CAN A HORSE LEARN WHILE UNDER THE INFLUENCE OF A TRANQUILIZER (ACEPROMAZINE MALEATE)?

Samantha C. Griffith

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A Thesis

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Auburn, AL
December 15, 2006

CAN A HORSE LEARN WHILE UNDER THE INFLUENCE OF A TRANQUILIZER

(ACEPROMAZINE MALEATE)?

Samantha C. Griffith

Signature of Author

Date of Graduation

VITA

Samantha Christine (Lambertus) Griffith, daughter of John and Barbara Lambertus, was born July 11, 1981 in Terre Haute, Indiana. She and her siblings Amanda, Randy and John Lambertus grew up in Terre Haute, Indiana. She graduated from Terre Haute South High School in 1999. She attended Purdue University in West Lafayette, Indiana for four years and graduated with a Bachelor of Science degree in Animal Science and a minor in Psychology in May, 2002. After graduation Samantha moved to Notasulga, Alabama where she began a graduate program in Animal Sciences at Auburn University under the direction of Dr. Cynthia A. McCall to study horse behavior. She married Lucas Griffith, son of Greg and Kelli (Hayes) Griffith, on October 16, 2004.

THESIS ABSTRACT

CAN A HORSE LEARN WHILE UNDER THE INFLUENCE OF A TRANQUILIZER (ACEPROMAZINE MALEATE)?

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Master of Science, December 15, 2006
(M.Ed., Auburn University, 2006)
(B.S., Purdue University, 2002)

54 Typed Pages

Directed by Cynthia A. McCall

Although tranquilizers commonly are used as "training aids," little is known about how this practice affects efficiency of learning in the horse. Forty mature horses were used to compare learning performance of tranquilized and non-tranquilized horses on spatial and discrimination learning tests. The spatial test was a one-choice "T" maze in which only one side was rewarded with feed, and the discrimination test was a choice between a white bucket and a black bucket in which only one color was rewarded with feed. On the test day horses were deprived of their usual morning concentrate ration until testing was completed as motivation to perform the tests. Horses were randomly assigned to either a control group, receiving 3ml of 0.9% saline, IM, or a tranquilized group, receiving 0.044 mg/kg acepromazine maleate IM. Horses were fitted with heart rate monitors during testing to establish that the horse had calmed down from the injection, and their heart rate had returned to resting value. Each horse then performed both learning tests on the same day. The horses' selections during the test were recorded and analyzed using a t-test. Mean heart rates for control and tranquilized groups (49.8±1.4 and 53.8±1.5 respectively), in the discrimination test, were not significantly different (P=0.06). Likewise, during the spatial test no difference was detected (P=0.36) between heart rates for control and tranquilized horses (55.1±4.0 and 51.3±1.5, respectively). Significant heart rate differences between the control and tranquilized horses, were not expected and the heart rate was used to verify that all horses began testing in a calm state. Mean percent correct responses for tranquilized and control horses in the spatial test (80.0±3.4 and 72.5±3.6, respectively) did not differ (P>0.13). Similarly, the discrimination test detected no difference (P>0.43) in mean percent correct responses for tranquilized and control horses (69.8±2.0 and 67.6±2.0, respectively). Results indicate tranquilized horses had similar learning performance on simple spatial and discrimination tests as those that were not tranquilized. Tranquilization makes the horse more tractable without significantly affecting learning performance. Thus, it is a tool that may be utilized effectively by less skilled horse handlers on fractious horses to perform aversive procedures, e.g. trailer loading or clipping, while allowing the horse to learn to tolerate these procedures.

ACKNOWLEDGMENTS

The author would especially like to thank her major professor Dr. Cynthia A. McCall for all of her patience, support, and guidance throughout her graduate program. The author also would like to thank Dr. Wendell McElhenney for all of his help with statistical analysis

The author would like to thank all of the graduate students for their support and friendship (Larry Garcia, Taylor Parsons, Jennifer Cofield, Carrisa Wickens and Jarod Eddy). She would also like to thank the undergraduate students who helped with data collection for her research, especially Heather Dull and Leah Shaddix. A debt of gratitude is owed to both Jarod Eddy and Carrisa Wickens for their assistance in data collection. These two people were vital to the data collection portion of this project as well as to the preliminary stages of this project.

A special debt of gratitude goes out to Greg Williams and the entire horse unit staff for all of their help with the author's project and throughout her graduate program.

The author most importantly thanks her family for all of their support throughout the years. Each of my family members played a vital part in helping me finish this program. She would especially like to thank her grandparents, John and Jane Lambertus, for having faith in her when others did not. Without the support of my husband, Lucas Griffith, I may have never completed the graduate program.

Style manual or journal used________Applied Animal Behavior Science___________

Computer Software used __________Microsoft Word 2000 and Microsoft Excel 2000

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INTRODUCTION

A horse's worth is determined by many factors including breed, sex, pedigree, conformation and training. However, a horse's ability to demonstrate learned responses under saddle or in harness often has the greatest influence on its value. It is of particular interest to humans to develop methods for estimating learning ability in animals that they control and handle. Because horses serve such an important role in recreational activities, such as dressage, racing, show jumping, and carriage work they are learning abilities of particular interest. Equestrian activities require specialized training and good learning ability on the part of the horse. Recently, the equine research community has shown a great deal of interest in methods of measuring equine learning ability. Methods investigated include discrimination learning (Mader and Price, 1980; McCall, 1989; Dougherty and Lewis, 1991), reversal learning (Warren and Warren, 1962; Fiske and Potter, 1979), concept learning (Sappington and Goldman, 1994), maze learning (McCall et al., 1981; Houpt et al., 1982), avoidance learning (Haag et al., 1980; Rubin et al., 1980), place learning (Heird et al., 1981; Heird et al., 1986), and observational learning (Baer et al., 1983; Baker and Crawford, 1986). These various experimental measures have never been used to assess the learning ability of tranquilized horses.

A maze is an useful method for studying learning ability in horses because it does not require manual dexterity. Mazes are also good tools for studying learning ability in horses because they involve abilities which would have been necessary to the survival of horses in the wild, such as finding their way across countryside on paths.

A discrimination test is also a useful method for studying learning ability in horses because aside from classical conditioning, simple discrimination is one of the most elementary forms of learning in animals and humans. A variety of discrimination tasks have been used as indicators of animals' abilities to learn.

Horses are large, highly mobile and unpredictable creatures. Therefore, horses often are tranquilized during mildly aversive training (e.g., loading in a trailer) or management (e.g., dental care) procedures to improve the safety of both animal and handler. It currently is unknown whether horses can learn effectively while tranquilized, making subsequent attempts at a particular training or management procedure easier or if tranquilization simply makes the horse more tractable during the initial attempt without the benefit of learning.

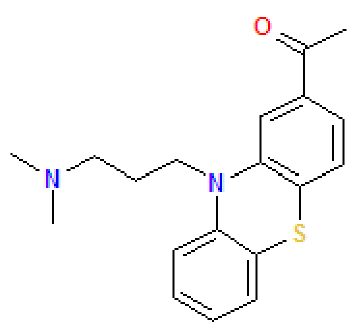
The purpose of the present study was to compare learning performance in tranquilized and non-tranquilized horses on two different types of learning tests. Results of this study will provide a better understanding of equine learning which may lead to more effective horse handling and training protocols.

LITERATURE REVIEW

Tranquilizers

Tranquilizers have been used widely as a way of calming animals and humans. The tranquilizer used in the present study was acepromazine maleate. Acepromazine maleate (ACE) formerly was known as actelypromazine and frequently is used in equine anesthesia. It is the 2-acetyl derivative of promazine (Figure 1) and has the chemical name 2-acetyl-10-(3-dimethylaminopropyl) phenothiazine (Hall et al., 2001).

Figure 1: Acepromazine maleate 1



It is the most potent phenothiazine derivative (Riebold et al., 1995). A phenothiazine derivative is a strong neuroleptic (antipsychotic) agent (Hall et al., 2001) with a relatively low toxicity.

Phenothiazine derivatives are dopamine antagonists, thus, they have calming and mood-altering effects. In human medicine, sedation is an unwanted side effect, but in veterinary medicine the phenothiazine derivatives are used primarily for this purpose.

Phenothiazine derivatives affect the cardiovascular system due to their ability to block α_1 adrenoceptors, resulting in an anti-adrenaline effect. This causes marked arterial hypotension primarily due to peripheral vasodilation, and a decrease in packed cell volume caused by splenic dilatation. Phenothiazine derivatives also exert an anti-arrhythmic effect on the heart (Muir et al., 1975; Muir, 1981). Acepromazine maleate is the most commonly used phenothiazine in veterinarian medicine today in the United Kingdom, North America, and Australia. Other phenothiazines, such as propionylpromazine, are used in Europe and their effects are similar to acepromazine (Taylor and Clarke, 1999).

Acepromazine maleate induces tranquilization, muscle relaxation, and a decrease in spontaneous activity. It also depresses respiration and decreases locomotor and behavioral responses. A horse may appear well sedated with ACE but still respond when stimulated (Taylor and Clarke, 1999). Acepromazine maleate has no analgesic effect (McKelvey and Hollingshead, 2003). In horses, it is highly protein-bound with an elimination half-life of 184.8 minutes and is detectable in plasma for up to 8 hours. However, exercise usually alters the pharmacokinetic course and pharmacodynamics of a drug (Ma, 1990). Chou (1998) reported an exercise-associated reduction of urinary ACE resident time after a single dose.

The recommended dose for horses is 0.044-0.088 mg/kg of body weight (Riebold et al., 1995). These doses may be given intraveneously (IV), intramuscularly (IM), or subcutaneously (SubQ). Onset of action occurs within 15-20 minutes following IV administration and lasts approximately 2 hours. Onset of action occurs within 45 minutes following IM administration. The actual duration of tranquilization with IM and IV injection depends on the dose but may persist for 6-10 hours (Thurmon et al., 1996). As the dose is increased, sedation is enhanced, but the dose response curve rapidly reaches a plateau after which higher doses do not increase, but only lengthen, sedation and increase side effects (Tobin and Ballard, 1979). In practice, the dose is chosen in relation to the length of sedation required and the purpose for which it is needed. A calming effect on the behavior of excitable animals can be seen at doses below 0.03 mg/kg of body weight, making ACE a drug prone to abuse especially in the equine performance industry. Excitement reactions are rare but have been reported following IV (Tobin and Ballard, 1979) or IM (Mackenzie and Snow, 1977) injection of the drug.

The most prominent sign that sedation has occurred in male horses is the extrusion of the penis from the sheath. Other signs include, but are not limited to, some drooping of the eyelids and slight protrusion of the third eyelid. Clinical doses have little effect on respiration. Even though sedated animals may breathe more slowly the minute volume of respiration usually is unchanged (Muir et al., 1975; Tobin and Ballard, 1979; Parry et al., 1982). Hypotension is prone to occur particulary after IV administration of ACE and can result in fainting and recumbency. Geldings and stallions may experience penile prolapse when ACE is administered intravenously.

In all species of animals, acepromazine causes a dose-related fall in arterial blood pressure (Kerr et al., 1972; Parry et al., 1982). This property is thought to be mediated through vasodilatation brought about by peripheral α_1 adrenoceptor block (Hall et al., 2001). The effects of clinical dose rates of ACE on heart rates generally are minimal according to most investigators (Mackenzie and Snow, 1977; Kerr et al., 1972; Parry et al., 1982), while others report no changes (Muir et al., 1979). ACE has little antihistamine activity but has a powerful spasmolytic effect on smooth muscle including that of the gut (Hall et al., 2001). It is metabolized in the liver and both non-conjugated and conjugated metabolites are excreted in the urine.

Equine enthusiasts need to keep in mind that ACE will not transform an aggressive horse into a docile one but will reduce the animal's awareness and response to external stimuli. Also, increasing the dose does not ensure more pronounced effects, as approximately 30-40% of horses administered ACE do not attain the desired effects. In the equine industry, ACE is used as an aid in training to produce standing restraint and to reduce stress prior to transportation because it is long acting, inexpensive, and does not produce severe ataxia. Because it tranquilizes without appreciably affecting coordination, ACE may be used to obtain better control of excitable horses at the racetrack or show arena and is thus prohibited in competition by most racing commissions and show horse organizations (Chou et al., 2002).

In 1982, the operant behavior of the horse, under the influence of ACE, was measured by the use of a modified 'Skinner' box apparatus (Ballard et al., 1982). The horses were trained, without ACE, to bob their heads over a feed bucket which resulted in the interruption of a light beam and a consequent food reward. The horses were switched to a variable-interval reinforcement schedule where they were able to adjust quickly to the test stimuli and to form a stable baseline response. The effect of ACE on this baseline response was measured by administering increasing doses of the drug or equal volumes of saline control to the horses ten minutes prior to introduction into the behavioral stalls. Ballard et al. (1982) found that when ACE was administered to horses before performing operant conditioned behavioral tests, a decreased rate of responding resulted. Horses showed a decrease in rate of response with doses as low as 0.004 mg/kg.

Discrimination Learning in Horses

Aside from classical conditioning, simple discrimination is one of the most elementary forms of learning in animals and humans. A variety of discrimination tasks have been used as indicators of animals' abilities to learn. During a discrimination task, the subject must respond to a stimulus that has been chosen as correct from among two or more stimuli presented. To keep the subject motivated in performing the task correct choices are reinforced (rewarded). The basic principle of the discrimination task is that those subjects capable of making the greatest number of correct choices have the greatest ability for learning.

One of the earliest recorded two-choice discrimination studies involving horses (Gardner, 1937) was also one of the simplest in design. Subjects were required to discriminate between a feedbox covered in black cloth and a feedbox which was not covered in cloth. This study successfully demonstrated that horses were capable of performing correctly in a two-choice discrimination task, opening the door for more advanced methods.

Mader and Price (1980) used two different three-choice visual discrimination tests to evaluate the effects of breed, age, and social dominance on discrimination learning ability of horses. Quarter Horses in this particular study learned significantly faster than Thoroughbreds, and no relationship between learning abilities and social dominance was detected. A significant negative correlation was found between age and learning ability on only one of the tests.

Discrimination tests are utilized to determine differences in learning ability between two or more treatment groups. In 1989, McCall used the two choice discrimination method to reveal that body condition and gender had no effect on learning ability in adult horses

A series of studies investigated horses' abilities to learn the concept of sameness under several different conditions (Flannery, 1997). Three horses were shaped to touch individually presented stimuli with their muzzles and then to make two responses to two matching cards from an array of three before experimentation began. The task in each experiment was to select the two stimulus cards that were the same and to avoid the non-matching stimulus card. Flannery (1997) used a discrimination task to demonstrate that horses can learn the concept of sameness, and that they are able to generalize this learning to a novel stimulus presentation situation. These results suggest that a relational discrimination test may be useful for assessing horses' learning abilities and the level of training appropriate for individual horses.

The ability of the horse to discriminate between colors has been investigated (Smith and Goldman, 1999) using a series of two-choice color versus gray discrimination problems. The results of this study demonstrated that horses do in fact have color vision that is at least dichromatic.

Warren (1962) found discrimination reversal learning tasks to be a feasible technique for measuring learning ability in individual horses. Fiske and Potter (1979) used a serial reversal learning discrimination combining spatial and brightness cues to investigate individual learning ability for yearling horses within a herd. Fiske and Potter (1979) reported the 'learning to learn' phenomenon in horses. Animals that utilize information learned previously to reduce the number of trials in subsequent learning sets are said to have learned to learn (Bitterman, 1965). Their research provided the groundwork for spatial learning tests.

Spatial Learning in Horses

The use of mazes in investigating learning behavior mainly has been applied to rodents. However, in the recent past this technique has been used with larger domestic animals, e.g. cattle (Arave et al., 1992; Boivin et al., 1992) and horses (Kratzer et al., 1977; McCall et al., 1981; Marinier & Alexander, 1994).

Most mazes constructed for large animals involve a simple Y or T maze. Kratzer (1977) investigated maze learning in Quarter Horses using a two-compartment maze which provided a single left- or right-side choice, and found that the horses showed learning ability based on decreases in latency and in errors as trials progressed.

The reliability of maze tests in equine learning research was investigated by Heird et al. (1986). They investigated whether two different maze tasks (discrimination and spatial), alternating over a series of testing but using the same horses, would yield consistent results. Heird et al. (1986) found that subjects learned more rapidly and reached higher levels of performance as the series of tasks progressed. It was found that learning occurred at a faster rate on the discrimination task compared to the gradual improvement in performance observed in the place tasks.

McCall et al. (1981) used Hebb-Williams closed field mazes to investigate learning abilities in yearling horses. Prior to testing, subjects were acclimated to the test area. Once testing began, subjects were tested on a new maze problem each day during a 12-day period. The horses quickly adapted to the testing procedure, were successful in learning each new problem, and the maze was useful in ranking the learning ability of the individual horses.

Arave et al. (1992) performed a study with dairy calves that involved a more complex maze. Arave et al. (1992) found that activity of calves was affected by sire, gender, trial direction and food source location. There were significant correlations between maze completion time and activity scores, between activity score and laterality and between time and laterality on some days (Arave et al., 1992). Mariner and Alexander (1994) used a similar maze to evaluate changes in learning ability and memory in horses. Two separate mazes similar in complexity and length and containing the same number of turns and the same number of blind pockets were used in their study. They found that all horses learned the first maze, but variation existed between them. The ability of the horses to remember also varied between subjects. This study demonstrated the suitability of the use of the maze to investigate learning and memory in horses.

Based on the results of the studies mentioned previously it can be concluded that spatial learning tests and discrimination tests are suitable ways to investigate learning ability in horses. However, none of these studies took into account the common practice in the horse industry of using a tranquilizer as a training aid. It is not known if horses can learn effectively while tranquilized, making successive attempts at a particular training or management procedure easier, or if tranquilization simply makes the horse more tractable during the initial attempt. The objective of the present study is to compare learning performance of tranquilized and non-tranquilized horses using a visual discrimination learning test and a spatial learning test.

MATERIALS AND METHODS

Subjects

Forty mature horses of varying ages, breeds, and genders housed at the Auburn University Horse Unit were selected for this study.

No horses used in this study had been exposed previously to the learning tests used in this study. All horses used in this study were utilized in teaching and riding activities by the Horse Unit and were accustomed to human contact and handling.

Horses were maintained on pastures which were predominantly coastal bermudagrass (*Cynodon dactylon*). Horses were allowed free access to pasture forage during all non-testing hours but were deprived of their daily concentrate ration until testing was completed. Fresh water was available in the pasture *ad libitum*.

Testing Procedure

Horses were assigned randomly to either the control (3ml of 0.9% saline IM; 20 horses) or to the tranquilized (0.044 mg/kg acepromazine maleate IM; 20 horses) group. Horses then were assigned randomly to a specific test day. The study took place from May 13 through May 23 of 2004.

Each horse performed two different learning tests on the same day with the test order randomly determined. On test days, each horse was fitted with a heart rate monitor

(Polar Accurex Plus, Polar Electro Inc., Kempele, Finland) and received an injection of either saline control or acepromazine maleate IM. Following injection, a 30 minute period was allowed for the ACE to induce tranquilization before testing commenced. At the end of testing horses were returned to their respective pastures.

Discrimination Learning Test

The discrimination test apparatus was constructed in a rectangular test stall with a packed soil floor measuring 5.6m by 3.1m. Three sides of the test stall were covered with a dark, heavy fabric, providing 1.7m high solid walls. The entrance way to the testing area was not enclosed with fabric; it consisted of a gate that could be closed behind the horse. The stimulus area of the test stall was divided by a 1.5m by 3.6m panel, constructed of metal pipe (livestock panel). A diagram of the test stall and the discrimination learning test apparatus is shown in Figure 2.

For the discrimination learning test, the stimuli consisted of a white feed bucket and a black feed bucket placed on the floor of the test area. The stimulus buckets were removable and could be switched between compartments. Between test sessions, both stimulus buckets were stored with grain in them to provide similar olfactory cues.

Horses were not acclimated to the test area prior to testing and each horse was tested only on one day. On the day of testing each horse was led to the test area, faced in the direction of the stimulus and released. The stimulus bucket not selected by the subject on this initial trial was designated the “correct” stimulus for that subject during the testing period. The subject would complete 30 selection trials on testing day, not including the initial trail, and the bucket choices were recorded for each trial.

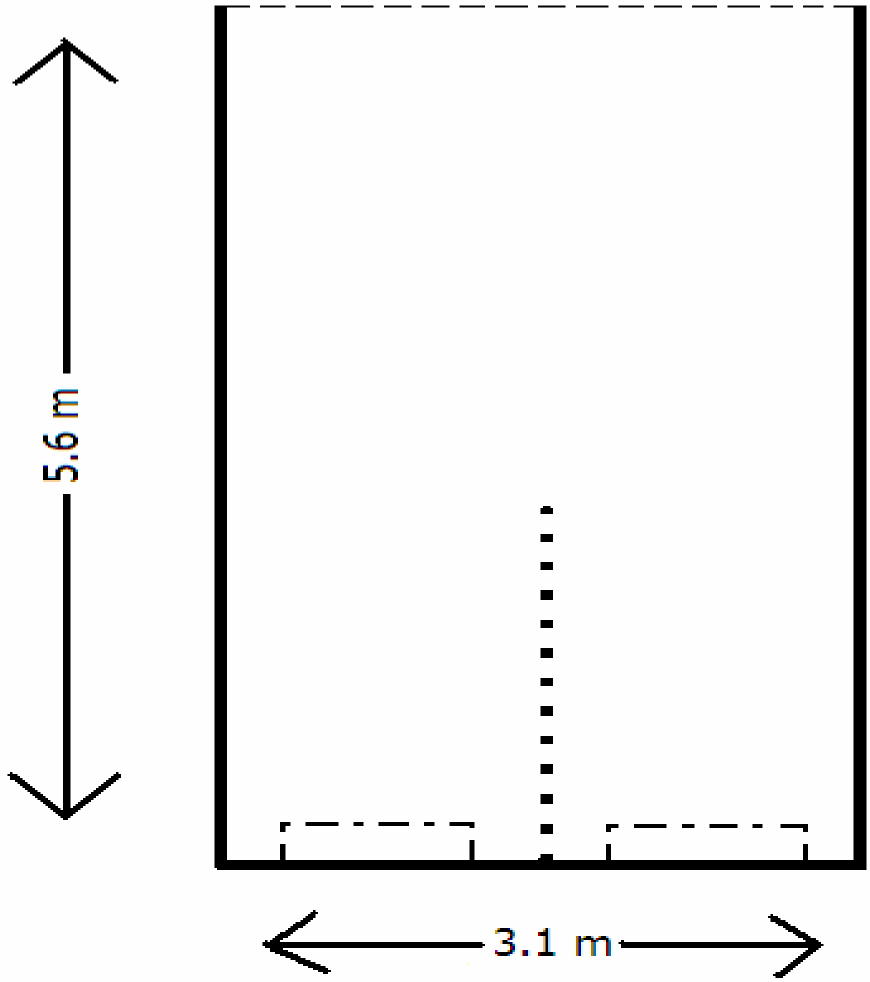


Figure 2: Discrimination test stall. Solid walls and partitions are designated by unbroken lines. Entryway is designated by a dashed line. Areas of feed buckets are designated by dot-dash lines. The divider is designated by a dotted line.

A selection trial consisted of the handler centering the horse directly inside of the entrance to the testing area and releasing it. The horse entered the testing stall unescorted and selected between the black or white stimulus buckets by entering a stimulus compartment and approaching the bucket. The presence of food in the stimulus bucket could not be determined visually from behind the stimulus area divider. Horses were considered to have made a recordable selection when their heart girth crossed into one of the stimulus compartments. Because the subjects could not see into the buckets before this point they were allowed to switch compartments if their posterior half was not already in the compartment. If the horse selected the correct color bucket, it would be allowed to eat the food reward (54.6g Life Design Compete, 10% CP, Nutrena Corporation, Minneapolis, MN) located within the bucket. However, an incorrect selection resulted in an empty bucket and no food reward. The subject then would be removed from test area after each trial was completed. The buckets would be prepared for the next trial while the handler faced the subject away from the stimulus wall. To eliminate biased cues, the sound of food being placed into both buckets could be heard. Then the horse was led into of the test stall, centered, and released for the start of the next trial. The discrimination was based on the presence of a relevant cue, the bucket color, and an ambiguous cue, spatial position. The spatial position of the stimuli within the stimulus compartments was reversed every five trials.

Spatial Learning Test

The spatial learning test was a simple T maze that utilized a barn aisle measuring 13m by 2.7m and two stalls measuring 3.6m by 3.4m. The majority of the test area was covered with a dark, heavy fabric to prevent outside distractions. This created solid walls a minimum of 1.7 m high in all areas where visual contact with conspecifics might have been possible, such as common walls between the barn aisle and other stalls and the start of the maze and the storage stalls. The barn aisle and stall flooring was packed soil. A diagram of the spatial learning test apparatus is shown in Figure 3.

Both stalls at the end of the maze contained an identical reward box that was fixed in position and could not be moved or knocked over by the subject. Between test days grain was stored in the reward boxes to provide uniform olfactory cues. To provide uniform olfactory cues during the test both reward boxes contained concentrate reward that was inaccessible by the subject. Subjects were not acclimated to the test area prior to testing. On the day of testing the subject was led to the start of the maze (leg of the "T") and released to travel down the maze. The side not selected by the subject on this initial trial was designated the "correct" stimulus for that subject during the testing period. The subject would complete 30 trials on testing day, not including the initial trail, and the selections were recorded. Each subject was tested only one day in this study.

A selection trial consisted of the handler centering the horse at the beginning of the maze and releasing it to travel down the maze. The horse traveled down the maze unescorted and selected between the right or left side of the maze by entering a stimulus compartment and approaching the box. The presence of food in the stimulus bucket

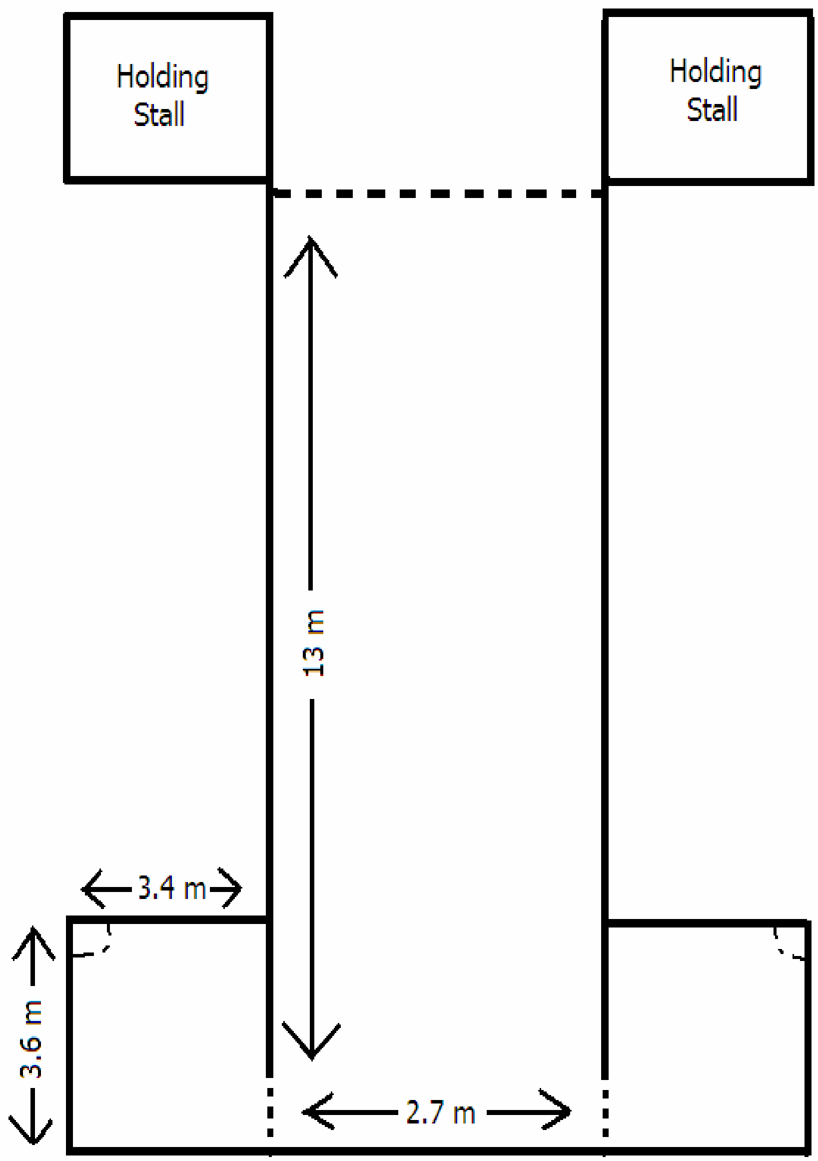


Figure 3: Spatial test apparatus. Solid walls are designated by unbroken lines. Entryway is designated by a dotted line. Areas of feed buckets are designated by dot-dash lines.

could not be visually determined from the entrance of the compartment. Horses were considered to have made a recordable selection when their front hooves crossed into one of the stimulus compartments. Since the subjects could not see into the buckets before this point they would have an opportunity to switch compartments if their front hooves were not already in the compartment. If the horses selected the correct compartment, it would be allowed to eat the food reward (54.6g Life Design Compete, 10% CP, Nutrena Corporation, Minneapolis, MN) located within the box. However, an incorrect selection resulted in an empty box and no food reward. The subject would be led from the stimulus compartment back to the beginning of the maze after each trial was completed. The boxes then would be prepared for the next trial while the handler faced the subject away from the stimulus compartments at the end of the maze. To eliminate auditory cues, the sound of food being placed into both boxes could be heard. The subject then would be turned around, centered, and released for the start of the next trial.

All resting heart rates, prior to administration of treatment, were recorded. Heart rate then was recorded every fifteen seconds during each test period. This information was used to evaluate if either the tranquilizer or the testing procedure affected the heart rate in the tranquilized horses compared to the control horses.

Statistical Analysis

Heart rate data was analyzed using a GLM procedure of SAS (SAS Inst. Inc., Cary, NC). Correct responses resulting from the discrimination learning test and the spatial learning test were analyzed for variation between subject groups (Control/Tranquilized) using the SAS t-test procedure.

RESULTS AND DISCUSSION

Three subjects were dropped from the discrimination test due to non-performance. To be classified as a non-performer a subject failed to complete ten trials, lasting five minutes each. At the end of each non-completed trial the subject was removed from the testing area. The subject then would be reintroduced to the test area at the start of the next trial. One subject was dropped from the spatial test due to a hoof abscess.

Eight observations on the heart rate monitor were lost due to technical difficulty. Five of the files belonged to horses in the control group, while three of the files belonged to horses in the tranquilized group. It was difficult to establish and maintain a heart rate on some of the horses using the human electrodes. More accurate heart rate data may have been obtained using an electrode specifically designed for a horse. To improve heart data the electrode should be lubricated with electrode gel (Lectron II Heart Rate Monitor Electrode Gel**)** and placed in direct contact with the skin.

The mean heart rate for the control and tranquilized horses in the discrimination test is shown in Figure 4. Mean heart rates for control and tranquilized groups (49.8 ± 1.4 and 53.8 ± 1.5 respectively), were not significantly different ($P=0.06$). The mean heart rates for control and tranquilized groups in the discrimination group approached significance. There are several reasons why this might have occurred, the main reason is

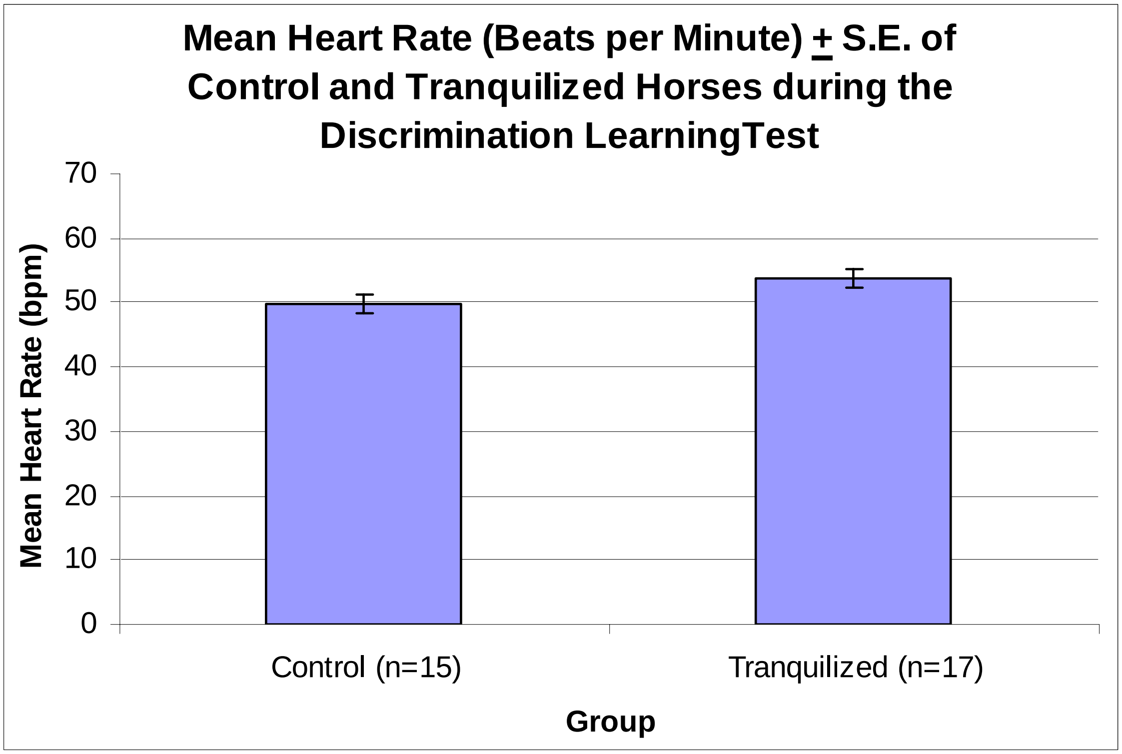


Figure 4. Mean heart rates for control and tranquilized groups was 49.8±1.4 and 53.8±1.5, respectively, during the discrimination test

that the discrimination test had an open back that allowed the horses to see con-specifics and to become easily distracted. To reduce distractions on the discrimination test it may be beneficial to put a solid barrier behind the horse, rather than the open barrier used in this study or to situate the foal area so that subjects are moving toward conspecifics when performing the test. During the spatial test no difference was detected (P=0.36) between mean heart rates for the two groups. The mean heart rate for the control and the tranquilized horses was 55.1$\pm$4.0 and 51.3$\pm$1.5, respectively, during the spatial learning test (Figure 5). Breed and gender were found to have no significant (P=0.97 and P=0.44, respectively) effect on heart rate during the discrimination test. Likewise, no significant differences were found between breed and gender (P=0.80 and P=0.17, respectively) during the spatial test. Heart rate differences between the control and tranquilized horses, were not expected. Acepromazine does not affect heart rate significantly (Kerr et al., 1972; Mackenzie and Snow, 1977; Muir et al., 1979). Mackenzie and Snow (1977) evaluated chemical restraining agents in the horse using five times the recommended dose of ACE. They found that ACE caused a slight elevation in heart rate approximately 60 minutes after administration. The heart rate monitors were used in this study as a reference point for the handlers. Once treatment was administered, the heart rate was used to establish that the horse had calmed down from the injection and had returned to its resting heart rate prior to testing.

The mean percent correct responses for control and tranquilized horses in the discrimination test (67.6$\pm$2.0 and 69.8$\pm$2.0, respectively) did not differ (P=0.43); (Figure 6). Mean percent correct responses ranged from 43.4 to 80.0. In 1936, Gardner, completed a feed box discrimination test using draft breeds. The average box error

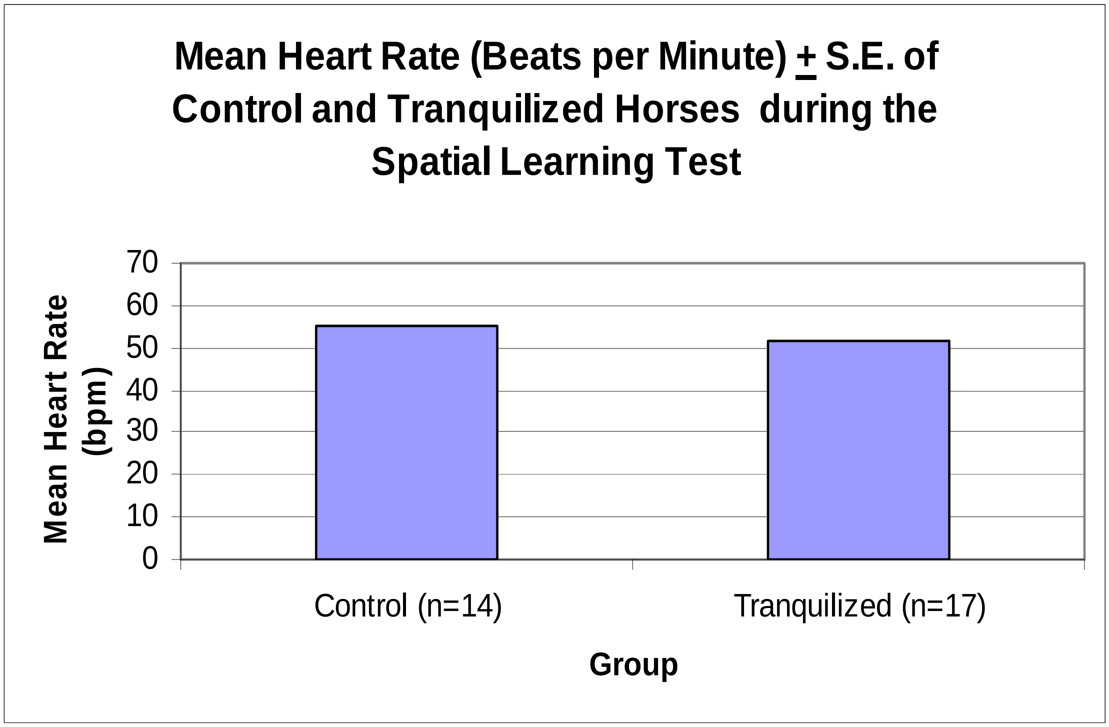


Figure 5. Mean heart rate for the control and the tranquilized horses was 55.1±4.0 and 51.3±1.5, respectively, during the spatial test.

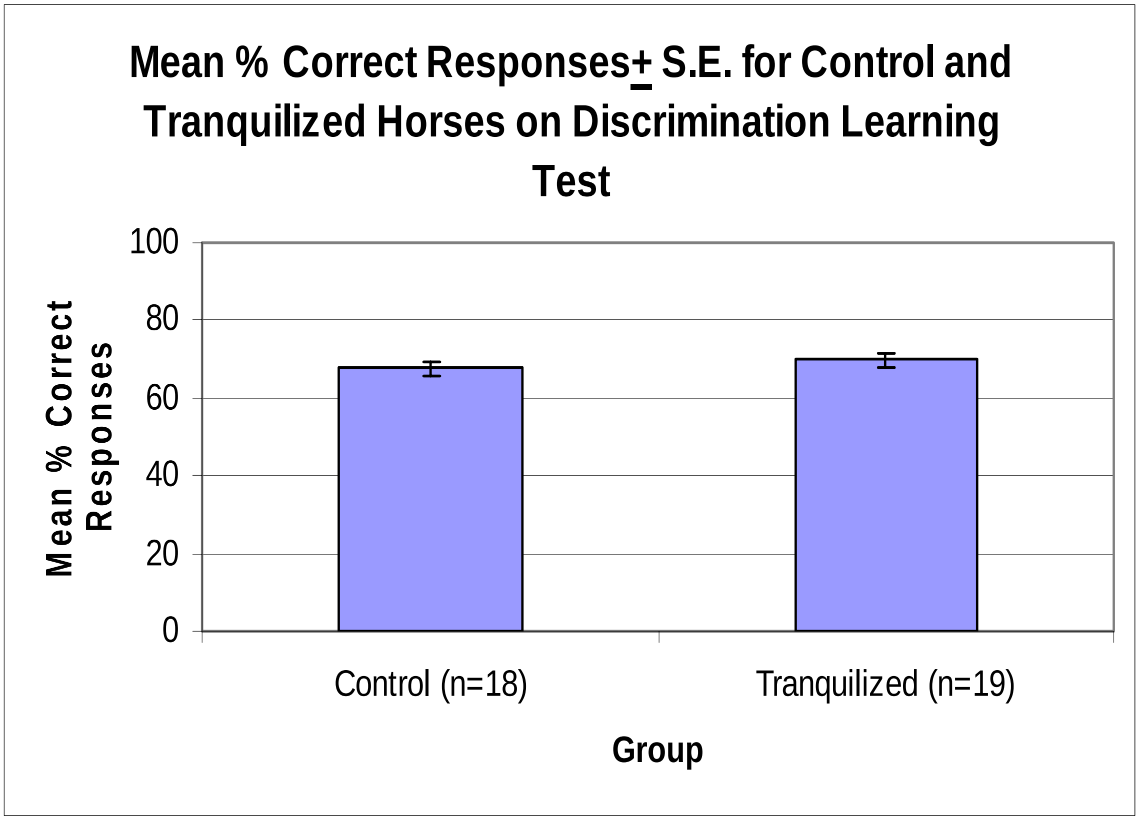


Figure 6. Mean percent correct responses for the control and tranquilized groups was 67.6±2.0 and 69.8±2.0, respectively, for the discrimination test.

reported was 0.43 while in the current study the average error was 0.30. Sappington and Goldman (1994) found all their subjects successfully learned a simple black verses white discrimination task, complementary to the discrimination test used in the present study. The discrimination test detected no difference in mean percent correct responses for breed and gender (P=0.20 and P=0.60, respectively).

Similarly, the spatial test detected no difference (P=0.13) in mean percent correct responses for control and tranquilized horses (72.5±3.6 and 80.0±3.4, respectively). This is illustrated in Figure 7. Mean percent correct responses ranged from 36.7 to 96.7. The error rate obtained during the spatial test is similar to the error rate approximately 20% reported by Kratzer et al. (1977). Heird et al. (1981) reported a similar learning performance in intermediately handled yearlings during initial acquisition of T-maze test. Warren and Warren (1962) also showed that two horses learned successive reversal problems very quickly. The spatial test detected no difference in mean percent correct responses for breed and gender (P=0.93 and P=0.17, respectively).

Acepromazine maleate had no effect on the learning ability of horses at the doses used during this study. As shown, in this study, tranquilized horses had similar learning performance on simple discrimination and spatial test as those that were not. Therefore, ACE effectively can be used when teaching a horse a new procedure.

However, the question remains how well can a horse then recall the information learned at a later point in time without the ACE? Drug-induced state-dependent learning is a well established phenomenon in psychology. The term is used to describe the finding that behavior learned in one drug state is better remembered when retention is tested in

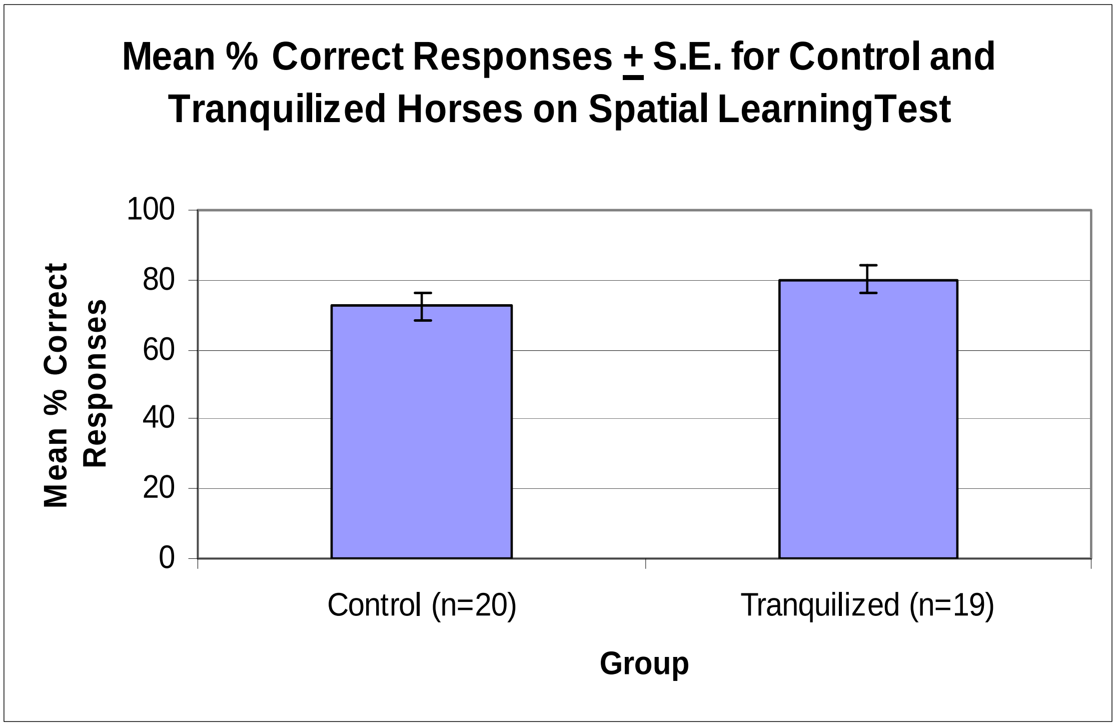


Figure 7. Mean percent correct responses for the control and tranquilized groups were 72.5±3.6 and 80.0±3.4, respectively, for the spatial test.

the same drug state (Lowe, 1986). In Lowe's study 24 human subjects were required to learn a simple route map after ingesting 0.66g alcohol/kg body weight and smoking two medium tar cigarettes. The subjects were tested 24 hours later under various drug states. The highest recall was observed in the alcohol and nicotine subjects while the placebo drink and nicotine subjects, along with the no drug subjects, had the lowest recall. In studies with human subjects, alcohol (Lowe, 1981), marijuana (Darley et al., 1974), barbiturate and amphetamine (Bustamente et al., 1970) and nicotine (Peters and McGee, 1982) have all been shown to produce state-dependent learning effects. Does acepromazine produce state-dependent learning? Based on the above mentioned studies it is possible that if a horse learns under the influence of ACE, their recall should also be greatest under the influence of ACE.

This study did not test the ability of the horse to recall the information that it learned. The sole purpose of this study was to see if a horse could learn under the influence of acepromazine. Now that it has been established that a horse can learn a simple spatial and discrimination test it would be interesting to see how the recall ability differs between control and tranquilized subjects.

IMPLICATIONS

All of the equine subjects in this study exhibited similar abilities to perform simple discrimination learning tasks as well as simple spatial learning tasks. Therefore, ACE at the doses used in this study does not affect the horse's ability to learn these types of tasks. A horse is capable of learning a task while sedated. However, it is not known how well a horse can recall that information for later use. It would be of interest to investigate the effects of ACE on learning routine procedures that are commonly encountered in horse management (e.g., trailer loading)

One of the limitations of this study was that it only considered whether the subject could learn under the influence of a tranquilizer. In retrospect, it would have been useful to test the recall of those same horses after a withdrawal period from the tranquilizer. It also might have been beneficial to record the temperature and humidity during test periods if testing during different times of day or over an extended period of time. Environmental conditions may affect motivation.

In this study temperature and humidity were not recorded because all horses were tested within a two week period at the end of May. Testing begin each day at seven in the morning and concluded no later then noon. Thus, temperatures and humidity were not extremely variable over the test days in this study.

Some of the test subjects also may have lacked motivation for performing the tests because they were allowed free access to pastures. In this study, it is not believed that motivation from differential hunger was an issue. Those horses identified as non-performers were so classified due to distractions during testing or injury. The adult horses used in this study were used to receiving concentrate feed twice a day. If subjects seem to have motivation problems it might be advisable to place the horses in the stall 12 hours prior to testing.

Because tranquilization with ACE makes the horse more tractable without significantly affecting learning performance, it is a tool that may be utilized effectively by less skilled handlers on fractious horses to perform mildly aversive procedures (e.g., trailer loading or clipping) while allowing the horse to learn to tolerate these procedures. However, because this tranquilizer is economical and easily administered it is often used unnecessarily in the equine industry. For example, ACE sometimes is administered prior to showing or sales inspections. When a horse is tranquilized prior to showing or sales inspections the true temperament of horses will be misrepresented. Tranquilizers should not be used in place of appropriate training.

Since ACE often is used unnecessarily in the equine industry, one needs to consider animal welfare. In the case of an inadequate trainer trying to perform an aversive procedure on a fractious horse it may be to the horse's benefit for the trainer to use ACE. An inadequate trainer can actually endanger the welfare of the horse and can cause the horse discomfort and pain. An inadequate trainer may try to force an un-tranquilized horse to perform an aversive procedure, potentially inflicting pain or causing injury to the horse, while a tranquilized horse will be more tolerant of the aversive procedure. For example, an inadequate trainer may resort to hurtful training procedures or training devices with an un-tranquilized horse when tranquilization might allow the horse to respond without these aversive procedures.

Future research might consider if ACE produces drug-induced state-dependent learning. That is, does the learning that takes place under ACE become less accessible to recall during the horse's normal state? A better understanding of ACE's impact on learning and tractability in horses would assist veterinarians, trainers, and horse owners in determining when and how ACE can be used as a tool to help horses learn to tolerate aversive procedures. This research may clarify if ACE really can be used as a tool to help horses learn to tolerate aversive procedures.

Additional studies should look at the recall ability of horses under tranquilizer (ACE) compared to the recall ability of horses not under the influence of a tranquilizer, as demonstrated in human subjects by Lowe (1986). Lowe explored drug-induced state-dependent learning in humans; finding that behavior learned in one drug state is better remembered when retention is tested in the same drug state. According to Lowe, horses in the tranquilized group will recall more while under the influence of the tranquilizer.

Finally, it might be beneficial to record the exact ages of the horses if all horses are not of mature age. Weanlings and yearlings with less training then mature horses can easily become distracted or lose motivation. The age of the horses used in this study were not collected because all horses were mature horses (5-23 years old) and were currently in a riding program. Drug interventions are likely to play an increasing role in horse training, care, and maintaining. Understanding their effects on learning and post-drug temperament is critical to humane and effective use of these chemical tools

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APPENDICES

Appendix 1: GLM procedure results for heart rate in the spatial test

Treatment	N	Mean	Standard Deviation
Control	15	55.1	15.6
Tranquilized	17	51.3	6.1

P=0.36

Appendix 2: GLM procedure results for heart rate in the discrimination test

Treatment	N	Mean	Standard Deviation
Control	15	49.8	5.4
Tranquilized	17	53.8	6.2

P=0.06

Appendix 3: T-test procedure results for mean percent correct responses in the discrimination test

Treatment	N	Mean	Standard Deviation	Minimum	Maximum
Control	18	67.6	8.3	43.3	76.7
Tranquilized	19	69.8	8.9	46.7	80.0

P=0.43

Appendix 4: T-test procedure results for mean percent correct response in the spatial test

Treatment	N	Mean	Standard Deviation	Minimum	Maximum
Control	20	72.5	16.2	33.3	93.3
Tranquilized	19	80.0	14.7	36.7	96.7

P=0.13

Appendix 5. Test date, treatment group and test order for each horse

Date	Name	Group	First Test	Breed	Gender
05/13/04	Dave	Control	Maze	Thoroughbred	Male
05/13/04	Money	Tranquilized	Discrimination	Quarter Horse	Male
05/14/04	Scarlet	Control	Discrimination	Quarter Horse	Female
05/14/04	Andy	Tranquilized	Maze	Paint	Male
05/14/04	GoGo	Control	Maze	Thoroughbred	Female
05/14/04	Regal	Tranquilized	Discrimination	Thoroughbred	Male
05/15/04	Yankee	Control	Discrimination	Warmblood	Male
05/15/04	Vinny	Tranquilized	Maze	Quarter Horse	Male
05/15/04	Montana	Control	Maze	Quarter Horse	Male
05/15/04	Radical	Tranquilized	Discrimination	Quarter Horse	Male
05/16/04	Flashy	Control	Maze	Thoroughbred	Male
05/16/04	Billy	Tranquilized	Discrimination	Thoroughbred	Female
05/16/04	Venture	Control	Discrimination	Thoroughbred	Male
05/16/04	Bourbon	Tranquilized	Maze	Quarter Horse	Male
05/17/04	Sunkist	Control	Discrimination	Thoroughbred	Male
05/17/04	Sterling	Tranquilized	Maze	Thoroughbred	Male
05/17/04	Major	Control	Discrimination	Thoroughbred	Male
05/17/04	Noah	Tranquilized	Maze	Quarter Horse	Male
05/18/04	Nie	Control	Discrimination	Thoroughbred	Female
05/18/04	Stick	Tranquilized	Maze	Thoroughbred	Male
05/18/04	Preacher	Control	Maze	Thoroughbred	Male

05/18/04	Tessy	Tranquilized	Discrimination	Warmblood	Female
05/19/04	Tejos	Control	Discrimination	Thoroughbred	Male
05/19/04	Bud	Tranquilized	Maze	Grade	Male
05/19/04	S. Sound	Control	Maze	Quarter Horse	Male
05/19/04	Flash	Tranquilized	Discrimination	Quarter Horse	Male
05/20/04	G. Effort	Control	Discrimination	Quarter Horse	Male
05/20/04	Blue	Tranquilized	Maze	Quarter Horse	Male
05/20/04	Mac	Control	Maze	Grade	Male
05/20/04	Gus	Tranquilized	Discrimination	Thoroughbred	Male
05/21/04	Ty	Control	Maze	Thoroughbred	Male
05/21/04	Babe	Tranquilized	Discrimination	Quarter Horse	Male
05/21/04	Dan	Control	Discrimination	Thoroughbred	Male
05/21/04	Franny	Tranquilized	Maze	Thoroughbred	Female
05/22/04	Nilla	Control	Discrimination	Quarter Horse	Male
05/22/04	Zip	Tranquilized	Discrimination	Quarter Horse	Female
05/22/04	Molly	Control	Discrimination	Thoroughbred	Female
05/22/04	Rubin	Tranquilized	Maze	Warmblood	Male
05/23/04	Dutch	Control	Discrimination	Thoroughbred	Male
05/23/04	Speck	Tranquilized	Maze	Thoroughbred	Male

Appendix 6: Number and percent correct responses for individual horses on the discrimination test.

Date	Name	Group	Number Correct	Percent Correct
05/13/04	Dave	Control	18	60.0
05/14/04	Scarlet	Control	20	66.7
05/15/04	Yankee	Control	19	63.3
05/15/04	Montana	Control	20	66.7
05/16/04	Flashy	Control	21	70.0
05/16/04	Venture	Control	21	70.0
05/17/04	Sunkist	Control	17	56.7
05/17/04	Major	Control	21	70.0
05/18/04	Nie	Control	20	66.7
05/18/04	Preacher	Control	20	66.7
05/19/04	Tejos	Control	20	66.7
05/19/04	S. Sound	Control	22	73.3
05/20/04	G. Effort	Control	23	76.7
05/20/04	Mac	Control	13	43.3
05/21/04	Ty	Control	21	70.0
05/21/04	Dan	Control	23	76.7
05/22/04	Nilla	Control	23	76.7
05/22/04	Molly	Control	23	76.7
05/13/04	Money	Tranquilized	22	73.3
05/14/04	Regal	Tranquilized	14	46.7
05/15/04	Vinny	Tranquilized	19	63.3
05/15/04	Radical	Tranquilized	24	80.0
05/16/04	Billy	Tranquilized	20	66.7
05/16/04	Bourbon	Tranquilized	20	66.7
05/17/04	Sterling	Tranquilized	24	80.0
05/17/04	Noah	Tranquilized	24	80.0
05/18/04	Stick	Tranquilized	16	53.3
05/18/04	Tessy	Tranquilized	22	73.3
05/19/04	Bud	Tranquilized	21	70.0
05/19/04	Flash	Tranquilized	22	73.3
05/20/04	Blue	Tranquilized	19	63.3
05/20/04	Gus	Tranquilized	21	70.0
05/21/04	Babe	Tranquilized	20	66.7
05/21/04	Franny	Tranquilized	23	76.7
05/22/04	Zip	Tranquilized	21	70.0
05/22/04	Rubin	Tranquilized	23	76.7
05/23/04	Speck	Tranquilized	23	76.7

Appendix 7: Number and percent correct responses for individual horses on the spatial test.

Date	Name	Group	Number Correct	Percent Correct
05/13/04	Dave	Control	21	70.0
05/14/04	Scarlet	Control	26	86.7
05/14/04	GoGo	Control	28	93.3
05/15/04	Yankee	Control	11	36.7
05/15/04	Montana	Control	22	73.3
05/16/04	Flashy	Control	18	60.0
05/16/04	Venture	Control	10	33.3
05/17/04	Sunkist	Control	26	86.7
05/17/04	Major	Control	28	93.3
05/18/04	Nie	Control	25	83.3
05/18/04	Preacher	Control	22	73.3
05/19/04	Tejos	Control	25	83.3
05/19/04	S. Sound	Control	23	76.7
05/20/04	G. Effort	Control	16	53.3
05/20/04	Mac	Control	20	66.7
05/21/04	Ty	Control	24	80.0
05/21/04	Dan	Control	23	76.7
05/22/04	Nilla	Control	22	73.3
05/22/04	Molly	Control	23	76.7
05/23/04	Dutch	Control	22	73.3
05/13/04	Money	Tranquilized	26	86.7
05/14/04	Andy	Tranquilized	25	83.3
05/14/04	Regal	Tranquilized	24	80.0
05/15/04	Vinny	Tranquilized	22	73.3
05/15/04	Radical	Tranquilized	27	90.0
05/16/04	Billy	Tranquilized	20	66.7
05/16/04	Bourbon	Tranquilized	11	36.7
05/17/04	Sterling	Tranquilized	27	90.0
05/17/04	Noah	Tranquilized	27	90.0
05/18/04	Stick	Tranquilized	23	76.7
05/18/04	Tessy	Tranquilized	27	90.0
05/19/04	Bud	Tranquilized	22	73.3
05/19/04	Flash	Tranquilized	16	53.3
05/20/04	Blue	Tranquilized	27	90.0
05/21/04	Babe	Tranquilized	25	83.3
05/21/04	Franny	Tranquilized	25	83.3
05/22/04	Zip	Tranquilized	26	86.7
05/22/04	Rubin	Tranquilized	27	90.0
05/23/04	Speck	Tranquilized	29	96.7

Appendix 8: Mean heart rate for each horse during the discrimination test.

Date	**Name**	**Group**	**Mean BPM**
05/13/04	Dave	Control	55.5
05/14/04	Scarlet	Control	54.2
05/15/04	Yankee	Control	46.5
05/15/04	Montana	Control	52.6
05/16/04	Flashy	Control	46.8
05/17/04	Sunkist	Control	43.8
05/17/04	Major	Control	43.9
05/18/04	Nie	Control	52.3
05/18/04	Preacher	Control	42.3
05/19/04	Tejos	Control	54.9
05/19/04	S. Sound	Control	44.7
05/20/04	Mac	Control	45.0
05/21/04	Ty	Control	55.0
05/21/04	Dan	Control	49.9
05/22/04	Nilla	Control	59.4
05/13/04	Money	Tranquilized	53.3
05/14/04	Regal	Tranquilized	55.4
05/15/04	Vinny	Tranquilized	43.1
05/15/04	Radical	Tranquilized	59.8
05/16/04	Billy	Tranquilized	45.9
05/16/04	Bourbon	Tranquilized	50.8
05/17/04	Sterling	Tranquilized	56.3
05/17/04	Noah	Tranquilized	48.3
05/18/04	Stick	Tranquilized	43.0
05/18/04	Tessy	Tranquilized	50.4
05/19/04	Bud	Tranquilized	59.6
05/19/04	Flash	Tranquilized	50.9
05/20/04	Blue	Tranquilized	59.9
05/21/04	Franny	Tranquilized	63.4
05/22/04	Zip	Tranquilized	59.1
05/22/04	Rubin	Tranquilized	57.7
05/23/04	Speck	Tranquilized	58.0

Appendix 9: Mean heart rate for each horse during the spatial test.

Date	Name	Group	Mean BPM
05/13/04	Dave	Control	46.1
05/14/04	Scarlet	Control	59.6
05/15/04	Yankee	Control	104.8
05/15/04	Montana	Control	56.6
05/16/04	Flashy	Control	61.9
05/17/04	Sunkist	Control	43.7
05/17/04	Major	Control	45.3
05/18/04	Nie	Control	54.6
05/18/04	Preacher	Control	42.1
05/19/04	Tejos	Control	51.2
05/19/04	S. Sound	Control	40.0
05/20/04	Mac	Control	47.4
05/21/04	Ty	Control	56.0
05/21/04	Dan	Control	55.7
05/22/04	Nilla	Control	61.7
05/13/04	Money	Tranquilized	49.2
05/14/04	Regal	Tranquilized	62.3
05/15/04	Vinny	Tranquilized	42.0
05/15/04	Radical	Tranquilized	53.5
05/16/04	Billy	Tranquilized	44.7
05/16/04	Bourbon	Tranquilized	53.6
05/17/04	Sterling	Tranquilized	50.5
05/17/04	Noah	Tranquilized	42.8
05/18/04	Stick	Tranquilized	45.4
05/18/04	Tessy	Tranquilized	54.0
05/19/04	Bud	Tranquilized	52.8
05/19/04	Flash	Tranquilized	52.0
05/20/04	Blue	Tranquilized	58.3
05/21/04	Franny	Tranquilized	53.0
05/22/04	Zip	Tranquilized	62.2
05/22/04	Rubin	Tranquilized	44.9
05/23/04	Speck	Tranquilized	51.3