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Original Research

Evidence for Sire, Dam, and Family Influence on Operant Learning in Horses

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ABSTRACT

To evaluate potential sire and dam effects on learning performance in horses, 102 ponies ranging in age from 47 days to 17 years received a single standard positive reinforcement–based operant "target training" session in their home environment. These animals were from a semi-feral herd of known parentage that had had standard minimal previous handling. Based on quantitative measures of latency to reach criterion and rate of correct responses, subjects were ranked into five levels of learning efficiency. Learning efficiency levels of various sire lines (sires and their offspring), dam lines (dams and their offspring), and sire/dam lines (mating pairs and their full sibling offspring) were compared. Learning efficiency level differed significantly among certain sire lines, dam lines, and sire/dam lines ($P < .05$, median test). Learning efficiency level also tended to differ among age groups as well as between males and females. Frustration/avoidance response frequency during training was negatively associated with learning efficiency and differed among sire and dam lines. Frustration/avoidance response frequency during training also differed significantly among age groups but not among males and females. These data provide evidence of sire, dam, and sire/dam effects on learning performance in horses in simple operant tasks analogous to those inherent in the training of domestic horses.

1. Introduction

In recent decades, a rapidly growing number of studies have explored the characterization of cognitive ability as well as factors affecting learning in domestic horses (*Equus caballus*) [1–3]. Research in this area includes investigation of the effects of breed [4], temperament [5], social dominance [6], age, and gender [7,8] on cognitive ability. A reasonable expectation is that cognitive ability, particularly as reflected in efficiency of associative learning, varies among horses and plays an important role in the success of the human-horse relationship as well as in training for specific work and performance [9].

Sire and dam effects on learning ability in horses, including both genetic and family environmental factors, apparently have not yet been formally investigated. Currently, exploration in the area of equine genetics has been focused on the heritability of genetic diseases [10], stereotypic behavior [11], performance [12,13], as well as coat color [14], morphology [15], and temperament [16]. In their work on performance of horses in operant and spatial learning tasks, Wolff and Hausberger [7] reported an incidental finding which was interpreted as a possible sire effect. Other authors have explored potential genetic effects on particular temperament or behavioral tendencies of the horse that are suspected to influence learning ability, particularly as it relates to interactions with humans [2].

An obvious challenge to addressing various influences on cognition in domestic horses concerns considerable individual variation in previous experience with humans as well as in training styles (positive vs. negative reinforcement vs. punishment based) inherent to the domestic

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horse industry. Most horses available for testing are far from naïve with humans and are rarely handled in a manner that would be considered sufficiently consistent for ruling out experience effects on learning. Available for use in the present study were 102 Shetland-type ponies reared within sire/dam families together in a semi-feral herd with minimal and standard (reinforcement based) human interaction, and with known parentage, genetic relatedness and family composition since the inception of the herd in 1994. Within the context of their home semi-feral environment, performance on a simple operant task was used to assess learning efficiency for subsequent comparison of sire, dam, and sire/dam lines as well as to explore age and gender differences.

2. Methods

2.1. General Design

One hundred two ponies from a semi-feral herd each received a single session of operant training (OT) on a simple task to touch the muzzle to a unique object, known among animal trainers as "target training," as an estimate of learning efficiency. To confirm that increased response during OT in fact represented learning due to reinforcement contingencies [17], a subset of animals initially served as yoked controls (YCs). Learning efficiency levels based on quantitative measures were compared among sires and their offspring, dams and their offspring, and mating pairs and their full sibling offspring. Procedures were in accordance with an institutional animal care and use committee–approved protocol.

2.2. Subjects

Subjects included 102 small Shetland-type ponies (48 males and 54 females) ranging in age from 47 days to 17 years. These animals were born and have been maintained within a semi-feral herd since 1994 at the University of Pennsylvania School of Veterinary Medicine in Chester County, Pennsylvania, principally for the purpose of observational study of their behavior under natural social conditions and seminatural environmental conditions. DNA-based parentage is confirmed for all offspring (Gluck Equine Parentage Testing Laboratory, University of Kentucky, Lexington, KY). All animals were reproductively intact and breeding freely. Handling by humans is limited to required preventive health care (daily observation usually at a distance, and as needed for annual vaccinations and deworming) done by highly skilled technicians experienced with these procedures and working under field conditions using positive reinforcement (food treats as needed for yearlings and adults, soothing scratching of neck, withers, chest, or rump for foals). In addition, between the age of 2 and 4 weeks, each foal receives one 30-minute "gentling" experience of positive reinforcement–based acclimation to human interaction with 21 specific compliance goals including touch all over the body, simulated veterinary examination and routine health care procedures, introduction of a halter, and introduction to leading if time allows. The animals are maintained in a 40-acre enclosure consisting of natural forages and natural water sources as well as supplementation in the deep winter with grass hay as needed to maintain reasonable body condition. Shelter consists of natural hedges and light forest within the enclosure. At the time of this work, the herd consisted of 11 harem groups and one bachelor band totaling 105 animals. Ninety-four of the 102 that were subjects of this study were still in the herd at the time. The remaining eight (four mature males and four mature females) had been removed from the herd within the last 3 years and maintained under similar environmental conditions in pasture groups. The four males that were no longer in the herd had been castrated. Each sire line included an individual sire and any of his offspring available for evaluation at the time. Each dam line included an individual dam and any of her offspring available for evaluation at the time. Each sire/dam line was a sire and dam pair and any of their full-sib offspring available for evaluation at the time. Only lines with four or more individuals were included in comparisons.

2.3. Operant Training Session Environment

For animals still in the herd, the OT session was conducted within their home environment. Each harem or bachelor group was first separated into a gated catch pen system within the herd enclosure. The subject was then lured or guided into a subenclosure adjacent to and within visual contact of the remainder of the family. For three mares with younger foals, the foal remained with the dam. For foal OT, their dam was positioned in an adjacent enclosure and fed grain near the separating gate. The foal and mare could maintain visual and tactile contact through the rails of the separating gate. These foals had had previous experience with such an arrangement for their initial 30-minute gentling session (see previously). Foals were allowed 5 minutes to acclimate and settle before the start of the training session. To avoid distraction of the subject from insects, insect repellant (Endure; VPL, Farnam, Phoenix, AZ) was applied to the substrate of the training enclosure and to the subject as needed. For one solitary bachelor stallion, the training was done in the open field. For the eight animals that were no longer in the herd, training was done either in their familiar pasture environment or a familiar stable adjacent their pasture. The training, viewing of video, extraction of quantitative measures, and subsequent ranking of learning efficiency were done blindly to relatedness of subjects.

2.3.1. Yearling and Older Subjects

For the 80 yearling and older subjects, the subject was allowed approximately 5 minutes to acclimate to separation from their family in the subenclosure before the start of a training session. The experimenter then entered the subenclosure and offered a palatable treat while applying a halter. Using the halter and a cotton lead attached to the lower ring, the experimenter calmly positioned the subject into a smaller training enclosure (1.73 × 1.07 m, Fig. 1). The enclosure's barriers consisted of a webbed stall guard in front, straw bale on top of a large plastic storage bin behind, and wooden board fencing on either side of the pony. The

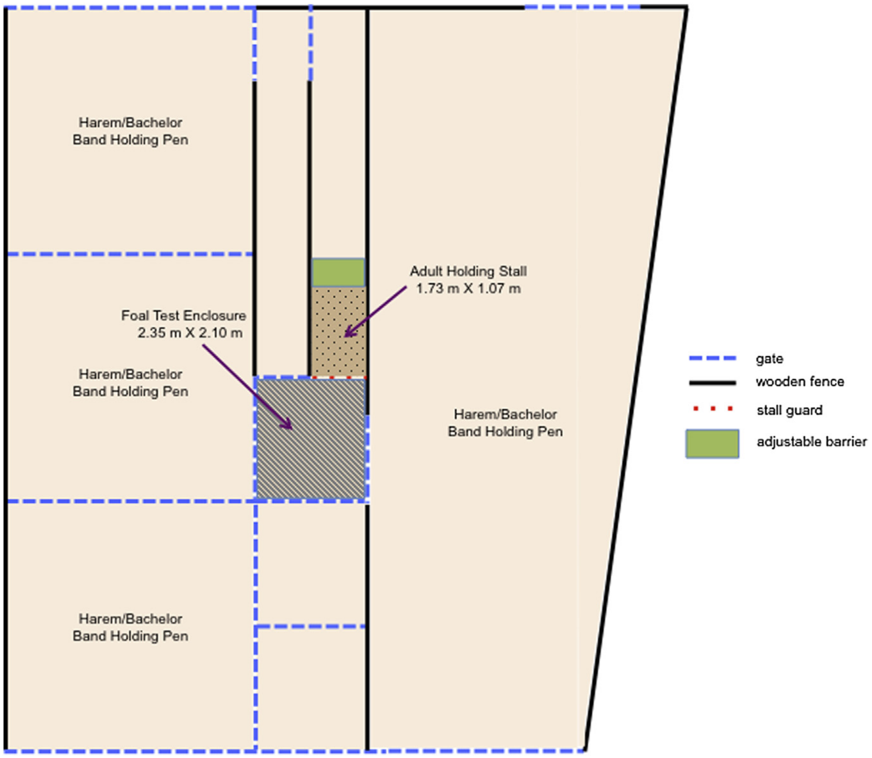

Fig. 1. Gated pen system located within the herd enclosure consisting of harem group holding areas along with a foal test subenclosure and adult holding stall.

single OT session was limited to a maximum of 10 minutes. The same experimenter conducted all training sessions. The experimenter was experienced with horse handling and training as well as had conducted preliminary practice trials using this protocol with one domestically reared pony as well as four adult ponies that had been born in this herd. The operant task, target training consisted of touching the muzzle to a plastic target (0.165 × 0.127 m pink fly-swatter with a 0.019 × 0.305 m white plastic handle) when presented at muzzle level approximately 0.15 m in front of the animal with the handle parallel to the ground (Fig. 2). A correct response was considered muzzle contact with the target within 5 seconds of presentation. Each correct response was followed simultaneously with removal of the target and delivery of primary reinforcement (0.005 kg pelleted feed familiar to these animals, Purina Equine Senior Active, Gray Summit, MO; www.horse.purinamills.com) along with secondary reinforcement (verbal "good") in the manner commonly done in target training of domestic animals. Touching of the handle was not considered a correct response. Incorrect response (touching the handle or not touching the target within 5 seconds of presentation) was followed with removal of the target from view, and representation after approximately 3 seconds. The feed was contained in a small rigid plastic bucket attached to a belt around the experimenter's waist and was delivered to the animal from the hand at the subject's muzzle level. For subjects that appeared reluctant to readily take feed from the experimenter's hand, the feed was delivered in a handheld 2-L rubber food bowl. As soon as the subject ingested the feed, the target was re-presented. After a series of five correct responses, the session continued for 10 additional presentations or until 10 minutes had elapsed from the start of the session. The rationale for this protocol was that five correct in a row likely reflected an understanding of the contingency. The additional 10 presentations was to reach a sufficient number of presentations to evaluate whether performance reached or exceeded what would be expected by chance alone, which would require a minimum of 12 correct responses in a series of 15 presentations.

Eight of the 102 yearling and older subjects (four males and four females) representing various age groups ≥1 year initially served as YCs. The YC procedure proceeded as for OT, except that target presentations and reinforcement were based on the reinforcement schedule of a previously trained OT subject, so not contingent on the YC subject's interaction with the target. This was accomplished using playback of an audio recording of an OT subject's session via earpiece worn by the experimenter to prompt delivery of reinforcement matching those of the OT subject rather than contingent on the response of the YC subject.

All training sessions were video recorded using a digital camcorder on a tripod positioned outside the enclosure to enable adequate view of all interactions of the experimenter and the subject. These recordings were subsequently evaluated to obtain the following quantitative measures of learning efficiency: (1) latency in seconds to criterion for learning, set at 12 or more correct responses on the final 15 presentations, which is greater than would be expected by chance alone, or completion of session at 10 minutes, (2) number of correct responses in those final 15 presentations, (3) number of correct responses in the entire session, (4)

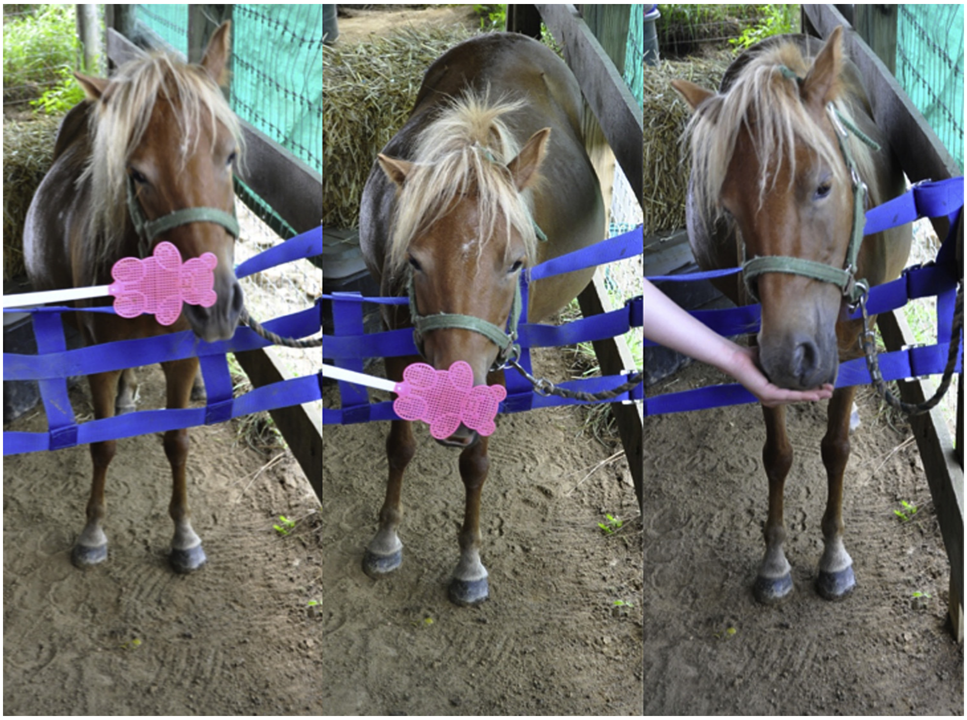

Fig. 2. Target training protocol for yearlings and older: presentation of the target (left), subject reaching to touch the muzzle to the target (middle), followed by the simultaneous removal of the target and delivery of primary reinforcement feed along with secondary reinforcement spoken "good" (right).

number of incorrect responses in entire session, and (5) frequency of target touches per minute of session. Using these measures, three indices of learning efficiency, each likely reflecting different aspects of the learning process, were calculated. These included (1) the percentage of correct responses in the final 15 presentations as an index of how solidly the learning had occurred (2) the frequency of target touches per minute of the training session as an index of interest and sustained focus on the task, and (3) the total incorrect responses in the training session as an index of error rate reflecting negatively on efficiency. Using these three indices sequentially as primary, secondary, and tertiary separators, learning efficiency of the 80 yearling and older ponies were ranked from 1 (greatest) to 80 (least). To obtain comparable learning efficiency estimates for these older ponies and the foals (see in the following), the ranks were used to reduce to five levels of learning efficiency, with 1 (greatest) to 5 (least). In addition, coincidental behaviors interpreted as frustration and/or avoidance in this context (turn head away, paw, vocalize, head toss, back away, and rear) were counted.

2.3.2. Foals

For the 22 foals (aged 7 to 16 weeks), OT involved a similar protocol adapted for the younger subjects. Based on preliminary work with foals, it had been judged that certain modifications to the protocol used with yearling and older ponies facilitated more reliable focus of the foals on the training. These included (1) having the foal unhaltered in a 2.35 × 2.10 m enclosure; (2) using a stationary target on the ground, in this case a gray rock that had been painted white in a random checkered pattern; and (3) accompanying each "presentation" with the spoken prompt "target" to draw the attention of the foal to the task. In addition to positive reinforcement for touching the target with the muzzle, because the target was stationary, positive reinforcement was continued for the duration of the contact. This target was positioned for approximately 2 minutes at each of three standard locations within the enclosure. Unlike yearlings and adults in this herd, foals of this age have not yet been introduced to solid feeds as a reward. In preliminary work, foals of this age consistently appeared well motivated by a scratching at the rump or neck. Therefore, the positive reinforcement for these foals consisted of scratching on the rump or neck. Quantitative measures for foal OT included (1) latency to consistent target touching (from initial placement of the target at the start of the session), (2) frequency of target touches per minute of session, (3) latency to begin holding on target, and (4) total time holding on target for session. Based on these specific measures, learning efficiency of the 22 foals was ranked overall and then into five levels, with 1 (greatest) to 5 (least). Coincidental frustration and/or avoidance behaviors were also counted for the foal subjects. Seven foals were initially tested in YC sessions using procedures as described for yearlings and adults.

2.4. Statistical Evaluation

Wilcoxon signed-rank test procedures were used to evaluate differences between OT and YC sessions. Pearson correlation procedures were used to evaluate intraobserver

Table 1
Learning efficiency level for yearlings and older, comparing initial-yoked control and OT subjects.

	Learning Efficiency Level (1 = Greatest to 5 = Least Efficient)		
	Range	Mean	Median
Control sessions (n = 8)	5	5	5
Subsequent training sessions of control subjects (n = 8)	1–5	2.94	3
Training sessions (n = 72)	1–5	3.75	4

Abbreviation: OT, operant training.

and interobserver reliabilities from video viewing through data entry, using a subset of four OT and one YC session, both for the yearlings and older ponies and for the foals. Median test and Kruskal–Wallis (with Mann–Whitney *U* tests for follow-up mean separation) were used to evaluate differences in learning efficiency level among sire, dam, and sire/dam lines and test the significance of differences among age groups and gender. Fisher's exact test procedures were used to evaluate differences among proportions of frustration/avoidance responses. Pearson correlation procedures were used to evaluate association between learning efficiency and frustration/avoidance responses. All evaluations were accomplished using Statistix version 10 (Analytical Software, Tallahassee, FL).

3. Results

3.1. Intraobserver and Interobserver Reliabilities

Intraobserver reliabilities (Pearson *r*, 0.9997 to 1.0) as well as interobserver reliabilities (Pearson *r*, 0.9798 to 1.0) were excellent for all measures.

3.2. Yoked Controls

As expected, learning efficiency, both for foals and for yearlings and adults, was low in the YC sessions compared with OT sessions. For foals, the correct response rates tended to be significantly higher for the seven OT foals than for YC foals (Wilcoxon signed-rank test; $P = .07$). In addition, the proportion of correct responses following the verbal prompt was greater for OT foals than control foals (Wilcoxon signed-rank test; $P = .007$). Learning efficiency of all seven YC-foal sessions ranked lower than all OT sessions. For yearlings and older, all eight YC sessions achieved the poorest learning efficiency ranks. The mean learning efficiency level for the eight YC sessions was five compared to 3.75 for OT sessions. In their subsequent OT sessions, these eight initially YC subjects had a mean learning efficiency level of 2.94. These results confirm that increased responding in OT sessions represented learning as a result of reinforcement contingencies.

3.3. Sire, Dam, and Sire/Dam Line Differences

Learning efficiency level differed significantly among sire lines, dam lines, and sire/dam lines ($P < .05$; median test).

Table 1 and Fig. 3 summarize the learning efficiency level and frustration/avoidance response frequency for eight sire lines, each with six or more individuals. In addition to the differences in learning efficiency found significant at $P < .05$ or $P < .01$ as indicated, the difference between one additional line tended toward significance ($P < .10$). Three sire lines had significantly fewer frustration/avoidance responses than one other line ($P < .01$; median test).

Table 2 and Fig. 4 summarize the learning efficiency level and frustration/avoidance response frequency for 15 dam lines, each with four or more individuals. Two of the 15 dam lines had learning efficiency levels significantly greater than two other lines (Mann–Whitney *U* test; $P < .05$). Two dam lines, with no frustration/avoidance responses, differed significantly from all other dam lines (Mann–Whitney *U* test; $P < .01$). Of the remaining 13 dam lines, six had significantly fewer frustration/avoidance

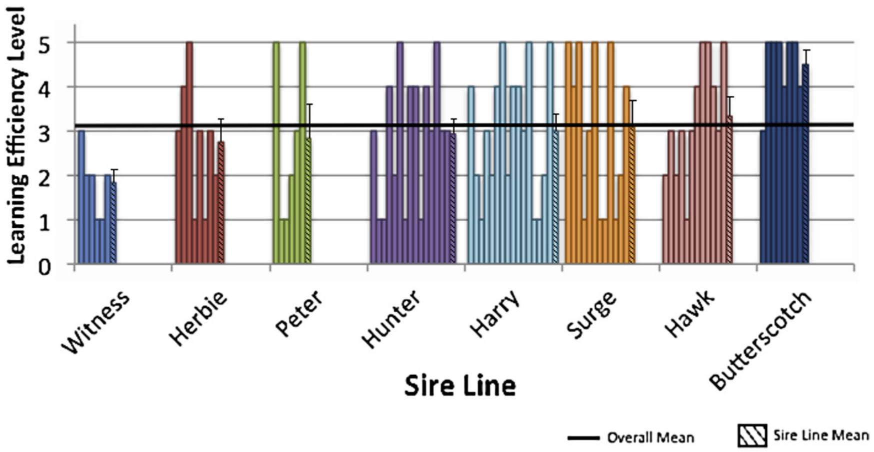

Fig. 3. Learning efficiency levels of individuals representing eight sire lines. Diagonally striped bar at right of each sire line cluster represents mean (SE) learning efficiency level of that sire line. Bold horizontal line represents overall mean for these 83 subjects. SE, standard error.

Table 2
Learning efficiency level and frustration/avoidance response frequency for eight sire lines.

Sire Line (n)	Learning Efficiency Level (1 = Greatest to 5 = Least Efficient)		Frustration/Avoidance Frequency Per Minute	
	Range	Mean	Range	Mean
Witness (6)	1–3	1.83^{a}	0–0.46	0.08^{a}
Herbie (8)	1–5	2.75^{a}	0–0.26	0.03^{a}
Peter (6)	1–5	2.83^{a}	0.53–3.23	1.64^{b}
Hunter (15)	1–5	2.93^{a}	0–0.08	0.32^{a}
Harry (16)	1–5	$3.00^{a,b}$	0–2.11	$0.45^{a,b}$
Surge (12)	1–5	$3.08^{a,b}$	0–0.89	$0.33^{a,b}$
Hawk (12)	1–5	3.33^{b}	0–2.33	$0.44^{a,b}$
Butterscotch (8)	3–5	4.50^{b}	0–1.67	$0.69^{a,b}$

Means within columns not sharing common superscripts differ ($P < .05$).

responses than one other line (Mann–Whitney *U* test; $P < .05$ or $P < .01$).

Table 3 and Fig. 5 summarize the learning efficiency level and frustration/avoidance response frequency for seven sire/dam lines, each with five or more individuals. One of the seven sire/dam lines had significantly lower learning efficiency than two other sire/dam lines (median test; $P < .01$ and $P < .05$). The sire/dam line with the poorest learning efficiency had significantly higher number of frustration/avoidance responses than one of the other sire/dam lines (Mann–Whitney *U* test, $P < .01$).

Considering all 102 subjects, frustration/avoidance response frequency was negatively associated with learning efficiency level (Pearson $r = 0.42$, 101 degree of freedom [df], $P < .001$). The frequency of frustration/avoidance responses per minute of the session was significantly different among sire, dam, and sire/dam lines. Frequency of frustration/avoidance responses per minute was also significantly different among age groups (Kruskal–Wallis, 3 df, $P < .00001$), with mean comparisons summarized in Table 4. The difference in frequency of frustration/avoidance responses between males and females was not significant (Mann–Whitney *U* test; $P > .10$).

Table 3
Learning efficiency level and frustration/avoidance response frequency for 15 dam lines.

Dam Line (n)	Learning Efficiency Level (1 = Greatest to 5 = Least Efficient)		Frustration/Avoidance Frequency Per Minute	
	Range	Mean	Range	Mean
Rachel (5)	1–3	$1.60^{a,b}$	0–0.20	0.04^{b}
Natalie (5)	1–3	$1.80^{a,b}$	0	0^{c}
Rainbow (9)	1–4	1.89^{a}	0–1.36	0.18^{b}
Cleo (7)	1–4	2.14^{a}	0–2.11	$0.39^{a,b}$
Nora (5)	1–4	$2.40^{a,b}$	0	0^{c}
Mirage (5)	1–4	$2.40^{a,b}$	0–0.58	0.25^{b}
Kelley (5)	1–5	$2.60^{a,b}$	0–0.89	$0.45^{a,b}$
Alli (6)	1–5	$2.67^{a,b}$	0–0.76	0.18^{b}
Dawn (5)	1–5	$3.20^{a,b}$	0–1.36	$0.63^{a,b}$
Gold Star (4)	1–5	$3.25^{a,b}$	0–3.23	$1.03^{a,b}$
Hermione (6)	2–5	$3.33^{a,b}$	0–0.71	0.17^{b}
Shower (5)	2–5	$3.40^{a,b}$	0–0.83	0.24^{b}
Joy (5)	2–5	$3.40^{a,b}$	0–2.50	$0.84^{a,b}$
Peanut (9)	2–5	3.67^{b}	0–0.08	$0.50^{a,b}$
Meg (5)	2–5	4.40^{b}	0–2.10	1.27^{a}

Means within columns not sharing common superscripts differ ($P < .05$).

3.4. Age and Gender Differences

Table 5 summarizes the learning efficiency level and frustration/avoidance response frequency for four age groups (foals, yearlings and 2-year-olds, mature adults aged 3 to 6 years, and 7 to 17 years). Mature adults aged seven to 17, tended to have greater learning efficiency than the 1- to 2-year-olds (Kruskal–Wallis, 101 df, $P > .05$). Frustration/avoidance response frequency for foals was significantly higher than each of the other three age groups (Mann–Whitney *U* test; $P < .01$). Frustration/avoidance responses were significantly greater for yearlings and 2-year-olds than for 7- to 17-year-olds (Mann–Whitney *U* test; $P < .05$).

Table 6 summarizes the learning efficiency level for males and females. The learning efficiency level tended to be greater for females than males (median test; $P < .10$).

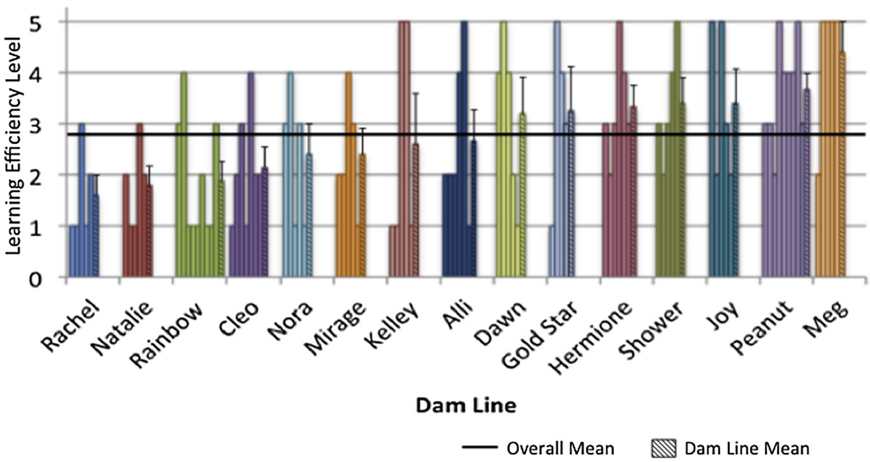

Fig. 4. Learning efficiency levels of individuals representing 15 dam lines. Diagonally striped bar at right of each dam line cluster represents mean (SE) learning efficiency level of that dam line. Bold horizontal line represents overall mean for these 86 subjects. SE, standard error.

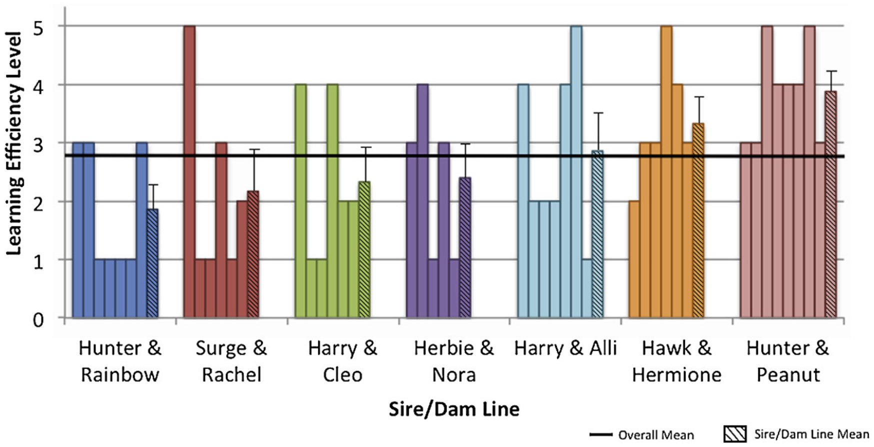

Fig. 5. Learning efficiency levels of individuals representing seven sire/dam lines. Diagonally striped bar at right of each sire/dam line cluster represents mean (SE) learning efficiency level of that sire/dam line. Bold horizontal line represents overall mean for these 45 subjects. SE, standard error.

4. Discussion

These findings provide evidence for effects of sire and dam on learning of a simple operant task in horses. Secondary findings included evidence that frustration/avoidance response frequency during the training session was negatively associated with learning efficiency, as well as evidence for differences among sire lines, dam lines, age groups, but not gender, in frequency of frustration/avoidance responses during this single operant training session.

Even though 102 animals from this herd were evaluated, because of the large number of family lines represented, the numbers of animals in each sire, dam, or sire and dam group were relatively low. It is likely that with increased numbers, further differences may become evident. Additionally, increased numbers would facilitate a more sophisticated factorial analysis, including evaluation of gender and age. This herd will be followed in coming years with similar evaluation to accumulate sufficient numbers for such analyses.

It should be emphasized that it is difficult to separate basic cognitive ability from basic temperament characteristics that affect learning but are also assumed to be under genetic and environmental influences [5,15]. Even in this model of a brief and simple operant assessment protocol conducted within a home semi-feral environment under relatively nonthreatening, positive reinforcement–based learning conditions, temperament characteristics likely affected performance. For example, in this brief protocol, six of the 80 adults failed to demonstrate learning as defined by greater than chance alone in terms of the number of correct responses in the final 15 presentations. Five of these six who failed to demonstrate learning also exceeded the mean frustration/avoidance response frequency of their corresponding age group. The six failures included two sets of full siblings and one set of half siblings. Each set shared either a dam or sire who themselves and their offspring until well into maturity had shown similar tendencies during interaction with humans. Although in the case of these particular subjects with this known family history it may be reasonable to speculate that basic temperament characteristics resulting in increased fear-based frustration/avoidance responses resulted in lower learning efficiency levels, it is likely equally reasonable to speculate that lower basic cognitive ability that delayed learning in turn increased frustration/avoidance responses. Similarly, it should be emphasized that for at least their first year of development, the subjects of this study were with their sire and dam as well as any half and full siblings still resident within their natal band.

Table 4
Learning efficiency level and frustration/avoidance response frequency for seven sire/dam lines.

Sire/Dam Line Sire and Dam (n)	Learning Efficiency Level (1 = Greatest to 5 = Least Efficient)		Frustration/ Avoidance Frequency Per Minute	
	Range	Mean	Range	Mean
Hunter and Rainbow (7)	1–3	1.86^{b}	0–0.27	0.04^{a,b}
Surge and Rachel (6)	1–5	2.17^{b}	0–0.26	0.08^{a,b}
Harry and Cleo (6)	1–4	2.33^{a,b}	0–2.11	0.45^{a,b}
Herbie and Nora (5)	1–4	2.40^{a,b}	0	0^{a}
Harry and Alli (7)	1–5	2.86^{a,b}	0–0.76	0.16^{a,b}
Hawk and Hermione (6)	2–5	3.33^{a,b}	0–0.71	0.17^{a,b}
Hunter and Peanut (8)	3–5	3.88^{a}	0–2.08	0.56^{b}

Means within columns not sharing common superscripts differ ($P < .05$).

Table 5
Learning efficiency level and frustration/avoidance response frequency for four age groups.

Age Group (n)	Learning Efficiency Level (1 = Greatest to 5 = Least Efficient)		Frustration/ Avoidance Frequency Per Minute	
	Range	Mean	Range	Mean
Foal (22)	1–5	3.00^{a}	0.20–3.23	1.28^{a}
Yearlings and 2 young (23)	1–5	3.48^{a}	0–1.80	0.31^{b}
3–6 young (28)	1–5	3.14^{a}	0–2.08	0.36^{b,c}
7–17 young (29)	1–5	2.48^{a}	0–1.36	0.11^{c}

Means within columns not sharing common superscripts differ ($P < .05$).

Table 6
Learning efficiency level for males and females.

Gender (n)	Learning Efficiency Level	
	Range	Mean
Male (48)	1–5	3.27[a]
Female (54)	1–5	2.76[a]

Means within columns not sharing common superscripts differ ($P < .05$).

Beyond the value of these results to basic understanding of horse cognition, research addressing equine cognition is of importance to humane and efficient animal husbandry and training. Positive reinforcement–based operant conditioning is inherent to many aspects of horse management and training, whether or not handlers recognize it as such. Confirmation of dam and sire effects on such operant learning efficiency is valuable. Traditionally, much of active training of horses has relied heavily on negative reinforcement and punishment methods, as opposed to the positive methods used here. Based on long-established general principles of learning, along with a growing body of work specifically in horses, current trends in equine science–based recommendations include incorporation or substitution positive reinforcement methods wherever practical in horse management and performance training [18–21]. Certainly, further work would be required to evaluate sire and dam lines in efficiency with negative reinforcement.

The popularized equivalent to the simple positive reinforcement–based operant training protocol used in this current protocol is known in animal training as target training. The technique has long been one of the basic training tools on which to positively shape animal behaviors, for example, as in training of various species, including horses, for circus and other competition and entertainment venues. For example, target training, using an auditory secondary reinforce in the form of a "clicker," is the basis of training the extraordinary behaviors in marine mammal exhibits. More recently, these science-based training methods have been quite widely adopted for companion animals, particularly dogs. Although within the mainstream horse industries, popularization and broad acceptance of clicker and target training seem to have lagged behind that of other domestic species, it is likely the most common scientifically sound positive reinforcement–based behavior modification technique currently in use with horses around the world.

In conclusion, this work provides evidence for sire and dam effects on learning efficiency in a positive reinforcement–based operant conditioning paradigm.

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