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Equine Operant Conditioning: Autoshaping, Observational Learning, and Discriminative Stimulus Intensity

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EQUINE OPERANT CONDITIONING: AUTOSHAPING, OBSERVATIONAL LEARNING, AND DISCRIMINATIVE STIMULUS INTENSITY

by

Paul H. Stewart

A thesis submitted in partial fulfillment of the
requirements for the degree

of

MASTER OF SCIENCE

in

Animal Science

Approved:

[redacted]

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This thesis is dedicated to my family. To my parents, Iril and Edith Stewart, for their unending support and encouragement. To my children, Lisa, Shawn, Julie, Richard, and Joshua, for the sacrifices they have endured and their support and understanding. And especially to my wife, Katherine, without whose love, support, understanding and long suffering this thesis would not have been possible.

Paul H. Stewart

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ABSTRACT

Equine Operant Conditioning: Autoshaping, Observational Learning, and Discriminative Stimulus Intensity

by

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Utah State University, 1991

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Department: Animal, Dairy and Veterinary Sciences

This thesis is comprised of three studies in which basic principles of operant conditioning were applied to horses. Autoshaping was examined as a method for horse training. Observational learning was investigated to confirm that naive horses can, in fact,

acquire novel behavior by observing experienced horses, and that the rate of acquisition with observation is more rapid than spontaneous responding without observation. A third study examined the effect of discriminative stimulus intensity on the acquisition rate of novel behavior.

All subjects learned to use an operant conditioning device. Subjects in the first study autoshaped. Observational learning was also demonstrated to be a means by which horses can learn. The rate of learning was significantly improved through observation. Intensity of the discriminative stimulus affects the acquisition of novel behavior. The subject exposed to the higher intensity stimulus acquired sustained manipulandum pressing significantly faster than other subjects.

It was concluded that horses acquire behavior in much the same manner as other species.

(77 pages)

INTRODUCTION

Horses were domesticated between 4,500 and 2,500 B.C. (Evans et al., 1977). Domestication has meant confinement to smaller than natural living space and an alteration of natural feeding and exercise habits. Throughout their lengthy period of domestication, the horse generally has adapted well in confinement. Nonetheless, troubling behavioral problems do occur and it was the object of this research to initiate an analysis of potential methods for dealing with such pathology.

Cribbing, wood chewing, weaving, stall walking, digging, finicky appetites, kicking stall walls, and other undesirable behaviors have been exhibited by some horses in confinement (Schafer, 1975; Waring, 1983). It is unlikely that such behaviors develop when horses are in their natural environment. Abnormal behavior can be debilitating to horses, destructive to facilities, and annoying to owners.

It is not clearly understood why some horses exhibit the behavior they do in confinement. Disruption of instinctive behavior is a possible explanation. Zoo animals frequently exhibit unnatural behavior that is attributed to confinement and disruption of natural behavior patterns (Markowitz, 1982).

Whatever the reason for the aberrant behavior in confined horses, it is likely that the behaviors can be modified by operant conditioning techniques. Basic principles of operant and respondent behavior have been found to be common to many animals, although differences in application exist relative to species adaptation and complexity. There are many examples of zoo animals that have exhibited undesirable behavioral changes in captivity that have had more natural or acceptable behavior established through the use of operant techniques (Markowitz, 1982). Since abnormal or undesirable behaviors in zoo animals can be eliminated by using operant techniques, it is probable that undesirable behavior in horses can also be eliminated operantly.

The little behavioral research reported with horses has confirmed that principles established for other species also apply to horses (Myers and Merker, 1960). However, there is a need to discover species-specific parameters that affect their behavior. Because so little systematic basic operant work has been done with horses, fundamental principles already demonstrated in other species should be examined to determine how to apply them to horses most effectively. Through the study of operant conditioning, optimal techniques for training and altering behavior may be established.

Three studies described in this thesis (observational learning, autoshaping, and the effect of the discriminative stimulus intensity on the acquisition of behavior) examined questions related to how horses acquire behavior. Autoshaping was examined as a means by which a horse can acquire the use of a manipulandum without the need of trained personnel. Observational learning was examined to determine whether arbitrary behavior can be acquired by a naive horse observing the behavior in another horse, and to see if observation decreases time needed to acquire an arbitrary behavior. The intensity of the discriminative stimulus was also examined to discover how intensity affects acquisition of a novel behavior.

REVIEW OF THE LITERATURE

This thesis was designed to aid in demonstrating that the principles of operant conditioning established with other species also apply to horses. A principal economic value of the horse is based on its trainability, yet little scientific research has been done to optimize training methods. Mullen et al. (1977) did a study comparing two methods of training to accustom horses to novel stimuli. This was a practical application of existing training methods that appears to be unique in the literature.

The use of a maze is common for behavioral research involving horses. Those studies examined maze learning ability (Williams, 1956; Kratzer et al., 1977; Haag et al., 1980; McCall et al., 1980) and discrimination reversal learning (Fiske and Potter, 1979). Non-maze methods have also been used to examine discrimination (Gardner, 1937a, 1937b; Mader and Price, 1980) and reversal learning (Warren and Warren, 1962). Their studies used methods in which grain was concealed behind or under a wood panel or door.

Rubin et al. (1980) used a technique similar to those used in operant chambers with laboratory animals in which intertrial interval during avoidance training was examined. An enlarged version of a shuttle chamber was used. The same approach was used by Haag et al. (1980) in which avoidance training was also studied.

Generally, principles of learning (operant conditioning) are examined with the aid of an operant chamber that allows control of the experimental environment. Studies are usually conducted using positive reinforcement (a subject activated feeder or waterer) of the behavior to be evaluated.

The use of subject-activated feeders for operant behavioral research with horses was previously limited to three studies. Myer and Merker (1960) reported a study with one horse in which five fixed-ratio (FR) schedules of reinforcement and three fixed-interval (FI) schedules of reinforcement were evaluated. The response rates recorded on a cumulative recorder "contained components similar to those of other organisms under the same schedules of reinforcement" (p. 164). In this study 1/2 cup of grain was used as a reinforcer and a session terminated after 30 reinforcements. The horse required 30 s to 1 min to consume 1/2 cup of grain.

Hagerbaumer et al. (1979) studied discrimination learning in young horses by reinforcing correct responses with a subject-activated feeder. When visual vs. auditory stimuli were examined, auditory stimuli resulted in faster trial completions. Application of punishment for incorrect responses was found to increase trial times. It was also determined that sex differences did not influence learning under the conditions of that study.

Operant techniques using water as the reinforcer have also been used to study sound localization by horses (Heffner and Heffner, 1986). In that study manipulandums were located to the left, center, and right of the subject. Reinforcement was delivered when a correct response was made matching the origin of the sound.

There has been no research involving autoshaping in horses. Autoshaping has been shown to be a method by which responding on a manipulandum can be established in several species (Davey, 1981; Mazur, 1990). Brown and Jenkins (1968) used the term "autoshaping" to describe the pairing of a neutral stimulus with reinforcement so responding will occur oriented toward the stimulus. This is a classical conditioning technique used to bring about an operant response. Their work established forward pairing as the most efficient procedure to establish an autoshaped response. Although numerous articles on autoshaping have appeared, Brown and Jenkins' work is the foundation for autoshaping, and their work provides an adequate pattern from which to study the effect of autoshaping on horses.

According to common wisdom, observational learning is a method by which horses acquire some novel behavior. Observational learning has been demonstrated in many species (Davey, 1981; Mazur, 1990) and there are numerous articles documenting various aspects of observational learning in these species. In the only study to involve horses (Baer et al., 1983) observational learning was not verified. The study involved 16 horses (2 groups of 8) in a V maze. The correct arm of the maze contained a white board and grain in a white bucket (goal box), which was randomly placed in either the left or right arm. the observer subject was positioned so it could watch the demonstrator leave the start box, walk to the goal box and eat. Apparently this design did not yield a verification of observational learning.

H. E. Adler (1955) states that most workers in the field use one of three methods to investigate observational learning. One method is a single space in which the demonstrator and the observer are both present and have access to the same manipulandum and reinforcer. A second method, originated by Thorndike, utilized two chambers. The observer in one chamber was able to watch the demonstrator in the other chamber. The observer did not have access to a manipulandum.

After observations were made, the demonstrator was removed from the functional chamber and the observer placed in the chamber. A third method (the Warden duplicate chamber) involves two identical chambers, each complete with its own manipulandum and reinforcer. The demonstrator in one chamber is visible to the observer in the other chamber and subjects are not moved.

Warden et al. (1955) set forth the following criteria for "imitation": (a) the task must be novel and sufficiently complex, (b) the response must appear immediately after observing the demonstrator, (c) practice must be excluded by the experimental conditions, (d) the act of the observer must be substantially identical with that of the demonstrator, and (e) a sufficient number of instances must occur under varied conditions to eliminate the chance factor.

An in-depth study of the complexity of behavior that could possibly be obtained by horses through observation was not the focus of this study. The intention was to simply demonstrate that horses could acquire novel behavior through observation. Because of the focus of this study, a review of the more than 180 articles on observational learning with other species is not given here.

The effect of discriminative stimulus intensity on the acquisition of novel behavior was not readily apparent from a search of the literature. Davey (1981) and Mazur (1990) related the importance the intensity of the conditional stimulus (CS) has on the acquisition of a conditioned response (CR) in classical conditioning. In addition, the discriminative stimulus (SD) intensity is a factor in various types of discrimination procedures in operant conditioning. It also has been shown that markedly increasing the intensity of the stimulus above the training stimulus increases the response rate. These stimulus intensity dynamism effects are found in operant and classical conditioning, but reference to SD intensity, as it relates to the acquisition of novel behavior, was not found.

EXPERIMENT 1

THE ACQUISITION OF NOVEL BEHAVIOR BY HORSES THROUGH AUTOSHAPING

Introduction

In the laboratory, animals acquire the use of a key or lever (manipulandum), which electronically activates reinforcement devices, through shaping and autoshaping. Shaping is a procedure whereby the trainer reinforces closer and closer approximations by the subject to the desired behavior until the desired behavior is reached.

Shaping is often best accomplished by a person who is experienced with the process, while autoshaping can be accomplished without the aid of any person, once the devices are in place and programmed. Shaping a horse to operate an operant device has been demonstrated (Myers and Merker, 1960; Heffner and Heffner, 1986); however, at most horse farms and stables, persons experienced in systematic and technically accurate operant training would probably not be available. Thus the shaping process could become expensive and haphazard, and result in undesirable behaviors.

Autoshaping is the use of classical conditioning pairing procedures to establish an operant response. This is done by pairing a neutral stimulus (illuminated manipulandum) and a naturally reinforcing stimulus (barley) in such a way that the animal responds on the manipulandum. A search of the literature indicated that autoshaping has not previously been demonstrated with horses. One objective of this research was to examine autoshaping as a method of training a horse to use an operant device (animal-activated feeder). A second objective was to demonstrate that when a behavioral principle is established in other animals, it is likely that it will also apply to the horse.

Materials and Methods

Subjects

Eight horses were subjects (See Appendix A and B), and all were naive to the apparatus. The horses were housed in dry lots and stalls and received a maintenance diet of alfalfa hay. Water was provided ad libitum. Operant feeders provided rolled barley during daily training sessions. The horses were being trained under saddle, and normal riding sessions continued on the days the experiment was in progress.

Although it is common for laboratory animals to be at a deprived weight when used in operant experiments, these horses were not. Most owners would not consider reducing their horses' weight in order to allow them to acquire the use of the apparatus (Myers and Merker, 1960), and the feeder would lose its value for behavior modification if a horse had to be deprived to continue using the feeder on a daily basis. However, grain is a highly palatable and preferred food, even at free feeding (hay) weight, and it is not often necessary to deprive horses of feed in order for them to exhibit a strong desire to consume grain.

Apparatus

The horses were tested in an 18 x 7 m shed. There were other horses in paddocks and stalls adjacent to the shed. The shed opened to the south and the feeder and manipulandum were located on the north wall. The test area (3.7 m wide, 7.6 m long) was partitioned off by plastic tarps to restrict visibility and distraction. Each horse was tied by a .76 meters rope to an eye bolt anchored in the wall next to the feeder. Three one-hundred watt light bulbs and ambient sunlight illuminated the area.

The feeders had a rotary delivery system (Figure 1) (designed and constructed by the author) that delivered approximately 30 grams of rolled barley per activation (Myers and Merker, 1960). The feeder was cased in polyvinyl chloride (pvc) pipe 39 cm diameter and 108 cm long. An end cap was placed in the bottom to provide an eating surface. A portion of pipe (70 cm long) was removed to provide access to the delivered barley.

The nose press-plate (manipulandum) (Figure 2) was a 15.5 cm red plexiglass disk, mounted on a 15.5 cm diameter pvc pipe 1.5 cm long. When pressed, the manipulandum activated one or more of four micro switches connected in parallel. The nose-plate was housed in a box made of .6 cm pvc, 20 cm square, 10 cm deep. The manipulandum was rear illuminated by a 12-volt automobile tail light bulb. The control system was a conventional 28-volt electromechanical control rack located in an adjacent room. The experimenter observed all subjects and all sessions from this room and therefore could make appropriate adjustments in the programming as sessions progressed. Responses and trials were automatically recorded on an electromechanical counter.

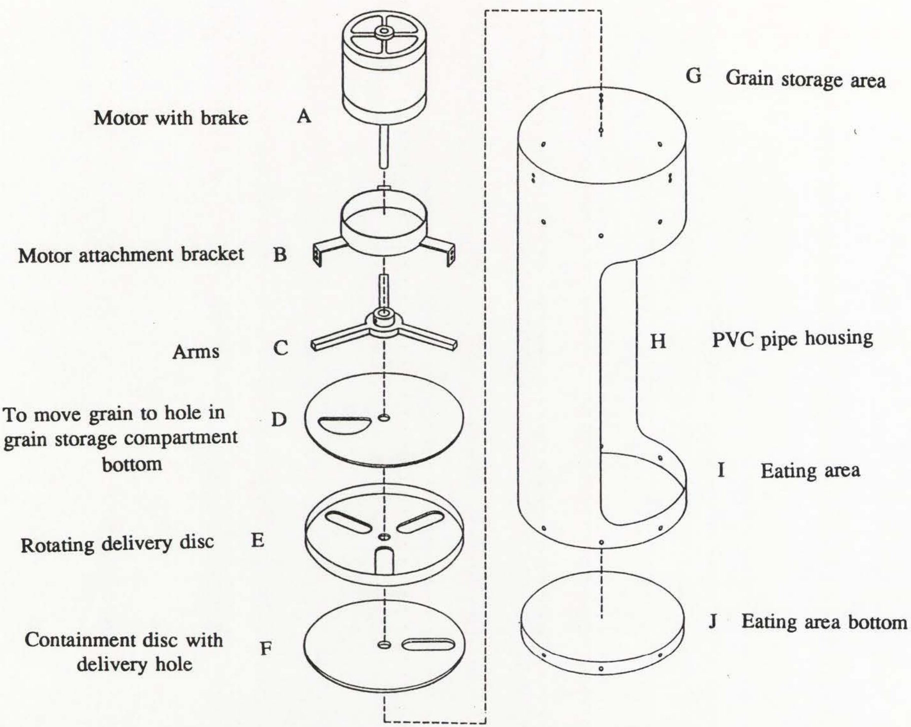

Figure 1. Rotary delivery grain feeder.

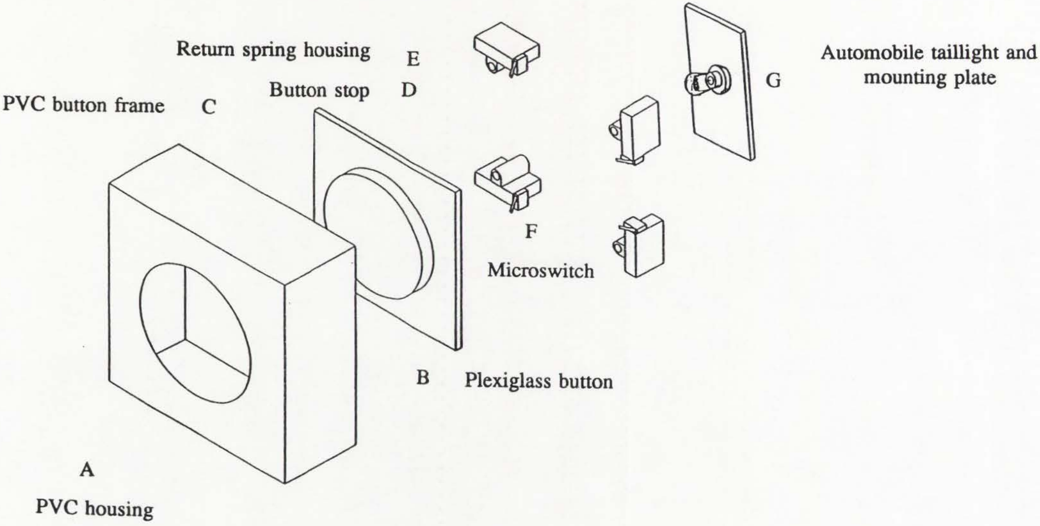

Figure 2. Manipulandum.

Procedure

Pre-Training

All subjects were tethered at the feeder (Figure 3) to habituate them to the delivery of grain and the modest noise from the feeder (magazine training). The manipulandum was inoperative with the light OFF. Grain was first placed manually in the area of the feeder to which grain was mechanically delivered by the feeder. When a horse began eating freely from the feeder, grain was delivered by remote control. A daily session lasted until the subject's allotment of grain was consumed (900 grams). Daily sessions continued until the horse would not move away while grain was delivered.

Baseline

Each subject was tethered individually near its own feeder. The manipulandum was operational but unilluminated. Barley was then delivered at 1 min intervals independent of the subject's behavior. The subject was exposed to three daily sessions with each session consisting of 30, 1 min continuous trials.

Results

No subjects responded during any of the 90 min trials, at which point the manipulation of conditions began.

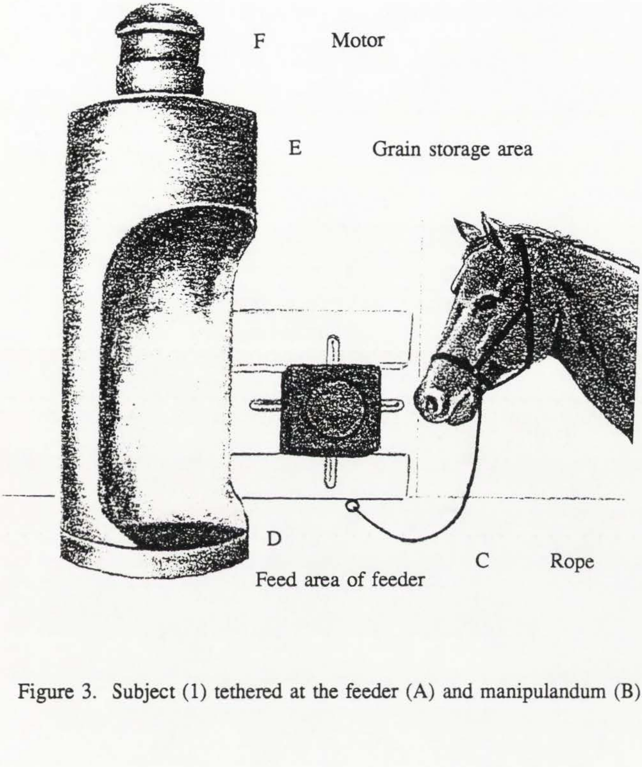

Figure 3. Subject (1) tethered at the feeder (A) and manipulandum (B).

Experiment 1-A

Subjects and Procedures

Four horses were subjects and each served as its own control. The manipulandum light (CS) was presented for 10 s. Upon termination of the manipulandum light, 30 grams of barley were delivered into the feed pan. Manipulandum illumination and delivery of barley constituted one paired stimulus trial. The CS was not illuminated during the interstimulus interval. The intertrial or interstimulus intervals were set for 1 min. (Subjects consumed the grain in 45 s ± 10 s). Barley was also delivered when a subject pressed the manipulandum, which would also terminate the trial. Each session consisted of 30 CS-food pairs unless the horse responded, whereupon the session was extended.

Autoshaping was considered to have occurred upon first response. After the first response, operant conditioning influenced further performance (Brown and Jenkins, 1968). That is, the behavior was immediately reinforced and therefore under the control of operant principles. Subjects were considered to have acquired maintained manipulandum pressing when manipulandum presses occurred in 4 of 10 consecutive CS-food trials. Acquisition of sustained responding or learning was considered to occur on the first of the four responses.

This criterion was based upon earlier work by the author in which it was noted that once a horse responded during 4 of 10 consecutive trials, the horse would continue to work. It was found that when 3 responses were made within 10 consecutive trials, sustained responding may not follow. Unaided sustained responding always occurred following responding in 40% of any 10 consecutive trials. Because sustained responding occurs at 40%, a higher percentage response rate seemed unnecessary.

All sessions started at approximately 1300 and lasted 30 to 45 min.

Results

Subject 1-10 (Figure 4 and Appendix A) accepted the procedure without incident and would reliably eat when the grain was delivered. The first autoshaping response occurred on the 90th paired trial. Four responses were made in rapid succession, but loose wire prevented reinforcement. Autoshaping continued after the malfunction was repaired. The next response was made in trial 186 (6th session) and criterion was reached on trials 186, 188, 192, 193. It was noted early in the experiment that this subject would turn its nose toward the illuminated manipulandum and stand motionless until grain was delivered.

Subject 2-10 (Figure 4 and Appendix A) first responded on the light OFF segment following the 44th trial (14th trial, 2nd session). The first appropriate response during light ON, was on the 46th trial (16th trial, 2nd session) and criterion was met on trials 46, 48, 49, 50. Early in the first session it was apparent that the horse was attentive to the light.

Subject 3-10 (Figure 4 and Appendix A) first responded on trial 76 (trial 30 of 2nd session). Criterion was reached on trials 76, 78, 81, 82. Early in the first session the filly was attentive to the light. Because this subject was attending to the illuminated

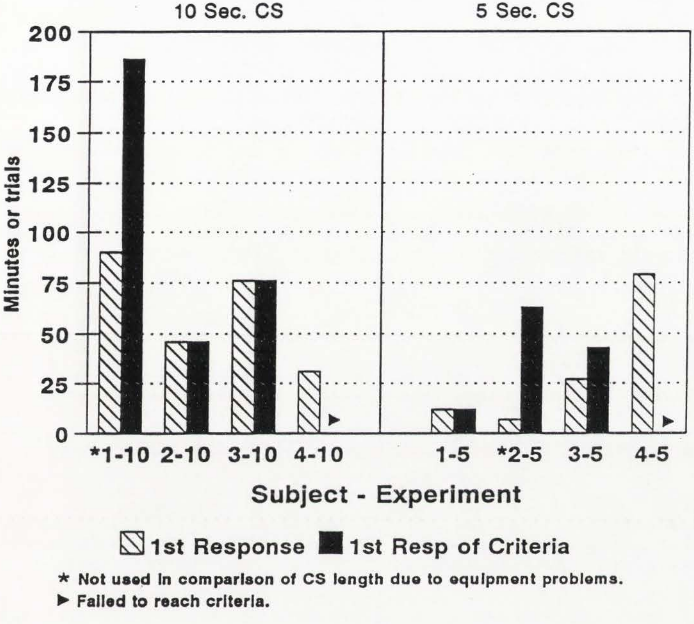

Figure 4. Trial in which first response was made and trial in which four responses with ten consecutive trials began, for the 10 s CS and 5 s CS of autoshaping.

manipulandum and her nose was extended close to the manipulandum, the first session was extended to 46 trials.

Subject 4-10 (Figure 4 and Appendix A) responded during light ON, on trials 31, 33, 34, and 165. Light OFF responses were made in trials 32, 84, and 91. After trial 34, the horse would extend its nose toward the light and then stand motionless until grain was delivered. On trial 200 (20th trial of the 7th session), the manipulandum light was changed to constant illumination and the 10 s CS experiment terminated. Subject 4-10 was originally not intended to be used in this study, but it was decided to replace Subject 1-10, because of equipment malfunction. When the number of trials needed to acquire the behavior exceeded that of subject 1-10, and it appeared that no further responding would occur, the experiment was terminated.

Experiment 1-B

Subjects and Procedures

Four subjects were used, with each horse serving as its own control. The experimental design was identical to Experiment 1 except the CS (light ON segment) was 5 s instead of 10 s.

Results

Subject 1-5 (Figure 4 and Appendix B), first responded on the 12th trial of session 1 and the criteria were met on trials 12, 13, 14, 16 of session 1.

Subject 2-5 (Figure 4 and Appendix B), first responded on the 7th trial. No further correct responding occurred during that session. In session 2 the filly appeared nervous and not attentive to the light. She stopped eating after 16 trials and the session was discontinued. By the 11th trial of the 3rd session, the filly was consistently placing her nose on top of the manipulandum box where a light leak had developed (when the light came on) and her nose would remain there until the grain was delivered. At the conclusion of this session the light lead was covered. This (and other stereotyped behavior) could be considered an autoshaped response because it was directed at a predictive light source. If considered appropriate, criteria would have been met on trials 57, 58, 59, 60. In the first session after the light leak was eliminated (4th total session), the filly persisted with the established behavior through most of the first half of the session. Gradually this behavior extinguished. In the 2nd session (5th total session) after restarting the experiment, appropriate responses occurred on trials 39 and 52. In session 3 (6th total session), criteria were met on trials 63, 65, 69, 71 (total 142, 144, 148, 150).

Subject 3-5 (Figure 4 and Appendix B) first responded on an unilluminated segment in trial 6. The first appropriate response was on trial 27. Criteria were met on trials 43, 44, 47, 53 (trials 3, 4, 7, 13 of session 2).

Subject 4-5 (Figure 4 and Appendix B) was not originally intended to be used in Experiment 1-B, but was used to replace subject 2-5 because of an equipment malfunction. Responses during light ON occurred during trials 79, 251, 266, and 275. Light OFF responses were made during trials 17, 135, 207, 243, 286, 287, and 314. Beginning in the first session the horse would extend his nose toward the manipulandum light and stand motionless until grain was delivered. This behavior persisted through the majority of the experiment. The experiment was terminated after 365 trials.

Experiment 1-C

Subjects and Procedures

Since Subject 4-5 had not acquired maintained manipulandum pressing when exposed to a 5 s CS in 365 trials, from the 366th trial the CS was lengthened to 60 s. The rest of the procedure remained the same as in the previous experiment.

Results

The first response occurred during the unilluminated segment of trial 2 of the 1 min CS (Figure 5). The first appropriate response occurred on trial 5. Once the first appropriate response was made, only 1 trial of 32 subsequent trials (trial 15 in which a response with the light OFF occurred) did not contain a response with the light ON. Criteria were met on trials 5, 6, 7, 8, but time taken to respond was not noted. Following these trials the time to response after light ON was recorded. There was a reduction in time to respond.

Experiment 1-D

Subjects and Procedures

Since Subject 4-10 did not acquire maintained manipulandum pressing when exposed to a 10 s CS after 200 trials, the manipulandum was illuminated continuously with no reinforcement delivered unless a response was made. The light would terminate

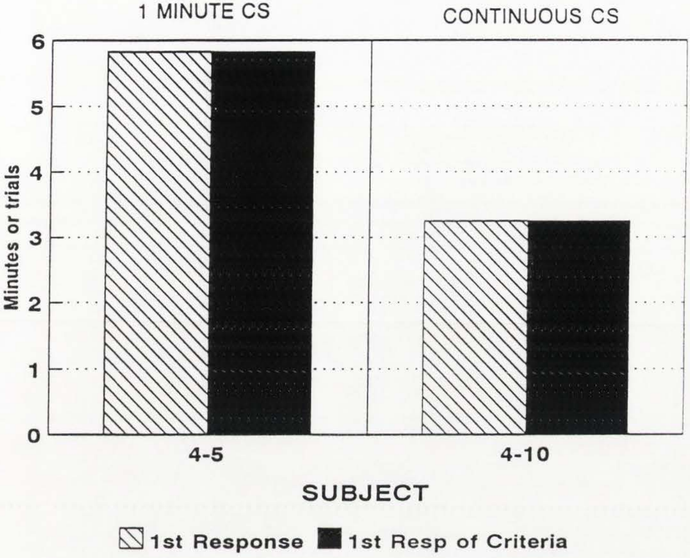

Figure 5. Trial in which first response was made and trial in which four responses within ten consecutive trials began for the 1 min CS and the continuous CS of autoshaping.

for 1 min after a response, then the manipulandum would be illuminated again after the 1 min interval.

This procedure was implemented because it was observed that the subject would extend its nose toward the manipulandum when illuminated and would stand motionless until grain was delivered. This behavior appeared to be a superstitious response that interfered with the acquisition of a pressing response. Eliminating the reinforcement for this behavior would extinguish it. Manipulandum pressing had previously been elicited through autoshaping and reinforced by the delivery of barley, so once motionless posturing was extinguished, it was likely that manipulandum pressing would emerge.

Results

This horse (Subject 4-10) responded 3 min and 15 s after the CS was illuminated continuously (Figure 5) and maintained the responding which began with this first response. The next response occurred 1 min and 30 s after re-illumination of the manipulandum. The final response of the session occurred 4 s after the manipulandum was re-illuminated for the last trial (230 trials total, 30 trials after continuous illumination).

Discussion

It can be difficult to evaluate the effectiveness of autoshaping, for once the subject makes one response, operant conditioning is affecting the further development of the behavior. However, if the trial is evaluated only by first response, it does not necessarily indicate that the desired response will be maintained.

All horses met the criteria of the first response being made before a series of 90 trials were completed (the length of the baseline trials) and well within the 160 trial criteria set forth by Brown and Jenkins (1968) for pigeons. No limit was placed on the number of trials in which an animal had to reach the criteria for sustained responding (which were that responses occurred in 4 of 10 consecutive trials, and acquisition of sustained responding or learning was considered to occur on the first of four responses), whereby all horses reached criteria. Although subjects 4-5 and 4-10 did not achieve the desired behavior when exposed to the 5 and 10 s stimulus, with the extension of the duration of the CS, responding occurred.

In all cases it became evident that the horses exhibited specific movements and(or) posturing (extending noses toward the illuminated manipulandum, and remaining motionless until grain was delivered) oriented towards the lighted manipulandum before responding. This type of behavior did not occur during baseline trials. The specific parameters used to establish and evaluate autoshaping may have interfered with the acknowledgment of acquisition of sustained manipulandum pressing. Motionless posturing of Subjects 4-5 and 4-10 was reinforced by the automatic delivery of grain and, consequently, this behavior resulted in delaying the prescribed response until the length of the CS was changed.

Two factors might explain Subject 2-5's orientation toward the light leak. First, the leak emitted a natural or white light (the manipulandum was red) and the feeder was made of white pvc. It has been demonstrated that autoshaping occurs more rapidly when the CS is the same color as the light that illuminates the feed hopper (Sperling et al., 1977). Although the eating area was not illuminated (except by ambient light) the color of the feeding apparatus and the light leak were similar. Davey (1981, p. 185) states "colour and form of the CS have no effect on the rate of autoshaped pecking in the pigeon [Perkins et al., 1975] unless the key colour is similar to the light illuminating the food hopper, in which case autoshaped responding is acquired sooner [Sperling et al., 1977]." Since the eating area was not light illuminated, similar color was not considered important. The manipulandum light was red because, to the author, there appeared to be more contrast between red illuminated and unilluminated plexiglass than white. A second factor is that the intensity of the light from the leak was brighter than that from the manipulandum (the light was shaded by a dark red plexiglass), and brighter light is more effective in eliciting a response.

When first response is used to evaluate autoshaping success, the average number of trials needed for the 5 s CS group was 51% less than for the 10 s CS group. However, because of the range of response, there was no statistically significant difference in time to first response between the lengths of the CS. When comparing the horses using the criteria of responses made in 4 of 10 consecutive trials, there was no significant difference between the two treatments (subjects 4-5 and 4-10 were not used in the comparison because of equipment problems that may have affected acquisition of the behavior).

Noting that Subjects 4-5 and 4-10 did not respond in the desired manner until the CS was extended, delaying sustained responding, a better strategy may be to start by displaying the CS for a variable length of 5 s, and after the first response is made, switch to a constant length stimulus.

Brown and Jenkins (1968) considered the variation of the length of the intertrial interval important. The intertrial interval was not varied in this study; it remained constant at 1 min. Through visual appraisal it appeared that no obvious behavior developed that adversely affected the autoshaping process.

Considering the wide range of responsiveness, autoshaping under the contingencies used in these experiments did not yield the desired uniform results. Problems that arose were as troublesome as those that would be encountered when an inexperienced person was involved in shaping. More research is needed to refine these techniques.

Conclusion

Horses can be autoshaped, although a wide range of responsiveness was exhibited. There was no significant difference between a 5 s and 10 s CS. Manipulating the CS duration is an effective strategy to extinguish superstitious posturing and to facilitate sustained responding.

Summary

Autoshaping has not previously been demonstrated with horses. This study examined whether a horse could be autoshaped and provided insight as to the use of autoshaping as a means by which horses could acquire the use of an animal-activated feeding device for behavior modification under normal management conditions. Eight horses were subjects, all naive to the apparatus and each horse served as its own control. The criteria were first response and acquisition of the behavior was defined as the occurrence of manipulandum presses in 4 of 10 consecutive trials. Acquisition of sustained responding or learning was considered to occur on the first of the four responses. Subjects were first habituated to the apparatus and a baseline of behavior established. Four experiments were then conducted. Experiments 1 and 2 involved either a 10 or 5 s conditional stimulus, respectively, and four naive horses were used in each experiment. In Experiments 1-A (10 s CS) and 1-B (5 s CS), first responses were made by all subjects. Criterion for behavior acquisition was met by three horses in each experiment. Experiment 1-C involved the horse that had not acquired continued responding with the 5 s CS. The CS was lengthened to 1 min. Sustained responding was achieved. Experiment 1-D involved the horse which had not acquired sustained responding during the 10 s CS. The CS with this subject was on continuously. Sustained responding was achieved. All horses were autoshaped, but there was a wide range of responsiveness. There was no significant difference in acquisition of manipulandum pressing behavior between the 5 s and 10 s CS.

EXPERIMENT 2

OBSERVATIONAL LEARNING IN TWO-YEAR-OLD TENNESSEE WALKER GELDINGS

Introduction

Observation is a method by which animals learn. Rates of learning improve when naive animals observe experienced animals performing tasks. Observation is considered by common wisdom to be one means whereby horses can acquire undesirable behavior from other horses, and it is also considered, by some, to be a method for improving horses' ability to acquire a desirable skill.

In the only previous study of observational learning involving horses, this association was not verified (Baer et al., 1983/84) and two possible explanations are proposed to explain why. The observer horses apparently did not associate the horse at the bucket, with eating grain, as was assumed. More importantly, the task was not sufficiently complex to provide a discernable contrast between the effects of observation and non-observation, as both were influenced by a simple operant conditioning once the first trial was made. A slight improvement was shown initially; however, by the end of the experiment there was no significant difference between the observers and non-observers.

The present study was designed to demonstrate some effects of observation on the acquisition of "non-traditional" behavior in horses. Pressing a manipulandum to deliver grain is not a traditional method by which horses obtain grain. Horses naturally investigate novel objects with their nose and upper lip, and initially pressing a manipulandum with its lip or nose is not novel in and of itself. The association of grain delivery with button pressing is a novel learning situation. It was thought this novel learning situation could be used to reveal the difference in rate of learning acquisition between observers and non-observers (in this case, spontaneous responding).

Materials and Methods

Subjects

Six two-year-old Tennessee Walker geldings were subjects (4 observers, 2 non-observers). All were naive to the apparatus. Two older Tennessee Walker geldings were trained as demonstrators. Between sessions, horses were communally housed in a 26 m^2 dry lot. Alfalfa hay was fed at maintenance. Water was provided ad libitum. Rolled barley was offered only from an operant feeder in daily experimental sessions. The subjects were also being trained under saddle, and normal riding sessions continued throughout the experiment.

Apparatus

The facilities and the experimental apparatus were the same as used in the autoshaping experiments described previously. In the observational phase of the study, two operant feeders were placed 1 m apart, separated by a partition (Figure 6). This partition prevented physical contact but allowed the horses to view each other. The partition consisted of a plywood panel mounted on a metal frame (1.07 m high and 2.13 m long) and a welded steel rod panel composed of 10.15 cm squares extended to

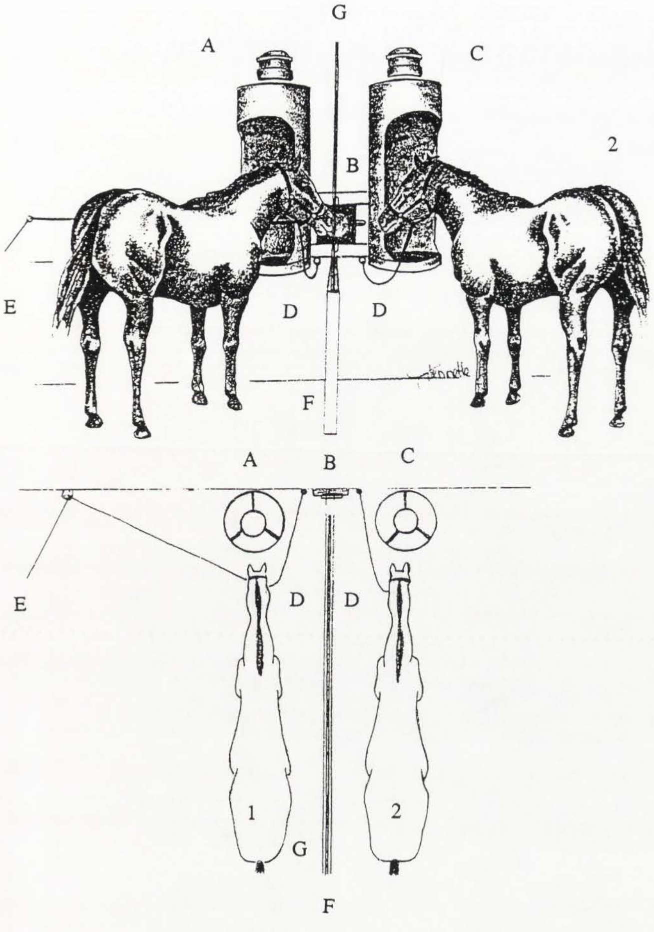

Figure 6. The demonstrator (1) and naive (2) horses tethered (D) side by side with one manipulandum (B) and two feeders (A and C). Separated by partition (G and F). The demonstrator could be restrained with rope (E).

the roof. The manipulandum was placed midway between the feeders. There was a 30.5 cm space between the partition and the manipulandum to provide access to the manipulandum by both horses. The demonstrator and the subject were tethered to the left and right feeders, respectively, by a 75 cm rope. A rope was attached to the noseband side ring of the demonstrator's halter, then passed through an eye bolt 2 m to the left of the feeder and extended to be controlled by the experimenter. This rope was used to restrict the demonstrator from access to the manipulandum.

Procedure

Subjects were habituated to the equipment with the manipulandum unilluminated and inoperative before the sessions began. Grain was first placed manually in the area of the feeder to which grain was mechanically delivered by the feeder. When a horse began eating freely from the feeder, grain was delivered by remote control. A daily session lasted until the subject's allotment of grain (1.5 kg) was consumed. Daily sessions continued until the horse would not move away while grain was delivered.

Two approaches were used to evaluate observational learning. Four subjects were observers and two subjects were non-observers. The four observers served as their own control in a single subject design. In addition, two non-observer subjects were used to examine the acquisition of the response without the aid of a demonstrator and to serve as a control group.

Statistical analysis involved a General Linear Models Procedure (SAS Institute, Inc., 1986). The dependent variables were one minute trials to first response and one minute trials to criteria. The treatments were observers vs. non-observers.

Non-observers were tethered individually at the operant feeder (Figure 7). The manipulandum was illuminated. A single press of the manipulandum was set to deliver barley. No assistance was given to the subjects to aid them in acquiring the pressing behavior. Learning was defined as the occurrence of manipulandum presses in 4 of 10 consecutive trials before 100 trials were concluded. Acquisition of sustained responding or learning was considered to occur on the first of the four responses.

Since each observer was to serve as its own control, a baseline of behavior was initially determined. The manipulandum was unilluminated and inoperative so that any manipulandum pressing would not be reinforced. The subjects were tethered at the feeder without grain (Figure 7) and had access to the inoperative manipulandum (50 min/day). The subject remained on this procedure until they stood for 50 min with zero responding.

The day following a criterion non-response extinction session, a naive subject (right side) and demonstrator (left side) were paired at the feeders (Figure 6). Both horses had access to a common manipulandum that operated both feeders. The manipulandum was continually illuminated during each session. Two responses (FR-2) were required by the demonstrator to activate the feeders. These responses were usually made rapidly while the demonstrator kept its nose close to the manipulandum. Upon delivery of grain, the demonstrator was allowed to eat and then restrained from pressing the manipulandum again for 1 min. The subject had access to the manipulandum continuously, and grain was delivered each time it pressed the manipulandum (FR-1).

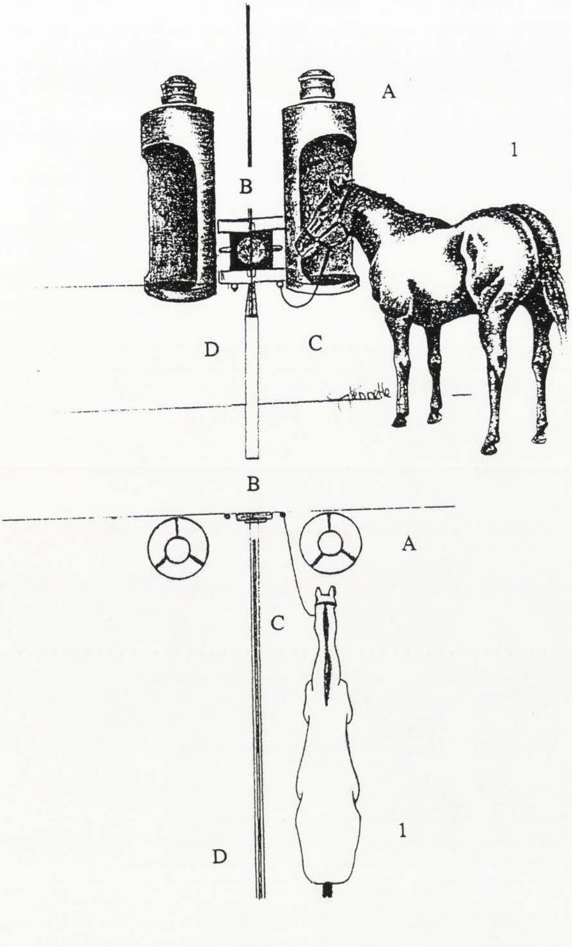

Figure 7. Non-observer subject or Observer subject (1) tethered at the feeder (A) without a demonstrator to establish a behavioral baseline. (Manipulandum (B), Tether Rope (C), Partition (D))

The criterion for successful learning was that manipulandum presses occurred in 4 of 10 consecutive trials before 100 trials were concluded. Each daily session consisted of 50 1-min trials.

Results

Non-Observers

Subject 1 (Figure 8) responded in trials 3, 7, 16, 43, 51, and 68 and criteria (4 within 10 trial) were met on trials 79, 83, 85, and 88.

Subject 2 (Figure 8) responded in trials 1, 28, and 46 and criteria were met on trials 53, 57, 58, and 60 (two responses were made in trial 60).

Observers

Extinction trials. Subjects 1 and 2 (Figure 8)--The extinction phase for these subjects were completed in two 50-min sessions. Both subjects made three responses in the first session, and none in the second.

Subject 3 (Figure 8)--The extinction phase for this subject was completed in four sessions. Four responses were made in the first session, two in the second, ten in the third, and none in the fourth. Four responses were made within 10 1-min segments on day three (trials 7, 8, 11, 14).

Subject 4 (Figure 9)--The extinction phase for this subject was completed in three sessions. Nineteen responses were made in the first session, six in the second, and none in the third.

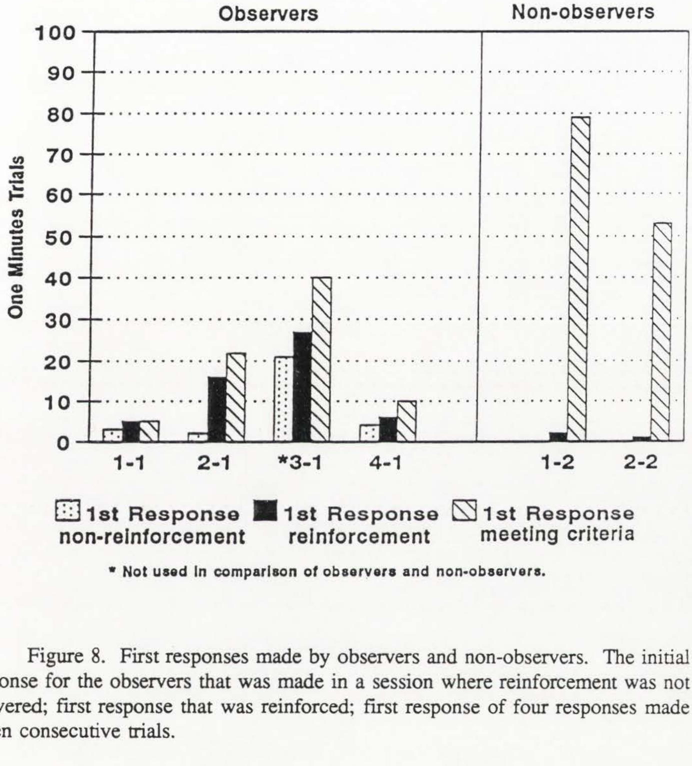

Figure 8. First responses made by observers and non-observers. The initial response for the observers that was made in a session where reinforcement was not delivered; first response that was reinforced; first response of four responses made in ten consecutive trials.

Observation trials. Subject 1 (Figure 9) responded in trials 5, 6, 7, 8, and in each consecutive trial. Criteria were achieved within the first session.

Subject 2 (Figure 9) responded in trials 16, 22, 23, 24, and in each consecutive trial. Criteria were achieved within the first session.

Subject 3 (Figure 9)--The first session was excluded because "accidental" presses were made on trials 7, 13, 15, 18, 20, and 23, when the horse extended its muzzle between the manipulandum and partition and because its head position operated the manipulandum with its cheek. Delivery of feed was prevented with this type of response by the experimenter, and the behavior ceased. Responses occurred in trials 27, 28, 40, and 41 of the second session and in each subsequent consecutive trial. Criteria were achieved within the second session. (Subject 3 was not used in the analysis because the unexpected method of pressing the manipulandum had to be extinguished.)

Subject 4 (Figure 9) responded in trials 6, 7, 10, 11, and in each consecutive trial. Criteria were achieved within the first session.

Discussion

The method used in this study was original and differed from the methods described by Adler (1955). The close association of the observer and demonstrator in the single chamber method was employed but the disadvantages of delay and dominance interaction were eliminated by restricting the demonstrator's access to the manipulandum after each delivery of reinforcement. A partition was also used to separate the demonstrator and the observer and their individual feeders. The partition permitted visual contact and allowed access to a common manipulandum.

The design in this research employed a novel and non-intuitive task. This task, however, was not so complex that the horse could not acquire the desired response through spontaneous behavior. To meet Adler's criteria the observer had one minute after the delivery of grain reinforcement (15 s ± after eating) to respond while the demonstrator was restricted from access to the manipulandum. Practice was not only excluded (as stated in Adler's criteria c), spontaneous responding was extinguished. To assure an identical response, nose, muzzle or lip presses were the only responses counted. The "chance factor" was reduced by extinguishing unreinforced (no barley was delivered) spontaneous responding (in pretraining) and by requiring maintained responding without the aid of the demonstrator after reinforced responding was established.

During baseline (extinction) sessions, all four observer subjects pressed the manipulandum, even though these responses were not followed with grain. Responding may have occurred because in the habituation sessions, standing and waiting for grain to be delivered, and eating, were behaviors that were accidentally reinforced by the automatic delivery of grain. In the absence of reinforcement, where it had occurred before, new behavior emerges (Pryor et al., 1969). The manipulandum was then "investigated" and pressed. Some sustained pressing of the inoperative manipulandum occurred because the act of pressing the manipulandum was (by definition) reinforcing to these subjects. When the "novelty" of pressing satiated, pressing extinguished.

All subjects acquired the behavior of pressing the manipulandum. Horses that observed the behavior demonstrated by another horse met criteria sooner than those that did not observe another horse (Figure 8). There was a significant difference in the mean responses between observers and non-observers ($P < .05$). It is important to note that observational learners had been on pre-trial extinction schedules, which may have actually retarded the acquisition of manipulandum pressing. Each observer horse may have responded more readily if extinction of manipulandum pressing had not occurred.

Observation of a behavior did not improve first response time (Figure 8). However, first response does not appear to accurately indicate acquisition of a behavior, as the non-observers pressed the manipulandum in earlier trials than the observers but were slower to acquire sustained manipulandum pressing behavior.

Social facilitation may have influenced the reemergence of responding. Social facilitation can be thought of as "contagious" behavior that involves an "instinctive tendency," where one animal acts as a "releaser" for an identical behavior in another (Thorpe, 1956). However, social facilitation is considered to be a transitory social phenomenon and it does not produce permanent behavioral changes (Davey, 1981). Moving an object with an upper lip or nose is an "instinctive tendency"; however, pressing a button or manipulandum in order to receive grain is not instinctive. When the behavior that is adapted is "non-instinctive," it is classified as "imitation learning" (Davey, 1981).

Both the observers and the non-observers spontaneously responded in the presence of the illuminated manipulandum when it was initially presented; however, observer responses were extinguished. The observers first response, in the observation trials, may have initially reerupted because of social facilitation, but sustained responding or "learning" that pressing the manipulandum would deliver grain was achieved through imitation learning. This is apparent because the observers obtained sustained responding more rapidly than the non-observers even though the non-observers initial response was more rapid than the observers (in the trials in which responses were reinforced by grain).

In addition, the predicted behavior, if observational learning did not occur, would be for the subject to stand and wait for the delivery of barley. Standing and "waiting" for barley to be delivered should have been reinforced when the demonstrator pressed the manipulandum and delivery of barley occurred. However, this did not occur, for the observer came to imitate the demonstrator's behavior.

Summary

The presence of some forms of behavior in horses has sometimes been attributed to observational learning. This study investigated a limited aspect of observational learning with Tennessee Walker geldings. Six naive two-year-olds were subjects. Four served as observers and two as control non-observers. Two methods were used in the evaluation: (a) a single-subject design with each observer serving as its own control, and (b) non-observers serving as a control group. Baseline performance was established for the observer without a demonstrator present. Following these sessions, naive and trained demonstrator horses were tethered at feeders, separated by a see-through partition. A single manipulandum, accessible to both horses, operated both feeders. The demonstrator was restrained from the manipulandum for 1 min after each delivery of barley. Observers had access to the manipulandum continuously. Non-observers were tethered at a feeder with no other horse present when the manipulandum was illuminated and the feed delivery system operational. Learning was defined as the occurrence of manipulandum presses in 4 of 10 consecutive trials before 100 demonstration trials were concluded. Acquisition of sustained responding or learning was considered to occur on the first of the four responses. The observers required 5, 10, 22, and 40 ($\bar{x} = 19.25$) demonstration trials, respectively, to meet criteria. The non-observers required 53 and 79 ($\bar{x} = 66$) trials. Horses can learn through observation. Naive subjects in this study learned significantly faster ($P < .05$) when they observed a trained horse operate a "nonintuitive" manipulandum.

Conclusion

Horses appeared to acquire novel behavior more quickly by observing other horses demonstrate the behavior. The observers required fewer trials to acquire a response than non-observers. Furthermore, the observers acquired the behavior even after pressing of the manipulandum had been recently extinguished.

EXPERIMENT 3

THE EFFECT OF THE INTENSITY OF THE MANIPULANDUM LIGHT AS A DISCRIMINATIVE STIMULUS ON ACQUISITION OF A NOVEL BEHAVIOR

Introduction

Discriminative stimulus (SD) saliency was not originally a focus of study for this thesis. Due to a procedural "error" (starting this experiment at dusk vs. midday in the other experiments) made by the author, an interesting comparison between intensity of the SD as it affects acquisition of novel behavior was noted.

It has been established that the SD saliency is important in stimulus discrimination and avoidance conditioning, and that the saliency of the CS is important in conditioning a response (Davey, 1981; Mazur, 1990). The effect of the SD saliency as it relates to the acquisition of a novel behavior is not reported in the literature.

Optimum SD saliency is not obvious. If the intensity of the manipulandum light is too weak, it may not be apparent to the subject. On the other hand, if the intensity is too strong, it may be aversive. Either extreme might delay the acquisition of a behavior. In this and previous studies a 12-volt car taillight was used because it was apparent to the author when illuminated and it was not so bright as to be uncomfortable to look at.

This study investigated the effect of two different light intensities on the discriminative stimulus on the acquisition of a novel behavior. The apparent intensity of the light was changed by varying the environmental light conditions. Light color and actual intensity did not vary, and distance from subject to manipulandum remained constant.

Materials and Methods

Subjects

A two-year-old Tennessee Walker filly (SH1) and a three-year-old Tennessee Walker pony cross gelding (SH2) were subjects for the higher intensity SD portion of the study. The subjects for the lesser intensity SD portion of the study were two two-year-old Tennessee Walker geldings (SL1 and SL2). All were naive to the apparatus. The horses were housed in dry lots and received a maintenance diet of alfalfa hay. Water was provided ad libitum. Rolled barley was offered from an operant feeder in daily sessions of the experiment. The horses were being trained under saddle, and normal riding sessions continued on the days the experiment was in progress.

Apparatus

The facilities and equipment were the same as used in previous experiments with the exception of lighting. The lesser intensity SD study took place in the shed, which was illuminated by three 100-watt light bulbs and ambient sunlight that filtered by the plastic tarps and openings in the walls of the building. The experiment started at approximately 1300 each day.

In the higher intensity SD study, the shed was illuminated with only one 100-watt light bulb illuminating the area and the experiment commenced after sunset.

Variation in environmental lighting caused an extreme difference in the apparent intensity of the SD. (The actual intensity of the 12-volt light was constant.)

Procedure

Subjects were habituated to the equipment during daylight conditions. The day following habituation, each horse was tethered alone at the operant feeder. The manipulandum was illuminated and the feeder was activated to deliver barley contingent upon manipulandum pressing. (No barley was delivered unless a response was made.) The subjects were to acquire use of the feeder through reinforcement of spontaneous responding.

The criteria for successful learning were that manipulandum presses occurred in 4 of 10 consecutive trials before 100 trials concluded. Acquisition of sustained responding or learning was considered to occur on the first of the four responses.

Statistical analysis was made using a General Linear Models Procedure (SAS Institute, Inc., 1986). The dependent variables were 1 min trials to first response and to criteria. The treatments were horses exposed to a less salient SD (non-observers from the observational learning study exposed to the SD in daylight hours) vs. horses exposed to a more salient SD (non-observers after sunset).

Results

Higher Intensity SD

Subject SH1 (Figure 9) responded on the first trial and responded continuously thereafter.

Subject SH2 (Figure 9) responded on the second trial then responded every other trial after the initial response. It was noted that subject SH 2 took longer to consume the grain and was still eating at the beginning of the alternate trials.

Lesser Intensity SD

Subject SL1 (Figure 9) responded in trials 2, 7, 16, 43, 51, and 68. Criteria were met on trials 79, 83, 85, and 88.

Subject SL2 (Figure 9) responded in trials 1, 28, and 46. Criteria were met on trials 53, 57, 58 and 60.

Discussion

There was no difference in the length of time it took the subjects to make the first response (H $\overline{x} = 1.5$, L $\overline{x} = 1.5$). There was a significant difference ($P < .05$) between the horses exposed to the higher intensity SD and the lesser intensity SD in acquiring the criteria (H $\overline{x} = 1.5$, L $\overline{x} = 66$). The horses exposed to the higher intensity SD acquired the behavior more quickly than horses exposed to the lesser intensity SD.

However, there are additional factors that may have influenced the results. The times at which the experiments occurred were different (1300 and after sunset). This

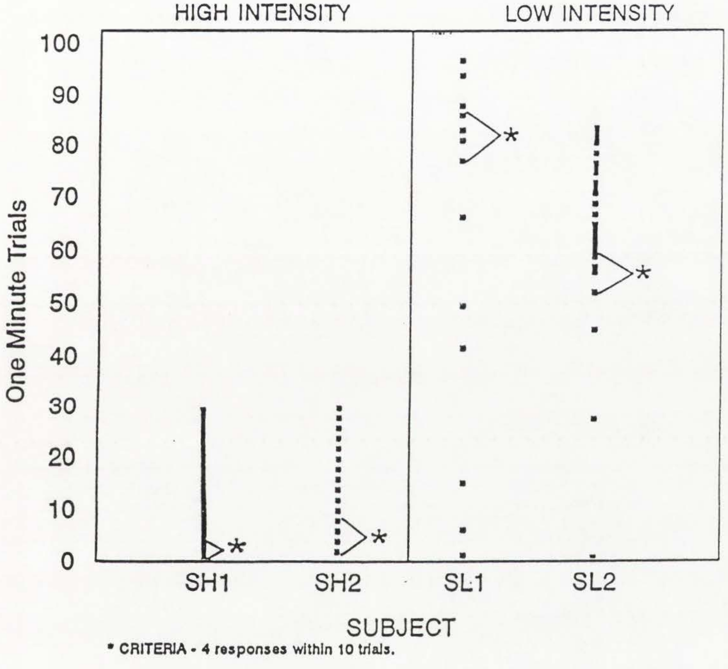

Figure 9. Response pattern of subjects exposed to high intensity SD and low intensity SD during 1 min trials.

time difference may have resulted in the subjects being at a different level of deprivation. The evening feeding had occurred before the experiment started, but the subjects were not allowed to finish their ration of hay. The time difference itself may not have altered the results significantly, but the inconsistency in feed deprivation may cause one to question the reliability of the comparison of SD intensities. However, there was a dramatic difference in acquisition rate on the desired response and the phenomenon should be explored further and defined more accurately.

Summary

It has been established that discriminative stimulus (SD) saliency is an important factor in discrimination and avoidance conditioning, and that the saliency of the conditional stimulus is important in conditioning a response. The effect of SD intensity as it relates to the acquisition of behavior was not found in the literature. This study investigated the effect of the intensity of the discriminative stimulus on the acquisition of behavior in a novel learning situation by horses.

A two-year-old Tennessee Walker filly and a three-year-old Tennessee Walker pony cross gelding were subjects for the higher intensity SD portion of the study. The subjects for the lesser intensity SD portion of the study were two two-year-old Tennessee Walker geldings. All were naive to the apparatus. The test facilities were identical to those detailed in the previous study. The variations were the difference in the "apparent" intensity of the SD, the time of day the trial occurred and, possibly, the length of deprivation. Subjects were tethered individually at the feeders. The manipulandum was illuminated and operative. No barley was delivered unless the manipulandum was pressed. Successful acquisition of sustained nose press behavior was defined as responses occurring in 4 of 10 consecutive trials. There was a significant difference in acquisition of sustained manipulandum pressing response between subjects exposed to different intensities of the discriminative stimulus. The subjects exposed to the higher intensity stimulus acquired sustained responding significantly faster.

Conclusion

The higher intensity stimulus group acquired sustained manipulandum pressing significantly faster than the lower intensity group. There was no difference in time to first response; however, there was a significant difference ($P < .05$) in acquisition of manipulandum pressing between the treatments. It is important to note that because of the possible differences in deprivation of the subjects, it is not clear if the difference in acquisition was strictly due to stimulus intensity.

GENERAL CONCLUSION SUMMARY

The results of the first two studies contained in this thesis are compatible with existing studies involving other species. Although the results of the stimulus intensity study are not definitive, the results are not inconsistent with operant principles. Operant and respondent research involving horses has demonstrated that principles which apply to other species apply to horses.

Due to the consistency of the application of behavioral principles across all species that have been examined, it is reasonable to assume that behavioral problems in horses, such as cribbing and stall weaving, can be corrected through operant conditioning techniques. Nevertheless, further research should be done to expand specific operant techniques with horses. Until such research is accomplished, one should feel comfortable using principles established in other species, on horses.

Reviewing the results of the three studies, the autoshaping subjects acquired sustained responding in an average of 124.25 trials with a range of 12 to 370 trials. The observer subjects acquired sustained responding in an average of 12.33 trials (omitting the subject that responded incorrectly at first) or in an average of 19.25 trials (including all subjects) with a range of 5 to 22 or 5 to 40, respectively. Non-observers or lesser intensity SD subjects acquired sustained responding in an average of 66 trials with a range of 53 to 79. The higher intensity SD subjects acquired sustained responding in an average of 1.5 trials, with a range of 1 to 2.

It would appear from these results that exposure to the high intensity SD conditions coupled with spontaneous responding is the most effective way to train a horse to use an animal-activated feeder without the use of experienced personnel. Autoshaping appears to be the least effective.

Future projects should include a more definitive study on the effects of SD intensity on the acquisition of novel behavior; a study on the use of operant feeders to eliminate undesirable behavior and enrichment of the environment of confined horses; the elimination of cribbing through operant techniques; and an operant vision test for horses.

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APPENDICES

Appendix A

TABLE A.1. SUBJECT 1-10, BLACK TENNESSEE WALKER GELDING NO. 1
5 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	# of Responses	Light On/Off
1	30	30	Equipment Malfunction		
2	60	30	90	1	On
3a	90	30		3**	Off
3b	96	6			
4	126	30			
5	159	33			
6	203	44	*186	1	On
			*188	1	On
			*192	1	On
			*193	1	On

*Trials with responses were made within a 10 trial segment.

**Four responses were in rapid succession. No reinforcement was delivered because of an equipment malfunction.

TABLE A.2. SUBJECT 2-10, BAY QUARTER HORSE FILLY NO. 1
3 YEARS OF AGE (FULL SISTER TO 2-5)

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	30	30			
2	60	30	44	1	Off
			*46	1	On
			47	1	Off
			*48	1	On
				2	Off
			*49	1	On
				2	Off
			*50	1	On

*Trials with responses were made within a 10 trial segment.

TABLE A.3. SUBJECT 3-10, BAY TENNESSEE WALKER FILLY 2 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	46	46			
2	86	40	*76	1	On
			*78	1	On
			*81	1	On
			*82	1	On

*Trials with responses were made within a 10 trial segment.

TABLE A.4. SUBJECT 4-10, SORREL QUARTER HORSE GELDING
4 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	30	30			
2	60	30	31	1	On
			32	1	Off
			33	1	Off
			34	1	On
3	90	30	84	1	Off
4	120	30	91	1	Off
5	150	30			
6	180	30	165	1	On
7	200	10			

Appendix B

TABLE B.1. SUBJECT 1-5, BLACK TENNESSEE WALKER GELDING NO. 2
4 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	30	30	*12	1	On
			*13	1	On
			*14	1	On
			*16	1	On

*Trials with responses were made within a 10 trial segment.

TABLE B.2. BAY QUARTER HORSE FILLY NO. 2
2 YEARS OF AGE (FULL SISTER TO 2-10)

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	30	30	7	1	On
2	46	16	(Stopped eating)		
3	79	33	*57 contact	(top of box)	On
			*58 contact		On
			*59 contact		On
			*60 contact		On
			79 contact		Off
4-1	109-30	30			
5-2	139-60	30	118-39	1	On
			131-52	1	On
6-3	*162-93	33	*142-63	1	On
			*144-65	1	On
			*148-69	1	On
			149-70	1	Off
			*150-71	1	On

*Trials with responses within a 10 trial segment.

TABLE B.3. SORREL TENNESSEE WALKER GELDING NO. 1
4 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	40	40	6	2	Off
			8	2	Off
			12	1	Off
			27	1	On
			30	1	On
				6	Off
2	70	30	*43	1	On
			*44	1	On
			*47	1	On
			*53	1	On

*Trials with responses were made within a 10 trial segment.

TABLE B.4. SORREL TENNESSEE WALKER GELDING NO. 2
5 YEARS OF AGE

Session	Total Trials	Session Trials	Trial in which Responses Occurred	No. of Responses	Light On/Off
1	30	30	17	1	Off
2	65	35			
3	100	35	79	1	On
4	130	30	135	1	Off
5	150	20			
6	180	30			
7	215	35	207	1	Off
8	250	35	243	1	Off
9	285	35	251	1	On
			266	1	On
			275	1	On
10	315	30	286	1	Off
			287	3	Off
			314	1	Off
11	350	35			
12	365	15			

Appendix C

TABLE C.1. RESPONSES RECORDED FOR AUTOSHAPING SUBJECT 4-5 WHEN EXPOSED TO 1 MIN CS AND TIME TO RESPONSE FOR ILLUMINATION OF CS

Trials in which responses occurred	No. of responses	Light On/Off	Time to response from illumination of CS
2	1	Off	
*5	1	On	
*6	1	On	
*7	1	On	
*8	1	On	
9	1	On	40 s
10	1	On	42 s
11	1	On	50 s
12	1	On	17 s
13	1	On	12 s
14	1	On	42 s
15	1	Off	
16	1	On	35 s
17	1	On	28 s
18	1	On	19 s
19	1	On	13 s
20	1	On	7 s
21	1	On	10 s
22	1	On	25 s
23	1	On	8 s
24	1	On	4 s
25	1	On	5 s
26	1	On	5 s
27	1	On	6 s
28	1	On	12 s
29	1	On	3 s
30	1	On	2 s

*Trials with responses were made within a 10 trial segment.

Appendix D

FIGURE D.1. RESPONSES RECORDED FROM AUTOSHAPING SUBJECT 4-10 WHEN EXPOSED TO A CONSTANT CS AND THE TIME TO RESPONSE FROM ILLUMINATION OF CS

Trials in which responses occurred	No. of responses	Light On/Off	Time to response from illumination of CS
*4	1	On	3 min 15 s
*6	1	On	1 min 30 s
*7	1	On	1 min
*9	1	On	2 min
10	1	On	30 s
11	1	On	50 s
14	1	On	2 min 15 s
15	1	On	1 min
16	1	On	1 min
17	1	On	20 s
18	1	On	10 s
19	1	On	12 s
20	1	On	7 s
21	1	On	10 s
22	1	On	30 s
23	1	On	9 s
24	1	On	13 s
25	1	On	14 s
26	1	On	10 s
27	1	On	5 s
28	1	On	6 s
29	1	On	7 s
30	1	On	4 s

*Trials with responses were made within a 10 trial segment.

Appendix E

TABLE E.1. RESPONSES RECORDED FROM SUBJECTS EXPOSED TO HIGH AND LOW INTENSITY DISCRIMINATIVE STIMULI

High Intensity		Low Intensity	
Subject SH1	Subject SH2	Subject SL1	Subject SL2
1	2	2	1
2	4	7	28
3	6	16	46
4	8	43	53
5	10	51	57
6	12	68	58
7	14	79	60 2r
8	16	83	61
9	18	85	62
10	20	88	63
11	22	90	64
12	24	96	65 2r
13	26	99	66
14	28	101	68
15	30	104	70 2r
16		106	71
17		107	72
18		110	73
19		111	74 2r
20		114	76
21		115	77
22		116	78
23		118	80 2r
24		119	82
25		121	83
26		122	84
27		123	85
28		124	
29		125	
30		126	
		127	
		128 2r	
		129	
		130	
		131 3r	
		132 2r	

*2r--two responses recorded during trial.