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Human facial discrimination in horses: can they tell us apart?

Sherril M. Stone

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Abstract The human–horse relationship has a long evolutionary history. Horses continue to play a pivotal role in the lives of humans and it is common for humans to think their horses recognize them by face. If a horse can distinguish his/her human companion from other humans, then evolution has supplied the horse with a very adaptive cognitive ability. The current study used operant conditioning trials to examine whether horses could discriminate photographed human faces and transfer this facial recognition ability a novel setting. The results indicated the horses (a) learned to discriminate photographs of the unrelated individuals, fraternal twins, and identical twins and (b) demonstrated transfer of facial recognition by spending more time with their S+ woman in the field test.

Keywords Horse · Human–horse · Facial recognition · Animal cognition · Facial discrimination

Introduction

The human–horse relationship has a long evolutionary history. Horses continue to play a pivotal role in the lives of humans and it is common for humans to think their horses recognize them by face. If a horse can distinguish his or her human companion human from other, then evolution has supplied the horse with a very adaptive cognitive ability. The current study used operant conditioning trials to examine whether horses could discriminate photographed human faces and transfer this facial recognition ability a novel setting. The results indicated that horses (a) learned to discriminate photographs of the unrelated individuals, fraternal and identical twins and (b) demonstrated transfer of facial recognition by spending more time with the reinforced woman (S+) in the field test. Horses (*Equus caballus*) have a long and varied evolutionary history. The first horses were more like small squatted, dog-sized creatures with four toes, not the beautiful creatures of modern times (Budiansky 1997). Over the course of 55 million years, the modern horse (*Equus*) evolved into a tall, elegant, and single-hoofed animal of graceful beauty. Through the course of this evolution humans began to keep horses as companions. For instance, cave paintings of horses have been discovered in areas of Eurasia which were known to be inhibited thousands of years ago by the Cro-Magnon humans (Diamond 1992). Archeological evidence from West Asia to the British Isles indicates that horses were among an elite group of animals referred to as the "big five": animals that humans domesticated for use as food, power, and clothing. Of the five species, only the horse provided vital military value and became an invaluable tool for settling the Americas. For instance, North American Indians used horses for hunting and for transportation during wars with other tribes. The newly arriving European settlers used horses to help conquer the land. Specifically, the settlers rode horses across the plains, hitched them to plows to till the ground, and hooked them to wagons to carry goods and families westward.

More recently, ranchers use horses for herding cattle, police officers use them for crime patrol, and others keep them as companions. Horses have also become popular animals for working with physically and emotionally disabled humans. Hippotherapy, e.g., has been shown to ease people's suffering from physical disabilities such as multiple sclerosis, cerebral palsy, and orthopedic maladies.

S. M. Stone (✉)
Oklahoma State University, 700 N. Greenwood,
Tulsa, OK 74106, USA
e-mail: smsbox@aol.com

Similarly, equine-assisted therapy has been shown to be effective for persons diagnosed with emotional disorders such as depression, attention deficit disorder with or without hyperactivity, and various posttraumatic stress disorders (Engel 1994; Heipertz-Hengst, unpublished data).

As evidenced by this long history of human–horse relationship (Budiansky 1997; Diamond 1992), it is no wonder that horses continue to play a pivotal role in the lives of humans. It is this rich and satisfying relationship that underlies the curiosity that humans possess about equine behavior, learning capacities, and cognitive abilities. Of particular interest is the ability of the horse to distinguish one human from another.

Various animals have been found to discriminate one human from another. For instance, Gunnison's prairie dogs (Slobodchikoff et al. 1991), rats (McCall et al. 1969), chimpanzees (Boysen and Berntson 1986; Parr and de Waal 1999; Parr et al. 2000), baboons (Martin-Malivel and Fagot 2001), rhesus monkeys (Rosenfield and Van Hoesen 1979) and other primates (Parr et al. 2000; Pascalis et al. 1999), sea lions (Schusterman et al. 1992), budgerigars (Brown and Dooling 1993), and pigeons (Herrnstein et al. 1976) have been shown to exhibit differential responses to individual humans.

In farm animals, cattle (Boissy and Bouissou 1988; Boivin et al. 1994, 1998), pigs (Hemsworth et al. 1994, 1996a, b), dairy calves (de Passille et al. 1996), sheep (Fell and Shutt 1989), llamas (Taylor and Davis 1997), and cows (Munksgaard et al. 1997, 1999) respond differently to familiar and unfamiliar people. For instance, Tanida et al. (1995) demonstrated that pigs approached a familiar person sooner than an unfamiliar person. Common companion animals such as cats (Podberscek et al. 1991) and dogs (Settle et al. 1994) have also been shown to respond more favorably to familiar people.

Researchers have investigated the visual cues that animals use to recognize individual people. For instance, Tanida et al. (1995) found that miniature pigs discriminated between handlers based on the color and brightness of their coveralls. However, their results also suggested that some miniature pigs discriminated between handlers who wore the same color of coveralls which suggested they used facial cues (Koda and Tanida 2001). Alexander and Shillito (1977) reported that ewes were better at distinguishing their lamb when its head was visible. Kendrick and Baldwin (1989) found that the temporal cortex of sheep responded to human bodies and Kendrick (1991) showed the same cell response to images of faces. Kendrick et al. (1995) demonstrated that sheep discriminated faces of their species and conspecies such as dogs, goats, and humans. Furthermore, Kendrick et al. (1996) suggested that facial discrimination in sheep is easier for familiar compared to unfamiliar sheep. Rybarczyk et al. (2001) found evidence of human facial discrimination in cows only when the person's body height was hidden. Finally, the results of studies with heifers (Boissy and Bouissou 1988), pigs (Hemsworth et al. 1994), and chickens (Jones 1994) suggest that animals not only discriminate between individual people, but also generalize their differential behavior to other humans.

Despite the growing number of studies examining facial recognition in various farm animals, there are very few studies that have investigated horses. Rather, researchers have concentrated on the effect of social status and social cognition on their behavior. Recently, Krueger and Heinze (2008) tested "following behavior" of horses toward humans. They found that observer horses would copy the following behavior of dominant horses from their social group but not subordinate horses or horses from a different social group.

Other researchers have used discrimination tasks to examine horses' ability to distinguish between non-human stimuli. For example, Sappington and Goldman (1994) examined discrimination learning in Arabian geldings and found that they were capable of discriminating various geometric shapes such as rectangles, half circles, and triangles. Similarly, Hanggi (1999) found that horses were capable of categorizing and sorting non-human stimuli according to their physical properties.

Grzimek (1944) was the first one to examine human discrimination in horses. The findings indicated that horses could not discriminate between familiar persons and strangers if both wore the same clothing. In contrast, Koda, Goto, Horikawa, Tsuchiya, and Tanida (unpublished data) demonstrated that ponies could discriminate between people wearing similarly colored clothing. They suggested that the horses used facial cues to distinguish between the people. Finally, Tanida, Koda, Horikawa, and Nagai (unpublished data) found that ponies could transfer discriminate learning from a three-dimensional (3D) to a two-dimensional (2D) setting. Specifically, the horses transferred their discriminative learning between people wearing similarly colored clothing from a 3D setting to the 2D photographic presentation of the same individuals.

DePauw (1992) noted there was a need for studies examining horses' capacity to recognize different people. He suggested that doing so would serve to enhance the human–horse bond. Therefore, it is advantageous for humans to increase their understanding of the irreplaceable and valuable animals (Rubin et al. 1980). The aim of this study was to examine whether horses could be trained to discriminate between 2D photographs of humans and transfer this knowledge to a 3D real world situation. Transfer of learning was defined and measured by the horses' behavioral responses when placed in a round pen with the two women presented in the 2D photographs.

Four hypotheses were examined in this study: (a) the horses would learn to discriminate the unrelated individuals and fraternal twins during the 2D discrimination training trials, (b) the horses would not learn to discriminate identical twins during the 2D discrimination training trials, (c) the horses would demonstrate transfer of facial discrimination of the unrelated individuals and fraternal twins by spending more time with the reinforced individual (S+) in a 3D setting, and (d) the horses would not show a preference for either of the identical reinforced twins (S+) in a 3D setting.

Evolution has equipped horses with one of the largest eyes of any living animal. Thus, vision is one of their most important sensory systems (Waring 1983). Horses have color vision (Grzimek 1952; Timney and Keil 1992), have good pattern discrimination skills (Dixon, unpublished data), and have advanced visual acuity (Timney and Keil 1992). Timney and Keil (1996) found that horses see red and blue better than other colors and are able to detect pictorial depth cues similar to that of humans. More recently, Hanggi et al. (2007) suggested that color vision in horses is similar to that of humans. Their results indicated that horses are dichromats with red–green deficiencies. However, no other study could be found to support the dichromatic vision in horses.

Apparatus

A 1.2 × 2.4 m stimulus wall was constructed with a 1.2 × 2.4 m bottom panel. Both of these panels were bolted to two wooden posts. All of the panels were painted with white latex water-based paint. On each top panel was a 40 × 45 cm hinged door that opened inward when pressed by the muzzle (Fig. 1). A 40 × 40 cm tray was behind each door. The food rewards were placed on both trays to control for odor bias.

The starting point was 16 m from the board. It was marked with cones and the sides were lined by orange tape. To ensure equal motivation (Mader and Price 1980) for all the horses, the owner provided the food treat most preferred by his/her horse (14% sweet feed, alfalfa cube, carrot, equine peppermint treat, or equine apple treat). Both S+ and S− trays contained 17 g of identical food. The daytime illumination, time of day, and weather were similar in the photographs and the field tests. The women wore the same clothing in the photographs and the field tests because Grzimek (1944) demonstrated that horses confused strangers with familiar persons if both wore the same clothing.

Stimuli

Laminated photographs (38 × 38 cm) of an unfamiliar woman (Fig. 2a), a set of fraternal twins (Fig. 2b), and a set of identical twins (Fig. 2c) were used as the reinforced (S+) and the non-reinforced (S−) stimuli. For the field tests, the S+ was presented with her counterpart in a round pen. It was assumed that the horses had formed a mental image, and thus, discriminatory ability if they spent more time with the S+ than near the S−. All of the humans were treated within the APA ethical guidelines. All of the horses were treated as required by the APA ethical guidelines and the Animal Welfare Act.

General procedure

The horses were trained and tested in their home environment. In addition, all of the horses, excluding the mare and foal, were trained and tested alone with no other horses in the viewing vicinity to control for "following behavior" reported by Krueger and Heinze (2008).

Pre-training trials: Stage 1

On Day 1 of the pre-training stage, both doors were locked in the open position. The leader led the horse to the doors 5 times and allowed the horse to eat from both trays for 5 s each. On Day 2, both doors were closed but unlocked for five trials. The leader led the horse to an alternating door (ABABA), opened it, and held it open to allow the horse to eat. On Days 3 and 4, for trials 1–5, the leader held the horse at the starting point. After the 5-s observation period, the leader led the horse to the doors (ABBABAAB), opened the door, and allowed a 5-s eating period while gently placing

Fig. 1 Front view and hinged door with tray of the stimulus wall used in both Experiment 1 and Experiment 2

the door on the horse's muzzle. Trials 6–10 were conducted in the same manner as trials 1–5 except that during the latter trials, the leader released the horse at the starting point rather than leading it to the doors. If the horse did not proceed to the doors after the 5-s observation period, the leader led the horse to the door, opened it, and gently placed the door on the muzzle while it ate. On Day 5, the leader released the horse at the starting point for all 10 trials and allowed it to choose its own door. If the horse did not advance to the board after the observation period, the leader turned the horse away from the board and waited for the 1-min intertrial interval before turning the horse around and beginning another trial. No stimulus cards were used in this training stage.

Stimulus training trials: Stage 2

On Day 1, both doors were closed. On trials 1–12, the leader led the horse to the S+ in the ABBABAAB sequence. For trials 13–24, the leader released the horse at the starting point. To control for subtle cueing, the leader kept her/his head bowed until the horse reached the board. If the horse correctly chose the S+ door, it was allowed to eat the reward. However, an incorrect response resulted in an immediate return to the starting point.

On Day 2, the same procedure was used as during trials 13–24 of Day 1 except that an incorrect response resulted in a stern "no" from the leader and an immediate return to the starting point.

Each session of this stage consisted of 24 trials with a 1-min intertrial interval.

Discrimination trials: Stage 3

Criteria for the discrimination trials required the horse to respond correctly to the S+ on 80% or 19 of the 24 trials, with a 1-min intertrial interval, for 3 consecutive days (Hanggi 1997; Kendrick et al. 2001) before moving to the field test. However, if the horse did not exhibit discrimination learning on any pair of photographs by the 60-day time limit, they were excluded from further study and were not tested in the round pen. When the horse responded correctly to the S+, a "1" was recorded for that trial. In contrast, if the horse responded incorrectly, a "0" was recorded for that trial.

Experiment 1

Subjects

Thirteen horses were included in Experiment 1. They were fed their normal diet of prairie hay, pasture grass, and grain. The grain did not have more 14% crude protein to meet the National Research Council (1989) nutritional requirements. One horse was included as a control. All owners signed an informed consent for the use of their horse(s) and were fully briefed about the procedures. All horses were treated within the APA ethical guidelines.

Stimuli

All photographs that contained Ahna (the unfamiliar woman) served as the S+ whereas the pictures without Ahna served as the S−. She was photographed standing in the middle of a grassy lawn (Ahna/No Ahna), sitting on a wooden park bench (Ahna/Bench), and sitting on a bale of hay (Ahna/Hay). The lawn, wooden park bench, and bale of hay were then photographed without her (Fig. 2a). All of the humans signed an informed consent and were treated within the APA ethical guidelines.

Apparatus adjustment

The foal (Teddy) was shorter than all of the other horses and could not reach the panel or feed bowl placed behind it. Therefore, during his training sessions, duct tape was used to tape the photographs low enough on the wall so that he could easily touch them with his muzzle. A feed bowl was placed on the ground between the photographs so he could access the food reward.

Experiment 2

Subjects

Six horses were included in Experiment 2. The horses were not those included in Experiment 1. Of these six horses, only five completed the discrimination training. One horse was dropped due to its inability to successfully complete the stimulus training. Of these five horses, four completed the field test. One was dropped from the field test due to his refusal to stay in the round pen. Two horses were included as controls. All owners signed an informed consent for the use of their horse(s) and were fully briefed about the procedures. All horses were treated within the APA ethical guidelines.

Stimuli

The fraternal twins were 20-year-old college students (Brooke and Brittany) (Fig. 2b) and the identical twins were 18-year-old high school seniors (Christi and Laura) (Fig. 2c). All of the twins had previous experience with horses and were not frightened to be in their presence. All of the twins signed an informed consent prior to their participation and were fully briefed on the procedure and risks of harm. All of the twins were treated within the APA ethical guidelines.

Fig. 2 **a** Photographs of Ahna/No Ahna, Ahna/Hay, and Ahna/Bench stimuli cards used in Experiment 1. **b** Photographs of the fraternal twins stimuli cards used in Experiment 2. Brooke on *left* and Brittany on *right*. **c** Photographs of the identical twins stimuli cards used in Experiment 2. Christi on *left* and Laura on *right*

Field tests

The field tests were conducted in a round pen visually mapped into equal sections. For Experiment 1, the pen was divided into three sections (Fig. 3a). In Experiment 2, the pen was divided into two sections (Fig. 3b). The leader brought each horse into a 50-ft round pen, led the horse to the center, faced it away from the gate, then released the lead rope and left the pen. One minute was provided prior to the beginning of the 30-min observation period to allow the horse to habituate to the pen and the leader's absence. An observer stood out of sight and video recorded the entire period for later analyses. The time the horse remained in the middle of the pen was not used in the analysis.

Results

Discrimination statistics

Experiment 1

Of the 13 horses that began this experiment, only 11 completed the discrimination training. Specifically, three horses completed the Ahna/No Ahna trials ($M = 4.1$ days, $SD = 2.20$), four completed the Ahna/Bench trials ($M = 4.0$ days, $SD = 1.34$), and four completed the Ahna/Hay trials ($M = 3.0$, $SD = 0.10$).

Experiment 2

Of the six horses that began this experiment, only five completed the discrimination training. All of the horses required more days to discriminate the fraternal twins than the identical twins. The horses assigned to the fraternal twin Brooke as the S+ reached criteria on Days 19, 20, and 21. The horses assigned to the fraternal twin Brittany as the S+ reached criteria on Days 19, 20, 21 and Days 20, 21, 22, respectively. In contrast, the horses assigned to the identical twin Christi as the S+ reached criteria on Days 9, 10, 11; Days 3, 4, 5; and Days 2, 3, 4, respectively. Finally, the horses assigned to Laura as the S+ reached criteria on Days 2, 3, 4.

Field tests

The purpose of the field tests was to examine transfer of learning. More specifically, the field tests were conducted to determine if the horses could transfer their learned S+ from the 2D photograph to a 3D real world setting. We defined transfer of learning as interacting with the S+ more than the S−. We video recorded all of the field tests for

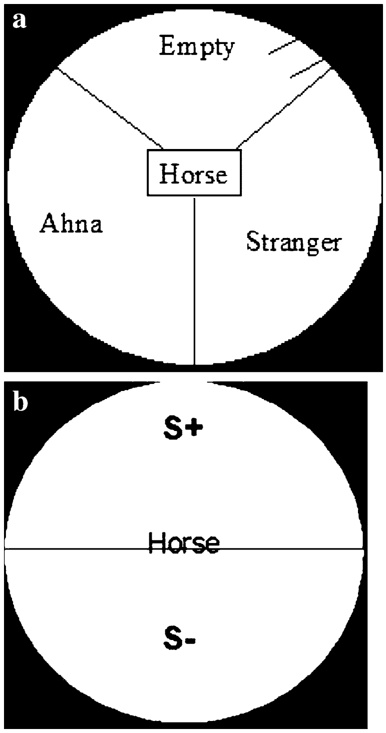

Fig. 3 **a** Field test representation of the sections used in Experiment 1. Ahna served as the S+ and the Stranger served as the S−. There was not anyone in the empty section. **b** Field test representation of the sections used in Experiment 2. The twins served as both the S+ and S−, depending on the horses' S+ assignment

analysis. However, the amount of time spent in each sector and the behaviors exhibited were recorded and analyzed later by two separate coders. Both coders agreed on all of the overt behaviors. This could be attributed to the clearly established operational definitions for each behavior. That is, during the pilot study, the various behaviors were clearly defined for future data collection.

The horses displayed two types of timed behaviors. Therefore, two separate times were recorded for each horse: (a) Time In each sector and (b) Stand By each stimuli. In addition, the horses exhibited four overt behaviors during the field test: (a) Look At stimulus, (b) Lick/Sniff/Nuzzle stimulus, (c) Rub Against stimulus, and (d) Butt/Kick/Bite stimulus. In Experiment 1, the horses stood within touching distance of the S+, remained in the sector out of her reach, or stayed in the empty sector. In Experiment 2, the horses stood within touching distance of the S+ or remained in the sector but out of her reach.

Experiment 1

One horse (Sam) spent the majority of the field test time in the Stranger's section and was very aggressive toward her. For instance, after each aggressive behavior toward the Stranger, Sam always walked to the S+, stood next to her, and nuzzled her face. After he nuzzled her approximately 10 s, he walked back to the Stranger, and again became aggressive toward her. He repeated this cycle of behavior of walking to the S+, nuzzling her face, and walking back to the Stranger for about 15 min. In addition, he became more aggressive each time; therefore, he had to be removed from the pen. Because of his removal from the pen, his data were excluded from the analysis. In addition, the foal (Teddy) never learned the discrimination task thus his data were also excluded from the analysis. Likewise, Teddy's nurse mare (Jimmie Ann) followed him everywhere he went so her data were also excluded from the analysis.

We hypothesized that without discrimination training the control horse would remain in the empty section because neither woman held any significance to him. As hypothesized, Pye spent twice the amount of time in the empty sector, grazing on the grass than with either woman. Pye spent 467 s in Ahna's sector, 430 s in the Stranger's sector, and 903 s in the Empty sector. In contrast, the trained horses remained in Ahna's sector for the majority of the field test. Results of the one-way ANOVA revealed a significant difference for the Time In behavior ($F_{2,9} = 5.582$, $p = 0.024$). A t test was conducted on the Stand By time to determine if the horses stood close enough to the S+ so that they could touch her. Thus, the empty sector was not included in the Stand By analysis. The results indicated a significant difference $t_6 = 5.077$, $p = 0.002$.

The results of the descriptive analyses indicated that, as a group, the horses displayed Look At Ahna 36 times and the Stranger 18 times. They exhibited Lick, Sniff, Nuzzle behaviors toward Ahna 19 times and the Stranger 6 times. The horses equally Rubbed Against Ahna and the Stranger, 5 times each. Other than Sam, the horses did not Butt, Kick, Bite Ahna; however, Sam did so 5 times to S− (Fig. 4a). However, due to the small number of horses in this experiment no significance testing was conducted for the behaviors (Table 1).

Experiment 2

In contrast to Experiment 1, the round pen was visually divided into half rather than into three sectors. Therefore, Time In each sector was the only timed variable recorded. Three overt behaviors were recorded during this field test: (a) Look At stimulus, (b) Lick/Sniff/Nuzzle stimulus, and (c) Approach stimulus. Unlike Experiment 1, none of the horses in Experiment 2 exhibited the Butt/Kick/Bite behaviors.

Fraternal twin field test

Due to the representative (nonequivalent group) design of this experiment, only two horses were included for each twin. Each twin represented both the S+ and the S− for the

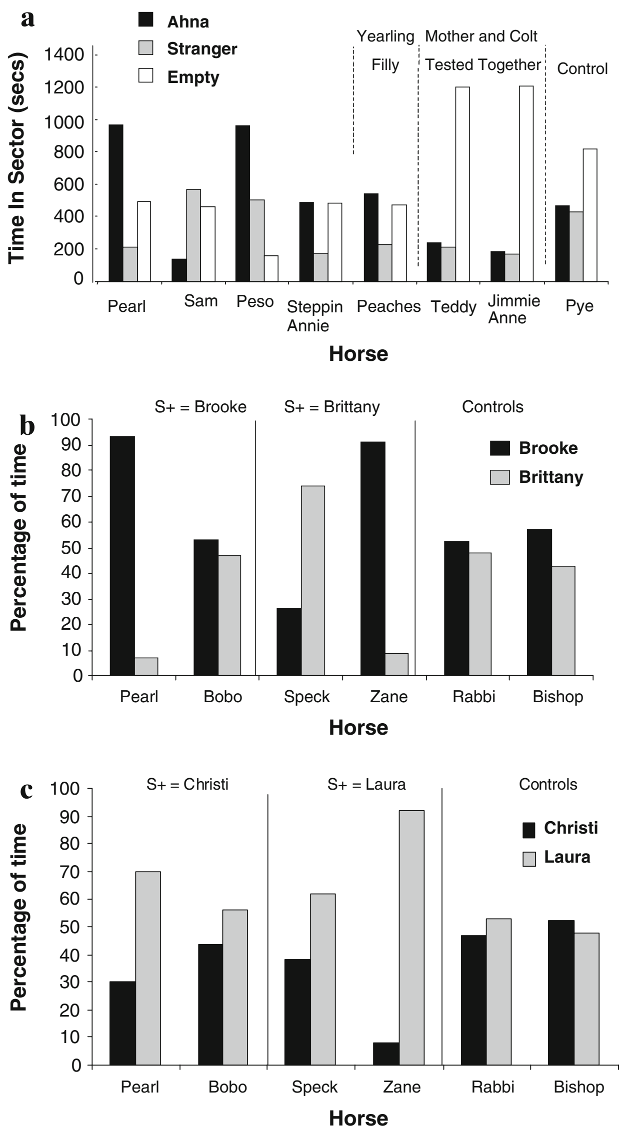

Fig. 4 **a** The results of the timed results for the Ahna/Stranger/Empty field test. **b** The results of the timed results for the fraternal twins' (Brooke and Brittany) field test. **c** The results of the timed results for the identical twins' (Christi and Laura) field test

Table 1 The results of the behaviors exhibited by the horses in the Ahna/Stranger/Empty field test

Behavior	*N*	Num/Secs	Mean	SD
Ahna sector				
Look At	7	71	10.14	6.09
Rug Against	7	6	0.86	1.86
Lick/Sniff/Nuzzle	7	38	5.43	5.65
Butt/Kick/Bite	7	0	0.00	0.00
Stand By	7	1,697 secs	242.43	118.30
Time In	7	3,518 secs	502.5 7	351.16
Aggressive	7	0	0.00	0.00
Non-aggressive	7	44	6.29	5.37
Stranger sector				
Look At	7	28	4.00	2.89
Rug Against	7	0	0.00	0.00
Lick/Sniff/Nuzzle	7	9	1.29	0.76
Butt/Kick/Bite	7	41	5.86	9.86
Stand By		1,191 secs	170.14	171.06
Time In	7	2,055 secs	293.57	167.88
Aggressive	7	41	5.85	9.36
Non-aggressive	7	9	1.29	0.76
Time In	7	4,469 secs	638.43	406.17

The data for the control horse (Pye) were excluded from these analyses

Num total number of occurrences for all the horses; *Secs* total number of seconds for all the horses

horses. Two control horses were included. The controls were not trained in the discrimination trials. The results of means' analyses for each twin revealed that, for the Time In (Fig. 4b) variable, the horses who were trained to respond to Brooke spent 861 s ($M = 430.50$, $SD = 366.99$) with her and 205 s ($M = 102.50$, $SD = 71.42$) with Brittany. The horses trained to respond to Brittany spent 1,274 s ($M = 637.00$, $SD = 831.56$) with Brooke and only 260 s ($M = 130$, $SD = 9.90$) with Brittany. The control horses spent 216 s with Brooke ($M = 108$, $SD = 74.95$) and 171 s with Brittany ($M = 85.50$, $SD = 91.28$).

The three overt behaviors were also analyzed using descriptive statistics. The horses that were trained to respond to Brooke displayed Look At her 1 time whereas 9 times to Brittany. These horses exhibited Lick, Sniff, Nuzzle behaviors toward Brooke 17 times and Brittany 14 times. These horses trained to respond to Brittany Looked At her 13 times but only 1 time to Brooke. These horses exhibited Lick, Sniff, Nuzzle behaviors toward Brittany 4 times and Brooke 5 times. None of the experimental horses Approached Brittany but they Approached Brooke 6 times. Finally, the control horses Looked At Brooke 2 times and Brittany 1 time, Lick, Sniff, Nuzzle Brooke 8 times and Brittany 6 times, and Approached Brooke 7 times but never Approached Brittany (Fig. 4b). Due to the small number of horses in this experiment, no significance testing was conducted for the behaviors (Table 2).

Identical twin field test

The results of means' analyses for the identical twins revealed that the horses spent more time with their S+ than their S−. Specifically, for the Time In variable the horses that were trained to respond to Christi spent 233 s ($M = 116.50$, $SD = 115.26$) with her and 135 s ($M = 67.50$, $SD = 20.51$) with Laura. The horses trained to respond to Laura spent 129 s ($M = 64.50$, $SD = 24.75$) with Christi and 690 s ($M = 345.00$, $SD = 164.05$) with Laura. The control horses spent 564 s with Christi ($M = 282.00$, $SD = 29.70$) and 552 s with Laura ($M = 276.00$, $SD = 164.05$).

Table 2 The results of the behaviors exhibited by the fraternal twins' (Brooke and Brittany) field test

Horse	Time In				Nuzzle				Look Back At			
	Brooke		Brittany		Brooke		Brittany		Brooke		Brittany	
	Secs	%	Freq	%	Freq	%	Secs	%	Freq	%	Freq	%
Pearl (Brooke)	690	93	52	7	8	89	1	11	1	11	8	89
Bobo (Brooke)	171	53	153	47	9	41	13	59	0	0	1	100
Speck (Brittany)	49	26	137	74	0	0	2	100	0	0	1	100
Zane (Brittany)	1,225	91	123	9	5	71	2	29	1	8	12	92
Rabbi (Control)	161	52	150	48	4	44	5	56	1	100	0	0
Bishop (Control)	55	57	41	43	4	80	1	20	1	50	1	50

Time In is indicated in s. The remaining seconds of the period were spent standing in the middle between the twins. This time was not calculated in the statistics. Nuzzle and Look are indicated in number of occurrences. The content in the parentheses indicates the S+ for each horse. Rabbi and Bishop served as the control horses for the field test

Table 3 The results of the behaviors exhibited by the horses in the identical twins' (Christi and Laura) field test

Horse	Time In				Nuzzle				Look Back At			
	Christi		Laura		Christi		Laura		Christi		Laura	
	Secs	%	Secs	%	Freq	%	Freq	%	Freq	%	Freq	%
Pearl (Christi)	35	30	82	70	3	75	1	25	1	17	5	83
Bobo (Christi)	153	44	198	56	18	82	4	18	3	100	0	0
Speck (Laura)	82	38	133	62	1	50	1	50	2	100	0	0
Zane (Laura)	47	8	557	92	2	33	4	67	7	78	2	22
Rabbi (Control)	143	47	160	53	1	50	1	50	3	38	5	62
Bishop (Control)	261	52	242	48	7	50	7	50	3	60	2	40

Time In is indicated in s. The remaining seconds of the period were spent standing in the middle between the twins. This time was not calculated in the statistics. Nuzzle and Look are indicated in number of occurrences. The content in the parentheses indicates the S+ for each horse. Rabbi and Bishop served as the control horses for the field test

The three overt behaviors were summarized using descriptive statistics. The horses that were trained to respond to Christi displayed Look At her 4 times and 5 times at Laura. The horses exhibited Lick, Sniff, Nuzzle behaviors toward Christi 21 times and toward Laura 5 times. The horses that were trained to respond to Laura displayed to Look At her 2 times and Christi 9 times. These horses exhibited Lick, Sniff, Nuzzle behaviors toward Laura 5 times and Christi 9 times. The horses Approached Laura 10 times but only Approached Christi 2 times. Finally, the control horses Looked At Christi 6 times and Laura 7 times; Lick, Sniff, Nuzzle Christi 8 times and Brittany 8 times; and Approached Christi 7 times and Laura 3 times (Fig. 4c). Due to the small number of horses in this experiment, no significance testing was conducted for these behaviors (Table 3).

Discussion

Although much variability existed between the horses in these experiments, as a whole, their discriminative results suggest that horses are capable of facial recognition. In addition, their overt behaviors in the round pen supported the hypotheses that facial recognition affected the horse–human interactions. Specifically, the results supported the hypotheses that (a) the horses would learn to discriminate the unrelated individuals and fraternal twins during the 2D discrimination training trials. In contrast to the hypothesis that (b) the horses would not learn to discriminate identical twins during the 2D discrimination training trials, the results showed that they did demonstrate discrimination learning. However, during the field tests, the results showed that (c) the horses, as a whole, spent more time with one of the fraternal twins (Brooke) even though she was not the S+ shown in their photograph during their discrimination training. Finally, the results supported the hypothesis that (d) the horses would not show a preference for either of the identical twins in a 3D setting after completing the discrimination training with the photographs. The control horses further supported these hypotheses by spending an equal amount of time and interacting equally with the unrelated women, the fraternal twins, and the identical twins.

Horses are social animals that have evolved and been bred to interact with humans. Only the free roaming mustangs, not dependent upon humans for survival, are free from human presence. In contrast, the control horses used in both of these experiments were domesticated and interacted daily with both women and men. Therefore, the time they spent in the women's section is indicative of curiosity and social communication. Horses use their sensory systems to learn to adapt to their environment. They communicate not only with each other but also with humans through their auditory, olfactory, tactile, and visual abilities (Budiansky 1997). Therefore, the control horses were clearly demonstrating normal horse behavior by checking out the women's presence in his/her territory, the round pen. After examining the women briefly, the satisfied their normal horse curiosity then they walked away and stayed nearly twice as long in the Empty section in Experiment 1 or spent an equal amount of time with each twin in Experiment 2. It could be possible that the women were not strong enough stimuli to elicit examination behavior; therefore, the horses continued grazing. Future studies should reexamine this using more sets of twins. In addition, sets of older twins should be examined to determine if horses respond differently based on age of the human. Moreover, future research should use men rather than women to determine if horses respond differently to genders.

An unexpected finding during Experiment 1 field tests was the display of aggressive behaviors Sam exhibited toward the S−. Specifically, he turned his butt toward the S−, butted her from where she was standing, and kicked her with his back leg. These behaviors also may account for the longer amount of time he spent with the S− than with the S+. In contrast, Sam exhibited non-aggressive and gentle behaviors toward the S+. Sam's behavior could have been a result of a prior threatening encounter with a woman resembling the S− thus he was sending her a message to leave his territory. Future studies should examine this by including a human that resembles a past abuser and pair him/her with an unknown human.

Despite the strong evidence of facial recognition by the horses in this study, it would be negligent not to make alternative explanations for the behaviors. For instance, the aggressive behaviors exhibited by Sam toward the S− may have resulted because of something other than transfer of discrimination training to a 3D facial recognition setting. That is, the Stranger may have represented a threat to Sam and therefore he was protecting himself. Although the women in both experiments were asked not to wear any type of fragrant soaps, perfumes, or shampoos on the day of testing, odor must be considered for Sam's aggressive behavior. His behavior may have been due to an offensive odor that the S− exuded that went undetected by the human participants. If such an odor was offensive to Sam, he may have behaved aggressively to remove the source. Similarly, the S− may have resembled someone from his past that treated him aversively.

An explanation for the successful discrimination learning concerns the clothing of all the women wore in the photographs. Timney and Keil (1992, 1996) found that horses have excellent visual acuity, depth perception, and the ability to see reds and blues. Therefore, the S+ in Experiment 1 wore a red checkered flannel shirt over a black t-shirt and denim blue jeans in the photographs and during the field tests. To account for Hanggi et al.'s (2007) finding that suggested horses are dichromats with red-green deficiencies, the women in Experiment 2 wore white t-shirts and denim blue jeans in the photographs and field tests. The results of both of the field tests suggest that the horses recognized the women by facial cues rather than clothing. As further evidence of facial recognition, a future study should be designed using a familiar person such as the daily handler as the non-reinforced stimulus (S−) and an unfamiliar person as the reinforced stimulus (S+).

Although the results of this study support the hypotheses, several limitations, which may have affected the horses' behavior, must be addressed. First, no baseline data were collected prior to beginning the discrimination training. It could be that the horses may have responded to the S+ stimuli at a higher rate than the S− stimuli regardless of the positive reinforcement value they held. Future studies should include a baseline test prior to the discrimination training. However, such studies would need to account for possible learning carryover effects. Secondly, in Experiment 1, Jimmie Anne and Teddy were trained and field tested together. Efforts to train Jimmie Anne on the discriminative stimuli without Teddy were unsuccessful. She broke free from the leader and ran to Teddy. Once Teddy was placed within her sight, she remained with the leader during the training. However, Jimmie Anne did not reach criterion. Her lack of learning could have been due to the presence of Teddy and/or his handler. Their presence may have negatively affected her results by averting her attention away from the learning task. Teddy was only 5-week old at the beginning of this study and his results suggest that he had not reached the cognitive ability for such learning. A future study should include foals at various ages to determine the optimal age at which discrimination learning can be accomplished in horses. One important limitation of this study was the small number of horses used in both experiments. Future studies would benefit from the use of larger sample sizes to allow more sophisticated statistical analyses.

Studies of facial recognition in animals have been debated and continue to divide the camps on the issue of animal cognition. Researchers on both sides of the issue have presented strong evidence for the existence and nonexistence of this cognitive ability. For the behaviorist, responses to similar stimuli are nothing more than stimulus generalization. However, the cognitive scientist asserts that animals are not merely mindless creatures that respond to stimuli. They are, instead, "intelligent" creatures with the ability to solve problems using classical, operant, and cognitive processes. The results of this study suggest that facial recognition is not entirely a behavioral or cognitive process but rather a combination of both. To exclude one from the other is to limit the advantages of each. For instance, stimulus generalization and facial recognition appear to work in concert with each other.

Applied implications

The use of horses for therapeutic reasons has seen a significant increase in the past 20 years (Fitzpatrick and Tebay 1996). Riding helps to rehabilitate various human disorders including language, physical, emotional, and social (DePauw 1992). Horse-assisted therapy has been used successfully with quadriplegics, those suffering from multiple sclerosis, cerebral palsy, and other neurological impairments (Netting et al. 1987; Wilson and Turner 1998). Horse–human interaction has also been shown to be effective for those suffering from depression, anxiety, and post-traumatic stress disorders (Engel 1994; Heipertz-Hengst, unpublished data).

This study demonstrated that using photographs could reduce the amount of time necessary to train horses. Horse industry professionals could incorporate photographic stimuli rather than use abusive techniques into training methods. Specifically, training time could be reduced if the horse is simply shown a photograph of their new riders as a means of acquainting the horse to them and shortening the bonding period. This study used a technique which has the potential to strengthen the horse–human bond. Simply, human companions could hang photographs of themselves in the barn for their horse to observe.

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