non-aggressive category was formed by combining the frequency counts for the Lick/Sniff/Nuzzle and the Rub Against totals.

Group statistics. Although Pearl and Peaches were tested together in the Star and Cross field test they were not tested together in the Ahna and Stranger field test. Peaches was willing to leave Pearl and Pearl did not become agitated when separated. Therefore, Pearl was tied inside the barn during Peaches' field test. Teddy, however, refused to leave Jimmie Anne. Likewise, Jimmie Anne would not allow the experimenter to take Teddy away. Thus, they were tested together during the Ahna and Stranger field test.

Figure 33 presents the Time In each sector for all of the horses while Figure 34 presents the Stand By time for all of the horses. Figure 35 depicts the number of times each horse Looked At the stimuli, Figure 36 presents the graph of the number of times each horse Rubbed Against the stimuli, and Figure 37 presents the graph for the number of Lick/Sniff/Nuzzle behaviors. Figure 38 depicts the number of Aggressive behaviors, Butt/Kick/Bite. Table 16 presents the descriptive statistics for the human field test.

Table 16

Sector	Behavior	N	Total Num/Secs	Mean	SD
Ahna	Look At	7	71	10.14	6.09
	Rug Against	7	6	.86	1.86
	Lick/Sniff/Nuzzle	7	38	5.43	5.65
	Butt/Kick/Bite	7	0	.00	.00
	Stand By	7	1697secs	242.43	118.30
	Time In	7	3518secs	502.57	351.16
	Aggressive	7	0	.00	.00
	Non-aggressive	7	44	6.29	5.37
Stranger	Look At	7	28	4.00	2.89
	Rug Against	7	0	.00	.00
	Lick/Sniff/Nuzzle	7	9	1.29	.76
	Butt/Kick/Bite	7	41	5.86	9.86
	Stand By		1191secs	170.14	171.06
	Time In	7	2055secs	293.57	167.88
	Aggressive	7	41	5.85	9.36
	Non-aggressive	7	9	1.29	.76
Empty	Time In	7	4469secs	638.43	406.17

Note. Num = total number of occurrences for all the horses, Secs. = total number of seconds for all the horses. Pye's data were excluded from these analyses.

Individual statistics. Table 17 presents the Ahna and Stranger field test statistics for the timed variables for each of the horses. The amount of time in each sector was also analyzed as a function of time for the entire field test. These statistics are presented as percentages of time. Table 18 presents the frequency variables for each of the horses. The frequency variables were only analyzed as a total number of occurrences rather than a function of time.

Table 17

Horse	Time In						Stand By			
	Ahna		Stranger		Empty		Ahna		Stranger	
	Secs	%	Secs	%	Secs	%	Secs	%	Secs	%
Pearl	968	58	209	13	490	29	323	33	34	16
Peso	965	59	503	31	154	9	368	38	147	29
Sam	136	12	569	49	457	39	105	77	526	92
Steppin Annie	488	43	174	15	482	42	239	49	144	83
Peaches	542	44	224	18	471	38	379	70	11	5
Jimmie Anne	182	12	168	11	1211	78	98	54	121	72
Teddy	237	15	208	13	1204	77	185	78	208	100
Pye	467	27	430	25	818	48	29	6	31	7

Note. Jimmie Anne and Teddy were tested together. E = empty sector. No Stand By data could be recorded for the Empty sector because a stimulus was required. Secs = total number of sectors, % = percentage of time. Pye was the control horse

Table 18

Horse	Look At		Lick/Sniff/Nuzzle		Rub Against		Butt/Kick/Bite	
	Ahna	Stranger	Ahna	Stranger	Ahna	Stranger	Ahna	Stranger
Pearl	5	2	5	0	2	1	0	2
Peso	7	4	1	1	0	0	0	3
Sam	17	2	3	0	0	0	0	27
Steppin Annie	19	10	8	2	0	0	0	0
Peaches	5	2	8	2	0	0	0	0
Jimmie Anne	13	5	0	1	1	0	0	0
Teddy	5	3	16	2	0	0	0	9
Pye	1	1	0	0	0	0	0	0

Note. Jimmie Anne and Teddy were tested together. No behavioral data could be recorded for the Empty sector because a stimulus was required. Pye was the control horse.

Pearl. Ahna reported that Pearl rubbed against her with her neck and body. Pearl also leaned against Ahna after each rub.

Peso. Peso circled the Stranger when he left her sector to go to Ahna's sector.

Sam. Sam was very aggressive towards the Stranger during the field test. The large percentage of time he spent in the Stranger's sector was accounted for by the aggressiveness he displayed. The experimenter halted the field test due to the aggressive acts and the danger they posed to the Stranger.

Steppin Annie. Steppin Annie slept most of the time she was in the Empty sector. When she failed to wake up during the last 10 minutes of the test she was removed from the round pen and the test stopped.

Peaches. Peaches transferred her discrimination training behaviors to the field test. She had been taught to push on Ahna's face in the photographic stimuli. During the field test, Peaches pushed on Ahna's face in real life. Ahna remained still and reported that she looked down Peaches nostrils during the interaction.

Jimmie Annie and Teddy. Jimmie Anne followed Teddy for most of the field test. She seemed to let him make the movements but she stayed by his side. Additionally, 15 minutes into the field test Teddy laid down in the Empty sector and Jimmie Anne stood over him, facing away from Ahna and the Stranger. During the last 10 minutes of the field test Teddy attempted several times to nurse the Stranger.

Pye (control horse). Pye provided the most support for the hypothesis during the field test by spending an equal amount of time in each sector contrary to the hypothesis that the horses would spend more time in Ahna's sector. Pye did not exhibit a significantly greater or lessor number of overt behaviors to either Ahna or the Stranger.

Statistical Analyses of Ahna Field Tests

Due to the single subject design of this study, no qualitative analysis other than mean statistics was performed. Instead, the data were analyzed qualitatively because during the field test Sam spent the majority of the time in the Stranger sector and was very aggressive during the entire time. To include his data in a qualitative analysis would bias the significance of the findings.

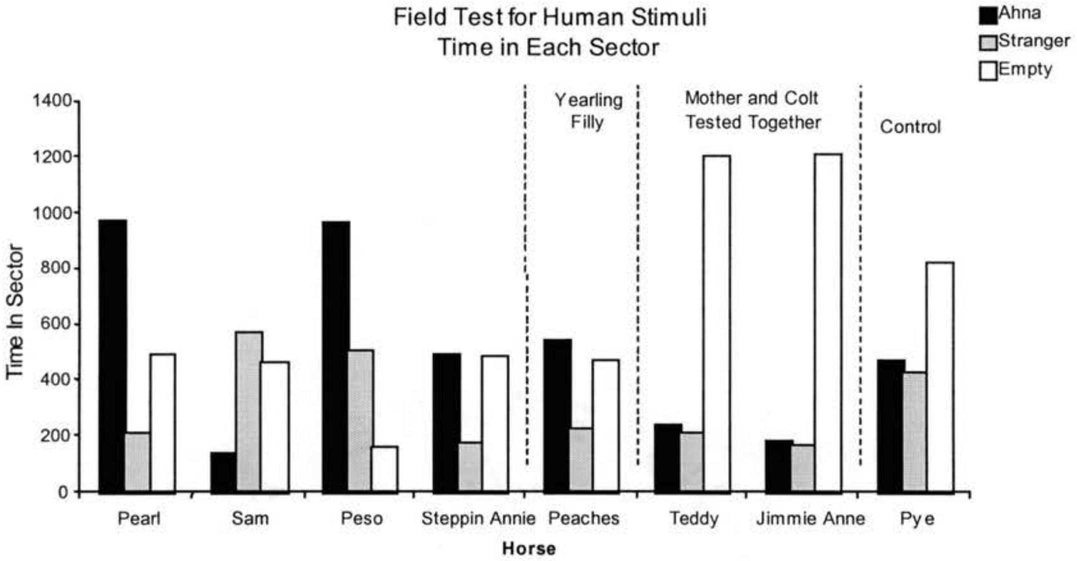


Figure 33. Amount of Time each horse remained in the Ahna sector, Stranger sector, and Empty sector during the human stimuli field test.

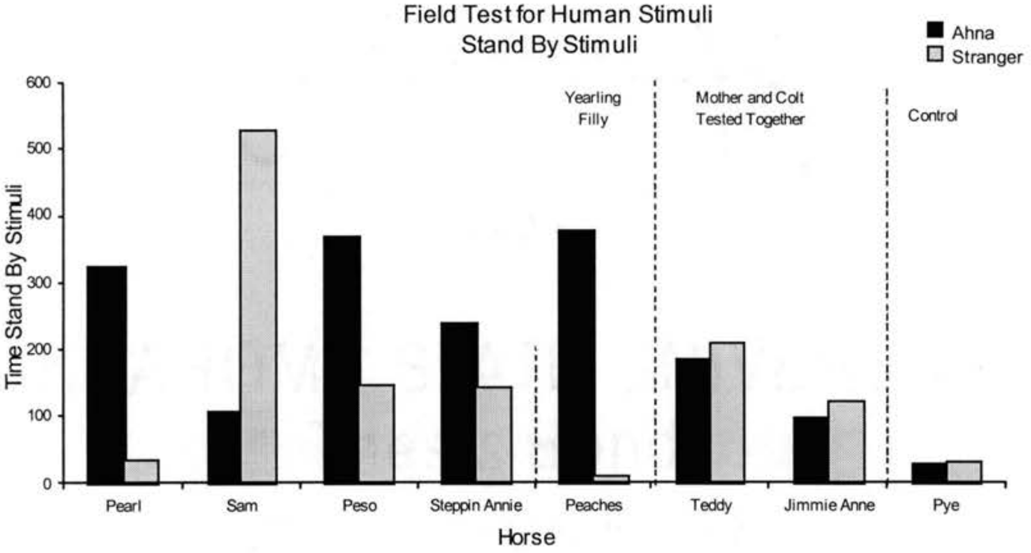


Figure 34. Amount of time each horse spent Standing By Ahna and Stranger during the human stimuli field test.

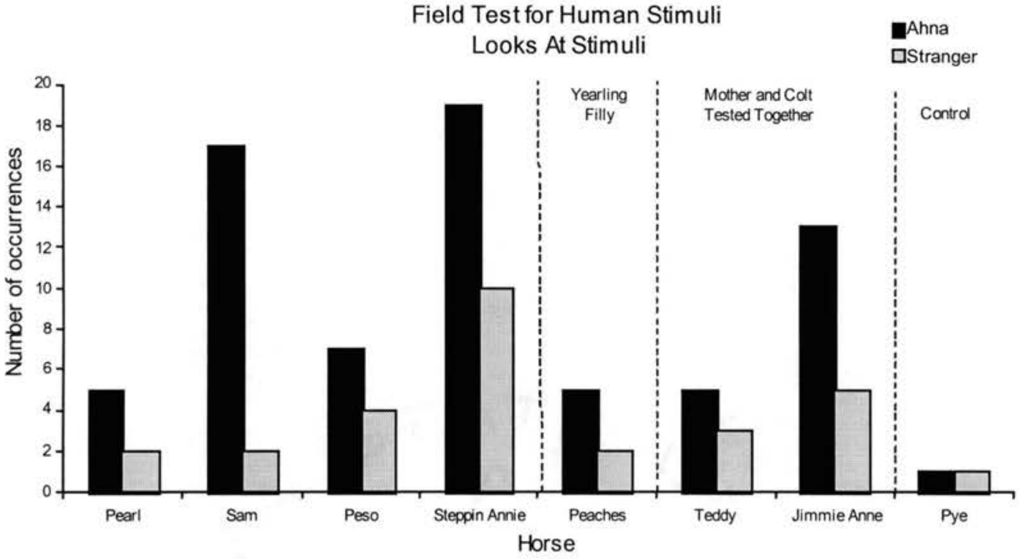


Figure 35. Number of times each horse Looked At Ahna and Stranger during the human stimuli field test.

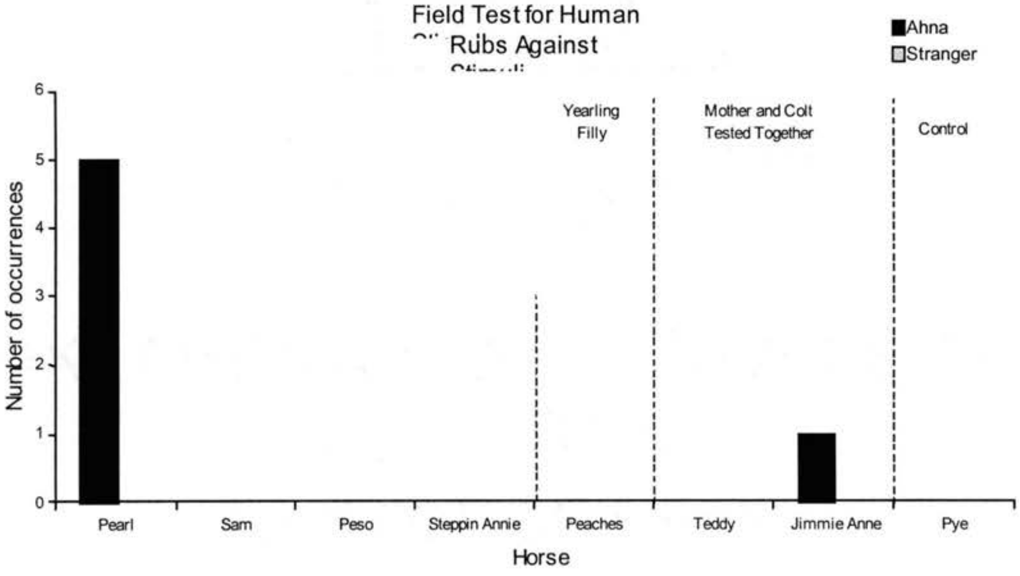


Figure 36. Number of times each horse Rubbed Against Ahna and Stranger during the human stimuli field test.

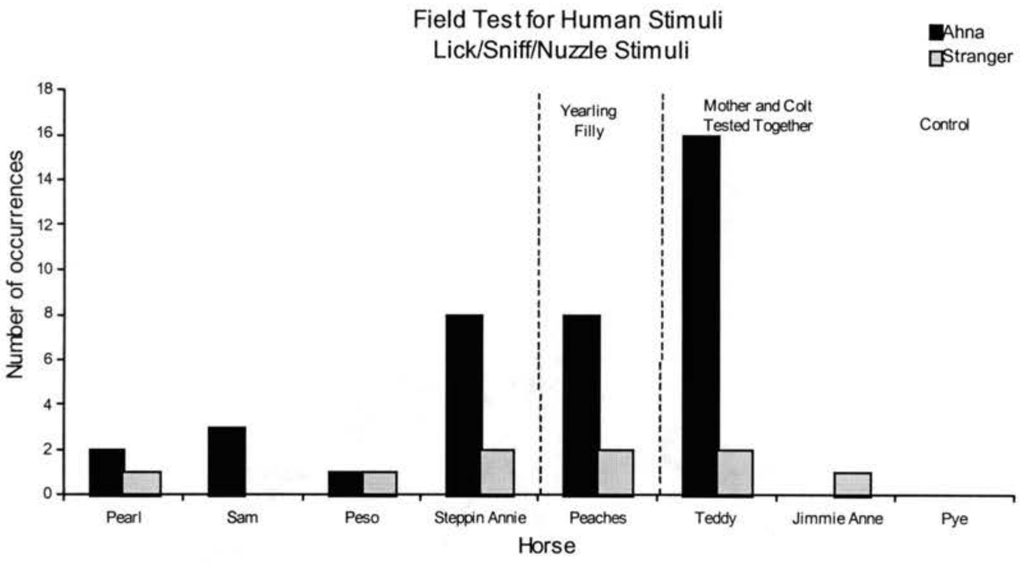


Figure 37. Number of times each horse Lick/Sniff/Nuzzled Ahna and Stranger during the human stimuli field test.

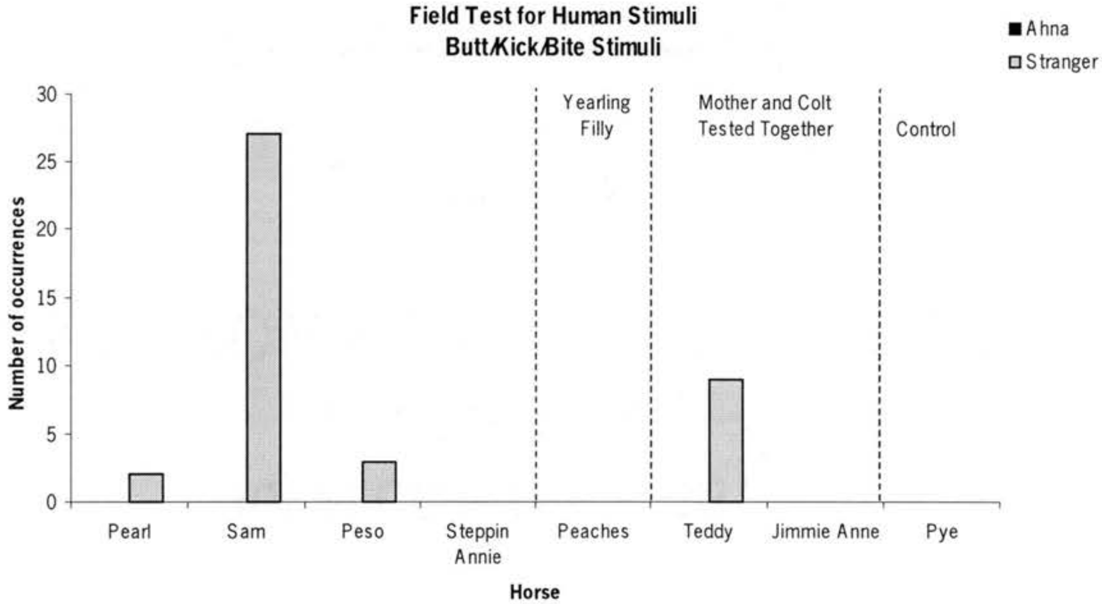


Figure 38. Number of Butt/Kick/Bite behaviors each horse exhibited towards Ahna and the Stranger during the human stimuli field test.

Field Support of Human Concept Hypothesis

The data used for Figures 34-38 was further analyzed to determine the degree of support for the hypotheses. It was hypothesized that the horses would spend more time in proximity to Ahna than to the Stranger. However, the inclusion of an Empty sector necessitated additional interpretation of the data. Therefore, three degrees of support were identified for the Time In variable: (a) Total Support, (b) Partial Support, and (c) No Support. However, only two degrees of support were possible for the behavior categories Stand By, Look At, Rub Against, Lick/Sniff/Nuzzle, and Butt/Kick/Bite due to the existence of only two stimuli, Ahna and the Stranger. The degrees of support were identified as: (a) Total Support and (b) No Support. Because the aggressive behavioral category was a finding of the field test and not anticipated prior to the study, these data could not be analyzed for a priori support or non-support of a hypothesis. Instead, these data are presented as post findings in support or non-support of the hypothesis that the horses had formed a concept of a specific person, Ahna, based on her representation of a positive reinforcement.

The field test data are presented in Table 19. The data represents the number of horses whose behavior supported the hypothesis. Additionally, Table 20 represents the field test data without Sam's results. Sam spent more time in the Stranger sector than in Ahna's sector. However, he also was very aggressive to the Stranger during the time he spent in her sector. Therefore, his data were excluded from the analysis due to the assumption that his behaviors skewed the interpretation.

Time In Sector

Total Support was defined as the horses spending more Time In the Ahna sector than in either the Stranger sector or the Empty sector. Partial Support was defined as the horses spending more Time In the Empty sector than in the Stranger sector. Finally, No Support resulted from the horses spending more Time In the Stranger sector than either the Star or the Empty sectors.

Stand By Stimulus

Total Support of the hypothesis was defined as the horses spending more time Standing By Ahna than the Stranger. No Support resulted from the horses spending more time Standing By the Stranger than Ahna.

Look At Stimulus

Total Support of the hypothesis was defined as the horses Looking At Ahna more often than they Looked At the Stranger. No Support of the hypothesis resulted when the horses Looked At the Stranger more than they Looked At Ahna.

Rub Against Stimulus

Total Support of the hypothesis was defined as the horses Rubbing Against Ahna more often than they Rubbed Against the Stranger. No Support of the hypothesis resulted when the horses Rubbed Against the Stranger more than they Rubbed Against Ahna.

Lick/Sniff/Nuzzle Stimulus

Total Support of the hypothesis was defined as the horses Lick/Sniff/Nuzzling Ahna more often than they Lick/Sniff/Nuzzled the Stranger. No Support of the hypothesis resulted when the horses Lick/Sniff/Nuzzled the Stranger more than they Lick/Sniff/Nuzzled Ahna.

Butt/Kick/Bite Stimulus

Total Support of the hypothesis was defined as the horses Butt/Kick/Biting Ahna less often than they Butt/Kick/Bit the Stranger. No Support of the hypothesis resulted if the horses Butt/Kick/Bit the Stranger less than they Butt/Kick/Bit Ahna.

Table 19

Ahna, Stranger, and Empty Variable						
	Time In	Stand By	Look At	Rub Against	Lick/Sniff/ Nuzzle	Butt/Kick/ Bite
Total Support	3	4	7	2	6	4
Partial Support	3	N/A	N/A	N/A	N/A	N/A
No Support	1	3	0	0	1	0

Note. No partial support possible for the Stand By, Look At, Rub Against, Lick/Sniff/Nuzzle, or Butt/Kick/Bite behavior categories due to the existence of only two stimuli. Sums below seven occurred when all the horses did not exhibit the behavior.

Table 20

Ahna, Stranger, and Empty Variable						
	Time In	Stand By	Look At	Rub Against	Lick/Sniff/ Nuzzle	Butt/Kick/ Bite
Total Support	4	4	6	2	5	3
Partial Support	2	N/A	N/A	N/A	N/A	N/A
No Support	0	2	0	0	1	0

Note. Field data without Sam's field results. No partial support possible for the Stand By, Look At, Rub Against, Lick/Sniff/Nuzzle, or Butt/Kick/Bite behavior categories due to the existence of only two stimuli. Sums below seven occurred when all the horses did not exhibit the behavior.

Aggressive vs. Non aggressive Behaviors

Figure 40 presents the Aggressive vs. Non-aggressive behaviors towards the Stranger. As depicted, the total number of Aggressive behaviors exhibited towards the Stranger was 41 (X= 5.86). Sam exhibited the most Aggressive behaviors towards the Stranger with 27 aggressive acts while Steppin Annie, Peaches, and Jimmie Annie exhibited none. A total of nine Non-aggressive behaviors were exhibited towards the Stranger (X=1.29).

The number of Aggressive behaviors exhibited towards the Stranger was compared with the number of Non Aggressive acts exhibited towards Ahna. It was observed that after the horses were Aggressive towards the Stranger they tended to approach Ahna and exhibit Non Aggressive behaviors. Figure 41 presents the results of the S+ (Ahna) versus the S- (Stranger) Aggressive and Non Aggressive behaviors. As shown, the total number of Non Aggressive behaviors towards Ahna was 44 and the number of Aggressive behaviors towards the Stranger was 41. However, Sam exhibited the majority of the Aggressive behaviors. Excluding his 27 Aggressive behaviors results in 14 Aggressive behaviors towards the Stranger. Teddy exhibited nine of these.

Figure 42 presents the total number of Non Aggressive behavior for both of the stimuli, the S+ and the S-. As shown, the horses exhibited more Non Aggressive behaviors were exhibited towards Ahna, 44 behaviors, than to the Stranger, nine behaviors. Finally, Figure 43 presents the total number of Aggressive behaviors for both stimuli. No Aggressive behaviors were exhibited towards Ahna but 41 Aggressive behaviors were exhibited towards the Stranger.

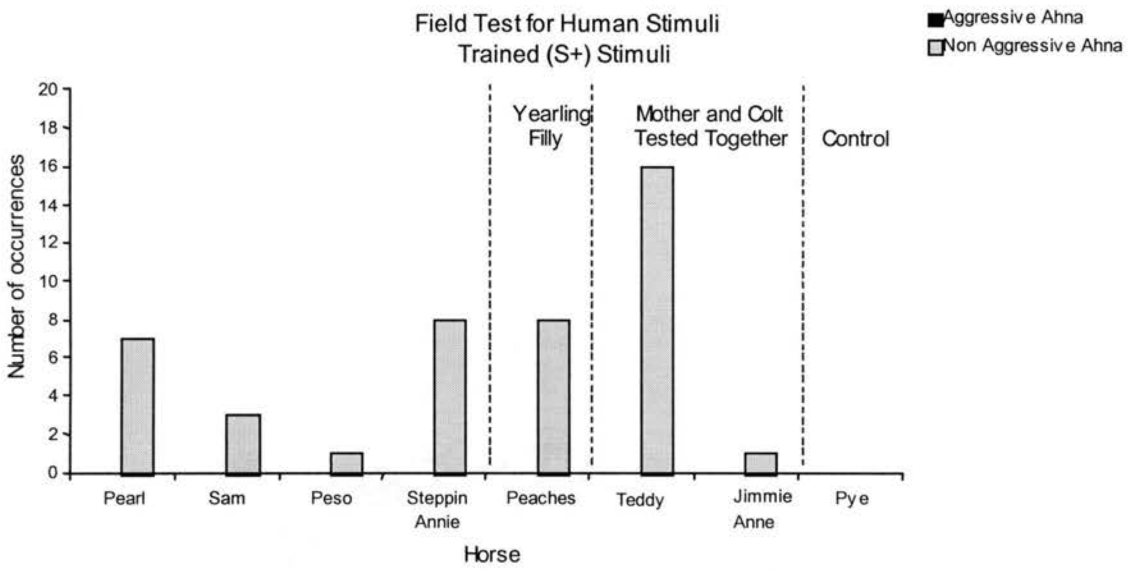


Figure 39. Number of Aggressive (Butt/Kick/Bite) and Non-aggressive (Rub Against, Lick/Sniff/Nuzzle) behaviors each horse exhibited towards the S+ (Ahna) during the human stimuli field test.

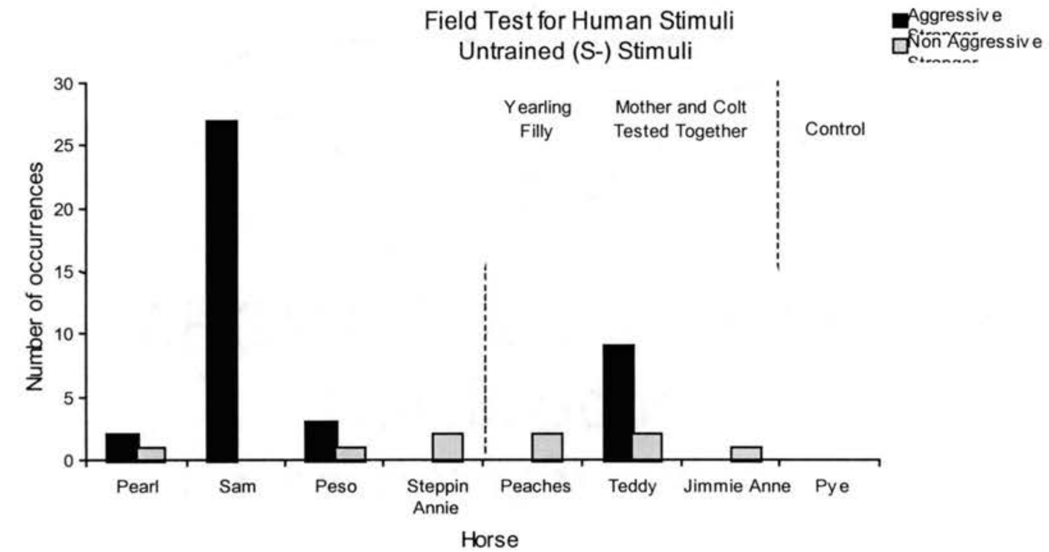


Figure 40. Number of Aggressive (Butt/Kick/Bite) and Non-aggressive (Rub Against, Lick/Sniff/Nuzzle) behaviors each horse exhibited towards the S- (Stranger) during the human stimuli field test.

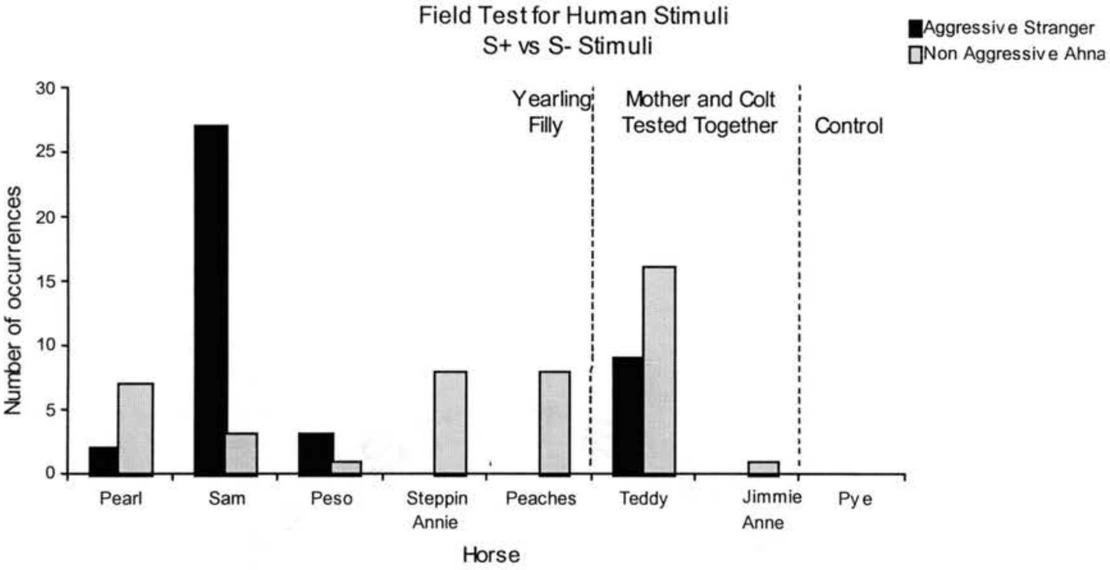


Figure 41. Number of Aggressive (Butt/Kick/Bite) behaviors to S- (Stranger) and Non-aggressive (Rub Against, Lick/Sniff/Nuzzle) behaviors to S+ (Ahna) during the human stimuli field test.

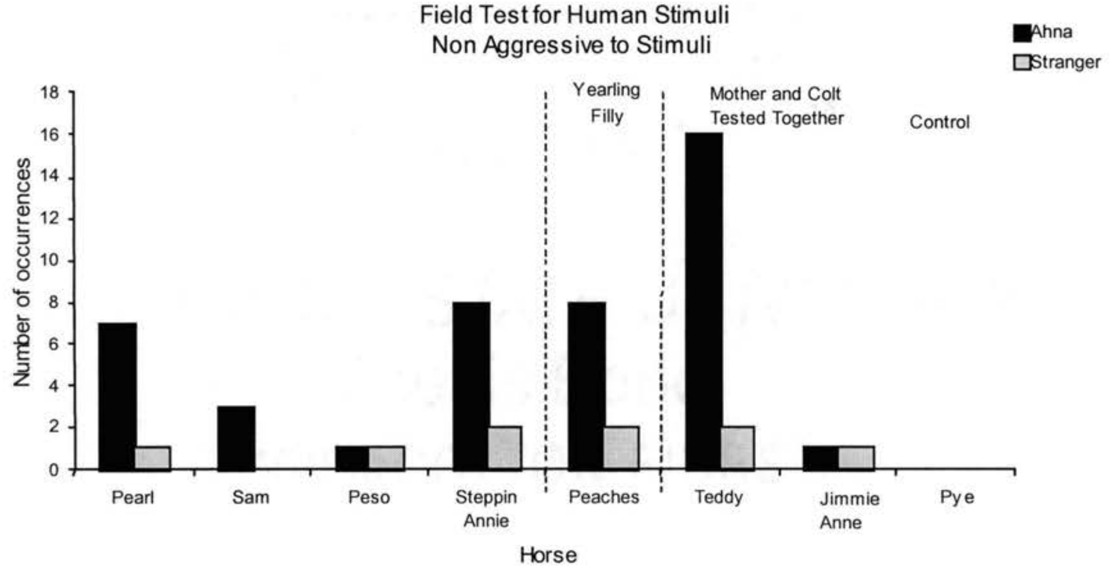


Figure 42. Total number of Non-aggressive (Rub Against, Lick/Sniff/Nuzzle) behaviors each horse exhibited towards Ahna and Stranger during the human stimuli field test.

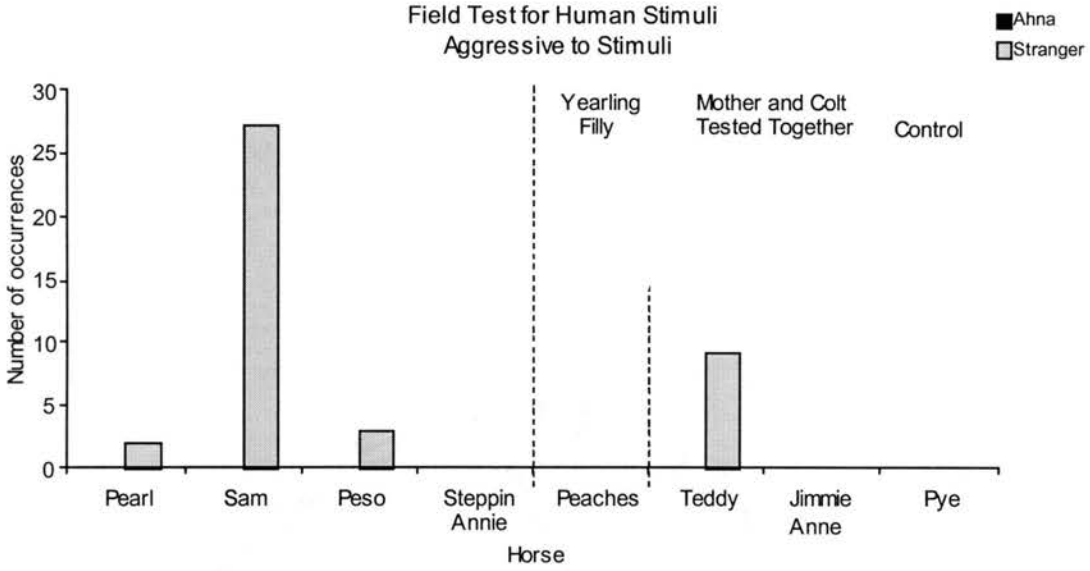


Figure 43. Total number of Aggressive (Butt/Kick/Bite) behaviors each horse exhibited towards Ahna and Stranger during the human stimuli field test.

General Summary of Results

Discrimination results

Star/No Star

All of the adult horses reached criterion on the Star/No Star discrimination training. Of the two young horses, Peaches reached criterion. Teddy was the only horse to fail to reach criterion on the discrimination task. The mean number of days to reach criterion for all of the horses was 5.3 days (*SD* = .98).

Star/Dogs

Four of the five adult horses reached criterion on the Star/Dogs photographic stimuli. Jimmie Anne did not reach criterion. Peaches and Teddy were not trained with this pair of photographic stimuli. When compared to the performance on the remainder of the photographic stimuli, the Star/Dogs required the longest number of days for the adult horses to reach criterion. The mean number of days to reach criterion was 6.1 (*SD* = 1.10). Whether this longer number of days was due to the complexity of the Star/Dogs photograph is unknown. Further study is needed to determine if, according to the learning to learn phenomenon, the horses would have done better on this photograph if it had been presented later in the experiment.

Star/Steps

All of the adult horses and Peaches successfully reached criterion on the Star/Steps photographic stimuli. Teddy was not trained with this photograph. Pearl, Peso, and Steppin Annie successfully discriminated the Star/Steps stimuli on Days one, two, and three thus reaching criterion on their first three attempts. The mean number of days to reach criterion was 4.2 (*SD* = 1.38).

Star/Hay

Only the adult horses were trained on the Star/Hay photographic stimuli. All of them successfully reached criterion. Peaches and Teddy was not trained with this photograph. Steppin Annie required seven days to reach criterion. However, it must be mentioned that she was the oldest horse at 29 years and this may have affected her memory and learning ability. Although she successfully learned to discriminate all of the Star photographs, she required more days than the younger horses. She also had to be stimulated numerous times during the intertrial interval because she tended to go to sleep. This may have affected her learning ability. Additional study is needed to determine if this is the case. The mean number of days to reach criterion was 4.3 (*SD* = 1.81).

Ahna/No Ahna

Three of the five horses successfully discriminated the Ahna/No Ahna photograph. Peaches and Teddy were not trained on this pair of photographic stimuli. Jimmie Anne never reached criterion. Steppin Annie reached criterion on only one day. This was followed by fewer correct responses on each succeeding day of training. As in the Star discrimination training, Steppin Annie had to be stimulated at times during the intertrial interval to keep her from going to sleep. Therefore, after eight days of unsuccessfully meeting criteria, Steppin Annie was moved to the next pair of photographic stimuli with the anticipation that new stimuli would sensitize her to the task. The mean number of days to reach criterion for all of the horses was 4.1 days (*SD* = 2.20).

Ahna/Bench

Four of the five adult horses successfully learned to discriminate the Ahna/Bench photographic stimuli. Jimmie Anne never learned the task. Peaches and Teddy were trained on the Ahna/Bench photograph rather than the Ahna/No Ahna photograph because Ahna's face was much larger in this photograph. Schrier and his colleagues (1984) found that monkeys learned to discriminate humans better and more quickly when the human slides consisted of close frontal views of head and shoulders. Additionally, the results of categorization tests of natural stimuli in rhesus monkeys indicated that they performed better when the human was prominent in the scene. Therefore, it was hypothesized that the younger horses would be less distracted by extraneous stimuli in this photograph and would be better able to distinguish the woman in the Ahna/Bench photograph than in the Ahna/No Ahna photograph. Peaches demonstrated successful discrimination learning by reaching criterion on day five of training. Teddy, however, never reached criterion on the Ahna/Bench stimuli pair. The mean number of days to reach criterion was 4.0 (*SD* = 1.48).

Ahna/Hay

All of the adult horses were trained on the Ahna/Hay photographic stimuli. Peaches and Teddy were not trained on this pair of photographic stimuli. Jimmie Anne successfully reached criterion. Peaches and Teddy was not trained with this photograph. Steppin Annie was alert during these training sessions and did not require stimulation to remain awake. Her results indicate she successfully learned the discrimination task in four days. The mean number of days to reach criterion on this photographic stimulus was 4.1 (*SD* = 1.34).

Learning to learn support

Harlow (1949) suggested that organisms exhibit increased performance of a task's criteria as discrimination training progresses. He termed this phenomenon learning to learn. This phenomenon has been demonstrated in various species including horses (Hanggi, 1999). As hypothesized, the horses in this study supported the learning to learn phenomenon. Specifically, four of the five adult horses required fewer days to reach criterion on both of the stimuli, Star and Ahna. Additionally, they responded correctly at a higher rate on each succeeding training day than they did on the previous training days. Likewise, the discriminative training appeared to carry over from each pair of photographic stimuli. For instance, four of the five adult horses performed exhibited more correct responses on the first trial of successive training days than they did on the first trial of each preceding day of discriminative training.

Concept Formation as Exhibited in Field Test

It was hypothesized that the horses would transfer their discriminative learning performance to the field when 3D stimuli were substituted for the 2D training stimuli. The results of the field test provided support for this hypothesis. Because the strictest test for conceptualization is the transfer of discriminative responding to novel or untrained stimuli, the current study substituted 3D stimuli for the 2D discriminative stimuli in the field test. The results of the field test also provided support for concept learning in horses. Specifically, the horses were allowed to choose between stimuli. The horses, overall, spent more Time In the Star sector than in the Cross sector. However, this finding was even more dramatic for the human field test. The horses, for example, spent more Time In Ahna's sector than in the Stranger's sector, spent more time Standing By Ahna than the Stranger, Looked At Ahna more than the Stranger, and Lick/Sniff/Nuzzled her more than the Stranger.

In comparison, Pye did not receive any discrimination training of either the Star or Ahna. However, he was included in the field test for both stimuli. His behavior clearly supported the hypothesis that the trained horses had formed a concept of the S+. During the Star and Cross field test Pye spent nearly identical amount of time in each sector. Even stronger support was found when Pye was tested in the human field test. He spent more time in the Empty sector than in either Ahna or the Stranger's sectors. The human stimuli held no significance to him. That is, he had not formed a concept of them as a result of discriminative positive reinforcement. Therefore, he spent his grazing time in the Empty sector.

CHAPTER V

Discussion

Herrnstein (1990) suggested that arbitrary, as well as, natural stimuli hold adaptive significance to animals. Survival, he proposed, is enhanced by the animal's ability to respond appropriately to various types of stimuli. By forming mental representations of stimuli and organizing them into discrete categories, animals are thus able to respond to an enormous number of stimuli without having first had previous experience with them. Animals respond to stimuli based on these mental representations through the process of generalization. However, generalization must not be confused with concept formation. Rather, generalization is the overt exhibition of conceptualization. To test this hypothesis the current study examined concept formation in horses for specific stimuli, particularly a geometric star and a woman. Horses have very good resolution acuity (Timney & Keil, 1992) and they respond to dept cues featured in photographs (Dougherty & Lewis, 1991; Timney & Keil, 1996). Therefore, the present study used photographs of arbitrary stimuli (Star and Cross) and natural stimuli (Ahna and Stranger).

The Star discrimination training and transfer test was completed prior to the Person discrimination and transfer test. The order of training was done due to previous findings that horses possessed discrimination ability for arbitrary stimuli (Fiske & Potter, 1979; Hanggi, 1999; Sappington & Goldman, 1994; Warren & Warren, 1962). Although other animals have shown successful discrimination of humans (D'Amato & VanSant, 1988; Herrnstein & Loveland, 1964; Schrier et al., 1984) no study of the natural category of person could be found for horses. Thus, after the horses completed the Star discrimination training and field testing, they began discrimination training on the natural stimulus.

The results of this study support previous findings that horses can learn to discriminate arbitrary stimuli (e.g. Giebel, 1958; Rensch, 1967; Sappington & Goldman, 1994). All of the horses in this study, except the foal (Teddy), successfully learned the first discrimination problem, Star/No Star, a simple black star on a white background versus a completely white stimulus. These results support the first hypothesis that the horses would demonstrate discrimination between stimuli during the training trials. These results were not surprising because previous research findings indicated that horses successfully discriminated black versus white stimuli. Gardner (1937), for instance, was the first to show that horses could discriminate between two feedboxes, one was covered with a black cloth and the other not covered. According to Thomas's (1986) hierarchy of learning abilities, this type of discrimination operated on Level 3, simple operant conditioning to obtain reinforcement.

More recently, researchers found evidence of higher levels of learning abilities in horses. Giebel (1958) showed that a horse could successfully discriminate 20 pairs of patterns concurrently. Likewise, Mader and Price (1980) demonstrated this level of learning in their horses when they found that Thoroughbred and Quarter horses successfully learned to discriminate stimuli presented in a three-choice problem. Likewise, Dougherty and Lewis (1991) found evidence of discrimination between a small (3.8 cm) circle and a large (6.4 cm) circle in three of their four test subjects. All of these findings support Level 5 learning, concurrent discriminations. McCall (1993) suggested that horses are able of learning at Level 5 because evolution equipped them with an excellent memory capability. Specifically, horses successfully incorporate new information into existing information which was learned from previous experiences. Only elephants have shown a high level of discrimination learning ability similar to the horse (Rensch, 1967). Recent studies, however, have shown that dolphins (Herman, 1980, 1987) and California sea lions (Schusterman & Kastak, 1998; Schusterman & Kreiger, 1984) also have the cognitive ability to learn at Level 5 and higher of the hierarchy.

The current results also provide further support for Hanggi's (1999) findings of categorization learning in horses and concurrent discrimination problem solving of arbitrary stimuli by horses as described by Level 5 of Thomas's (1986) hierarchy of learning. Additionally, the horses in her study responded correctly to novel stimuli during transfer tests, a necessity of concept learning. However, she was hesitant to label her findings as conceptualization because true concept learning requires that the individual categorize stimuli by characteristics other than physical attributes (Allen & Hauser, 1996). Instead, she suggested that her horses categorized the black and while stimuli using unknown exemplars. Whether these exemplars were part of the stimulus cards or the stimuli was unexplained by her results.

Four of the five adult horses' performance added further support for discrimination ability of natural stimuli. For example, Pearl, Sam, and Peso reached criterion on the first three days. Steppin Annie required six days to reach criterion. Only Jimmie Anne failed to reach criterion on the Ahna/Bench photograph. The Ahna/Hay results were similar. That is, Pearl, Sam, and Peso completed criterion on the first three days and Steppin Annie completed criterion on day five of training. Jimmie Anne, in contrast, never reached criterion. Further study is needed to understand Jimmie Anne's inability to discriminate the person stimuli. However, it is hypothesized that her energy expenditure was used to produce milk and nurse her foal rather than on cognitive activities. It would be necessary to develop a study of nursing mares and non-nursing mares to analyze the effect of nursing on discrimination learning ability.

One interesting observation was the interest level of the horses. Of the seven horses, six of them, including Teddy, appeared very willing to participate in the trials. The only horse that seemed preoccupied was Jimmie Anne. This may be attributable to her maternal nature. She appeared to be more concerned with keeping her foal in check than participating in the training. The other horses, in contrast, became anxious when the experimenter and assistants arrived. They showed such behaviors as neighing, running to the gate, crowding around the gate to be let in the testing area, and nuzzling the stimulus panels even before the wall was ready for the trials to begin.

Another interesting observation was the self-timing behaviors exhibited by Pearl and Peso. They began to move on their own without the leader holding their halters. For instance, both of them, after obtaining the food reward behind the panel, turned around, walked back to the cones, stood by the leader facing away from the wall, turned around when the leader turned, and waited the allotted 5-second observation period. When the leader took one step sideways to the left, both horses walked to the board. This became their cue and they did not have to be held until time to proceed. An interesting study would be to examine horses ability to self-time. That is, it was observed that Pearl and Peso seemed to know when the 5-second observation period had elapsed. However, it is unknown if, as with Clever Hans, if the leader was providing any subtle cues. Therefore, a carefully designed study is needed to assess this sense of time behavior.

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conceptualization. Specifically, after successfully learning to discriminate the Ahna photographs, it was hypothesized that the horses would transfer their performance to the field when Ahna was present in person. The strictest test for conceptualization is the transfer of discriminative responding to novel or untrained stimuli are presented. The results of the field test provided evidence of specific concept formation.

The horses were allowed to choose between Ahna and the Stranger. The real life women were deemed novel stimuli due to their 3D nature, whereas the photographic stimulus was only a 2D representations of Ahna. If the horses had formed a concept of Ahna, then it was hypothesized that they would discriminate between the two women by spending more time with Ahna than the Stranger. As a comparison, a control horse (Pye) was included in the current study. He did not receive any discrimination training of either the arbitrary or natural stimuli. However, he was included in the field test for both stimuli. His behavior clearly supports the hypothesis that the trained horses had formed a concept of the positive stimuli. For instance, during the Star and Cross field test Pye spent nearly identical amount of time in each sector. Even stronger support was found when Pye was tested in the human field test. He spent more time in the empty sector than in either of the human sectors. His time in the human sectors was nearly identical. Some researchers could argue that by spending any time in the human sectors, Pye contradicted the concept hypothesis. However, this argument is contrary to the social nature of horses.

Horses are social animals that have evolved and been bred to interact with humans. Only the free roaming mustangs, not dependent upon humans for survival, are free from human presence. Pye, on the other hand, is domesticated and interacts daily with a woman. Therefore, the time he spent in each human sector is indicative of curiosity and social communication. Horses use their sensory systems to learn and adapt to their environment. They communicate not only with each other but also with humans through their auditory, olfactory, tactile, and visual abilities (Budiansky, 1997). Therefore, Pye was clearly demonstrating normal horse behavior by checking out the humans' presence in his territory, the round pen. After examining them briefly and satisfying normal horse curiosity, Pye walked to and stayed nearly twice as long in the Empty sector than in either human sector. The women simply held no adaptive significance to him, therefore, he went about his business of grazing.

Another very unexpected finding during the field test was the display of Aggressive and Non-aggressive behaviors towards the women. On average, the horses were more Non-aggressive towards Ahna than the Stranger and much more Aggressive towards the Stranger than to Ahna. As mentioned previously, horses use their sensory behavior to communicate with their environment. Likewise, horses display their emotion through various behaviors. For instance, one of the most common aggressive displays of behavior of horses is ear pinning and butting. When a horse turns its butt towards a stimulus it is sending the message that the stimulus is in her/his territory. If the stimulus is a human the message is clear, *leave my territory, there will be no interaction between us* (Roberts, 1997). This behavior was clearly demonstrated in the field test by Sam. Not only did he turn his butt towards the Stranger, he pushed her with his butt from where she was standing and kicked her with his back leg. These behaviors also may account for the longer time spent with the Stranger. That is, Sam spent nearly four times the amount of time with the Stranger than he did with Ahna. However, closer examination of the results indicates that he was interacting aggressively with the Stranger during the time he spent near her. In contrast, when Sam was with Ahna he was exhibiting Non-aggressive and gentle behaviors such as Licking/Sniffing/Nuzzling her. Additionally, he Looked at Ahna eight times more than the Stranger. Pearl, Peso, and Teddy also exhibited Aggressive behaviors towards the Stranger, however in lessor frequency. Once again, Pye added support for the conceptulization hypothesis. He exhibited neither Aggressive nor Non-aggressive behaviors towards either Ahna or the Stranger. He only looked at each one once and this was during his first and only interaction with them.

Although much variability existed between the horses, they, as a species, demonstrated conceptualization by spending more time in Ahna's sector, spending more time Standing By, within reach, of Ahna, exhibiting less aggressive behaviors towards her, and exhibiting more non aggressive behaviors towards her. The current results also indicate that the horses are not limited by geometric stimuli such as found by Sappington and Goldman (1994) in their findings of triangularity. Rather, the horses exhibited evidence of forming human concepts such as found in monkeys (D'Amata & VanSant, 1988; Sands et al., 1982; Schrier et al., 1984).

Despite the strong evidence of concept formation by the horses in this study, it would be negligent not to make alternative explanations for the behaviors under consideration. For instance, the aggressive behaviors exhibited by Sam towards the Stranger may have resulted because of something other than concept formation. That is, the Stranger may have represented a threat to Sam and therefore he was protecting himself. Although the women were asked not to wear any type of fragrant soaps, perfumes, or shampoos on the day of testing, odor must be considered. Sam's aggressive behavior may have been due to an offensive odor that the Stranger exuded that went undetected by the human participants. If such an odor was offensive to Sam, he may have behaved aggressively to remove the source. Similarly, the Stranger may have resembled someone from his past that treated him aversively. If this is the case, then his behavior may have been nothing more than simple stimulus generalization for physical characteristics rather than concept formation. However, the owner stated that no other human had interacted with Sam since birth; therefore, this explanation is weak but possible. Additionally, Ahna and the Stranger resembled each other in hairstyle, hair color, physical height, and stature. Thus, these attributes do not explain the differences in behavior exhibited by all of the horses.

An explanation for the successful discrimination learning concerns the clothing Ahna wore in the photographs. Timney and Kiel (1992; 1996) found that horses have excellent visual acuity, depth perception, and the ability to see reds and blues. This may have biased the current Person discrimination results. That is, in the photographs Ahna wore a shirt with dark colors, including red. Therefore, it could be that the horses were responding to the color of the clothing rather than to Ahna. To control for this confound during the field test, Ahna wore clothing without the color red because previous research with monkeys suggested the positive transfer they exhibited may have been due to the red clothes worn by the human stimulus (D'Amato & Van Sant, 1988). The results of the field test suggest that the horses had indeed formed a concept of Ahna, not her clothing.

Although the results of this study support the hypothesis, several limitations, which may have affected the horses' behavior, must be addressed. First, no baseline data were collected prior to beginning the discrimination training. It could be that the horses may have responded to the S+ stimuli at a higher rate than the S- stimuli regardless of the positive reinforcement value they held. However, due to possible learning carryover effects, baseline data with the treatment stimuli were not possible. Secondly, the use of only one control horse may have skewed the field test results. Future studies may benefit from the use of more than one control animal. Thirdly, Jimmie Anne and Teddy were trained and field-tested together. Efforts to train Jimmie Anne on the discriminative stimuli without Teddy were unsuccessful. She broke free from the leader and ran to Teddy. Once Teddy was placed within her sights beside the stimulus wall she remained with the leader during the training. However, Jimmie Anne did not reach criterion as often as the other adult horses. Her lack of learning could have been due to the presence of Teddy or his handler. For example, their presence may have negatively affected her results by averting her attention away from the learning task.

Finally, one of the most significant limitations lies in the lack of two S+ human stimuli in the discrimination training phase. Future studies should train half of the horses with, for instance, Ahna as the S+ and the other half of the horses, with the Stranger as the S+. The field test would be conducted as in the present study. The presence of both S+ may provide stronger support for the hypothesis that the horses formed a concept of a specific person. Specifically, if they responded more favorably to the S+ that they had learned to discriminate, their behavior would suggest they were acting upon their conceptualization of the S+.

Studies of concept formation in animals have been bitterly debated and continue to divide the camps on the issue of animal cognition. Researchers on both sides of the issue have presented strong evidence for the existence and non-existence of this mental ability. For the behaviorist, concept formation is nothing more than stimulus generalization. However, the cognitivist asserts that animals are not merely mindless creatures that respond to stimuli. They are, instead, thinking creatures with the ability to solve problems using classical, operant, and cognitive processes. It is the conclusion of this researcher that concept learning is not an either behaviorist or cognitivist process but rather a combination of both. To exclude one from the other is to limit the advantages of each. For instance, stimulus generalization and concept formation, though separate, may be linked.

Just as categorization is one process of conceptualizing stimuli, generalization may be the behavioral process by which the mental representation is compared to a novel stimulus. Additionally, conceptualization requires that the organism be cognitively able to discriminate stimuli. Thus, when presented with a novel stimulus, the animal searches its memory for a category that possesses similar characteristic attributes. Once a similar category is found in memory, the animal responds or ignores the presenting stimulus accordingly. The more similar the novel stimulus is to the abstract mental representation, the more similar the behavioral responses will be. Generalization, then, may be nothing more than the behavioral expression of the conceptualized stimulus. It remains unknown what features the animal uses to construct these concepts but to deny the possibility of animal cognition, specifically concept formation, is detrimental to gaining more knowledge of animals' capacities. Further study is needed to examine this issue.

Applied Implications

The use of horses for therapeutic reasons (known as equine therapy when applied to psychological problems and known as Hippotherapy when applied to physical disabilities) has seen a tremendous increase in the past 20 years (Fitzpatrick & Tebay, 1996). It has been shown that horse riding helps to rehabilitate various disorders including language, physical, emotional, and social (DePauw, 1992). Specifically, horse-assisted therapy has been used successfully with quadriplegics, those suffering from multiple sclerosis, cerebral palsy and other neurological impairments (Netting, Wilson, & New, 1987; Wilson & Turner, 1998).

Animals other than horses (e.g., dogs, cats, kittens, guinea pigs, hamsters, fishes, and birds) have been used as therapeutic agents throughout history and people of all ages benefit from interacting with them. For instance, Kidd and Kidd (1985) found that animals such as dogs, cats, fish, birds, and hamsters teach life skills to children, increase responsibility, and provide opportunities to learn reproductive principles. Additionally, animals have been found to reduce loneliness of homeless individuals, the elderly (Kidd & Kidd, 1994) and women (Zasloff & Kidd, 1994), strengthen social interaction skills of the elderly (Brasic, 1998), benefit mentally and physically disabled adults (Corson, Corson, Gwynne, & Arnold, 1977), and result in greater stress-reducing effects than the presence of a good friend (Allen et al., 1991).

<u>Concept Formation Training for Companion/Therapeutic Horses</u>. This study has shown that a method using photographs to reduce the amount of time necessary to train horses is successful. Horses (*Equus caballus*) have become popular animals for working with physically and emotionally disabled humans. Equine therapy, for example, has been shown to be effective for those suffering from multiple sclerosis, cerebral palsy, those suffering from orthopedic problems, the emotionally disabled, and various other posttraumatic disorders (Engel, 1994; Heipertz-Hengst, 1994).

An examination of the literature on equine-assisted therapy and Hippotherapy revealed that guidelines are established for the selection of therapeutic horses. For instance, horses are selected on the basis of their temperament, size, symmetry, balance, and muscle tone (Fitzpatrick & Tebay, 1996). Additionally, guidelines are also in place for the selection of therapists and personnel used in such programs. However, as DePauw (1992) noted, there is a need for studies examining human-horse interaction. He suggested that such studies should include, for example, 3D movements of the horse, the effects of sensory stimulation, and the horse-human bond. Dougherty and Lewis (1991) suggested that many behavior problems of horses arise due to inappropriate conditioning techniques or techniques intended for other training purposes rather than the desired behavior. Therefore, this study was able to examine a possible training technique to strengthen the human-horse bond.

Although there are universal training standards and regulations pertaining to the personnel of therapeutic riding programs and Hippotherapy programs, there are no guidelines covering the training procedures for the horses. Typically what is done is simply to adapt or as behaviorists refer to it, habituate, the horse to the rider and the rider to the horse. As the habituation literature shows, the course of habituation is especially sensitive to training variables such as stimulus intensity and the time between stimulus presentations and is in many ways an inefficient training technique. The aim of this proposal is to reduce and standardize training time by taking advantage of the learning ability of horses and the recent findings suggesting that animals, including horses, can form concepts or mental representations.

Most of the equine research has concentrated on simple discrimination learning, observational learning, avoidance learning, maze learning, and the effects of handling or experience on future learning (e.g. Gardner, 1937; Haag et al., 1980; Marinier & Alexander, 1994). In contrast, only one study has been conducted to examine concept formation in horses. Sappington and Goldman (1994) found discrimination learning and concept formation in Arabian geldings. In addition, Hanggi (1999) found evidence of categorization learning in horses using pairs of geometric shapes. The ability of the horses to learn in this manner suggests that they can be used as tools for therapeutic interventions and standardized training protocols can be developed.

In conclusion, whereas the historical perspective excluded the existence of animal cognition, many current researchers have found evidence that animals do use some type of cognitive mechanism to learn how to respond to the problems posed by stimuli in their environment. These environmental problems include survival, bonding to a caregiver, foraging, protection from predators, depletion of environmental habitat, and preservation of species through sexual selection. Although the mechanisms are not fully understood, researchers have shown that some animals are capable of using complex cognitive mechanisms that more closely resemble human cognitive abilities. For example, Andrew and Harlow (1948) found that rhesus monkeys were able to form a concept of triangularity as did Sappington and Goldman (1994) in their study of horses. Herman (1987) found evidence that bottlenosed dolphins respond to compute-generated acoustic signals and Irene Pepperberg has shown that a grey parrot named Alex can discriminate stimuli using categorization characteristics such as sameness/difference to form concepts. Perhaps the most supportive study, however, was Herrnstein and Loveland's (1964) study involving concept formation in pigeons. They found that when operant procedures were used to train pigeons to peck at a key when a slide contained a picture of a person, the pigeons responded correctly to the person slides. However, the pigeons who did not receive a reward when they pecked at the slides that did not contain images of people, rapidly learned to discriminate the stimuli. This discriminatory learning was also evident in pictures presented for the first time. They concluded that animals group stimuli into discrete categories based on some common characteristic and therefore form a mental representation, or concept, of the similar stimuli. Future studies should concentrate on better understanding, not questioning the existence, of these cognitive mechanisms. Comparative studies need to be designed and conducted to examine cognitive mechanisms across the phylogenetic scale of human and non-human species.

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Pearl and Rachel.

Rachel, Sam, and Virgil.

Peaches and Marty.

Rachel, Peso, and Virgil.

Rachel, Steppin Annie, and Virgil.

Jessica, Pearl, and Sherril demonstrating wall and door.

Teddy, Rachel, Jimmie Anne, and Virgil.

Pye.

Pearl, Sherril, and Peaches.

Ahna and Nikki.

Teddy, Jimmie Anne, and Rachel.

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VITA

Sherril M. Stone

Candidate for the Degree of

Doctor of Philosophy

Thesis: SPECIFIC CONCEPT FORMATION IN HORSES: YOU SURE LOOK FAMILIAR

Major Field: Experimental Psychology

Biographical:

Education: Graduated from Putnam City High School, Oklahoma City, Oklahoma in May 1978; received Bachelor of Business Administration in Finance from Central State University in May 1985; received Master of Arts in Psychology from University of Central Oklahoma in May 1997. Master of Science degree with a major in Experimental Psychology at Oklahoma State University in December, 1999. Completed the requirements for the Doctor of Philosophy with a major in Experimental Psychology at Oklahoma State University in May, 2001.

Experience: Employed by Oklahoma State University, Department of Psychology as a graduate teaching instructor and teaching assistant, 1998 to present; employed by Redlands Community College, Department of Psychology and Sociology as an adjunct faculty member, 2000 to present; employed by University of Central Oklahoma, Department of Education, Edmond, Oklahoma as a research and statistical assistant, 1996-1997; volunteered as teaching assistant for Oklahoma State University, Department of Psychology, undergraduate Evolutionary Psychology, 1999; enrolled as teaching assistant at University of Central Oklahoma, Department of Psychology, undergraduate Experimental Psychology, 1996.

Professional Memberships: Southwestern Psychological Association, Oklahoma Psychological Society/Oklahoma Psychological Association, Psi Chi Honor Society.