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The use of blended positive and negative reinforcement in shaping the halt response of horses (Equus caballus)

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Abstract

Twenty horses were paired for age, sex and breed and placed into one of two groups. The horses in Group A (control) were reinforced using only negative reinforcement (NR) while those in group B (treatment) were reinforced with both positive reinforcement (PR) and NR concurrently. All horses were shaped for the halt response while being driven in long-reins over a period of 5 consecutive days. On day 1, all horses were given a baseline test of 20 random halts while being long-reined in an indoor arena. On days 2–4, the shaping of the halt response continued with horses being reinforced according to the group to which they had been allocated. On day 5 of testing the baseline test was repeated (final test). During the baseline and final tests, behavioural responses and accuracy of completion of the halt response were recorded. Heart rates were recorded continuously during testing. One-way analysis of variance in randomised blocks and analysis of covariance using baseline data as a covariate showed no effect on latency to halt. However, horses reinforced with both NR and PR shook their heads vertically less and were more likely to lick their lips than those reinforced with NR only. There was also a trend for an increase in roundness of outline of the horses that were reinforced with both PR and NR. These results suggest that the implementation of PR effectively into equitation training may improve the welfare of the horse.

Keywords: *animal welfare, behaviour, equitation, horse, reinforcement, training*

Introduction

Millions of horses are utilised by humans worldwide (Endenburg 1999) for a vast range of activities such as leisure, competition, racing and therapy (Robinson 1999). The usefulness of horses in these activities is dependent on their ability to learn (Kratzer *et al* 1977; Haag *et al* 1980; McCall *et al* 1993; Sappington *et al* 1997) and their value is greatly increased by training (Mader & Price 1980; Heird *et al* 1986a,b; McCall 1990). Human use of horses can place stress on the animals and raises concern for horse welfare (Ewbank 1985; Ödberg & Bouissou 1999). It is recognised that chronic pain can cause horses to exhibit behaviour problems (Casey 2002) but horse welfare involves more than just physical soundness (Ödberg 1987). Therefore, improving the way domestic horses are trained and handled would enhance their welfare (van Niekerk 1980).

Horse training deals with the modification of behaviour and almost all of the principles of learning theory that apply to other species also apply to horses (Potter & Yeates 1990), specifically the stimulus-response-reinforcement relationship (Fiske 1979; van Niekerk 1980; Potter & Yeates 1990; Cooper 1998) of which trainers should develop a clear understanding. Reinforcement is used in operant conditioning to increase the probability of a response occurring because that response is followed by an important event (Lieberman 2000); thus reinforcement must be contingent upon the response (Houpt 1991).

Reinforcement can be defined as either positive or negative (Perone 2003) where positive reinforcement is the addition of a stimulus (a positive reinforcer) immediately after a desired behaviour is performed (Voith 1986; Cooper 1998; Karrasch & Karrasch 2000; MacDonald 2003) and negative reinforcement involves the removal of an aversive stimulus immediately after a desired behaviour is performed (Voith 1986; Cooper 1998; Karrasch & Karrasch 2000; Waran *et al* 2002; MacDonald 2003). Reinforcement is further divided into primary and secondary (McCall 1990; Potter & Yeates 1990). Primary reinforcers have natural reinforcing properties (Potter & Yeates 1990) linked to the biological needs of the horse (Wolski 1984), such as food, water, shelter and comfort (McCall & Burgin 2002; McGreevy 2004). Secondary reinforcers are neutral stimuli that have been paired with primary reinforcers and thus have a conditioned reinforcing value to the horse (Wolski 1984), for example, pats on the neck and verbal praise (Cooper 1998). Reinforcers need to be employed according to their effectiveness (Mills & Nankervis 1999; Marschark & Baenninger 2002; Perone

2003) and not all reinforcers will have the same effect (Shettleworth 1972) on different horses.

Negative reinforcement is commonly misunderstood (Mills & Nankervis 1999; MacDonald 2003), often being confused with punishment (Shields & Gredler 2003) and is often incorrectly applied. Hence, better training methods need to be employed to improve the welfare of horses in training (McLean 2003). In studies on human as well as non-human animals, Perone (2003) concluded that correctly applied negative reinforcement can be very effective if applied at the correct time and with the appropriate intensity. Potter and Yeates (1990) suggested that negative reinforcement is perhaps more effective than any other type of training in causing one type of response to be abandoned and another adopted.

Horses appear to be highly sensitive to negative reinforcement as they are a prey animal and are thus especially motivated to avoid aversive stimuli (Cooper 1998; Casey 2002). However, if not implemented carefully, attempts at negative reinforcement can encourage fear (Waran *et al* 2002). Likewise, van Niekerk (1980) and Dougherty and Lewis (1991) reported that equine tactile senses are very well developed and humans capitalise on the sensitivity of horses' mouths when seeking to exert control via the bit. However, due to the sensitivity of the horse's mouth, this is possibly the primary source of aversive stimulation and, if used inappropriately, can cause discomfort and pain (Friedberger 1970) to the extent of bone spurs on the diastema (Cook 2002).

Due to the nature of equitation, the use of positive reinforcement (for example, a food reward delivered by hand) is not implemented easily by a rider and is potentially less likely to reinforce the targeted behaviour (McCall *et al* 1993; Waran *et al* 2002). Thus, positive reinforcement is not always feasible in horse training (Potter & Yeates 1990). Consequently, trainers mainly use negative reinforcement (van Niekerk 1980; Voith 1986; McCall 1989, 1990; Sappington *et al* 1997; Cooper 1998; McLean 2003) and secondary reinforcement (McCall 1990; Potter & Yeates 1990; Sappington *et al* 1997) although most horse handlers and riders seem unaware of this. A recent survey of accredited equestrian instructors in Australia showed that only 7.8% could explain correctly the use of negative reinforcement as it relates to horse training (Warren-Smith & McGreevy, at press). Most considered the release of an aversive stimulus to be positive reinforcement. This could, in part, indicate why most horse trainers do not seek to apply correct positive reinforcement to their training (Dougherty & Lewis 1991).

Most research involving positive reinforcement with horses has been conducted on non-equitation related activities such as mazes (eg Haag *et al* 1980; McCall *et al* 1981; Marinier & Alexander 1994; Heird 1996a,b;) and so, while they may yield valuable results, they are not always directly transferable to traditional equitation (Dougherty & Lewis 1991). Only a limited number of studies have reported using both positive and negative reinforcement for comparison. Haag *et al* (1980) found a significant correlation with the learning ability of a group of ponies (n = 10) in both a shock avoidance trial and in a single choice maze. Visser *et al* (2003) used an avoidance test with puffs of air and measured learning performance by percentage of correct responses and, in a reward test, measured performance by latency to obtain the reward and found some horses did not respond to the aversive stimulus. Dougherty and Lewis (1991) found that tactile stimuli were effective for stimulus control of a horse's operant responses.

The timing of reinforcement is critical (Mills 1998) and recommended maximal latencies before reinforcing range from within 0.5 s of a response (Voith 1986) to 30 s (Kiley-Worthington 1997). Wynmalen (1952) stated that release of the aid should occur when the rider feels the horse is going to respond. A recent study using negative reinforcement in teaching foals to lead (Warren-Smith *et al* 2005) showed that for response acquisition, reinforcement should be given immediately the behaviour commences and that, for refining responses, reinforcement may be more effective if delivered at the completion of the desired response.

Employing a custom-built 'remotely-operated pump' (reward device) that delivers a small food reward into the horse's mouth, the current study was designed to determine the effectiveness of a blend of both positive and negative reinforcement in shaping responses to a halt stimulus.

Materials and methods

Animals

Twenty horses (age 10.4 [± 1.2 yrs]) of mixed breed (15 thoroughbreds, 3 warmbloods and 2 part-Arabs) and sex (13 geldings and 7 mares) were chosen on the basis of their response to an initial selection test that indicated the reinforcing effect of molasses water (10% solution) on them.

Selection trial

Twenty-five horses were led a 10 m distance over a small cross-rail obstacle (30 cm height). The horses were then offered access to a bucket of molasses water (10 g l^{-1} molasses in aqueous solution) as a reward. They were subsequently led over the obstacle twice more, each time being rewarded with access to the molasses water. If the time taken to complete the task decreased, it was considered that the molasses water had had a reinforcing effect on these horses and they were then selected for further testing.

The horses were housed in paddocks (approximately 15–20 ha) at the University of Sydney, Orange Campus Equine Centre. They were maintained on pasture and supplemented with a concentrate feed (Pryde's BioMare Cubes, Pryde's Easifeed, PO Box 632, Gunnedah, NSW 2380, Australia) and pasture hay to meet National Research Council (1989) equine nutritional guidelines.

Baseline test

All selected horses had patches (5 × 5 cm) clipped approximately 15 cm below wither height on the right thorax and behind the elbow on the left side (located under the site of

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Figure 1

The telemetrically operated reward device fastened firmly to the lunge roller on the horse's back. A 60 ml syringe with a flat tab plunger is held in place by a thick, strong elastic band. Attached to the syringe is 1.7 m of plastic tubing held in place on the horse's mane with two large clips, one at approximately the second thoracic vertebra and the other approximately in line with the fourth cervical vertebra. The tubing travels through keepers on the brow-band and cheek-piece of the bridle and then slides into a hole drilled into the middle portion of the bit ring of a plain eggbutt snaffle bit. This hole had been drilled towards the centre of the bit and opened onto the dorsal surface of the tongue approximately 2.5 cm from the bit's central joint.

placement of the lunge roller) to facilitate placement of two Polar Accurex heart rate monitor (Polar Accurex II, Baumann & Haldi, Switzerland) electrodes. To improve conductivity, each heart rate monitor electrode was applied with liberal water-based lubricant. Two horses were then led together to the indoor arena; the first horse to be tested being fitted with the lunge roller, heart rate monitor, bridle and long-reins in preparation for long-reining (McGreevy *et al* 2005). Each horse was given a 2 min warm-up session which consisted of walking with turns and transitions to halt prior to the commencement of the test. Each horse was then given a baseline test which consisted of being driven in long-reins while 20 random halts were achieved during a 30 minute session. The halting was planned so that two halts occurred down each side of the long-sides of the oblong arena. The halts occurred in different locations to avoid any anticipation by the horses. At all times during testing, the second horse of the pair was held towards the edge of the arena to minimise the effects of separation distress.

Training days

After all horses had completed the baseline test, they were paired for age, breed and sex with one from each pair being assigned to either the control group (group A) or the treatment group (group B). Group A was trained using traditional (English) training regimes (negative reinforcement [NR]) and group B received positive reinforcement (PR) as well as NR. Each horse, irrespective of group, was fitted with the reward device located on the lunge roller but the reward device was not activated to deliver the liquid reward to the horses in the control group. All horses were driven in long-reins for one 30 min session on each of three days in the indoor arena. Each horse was given the cues to perform transitions between halt and walk.

Final test

Following the three days of training, the initial baseline test (as described above) was repeated with the horses being reinforced according to their treatment group. The sequence of the testing for the pairs alternated.

Personnel

The same personnel carried out the same tasks on all testing and training days throughout the trial. Both the person who conducted all the driving of the horses (driver) and the person who gave the commands and activated the reward device (rewarder) wore headsets (RadioShack TRC-506 1-Channel FM Walkie-Talkie, RadioShack Corporation, Fort Worth, Texas, USA) so communication could occur with minimum influence on the horses. The rewarder stood at a

Table 1 The means and probabilities of the responses exhibited by the two groups of horses during the baseline and final tests.

	Means of responses (n = 20)					
	Baseline test		Final test		ANCOVA	
	Control	Treatment	Control	Treatment	Probability	Covariate
Champ on bit	1.2	1.9	0.9	1.3	0.737	0.003**
Chew	5.9	6.9	6.1	7.6	0.101	0.367
Defaecate	0.0	0.1	0.1	0.1	0.591	0.799
Did not stop	0.0	0.0	0.1	0.2	0.555	0.000a
Halt not maintained	0.1	0.7	0.1	0.3	0.462	0.778
Halt square	0.9	0.6	1.1	0.8	0.598	0.387
Head down	0.8	1.2	1.9	2.3	0.737	0.306
Head low	0.0	0.0	0.0	1.2	0.256	0.000a
Head shake lateral	0.3	0.4	0.4	0.2	0.381	0.818
Head shake vertical	2.2	2.1	3.1	1.3	0.021*	0.011**
Head tilt	0.2	0.1	0.0	0.0	#	#
Head up	1.9	1.1	1.6	0.8	0.806	0.003**
Lick lips	0.1	0.6	0.7	5.6	0.012*	0.229
Lip movement	0.1	0.1	0.0	0.0	1.000	0.000b
Open mouth	7.8	7.1	4.9	3.8	0.457	0.928
Roundness	1.5	0.6	1.0	2.8	0.141	0.537
Snort	0.2	0.2	0.1	0.0	0.347	0.347
Steps taken to achieve halt	3.3	3.9	3.7	4.0	0.198	< 0.001***
Travel sideways	0.5	0.2	0.7	0.3	0.869	0.060*

Group A (control) was trained using traditional training regimes (negative reinforcement, NR) and group B (treatment) received positive treatment (PR) as well as NR. Values for each group were not significantly different except where indicated: * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. Covariate of 0.000a indicates that there were no occurrences of these responses in the baseline test. Covariate of 0.000b indicates that there were no occurrences of this response in the final test. # insufficient data to analyse.

minimum distance of 20 m from the driver and thus, from the test horse.

The horses were driven along the long side of a full-sized dressage arena (60 × 20 m; length × breadth) but using only half the arena (60 × 10 m). At random intervals during this driving, but only when the horses were travelling on a straight line, the rewarder would say "Halt now" quietly into the microphone of the headset. The driver would then signal the horse to halt via tension on both reins and once the horse had halted, this tension was released. The amount of tension required to be applied to the reins to elicit the halt response could not be measured during the conduct of this trial. However, in the absence of rein tension measures, the stimulus was applied as necessary for the halt to be achieved. The horses in group B were also rewarded with 5 ml molasses water delivered telemetrically by the rewarder at the same time as the release of the rein tension occurred. Each halt was maintained for 2 s after which time the horses were then signalled to walk forward via a rhythmic shake of the reins on the horse's gaskin. If the horse moved off before the 2 s interval, this was recorded as the halt not being maintained. This procedure continued until 20 halts had been signalled.

Reward device

The reward device measured 12 × 28 cm and weighed 2.4 kg. It was fastened firmly to the lunge roller on the horse's back with four straps, one fixed at each corner of the device (see Figure 1). The reward device was designed such that a 60 ml syringe with a flat tab plunger could be fitted and held in place by a thick, strong elastic band. This plunger was depressed telemetrically such that the desired amount (5 ml) of molasses water was released to the horse.

Attached to the syringe was 1.7 m of plastic tubing (Luer Tube, Tuta Laboratories, Australia) which was held in place on the horse's mane with two large clips, one at approximately the second thoracic vertebra and the other in approximate line with the fourth cervical vertebra. The tubing was then placed through keepers on the brow band and cheek piece of the bridle and slid firmly into a hole that had been drilled into the middle portion of the bit ring of a plain eggbutt snaffle bit. This hole was such that it went towards the centre of the bit and opened out to the surface approximately 2.5 cm from the centre joint. This enabled the molasses water to be delivered close to the midline of the horse's mouth, at the level of the diastema, upon remote activation of the reward device. The button used for the remote control measured 4.5 × 3.5 cm and as such, was easily activated covertly, such that only the rewarder was aware of it being activated. The reward device was always fitted to the horse such that the driver was unable to see which horses were being positively reinforced during testing.

The experimental protocol was approved under Protocol Number OAC/1-2003/3/3705 (Animal Care and Ethics Committee, University of Sydney, Australia). All testing was conducted at the University of Sydney, Orange Campus Equine Centre.

Measurements and data analysis

All responses exhibited by the horses were recorded on videotape for subsequent analysis. The behavioural responses recorded (chewing, licking lips, lip movements, head shaking vertically, head shaking laterally, snorting and defaecation) were described according to Waring (2003). Additional responses included the horse being 'on the bit' (roundness) or 'halting square' and were defined according to the Fédération Equestre International (2003). Other measurements recorded were the number of steps taken by the horse to achieve the halt after the application of the stimulus, the head position during halting, whether or not the horse opened its mouth, was champing on the bit, travelled sideways and whether or not the halt was achieved (2 s immobility).

All measurements were taken after the completion of the 2 min warm-up for both the baseline and final tests. The behavioural responses and the time taken to achieve the halt after the application of the halt stimulus were recorded for each halt. The average heart rate recorded during testing was used in the analysis. Data were analysed using one-way analysis of variance in randomised blocks and with analysis of covariance with baseline data as a covariate. All calculations were performed using Genstat (2003).

Results

The horses in group A (NR only) shook their heads on the vertical plane more ($P = 0.021$; Table 1) than those in group B (PR and NR combined). The horses in group B were more likely to lick their lips than those in group A ($P = 0.012$; Table 1). There was no difference in heart rate between the groups of horses in either the baseline test (48.9 and 50.9 bpm; group A and B, respectively) or the final test (48.8 and 49.4 bpm; group A and B, respectively; $P = 0.719$). The use of PR did not cause the horses to achieve the halt any quicker than those in the control group in the final test (3.3 and 3.4 s; group A and B, respectively; $P = 0.851$). Analysis of variance showed no significant differences between groups for the responses of chewing, defaecation, head down, head shake laterally, opening of mouth, roundness, the halt not being maintained, halt square and snorting. There was also no difference in the number of horses that did not stop, tilted their head, put their head lower or moved their lips during testing (Table 1). Analysis of covariance showed no significant covariate effect for the same responses and there was also no treatment effect on the behavioural responses of champing, head up, steps taken to achieve halt or sideways travel (Table 1).

Discussion

The horses that were reinforced with negative reinforcement only (release of bit pressure) shook their heads vertically more in response to the halt stimulus than those horses reinforced with the blend of positive and negative reinforcement. This is a noteworthy outcome that has considerable importance in equitation as a steady head carriage of the horse is highly desired (Marshall 1981; Anon 1986; Anon 1988). It could be considered that an unsteady head carriage could be an indication of discomfort or an expression of conflict behaviour. Assuming that this is not due to inappropriate application of negative reinforcement, then the use of positive reinforcement in training may enhance this training outcome and promote a more steady head carriage in the horse.

As this trial used a gustatory reward, it is not surprising that the horses that received the positive reinforcement were more likely to lick their lips. In equitation, it is generally considered to be a good sign when a horse is mouthing the bit as it is believed to be an indicator of the horse relaxing and 'accepting' the bit (Podhajsky 1967; Anon 1990). As the horse is an obligatory nose-breather, the evidence of bits affecting any buccal seal is slim. However, it would be interesting to look at lip-licking without any oral apparatus because, as Cook (1999) has indicated, the bit may trigger some element of the deglution reflex. If positive reinforcement, as specified in the current trial, made horses more likely to mouth the bit, perhaps riders and trainers will be less likely to encourage mouthing by inappropriate use of the reins. This would, in turn, lessen the amount of inhumane rein tensions to which horses are exposed. It is noted that this type of positive reinforcement would not be permitted in competition, so it would be a method for training only, which could augment the horse's acceptance of the bit.

Although not significant, there was an increased occurrence of roundness in the final test for the horses that had both positive and negative reinforcement (1.0 to 2.8 baseline and final tests, respectively) and a decrease in the negative reinforcement only horses (1.5 to 0.6 baseline and final tests, respectively). Roundness of outline is one of the fundamentals of equitation (Marshall 1981; Anon 1986) and anything that increases it would be a valuable addition to the trainer's tool-kit. Especially during attempts to induce roundness, direct observation has shown that some riders force their horse's head into position via unnecessary and inhumane use of the reins, the process of which defies the principles of reinforcement. Naturally, this has only limited success and the rounded outline that may be achieved will never replicate that of true roundness (Marshall 1981). Thus, if the application of positive reinforcement in the form of a gustatory reward, as it was used in this trial, could enhance the attainment of roundness in a more humane way, then it could lead to a significant improvement of the welfare of the horse in equitation. The lack of significance in the current results could reflect the small sample size (Berndtson 1991).

The use of positive reinforcement in the form of food rewards in equitation is generally challenging for the rider. The use of the reward device has shown to be a method that may, at least in part, overcome this challenge. Horses demonstrate preference for certain foodstuffs over others and an individual difference that is likely, in part, to be genetic (Randall *et al* 1978). It has been suggested that reinforcement is stronger when foodstuffs other than the normal diet (ie a 'treat'; Mal *et al* 1993) are used or after the subject has been deprived of that foodstuff for a period of time (Rubin *et al* 1980; Mills 1998). However, the horse needs to be familiar with the reward selected since the consumption of novel flavours may be affected by neophobia (Launchbaugh *et al* 1997; Murphy *et al* 1999). Molasses water, chosen as it is attractive to horses (Frape 1986; Anon 1988), was not part of the usual diet and seemed to be an effective reinforcer for the horses used in this trial. However, the intra-oral release of 5 ml molasses water whilst they were being worked would certainly have been a novel stimulus for the horses used in this trial. Therefore, the use of similar technology, such as the reward device, with a longer baseline period that allowed more time for the horses to become accustomed to this mode of delivery of positive reinforcement and with a technique refined so as to suit ridden activities, would be worth further investigation.

While there is little scientific literature on the subject of long-reining, it is widely used for schooling horses (Wynmalen 1985). There are arguments both for and against its use (Wynmalen 1952; Podhajsky 1967). As long-reining involves the handler being in a position behind the horse, it requires horses to overcome their innate fear of being followed (Hafez *et al* 1969; McLean 2003). In addition to this, the length of the reins in long-reining can inhibit the delivery of an instant release as can be achieved in riding, when the reins are shorter (Wynmalen 1985) and also means that greater rein tensions are required when long-reining compared with riding (Warren-Smith *et al*, in press). This could explain why the time to achieve the halt response in both groups of horses increased over the testing period.

Given that the horses reinforced with a blend of both positive and negative reinforcement showed improved performance to the halt response when measured by head shaking vertically and, perhaps to a lesser extent, roundness, this highlights the need for extensive investigation of the merits of positive reinforcement in equitation training. The current findings support Potter and Yeates (1990) and Mills (1998), who concurred that positive reinforcement could be valuable and that opportunities need to be sought for its implementation. By refining the current technique to overcome the novelty of the mode of delivery of the reinforcer and training for more than 5 days would make this intervention more relevant to current training practices and could have substantial welfare benefits for horses in training.

Animal welfare implications

Horses subjected to blended positive and negative reinforcement in training responded favourably in key areas, ie head position and head carriage during exercise as well as mouthing of the bit. As direct observation has shown, horses are often forced to achieve these outcomes by inhumane pressures that defy the principles of reinforcement. There are viable alternatives that can and should be implemented; one of which is the use of positive reinforcement. The use of equipment such as the reward device has shown that the application of positive reinforcement in equitation is feasible and, therefore, attempts should be made to put it into practice in everyday horse training to improve the welfare of horses.

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