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Evaluation of operant learning in young foals using target training

Elena V. Martinez de Andino*, Sue M. McDonnell

Havemeyer Equine Behavior Lab at New Bolton Center of University of Pennsylvania School of Veterinary Medicine, 382 West Street Rd., Kennett Square, PA 19348, USA

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ABSTRACT

The primary purpose of this study was to characterize operant learning performance of young foals. For each of 26 foals, aged 6–20 weeks, learning performance was quantitatively evaluated in a single brief training trial using a standard operant conditioning task and paradigm analogous to those common to training and management of domestic horses, popularly referred to as "target training." With no human interaction in the interim, retention of the learning was evaluated seven to 26 days after the initial training trial. All 26 foals demonstrated learning in this operant paradigm. In this operant paradigm, learning was as efficient in the foals of 6 weeks to 3 months of age (n = 14) as foals of 3–5 months of age (n = 12). Some evidence was found for more efficient learning in female (n = 13) than in male foals (n = 13), as well as in certain sire lines. Seventeen of the 26 foals (65%) met the criterion for retention. Differences in the proportions of males and females and of younger and older foals that met this criterion were not significant (Fisher's Exact Test). This work demonstrates the ability of young foals to efficiently learn and to retain an operant task.

1. Introduction

How and when horses learn are important to training efficiency and efficacy, as well as horse and handler compatibility and safety. Much of the large body of published work on principles of learning that generalize to all species certainly apply to the horse and other domestic animals. In addition, in recent decades there has been a growing interest and resulting body of literature concerning learning specifically in horses (McCall, 1990; Hanggi, 2005; Nicol, 2005; Murphy and Arkins, 2007; Leblanc, 2013). Example topics addressed have included spatial task learning (Haag et al., 1980; McCall et al., 1993; et al., 1996Wolff and Hausberger, 1996; Murphy et al., 2004; Hothersall et al., 2010), simple stimulus and concept discrimination (McCall, 1989; Sappington and Goldman, 1994; Hanggi, 2003; Visser et al., 2003; Hanggi and Ingersoll, 2009; Hothersall et al., 2010), and interocular transfer of learning (Hanggi, 1999). Factors studied affecting learning have included breed (Mader and Price, 1980; Hausberger et al., 2004; Lindberg et al., 1999), age (Haag et al., 1980; Mader and Price, 1980; Houpt et al., 1982; Lindberg et al., 1999; Visser et al., 2003; Lansade et al., 2004; Murphy et al., 2004; Krueger et al., 2014), sex (McCall et al., 1993 Wolff and Hausberger, 1996; Murphy et al., 2004), social dominance (Haag et al., 1980; Mader and Price, 1980), emotional reactivity (Heird et al., 1981; Heird et al., 1986; Visser et al., 2003; Lansade et al., 2004; Mengoli et al., 2014), rearing conditions (Houpt et al., 1982), nutritional condition (Haag et al., 1980; Hanggi, 2003), social observational learning opportunity (Clarke et al., 1996; Lindberg et al., 1999), and early intensive handling (Heird et al., 1981; Heird et al., 1986; Williams et al., 2002; Lansade et al., 2004; Spier et al., 2004; Santamaria et al., 2005; Ligout et al., 2008).

Understanding learning in juveniles is important, particularly to the extent that it may be related to or may affect later trainability. Recently, researchers at Bristol reported that 5 of 5 domestically managed foals ranging in age from 17 to 21 weeks successfully demonstrated visual discrimination learning in an operant paradigm (Hothersall et al., 2010). To our knowledge, no systematic studies of learning have included foals younger than 17 weeks. The primary purpose of this study was to characterize learning performance of foals 6–20 weeks of age. A standard operant conditioning task analogous to tasks common to training and management of domestic horses was used to evaluate initial learning as well as retention. Secondary objectives included comparing performance of (a) younger and older foals, (b) male and female foals, and (c) foals of different sire lines. Additionally, we explored behavioral correlates of learning performance. We hypothesized that foals would demonstrate learning, and that learning efficiency would vary among sire lines. We had no hypothesis concerning effects of age or sex.

2. Materials and methods

This study was conducted during July to August 2013 with all animal care and procedures approved by the Institutional Animal Care and Use Committee of the University of Pennsylvania.

* Corresponding author.
E-mail address: suemcd@vet.upenn.edu (S.M. McDonnell).

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2.1. Subjects

Subjects included 26 Shetland-type pony foals (13 males and 13 females), ranging in age from 47 to 139 days at the time of their initial learning assessment trial. These foals were born during 2013 foaling season within the semi-feral herd of Shetland-type ponies maintained at the University of Pennsylvania's New Bolton Center primarily for the purpose of observational study of equine behavior under natural social conditions. The herd was maintained on all natural forage, water sources, and shelter through the period of study. Previous handling of these foals had been limited to a single 30-min session of gentle handling alongside their dam and harem group at between two and four weeks of age. This procedure is meant to acclimate the foal to touch to all parts of the body during quiet, gentle interaction with humans.

These 26 foals represented offspring from a total of 7 sire lines (common sire or grandsire). Three of these sire lines had 4 or more foals (4,6 and 8), such that learning performance by sire line could be compared.

2.2. Learning assessment

2.2.1. Environment

Learning assessments were done using a sub-enclosure within the herd enclosure. This sub-enclosure is formed by closing gates at either end of a laneway through which the herd passes daily on treks from grazing to water, and where the herd occasionally rests and loafs. On the day of assessment, each harem group was held as it passed through the laneway, such that the group could comfortably loaf together as a harem for the duration of their foals' trials. For each individual foal trial, the dam and foal were separated into a sub-enclosure adjacent to the harem group enclosure by quietly luring the dam with a small amount of palatable feed. Once in the assessment enclosure, the foal was separated into an adjacent pen (2.35 m × 2.10 m). The dam was kept comfortably occupied with a palatable feed along the gate separating the mare and foal pens, where the foal and dam could see and interact vocally but not touch one another. The three remaining sides of the foal enclosure were lined with standard equestrian vinyl covered padding.

Three standard target locations included midway along the gate separating the foal and dam and along each of two other sides of the pen. These were measured and marked on the natural substrate.

Each learning assessment trial was video/audio recorded (Sony HDR-XR520 with digital high definition 0.45X wide angle lens with macro; Minato, Tokyo, Japan). The video camera on a tripod was positioned outside the foal pen to span the entire pen.

2.2.2. Procedure

The experimenter entered the foal pen and quietly approached the foal, gauging and adjusting manner and pace of approach so as to establish tactile contact while eliciting minimal avoidance behavior. Once contact was established, the experimenter proceeded with gentle scratching of the foal to identify an area to which it responded especially favorably (typically at the withers, chest neck, or rump which are the common mutual grooming sites for horses; McDonnell, 2003). This scratching is used routinely in our laboratory and clinic as primary positive reinforcement for young foals in lieu of food rewards to which they are not yet acclimated since they are nursing. Example indications of a foal's positive perception of the scratching include wiggling the body part back and forth as if to facilitate scratching, presenting, moving toward or pushing the body part into the scratching hand, or raising the hindquarters toward the hand scratching. The duration of this acclimation phase of the trial varied with individual foal, ranging approximately from 30 s to 135 s.

In the following 2.5 min, the unconditioned (primary) reinforcement (UCR) of scratching was paired with the spoken word "good" as a conditioned (secondary) reinforcer (CR). UCR-CR pairing was repeated at approximately 10-s intervals for 10 pairings. After the 10 pairings, the CR was presented alone to evaluate for behavioral indications of anticipation of UCR (e.g. presenting body part to experimenters, gazing toward experimenter's hand, nibbling experimenter as in mutual grooming initiation gesture). If none, UCR-CR pairings continued for an additional 30 s. The duration of this classical conditioning or "loading" phase was based on preliminary trials with adult animals using the same UCR-CR pairings.

The remainder of the 6-min trial was devoted to operant shaping of touching and holding the muzzle to a target object in response to a verbal prompt. The designated target was a rock (approximately 23 cm × 15 cm × 9 cm) obtained from the herd enclosure that had been painted with white stripes (5 cm wide at 5 cm intervals running lengthwise) (Alu-Spray Non-Toxic Aerosol, Vetoquinol NA for Neogen Corporation, Lexington, Kentucky, USA)

The target was initially placed midway along the gate nearest the dam and then moved to the locations progressively further from the dam, for approximately 2 min at each location.

After initial placement of the target, if the foal did not voluntarily attend to it within an approximately 5 s, the experimenter gently guided the foal toward the target. As the foal first appeared to focus on the target (gaze or investigate with pawing) the experimenter spoke the work "target" as a prompt. When the foal touched the muzzle to the target, the experimenter simultaneously spoke the word "good" and delivered a scratch of 2–3 s duration. For as long as the foal held the muzzle to the target, the UCR-CR pairings were continued at 2–3 s intervals. If the foal appeared to lose focus on the target for 15 s, it was again gently guided back toward the target. This guiding of the foal to attend to the target typically occurred, if at all, once or twice at the beginning of the shaping session, and only occasionally later during the session.

2.2.3. Yoked controls

To evaluate that learning in fact occurred, seven of the 26 subjects served as yoked controls. Procedures for yoked controls were similar to those for operantly trained foals, with the exception that prompts and reinforcements were delivered on the schedule received by a trained foal matched for age and sex rather than based on the yoked foal's own response. This was achieved using audio playback of the matched training trial via wireless earpiece to the experimenter. After a three-week washout period, these seven foals were subjected to operant training trials for inclusion of their data with other trained foals. On this second exposure, a total of one minute was devoted to acclimation and refresher-loading before proceeding to the operant conditioning phase as described above for all other 19 subjects. The rationale for subsequent use of these 7 foals in operant training was that no evidence of learning was observed in their yoked trial and that the brief control trial experience did not appear to be particularly positive or negative such that it would affect a subsequent operant conditioning trial.

2.2.4. Measures from video analysis

From the video record of each trial, the learning measures defined in Table 1 were derived.

2.2.5. Retention assessment

To evaluate retention of the learned operant task, between 7 and 26 days after the initial target training trial, each foal received an abbreviated second training trial. Procedures and measures were the same as for the initial training trial except that the duration of the classical conditioning phase was limited to 1 min, the operant conditioning phase was limited to 2 min, and the target was located at a new position in the center of the enclosure.

Table 1
Measures evaluating learning, attention/interest, and frustration/avoidance.

Learning measure	Operational definition	Interpretation
Latency to conditioned response	Elapsed time in seconds from first reinforced touch of the target to an increased rate of touching target, defined as three reinforced touches within 5 s	Shorter latency suggests more efficient learning, possibly reflecting higher learning ability.[a]
Correct response frequency	Frequency of target touches nosing = 1 touch pawing = ½ touch holding = 1 touch for every 3 s of sustained contact	Higher frequency suggests more efficient learning, possibly reflecting higher learning ability.[a]
Correct response to verbal prompt rate	Number of verbal prompts followed by target touches divided by the total number verbal prompts	A number closer to 1 suggests a better understanding of the verbal prompt and thus more efficient learning, likely reflecting higher learning ability.[a]
Frequency held target	Number of times foal held muzzle to the target for > 3 s	A higher frequency suggests a higher level of understanding the target task, likely reflecting a higher learning ability.[a]
Total duration held target	Cumulative time in seconds foal held muzzle to the target for > 3 s	Greater duration suggests more efficient learning, likely reflecting a higher learning ability.[a]
Overall rank	Foals ranked from 1 (most efficient learner) to 26 (least efficient) based on total duration held target, correct response to verbal prompt rate, and correct response frequency.	Lower value suggests better understanding of task, likely reflecting higher learning ability.

Measure of frustration/avoidance	Operational definition	Interpretation
Frustration/avoidance response frequency	Frequency of frustration/avoidance responses (e.g. head toss or shake, paw, kick, stamp, tail swish, ears back, bite, rear, turn butt, scoot away, turn head back, defecation) during operant conditioning.	Higher frequency suggests confusion that may reflect lower learning ability.[a]

Subjectively judged indices of attention/interest	Operational definition	Behavioral basis of judgment
Interest in experimenter	At completion of trial, experimenter's subjective rating from 1 (low) to 5 (high) foal's interest in experimenter	Index based on behaviors such as approaching, lingering near, nudging, and sniffing experimenter; maintaining visual contact with experimenter; positioning/presenting scratch location to experimenter; and initiating play including nudges, pawing, and nipping.
Interest in target	At completion of trial, experimenter's subjective rating from 1 (low) to 5 (high) foal's interest in the target	Index based on behaviors including approaching, nudging, sniffing, pawing, and maintaining visual contact with target.
Interest in performing operant task	At completion of trial, experimenter's subjective rating from 1 (low) to 5 (high) foal's interest in the operant conditioning task	Index based on positioning as if anticipating reward, energetically cycling between touching target and engaging with experimenter, and touching target as if purposefully to reinitiate scratching reward.

[a] Factors also likely affecting this measure are individual variability in reinforcement value, satiety, competing motivations, and distractions.

2.3. Inter-observer and intra-observer reliabilities

To estimate intra-observer reliability of these measures, three weeks after the initial extraction of data from video and calculation of measures, the principal experimenter repeated the process without reference to previous results. To assess inter-observer reliability, a second technician not otherwise involved in the study similarly extracted data from video and calculated measures. For each of 5 variables (latency to conditioned response, correct response frequency, correct response to verbal prompt rate, frequency held target, total duration held target, frustration/avoidance response frequency) Pearson Correlation methods were used to estimate inter-observer and intra-observer reliability.

2.4. Statistics

Data were evaluated using Statistix 10 (Analytical Software, Tallahassee, Florida, USA). To evaluate that operant learning had occurred, for each of the 6 learning measures and the measure of frustration/avoidance response defined in Table 1, Wilcoxon Signed Rank Test procedures were used to compare results of yoked control subjects with those of their matched operantly trained subjects. In addition, for yoked control subjects, their yoked control trial results were similarly compared with results of their subsequent operant training trial. The Mann-Whitney U Test was used to compare results of the 7 initially yoked control subjects in their subsequent operant training trial with those of the 19 naïve subjects.

For each of the 10 measures, effects of age (< 3 months vs. > 3 month) and sex were evaluated using Wilcoxon Rank Sum Test procedures. For the three predominant sire lines (n = 4, 6, and 8), sire line effect was evaluated using Kruskal-Wallace One-Way non-parametric ANOVA.

Associations of the three subjectively judged indices with each other as well as with each of the six learning measures (excluding overall rank) were evaluated using Pearson correlation procedures. A probability of < 0.05 was considered significant. A probability of > 0.05 and < 0.1 was considered a tendency toward significance.

Retention was evaluated by comparing each individual subject's latency to conditioned response in the operant conditioning phase, correct response rate (correct response frequency per minute of the operant conditioning phase), correct response to verbal prompt rate, rate held target (frequency held target per minutes of operant conditioning phase), and percentage time held target (total duration held target divided by seconds of operant conditioning phase) in the retention trial to that of the initial training trial. The criterion for demonstrated retention of the target training task was change indicating improvement in at least 4 of the 5 learning measures. Fisher's Exact Tests were used to compare proportions of male and female foals, younger and older foals, and foals of various sire lines that met the criterion for retention.

Table 2
Pearson R values for intra-observer and inter-observer reliability on measures.

Measure	Intra-observer R	Inter-observer R
Latency to conditioned response	1	0.98
Correct response frequency	1.00	1.00
Correct response to verbal prompt rate	0.99	0.99
Frequency held target	0.99	0.91
Total duration held target	1.00	0.98
Frustration/avoidance response frequency	0.98	0.88

3. Results

3.1. Intra- and inter-observer reliabilities

Intra- and inter-observer reliabilities are detailed in Table 2. All were excellent and well above acceptable levels (Martin and Bateson, 2007).

3.2. Learning success

For four of the six learning measures the 7 yoked control foals differed from their 7 matched operantly trained foals. Operantly trained foals had shorter latency to conditioned response (Wilcoxon Signed Rank Test, $W = 28$, $P = 0.0078$; mean ± SE, 30.4 ± 12.78 s) compared to yoked controls (360 s, none achieved this criterion). Operantly trained foals also had greater correct response frequency than yoked controls ($W = -24$, $P = 0.023$; trained: 33.0 ± 4.61, yoked: 16.0 ± 2.99. Operantly trained foals also had greater a rate of correct response to verbal prompt ($W = -28$, $P = 0.0078$; trained: 0.84 ± 0.029, yoked: 0.17 ± 0.032) and a lower rank ($W = 28$, $P = 0.0078$; trained: 9.9 ± 3.05, yoked: 25.4 ± 1.81). In addition, operantly trained foals had fewer frustration/avoidance responses than yoked controls ($W = 22$, $P = 0.039$; trained: 4.0 ± 0.49, yoked: 8.9 ± 1.67).

For the 7 yoked control foals, their latency to conditioned response was greater as yoked controls than when subsequently operantly trained ($W = 28$, $P = 0.0156$; mean ± SE, 360 ± 0 s, none achieved criterion vs 42.7 ± 12.09 s). Their correct response to verbal prompt rate was significantly lower as yoked controls than when trained ($W = 28$, $P = 0.0156$; mean ± SE 0.17 ± 0.03 vs 25.43 ± 4.27). In addition, for the 7 initially yoked control subjects, results for all measures in their subsequent operant training trial were similar to those of the remaining 19 naïve operant training subjects (Mann Whitney U, $P > 0.10$ in all cases). For all learning measures, means were similar. Accordingly, we judged that the yoked control experience did not significantly affect performance in the subsequent operant training and thus included results of the operant training trial of the initial yoked control subjects in further analyses.

3.3. Descriptive summary of operant training results

The results for all 26 operantly trained foals are summarized in Table 3. As examples, the foal that ranked most efficient had 17 s latency to conditioned response, a correct response frequency of 39, a correct response to verbal prompt rate of 0.77, a frequency held target of 6, and 82 s total duration held target, with 5 frustration avoidance responses, a rating of 2 for interest in experimenter, 5 for interest in the target, and 4 for interest in performing the operant task. The foal that ranked least efficient had 16 s latency to conditioned response, a correct response frequency of 5, a correct response to verbal prompt rate of 0.21, a frequency held target of 1, and 5 s total duration held target, with 12 frustration avoidance responses, a rating of 3 for interest in experimenter, 2 for interest in the target, and 2 for interest in performing the operant task.

Table 3
Target training trials for 26 foals.

Measure	Range	Mean	SE
Learning			
Latency to conditioned response (sec)	9–157	42.7	7.06
Correct response frequency	5–56	24.7	2.36
Correct response to verbal prompt rate	0.21–1.0	0.66	0.038
Frequency held target	0–10	3.2	0.52
Total duration held target (sec)	0–82	25.2	4.28
Frustration/avoidance			
Frustration/avoidance response frequency	1–18	7.5	0.89
Subjectively judged indices of attention/interest			
Interest in experimenter (1 least, 5 most)	1–5	3.2	0.27
Interest in target (1 least, 5 most)	1–5	2.6	0.23
Interest in performing operant task (1 least, 5 most)	1–5	2.6	0.19

3.3.1. Evaluation of age effect

For each of the 10 measures, differences between younger (< 3 months, n = 14) and older (> 3 months, n = 12) foals were not significant (Wilcoxon Rank Sum Test, $P > 0.10$).

3.3.2. Evaluation of sex effect

The female foals (n = 13) had significantly lower latencies to conditioned response than the male foals (n = 13) (Wilcoxon Rank Sum Test, $Z = 2.49$, $P = 0.015$, female: 32.2 ± 10.87, male: 53.15 ± 8.43). Female foals tended to have greater rate of correct response to verbal prompt than males ($Z = 1.77$, $P = 0.074$; female: 0.71 ± 0.04, male: 0.61 ± 0.06). For the remaining 8 measures, differences between males and females were not significant ($P > 0.10$).

3.3.3. Evaluation of sire line effect

Of the three sire lines compared, the Surge line (n = 4) had significantly greater correct response to verbal prompt rate than the Butterscotch line (n = 8). Latency to conditioned response tended to be lower for the Harry line (n = 6) than the Butterscotch line ($P < 0.10$). For all other measures, no significant differences among sire lines were detected.

3.4. Association of learning with subjectively judged attention/interest

Interest in the experimenter was negatively correlated with frequency of avoidance/frustration responses (Pearson $R = -0.58$, $DF = 24$, $P = 0.003$). Interest in the target was negatively correlated with latency to conditioned response ($R = -0.51$, $DF = 24$, $P = 0.072$), positively correlated with correct response frequency (R 0.60, $DF = 24$, $P = 0.001$), positively correlated with correct response to verbal prompt rate ($R = 0.51$, $DF = 24$, $P = 0.007$), frequency held target ($R = 0.46$, $DF = 24$, $P = 0.019$), and negatively associated with overall rank (higher rank more efficient) ($R = -0.42$, $DF = 24$, $P = 0.030$). Interest in the task was positively correlated with correct response frequency ($R = 0.78$, $DF = 24$, P 0.0000), correct responses to verbal prompt ($R = 0.55$, $DF = 24$ $P < 0.003$), and frequency held target ($R = 0.64$, $DF = 24$, $P = 0.0005$)). Interest in task was negatively correlated with overall rank ($R = -0.60$, $DF = 24$, $P < 0.003$).

Interest in the target and interest in the task were highly correlated ($R = 0.72$, $DF = 24$ $P < 0.0000$).

3.5. Retention assessment

Seventeen of the 26 foals (65%) met the criterion for retention. Differences in the proportions of males and females and of younger and older foals that met this criterion were not significant (Fisher's Exact Test). For one sire line, all 8 foals met the criterion for retention. For this sire line, this proportion was significantly greater than for two other sire lines (2 of 6 and 0 of 2 foals retained) ($P < 0.05$), and tended to be significantly different from that of another (1 of 3 foals retained) ($P < 0.10$).

Seven of the 17 foals that met the criterion for retention improved on only 4 of the 5 measures considered. In all cases, the score, although not improved, was very close or the same as in the initial target training trial. The most common measure that failed to improve was correct response to verbal prompt rate (n = 4).

4. Discussion

Our findings that 26 of 26 young foals met our criterion for acquisition of the conditioned response within 9–157 s of a single 6-min operant "target training" trial, while none of seven yoked control foals met the criterion. This confirms that young foals can efficiently learn simple operant tasks. Similarly, our result that 17 of those 26 met criterion for retention when tested one to four weeks later, indicates that young foals can retain operantly learned tasks. Further, we found that operant learning was as efficient in the foals of 6 weeks to 3 months of age as foals of 3–5 months of age. These results also suggest that learning may be more efficient in female foals as well as in certain sire lines.

To our knowledge, this is the first report of systematic study of operant conditioning in foals this young. Subsequent work in our lab using operant discrimination learning indicates that foals as young as 1 day learned with similar efficiency. A previous study evaluated 21 foals between the ages of 30 and 50 weeks on performance in a target training task, visual discrimination task, and spatial reversal task using positive reinforcement as well as in a pressure-response test using negative reinforcement (Ahrendt et al., 2014). Results indicated that foals could learn these tasks.

Clear demonstration of the ability of foals this young to efficiently learn with simple operant procedures similar to those commonly used in training of older juvenile and adult horses means that this type of training can and likely should be recommended as a productive positive form of early handling. Basic operant training with specific management goals, for example standing for grooming, veterinary and routine health care procedures, coming to a handler from pasture, or loading for transport, would likely be a more productive and less problematic human-animal interaction than simply playing with or cuddling a foal. Playing and cuddling type interactions are not recommended, as it is believed that they often lead to over-bonding to humans including problematic behavior characterized as a lack of respect for species-differences (Grogan and McDonnell, 2005). Operant training with specific practical goals would serve to introduce the foal from an early age to taking meaningful direction from human handlers. These questions certainly merit further research. Further questions of applied significance requiring further study include the best pace of training of various operant tasks, various types and schedules of reinforcement, and best age for introduction of specific tasks to foals.

In learning research it is common and expected for any particular task that certain individual subjects appear uninterested in the task, either passively avoiding participation or actively engaging in incompatible activities, and as such are known as "non-responders" for the particular task or paradigm (Terrace, 1974). It is notable that all 26 foals in this work participated in the operant task in this paradigm, resulting in zero non-responders. When working with adult horses in learning studies, we have encountered higher rates of non-responders for any given training paradigm. It was our subjective impression that foals may be generally more interested than older horses in operant tasks. If this impression holds true, it may be another reason to introduce young foals to organized training. Certainly other factors likely play a role, including appropriateness of the task and previous experience with training.

Previous work addressing differences in learning ability of male and female horses has been fairly limited. Wolff and coworkers found no differences among male and female horses in feed box-opening task but found that a greater proportion of females succeeded within 3 attempts within no more than 11 min at a food location detour task (Wolff and Hausberger, 1996). In another study of spatial task learning, males demonstrated superior performance in a hidden food location task in which the critical cue was distance between a stall door and barrier within the stall hiding the food reward (Murphy et al., 2004).

The positive reinforcement used with the young foals in our study was scratching at the mutual grooming sites (chest, neck, shoulder, withers, and rump; McDonnell, 2003). A previous study that worked with young adult animals concluded that tactile stimulation is ineffective as a positive reinforcement for horses in a learning paradigm (Sankey et al., 2010) and for visual attention on a human handler (Rochais et al., 2014). Scratching was used as a positive reinforcement because these foals were nursing and not yet acclimated to food treats. The response of these young foals was clearly judged to reflect pleasurable reaction to the scratching. Massage and scratching/grooming by handlers have been found to reduce heart rate in horses (Lynch et al., 1974; Feh and De Mazieres, 1993). Massage by handlers has been found to lower cortisol levels in dogs (Hennessy et al., 1998). It is tempting to speculate that early systematic training using tactile reinforcement of this type may set these animals up for lifelong increased value of tactile positive reinforcement, so as to avoid the often problematic food treats typically used in operant training of horses. Similarly, early establishment of secondary verbal reinforcement could reduce the need for food rewards. Both Williams et al. (2004) and McCall and Burgin (2002) concluded that an auditory secondary reinforcer (clicker) neither improved learning efficiency nor delayed extinction of the particular task in their studies. McCall and Burgin (2002), however, reported that the secondary reinforcer was subsequently effective as the sole reinforcement of new tasks. In their design, perhaps the secondary reinforcer had not been paired sufficiently with the primary reinforcer to affect the outcome of the entire training but did take on positive value by the end of the training to carry positive value to new training situations.

5. Conclusion

Based on these results, we conclude that young foals can efficiently learn and retain an operant task. Operant learning performance of foals less than 3 months of age was similar to that of foals of 3–5 months of age. These results also suggest that female foals may be more efficient learners of this type of operant task.

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References

Ahrendt, L.P., Christensen, J.W., Nicol, C., Malmkvist, J., 2014. Foals' learning performance in four different learning tasks (Abstract). In: Christensen J.W., Ladewig, J., Adhrent, L.P., Malmkvist, (Eds). International Society for Equitation Science 2014: Proceedings of 10th International Equitation Science Conference; Aug 6–9; Denmark.T jele: DCA, p. 34.
Clarke, J.V., Nicol, C.J., Jones, R., McGreevy, P.D., 1996. Effects of observational learning on food selection in horses. Appl. Anim. Behav. Sci. 50, 177–184.
Feh, C., De Mazieres, J., 1993. Grooming at a preferred site reduces heart rate in horses. Anim. Behav. 46, 1191–1194.
Grogan, E.H., McDonnell, S.M., 2005. Mare and foal bonding and problems. Clin. Tech. Equine Pract. 4, 228–237.
Haag, E.L., Rudman, R., Houpt, K.A., 1980. Avoidance, maze learning, and social dominance in ponies. J. Anim. Sci. 50, 329–335.
Hanggi, E.B., Ingersoll, J.F., 2009. Long-term memory for categories and concepts in horses (*Equus caballus*). Anim. Cogn. 12, 451–462.
Hanggi, E.B., 1999. Interocular transfer of learning in horses. J. Equine Vet. Sci. 19,

518–524.

Hanggi, E.B., 2003. Discrimination learning based on relative size concepts in horses. Appl. Anim. Behav. Sci. 83, 201–213.

Hanggi, E.B., 2005. The thinking horse: cognition and perception reviewed. In: Proceedings of the 51 St American Association of Equine Practitioners Annual Convention. December 3–7; Seattle, WA. pp. 246–255.

Hausberger, M., Bruderer, C., Le Scolan, N., Pierre, J.S., 2004. Interplay between environmental and genetic factors in temperament/personality traits in horses (Equus caballus). J. Compar. Psychol. 118, 434–446.

Heird, J.C., Lennon, A.M., Bell, R.W., 1981. Effects of early experience on the learning ability of yearling horses. J. Anim. Sci. 53, 1204–1209.

Heird, J.C., Whitaker, D.D., Bell, R.W., Ramsey, C.B., Lokey, C.E., 1986. The effect of handling at different ages on the subsequent learning ability of 2-years-old horses. Appl. Anim. Behav. Sci. 15, 15–25.

Hennessy, M.B., Williams, M.T., Miller, D.D., Douglas, C.W., Voith, V.L., 1998. Influence of male and female petters on plasma cortisol and behaviour: can human interaction reduce the stress of dog in a public animal shelter? Appl. Anim. Behav. Sci. 61, 63–77.

Hothersall, B., Gale, E.V., Harris, P., Nicol, C.J., 2010. Cue use by foals in a discrimination learning task. Anim. Cogn. 13, 63–74.

Houpt, K.A., Parsons, M.S., Hintz, H.F., 1982. Learning ability of orphan foals, of normal foals and of their mothers. J. Anim. Sci. 55, 1027–1032.

Krueger, K., Farmer, K., Heinze, H., 2014. The effects of age, rank and neophobia on social learning in horses. Anim. Cogn. 17, 645–655.

Lansade, L., Bertrand, M., Bouissou, M.F., 2004. Effects of neonatal handling on subsequent manageability, reactivity and learning ability of foals. Appl. Anim. Behav. Sci. 92, 143–158.

Leblanc, M.A., 2013. The Mind of the Horse: an Introduction to Equine Cognition. Harvard University Press, Cambridge.

Ligout, S., Bouissou, M.F., Boivin, X., 2008. Comparison of the effects of two different handling methods on the subsequent behaviour of Anglo-Arabian foals toward humans and handling. Appl. Anim. Behav. Sci. 113, 175–188.

Lindberg, A.C., Kelland, A., Nicol, C.J., 1999. Effects of observational learning on acquisition of an operant response in horses. Appl. Anim. Behav. Sci. 61, 187–199.

Lynch, J.J., Fregin, G.F., Mackie, J.B., Monroe Jr., R.R., 1974. Heart rate changes in the horse to human contact. Psychophysiol 11, 472–479.

Mader, D.R., Price, E.O., 1980. Discrimination learning in horses: effects of breed, age and social dominance. J. Anim. Sci. 50, 962–965.

Martin, P., Bateson, P., 2007. Measuring Behavior: an Introductory Guide. Cambridge University Press, Cambridge.

McCall, C.A., Burgin, S.E., 2002. Equine utilization of secondary reinforcement during response extinction and acquisition. Appl. Anim. Behav. Sci. 78, 253–262.

McCall, C.A., Salters, M.A., Simpson, S., 1993. Relationship between number of conditioning trials per training session and avoidance learning in horses. Appl. Anim. Behav. Sci. 36, 291–299.

McCall, C.A., 1989. The effect of body condition of horses on discrimination learning abilities. Appl. Anim. Behav. Sci. 22, 327–334.

McCall, C.A., 1990. A review of learning behavior in horses and its application in horse training. J. Anim. Sci. 68, 75–81.

McDonnell, S.M., 2003. The Equid Ethogram: a Practical Field Guide to Horse Behavior. Eclipse Press, Lexington.

Mengoli, M., Pageat, P., Lafont-Lecuelle, C., Monneret, P., Giacalone, A., Sighieri, C., Cozzi, A., 2014. Influence of emotional balance during a learning and recall test in horses (*Equus caballus*). Behav. Process. 106, 141–150.

Murphy, J., Arkins, S., 2007. Equine learning behaviour. Behav. Process. 76, 1–13.

Murphy, J., Waldmann, T., Arkins, S., 2004. Sex differences in equine learning skills and visuo-spatial ability. Appl. Anim. Behav. Sci. 87, 119–130.

Nicol, C.J., 2005. Learning Abilities in the horse. In: Mills, D.S., McDonnell, S.M. (Eds.), The Domestic Horse: the Origins, Development and Management of Its Behavior. Cambridge University Press, Cambridge, pp. 169–183.

Rochais, C., Henry, S., Sankey, C., Nassur, F., Goracka-Bruzda, A., Hausberger, M., 2014. Visual attention, an indicator of human-animal relationships? A study of domestic horses (Equus caballus). Front. Psychol. 5http://dx.doi.org/10.3389/fpsyg.2014.00108. (article 108).

Sankey, C., Henry, S., Gorecka-Bruzda, A., Richard-Yris, M.A., Hausberger, M., 2010. The way to a man's heart is through his stomach. What about horses? PLoS One 5, e15446. http://dx.doi.org/10.1371/journal.pone.0015446.

Santamaria, S., Bobbert, M.F., Back, W., Barneveld, A., van Weeren, P.R., 2005. Effect of early training on the jumping technique of horses. Am. J. Vet. Res. 66, 418–424.

Sappington, B.F., Goldman, L., 1994. Discrimination learning and concept formation in the Arabian horse. J. Anim. Sci. 72, 3080–3087.

Spier, S.J., Berger Pusterla, J., Villarroel, A., Pusterla, N., 2004. Outcome of tactile conditioning of neonates, or imprint training on selected handling measures in foals. Vet. J. 168, 252–288.

Terrace, H.S., 1974. On the nature of non responding in discrimination learning with and without errors. J. Exp. Anal. Behav. 22, 151–159.

Visser, E.K., van Reenen, C.G., Schilder, M.B.H., Barneveld, A., Blokhuis, H.J., 2003. Learning performances in young horses using two different learning tests. Appl. Anim. Behav. Sci. 80, 311–326.

Williams, J.L., Friend, T.H., Toscano, M.J., Collins, M.N., Sisto-Burt, A., Nevill, C.H., 2002. The effects of early training sessions on the reactions of foals at 1, 2, and 3 months of age. Appl. Anim. Behav. Sci. 77, 105–114.

Williams, J.L., Friend, T.H., Nevill, C.H., Archer, G., 2004. The efficacy of a secondary reinforcer (clicker) during acquisition and extinction of an operant task in horses. Appl. Anim. Behav. Sci. 88, 331–341.

Wolff, A., Hausberger, M., 1996. Learning and memorization of two different tasks in horses: the effects of age, sex, and sire. Appl. Anim. Behav. Sci. 46, 137–143.