Horses (Equus caballus) use human local enhancement cues and adjust to human attention.

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Abstract

This study evaluates the horse (Equus caballus) use of human local enhancement cues and reaction to human attention when making feeding decisions. The superior performance of dogs in observing human states of attention suggests this ability evolved with domestication. However, some species show an improved ability to read human cues through socialization and training. We observed 60 horses approach a bucket with feed in a three-way object choice task when confronted with a) an unfamiliar or b) a familiar person in 4 different situations: 1) squatting behind the bucket, facing the horse (2) standing behind the bucket, facing the horse (3) standing behind the bucket in a back-turned position, gazing away from the horse and (4) standing a few meters from the bucket in a distant, back-turned position, again gazing away from the horse. Additionally, postures 1 and 2 were tested both with the person looking permanently at the horse, and with the person alternating their gaze between the horse and the bucket. When the person remained behind the correct bucket it was chosen significantly above chance. However, when the test person was turned and distant from the buckets, the horses' performance deteriorated. In the turned person situations the horses approached a familiar person and walked towards their focus of attention significantly more often than with an unfamiliar person. Additionally, in the squatting and standing person situations, some horses approached the person before approaching the correct bucket. This happened more with a familiar person. We therefore conclude that horses can use humans as a local enhancement cue independently of their body posture or gaze consistency when the persons remain close to the food source, and that horses seem to orientate on the attention of familiar more than of unfamiliar persons. We suggest that socialization and training improve the ability of horses to read human cues.

Keywords:

human-horse interaction, horse, attention-reading, position, familiarity

Introduction

This study focuses on the propensity of a domestic species, the horse (Equus caballus), to react to the focus of human attention depending on the body posture and familiarity of the test person. Recent studies revealed large differences between species in recognising the focus of human attention, with dogs (Canis lupus familiaris) out-performing other species, including chimpanzees (Gácsi et al. 2004; Hare et al. 2002). The partially contradictory studies by Hostetter et al. 2007, Gácsi et al. 2004, Gácsi et al. 2005, Theall and Povinelli 1999, and Virányi et al. 2004 provoked lively discussion over whether the studies should be assessed on a behavioural or a cognitive representational level. While behavioural explanations (Povinelli and Vonk 2003) emphasise the animal's ability to learn to use the focus of attention as a cue, cognitive explanations highlight the animal's understanding of the signaller's intentions (Tomasello et al. 2003). In humans and primates sensitivity to different states of attention has been proposed as the phylogenetic basis for theory of mind and language abilities (Itakura 2004; Povinelli and Eddy 1996; Tomasello et al. 2003). Generally, the ability to take advantage of other species' focus and state of attention

is advantageous for the avoidance of predators and competitors, for resource allocation, and for communication. For example, hand raised ravens follow the direction of an experimenter's gaze towards distant locations and behind obstacles. As the bird's gaze-follow responses were affected by the type of the gazing, the age of the animals and also by learning, the authors suggested that cognitive mechanisms could direct the raven's visual co-orientation (Bugnyar et al. 2004). For prey animals, such as horses, a cross-species ability to use the focus of attention as a cue would provide particular survival benefits (Goodwin 2002).

The superiority of dogs over other species in this area has been attributed to domestication (Call et al. 2003). Brauer et al. (2004) and Schwab and Huber (2006) found that dogs adjusted their behaviour according to the state of a human's attention, and Gácsi et al. (2004) found that dogs could distinguish between different states of human attention in fetching games and begging behaviour. Dogs recognised various cues associated with human attention, and the human's head orientation seemed to be an especially important factor. Dogs were more likely to choose those humans who oriented themselves towards the animals both in a food-begging situation and a toy-fetching game. Some dogs brought the object to the front of the person even when they were facing away, and they begged from the person facing them in preference to the person facing away (Gácsi et al. 2004; Virányi et al. 2004).

Such tasks have been determined to be cooperative in nature (Hare 2001), and especially domestic species have been bred for cooperativeness with humans (Gácsi et al. 2005; Miklósi et al. 2003). The domestication theory has been supported by the fact that cooperatively working dog breeds outperformed independently working breeds in such tasks (Gácsi et al. 2009a). However, the strongest support for the domestication theory comes from the famous silver fox study. Foxes selected for their tameness and willingness to approach humans showed some characteristics of dog morphology and were better at giving their attention to humans, as well as in reading human cues, than a group of wilder foxes (Hare et al. 2005). Nevertheless the significance of domestication for cognitive skills in reading human states of attention remains controversial, and recent studies in wolves and chimpanzees have provided mixed results. Theall and Povinelli (1999) reported that chimpanzees did not discriminate between an attentive (eyes open) and inattentive (eyes close) human, whilst Hostetter et al. (2001) showed that chimpanzees did discriminate between an attentive (facing toward) and inattentive (facing away) experimenter. In the case of dogs the head direction of humans seemed to be more important than the gaze, when comparing the performance of guide dogs of blind owners to pet dogs of sighted owners (Gaunet 2008; Ittyerah and Gaunet 2009). Furthermore, some studies showed wolves to be inferior (Hare et al. 2002; Miklósi et al. 2003; Virányi et al. 2008) and others superior (Udell et al. 2008) to dogs in their ability to read human cues and recognise their state of attention.

Dogs may have inherited the ability to read human given cues from wolves through a process of selection and convergent evolution or, as in chimpanzees, may have gained it through socialization to humans and training (Hare et al. 2002). Itakura et al. (2001) found that if chimpanzees were brought up by humans it made little difference in a food location task whether cues were given by another chimpanzee or a human. In a recent study, Gácsi et al. (2009b) elaborate on delayed emergence of socialisation in hand reared wolves compared with dogs. Dog pups outperformed hand reared wolf pups, but adult animals in hand reared wolves were as skilled at utilizing human pointing gestures as dogs.

As animals are tested by human experimenters in object choice tests, their relationship with the human should be considered, as the familiarity of a human experimenter may be of central importance. Socialisation and training may be the key factors in the different responses to familiar and unfamiliar persons in horses (Hausberger et al. 2008), as has been reported for approaches to unknown and known persons in dogs (Rappolt 1979). Results for approaches and interactions with known and unknown persons by cattle are partly contradictory. Rousing and Waiblinger (2004) found that although the cows' approaches to a test person were not affected by the familiarity of the human, the latency to touch an unknown person was shorter than with a known person, which they suggest could be caused by the cow's curiosity for novelties. On the other hand Breuer et al. (2003) found no difference between the interactions with familiar and. unfamiliar humans in heifers. She claims that positively handled heifers approached humans faster and interacted more with the person than their negatively handled counterparts (Breuer et al. 2003). Heart rate in cats varied according to whether they were petted by familiar or unfamiliar persons (Slingerland et al. 2008). Generally, horses show similar reactions towards familiar and unfamiliar humans (Henry et al. 2005; Lansade and Bouissou 2008), and they discriminate familiar and unfamiliar persons at the same speed (Stone 2010), which may be caused by the horse's generalization of positive and negative experiences from familiar to unfamiliar persons (Hausberger and Muller 2002; Hausberger et al. 2008; Krueger 2007). Some authors propose that early contact with foals can lead to positive or negative associations with humans (Henry et al. 2005, 2006; Landsade et al. 2004, 2005). Even the handler's relationship to the dam shapes a foal's behaviour towards humans in the future (Henry et al. 2005).

Horses are indeed a good model species on which to test the effects of domestication, socialisation, and training on the animal's ability to use the focus of human attention as a cue. During domestication, 2.500 – 5.000 years ago (Clutton-Brock 1981), horses might have been selected for their ability to respond to human cues. Like goats, horses are not kept in close proximity to humans, but for centuries humans relied on the performance of horses in battle, for farming and for transportation. The selection and training of horses for fast and subtle reactions to human cues has been of major importance from ancient times (Xenophon 426 – 355 b.C.) up until today. The skill of horses in responding to human facial and gestural cues is known from the case of Clever Hans in the early 20th century. Clever Hans was claimed to have the arithmetic skills of a 12 year old child and other extraordinary skills. Although subsequent observations revealed that he could not count, he was nevertheless extremely skilful in reading subtle human facial expressions and body movements, which he used to decide when to begin tapping with his hoof and when to stop. He even generalized the cues given by his trainer to unfamiliar persons (Pfungst 1907).

Surprisingly few studies have addressed the horse's abilities to respond to human attention as a cue, although horses have been shown to be able to read attention states when provided with body orientation, head orientation or gaze cues, and some horses walked around an "inattentive", turned-away person to attract attention (Proops and McComb 2010). There have been three further studies published on the horse's performance in object choice tasks. Two out of four horses could use touch cues and one horse could use pointing cues in the McKinley and Sambrook (2000) study. Furthermore horses were able to use pointing gestures from both a standing and a squatting person when her hand was briefly held close (~ 10 cm) to the target, or her arm was permanently held (either close ~ 10 cm or distant ~ 80 cm) in direction of the target (Maros et al. 2008). In a recent study (Proops et al. 2010), horses were able to use a persons permanent pointing with an extended arm (~ 65 cm distant to the target) and the placement of a marker in front of the bucket (i.e. a coloured wooden block) as a cue, but not momentary tapping at the feed bucket, nor body orientation and gaze (head) alternation cues by the person.

The present study is the first to address possible effects of human body posture and gaze, as well as the familiarity of the person, on the horse's propensity to use a human as a cue to find food. As the horses were allowed to observe the process of feed being placed in the bucket, valuable information will be gained on how horses prioritize their own knowledge compared to other information. In some previous studies, cueing by persons was necessary to encourage the horses to perform in object choice or in attention tasks (Maros et al. 2008; McKinley and Sambrook 2000; Proops and McComb 2010; Proops et al. 2010). However, there is only limited knowledge of how the horse's use of its own memory is influenced by the local enhancement of the presence of the person, the person's familiarity and the person's body posture, or potentially distracting cues, such as the person's gaze and person facing away from the focus of the test. We measured horses' choices in approaching a bucket with feed in a three-way object choice task when confronted with a) an unfamiliar or b) a familiar person in 4 different positions/postures: 1) squatting behind the bucket, facing the horse and either looking steadily at the horse with a permanent gaze (1a) or alternating their gaze between the horse and the bucket (1b), (2) standing behind the bucket facing the horse and either alternating their gaze between the horse and the bucket (2a) or looking steadily at the horse with a permanent gaze (2b), (3) standing behind the bucket in a back-turned position, gazing away from the horse, and (4) standing a few meters from the bucket in a distant back-turned position, again gazing away from the horse.

For this study we hypothesize:

a) That the horse's performance may vary according to whether the tester is an unfamiliar or a familiar person. Previous findings (dogs: Rappolt 1979, horses: Hausberger et al. 2008) suggest that some animals perform better in training tasks when tested by familiar persons. It remains to be seen whether this also applies to object choice tasks. This aspect in particular may provide data for the hypothesis that the horse's performance in object choice tasks is affected by their socialisation and training.

b) That the constancy of the person's gaze when facing the horses affects their choice (i.e. using permanent or alternating gaze). Gaze patterns have been shown to alter other species behaviour (Kaplan and Roger 2002). Alternating gazes may influence the attention for the tasks, but has not proved to be effective in horses so far (Proops et al. 2010).

c) That the horse's choice of feed bucket may be affected by the person's posture, i.e. squatting, standing. Horses may perform better when the experimenter is squatting, because upright frontal postures may indicate the person's dominance and his/her intention to monopolise a food source, as indicated by anecdotal reports (Miller and Lamb 2005). However, scientific literature has so far stated no effect of human posture on horses' attention or performance (Maros et al. 2008; Proops and McComb 2010; Proops et al. 2010).

d) That the horse's performance varies depending on the person's focus of attention, i.e. when he/she faces the horse or turns away. As shown in primates (Kaminski et al. 2004), we would expect the horse's performance to deteriorate when the experimenter turns and faces away, i.e. turns his/her focus of at-

tention away from the task.
e) Finally, that horses use humans as local enhancement cues. When the person moves away from the feed buckets, and thus avoids providing local enhancement cues for a particular feed bucket, the horse's choices of that bucket should decline, but their approaches to the persons, and their orientation on the person's focus of attention, should be enhanced.
In addition to gaining new insights into the horse's use of human attention as a cue, an understanding of the influence of the human's body posture, gaze and familiarity on the horse's behaviour towards humans would facilitate the selection of suitable test persons and test situations in cognition tasks, or support the claim that persons should be removed from studies that should not be affected by human cueing.

Material and Method

Animals
We investigated the behaviour of 60 horses, including 27 Standard-breds, 1 Arab, 1 Arab-Trakehner-mix, 8 Trotters, 7 Haflingers, 4 Icelandic horses and 12 ponies. Among these were 2 stallions, 29 mares and 29 geldings, all aged between 3 and 28 years (mean age: 13.27, SD = 6.1). They were in 14 different locations, and all the horses were either constantly kept in open stabling with permanent access to pasture, or kept in social groups on pasture during the day and stabled in boxes overnight. In 9 locations we tested the horses with a familiar person and in the other 5 with an unfamiliar person. The horses' sleeping areas included bedding of straw or wood shavings. All horses were in excellent feeding condition; their feed was composed of hay twice a day and a compound feed once or twice a day, and in addition they had access to grass in their pastures. As far as was known, all horses had comparable histories with humans. They were all leisure horses trained in a conventional way.

Experimental area
We conducted the study in a part of the paddock or riding arena familiar to the horses. For the test, a 20m x 20m area was fenced off to prevent horses other than the particular test horse from seeing the test area from the outside. Nervous horses were tested in the proximity of a group mate that had already finished the test. Three feed buckets were placed on the ground 2 metres away from each other in a curved alignment to ensure equal walking distances to all three buckets (Fig.1). In both experiment 1 and experiment 2 (detailed below under Test Phase) a test person placed him/herself behind a randomly chosen bucket and was either
a) unfamiliar, for 32 of the test horses (19 horses were used for experiment 1 (N = 19) and 12 for experiment 2 (N = 12), plus 1 substitute for a side biased horse) or,
b) familiar (through several years contact) for 28 of the test horses. Here 16 horses participated in experiment 1 (N = 16) and 12 horses in experiment 2 (N = 12). The familiar person was either the owner or the main caretaker of the particular horse.
An assistant led the horse by its halter to a central starting position. The distance from the starting position to the buckets had to be adjusted to the different conditions in the particular stable, but was always between 6 and 9 meters. Pieces of apple and carrot were used as incentives for the horse to approach the bucket.
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Habituation phase
Three persons took part in the test, a test person who gave the cues, an assistant who recorded the data, and another assistant who handled the horse. To ensure that all horses would approach the feed buckets reliably and that the buckets would be equally marked with saliva, the handling assistant led each horse by its halter towards the buckets and allowed it to feed from all three. The horses fed until the buckets were empty and were allowed to check that there was no feed left in any of the three buckets. The assistant then led the horse to the starting position. He/she always approached and handled the horses by their halters from the left, as all the horses were used to being handled from this side. At the starting position the horse was offered feed from the test person's hand. Then the test person walked with further feed in his/her extended hand and placed

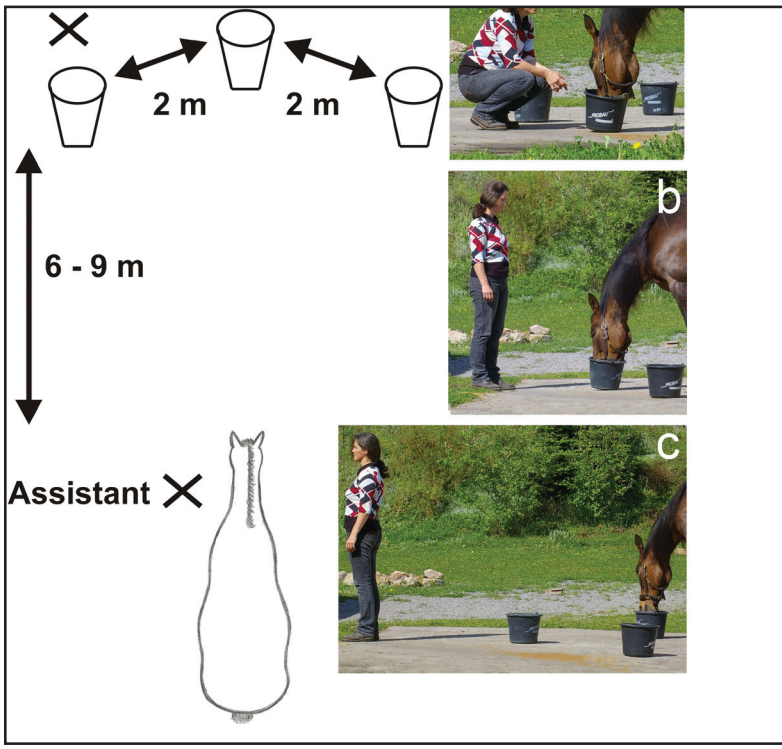


Fig. 1: Experimental set-up
Test situations: a) squatting person
b) standing person c) turned-distant person

it in one of the three buckets. Very cautious horses were at first allowed to follow the test person until he/she had reached the position behind the bucket, and later on they were held at the starting position by the assistant, as were most horses right from the beginning. The assistant handling the horse faced a predetermined fixed point throughout this procedure, and released the horse, turning his/her back to the feed buckets and remaining in this turned position at the starting point. The horse was allowed to move freely in the experimental area. After it had made its choice of a certain bucket or approached the test person, the assistant turned around, approached the horse, took it by its halter, turned it either to the left or to the right (counterbalancing for side effects) and led it back to the starting position. The habituation phase was completed when the horses approached the feed buckets spontaneously and without hesitation when their name was called. The horses rapidly learned that the turned assistant would not intervene in their choice making procedure and ignored her/him during the tests. On average horses needed two to three trials but never longer than six trials to reach criteria.

Test phase

When the horse walked freely towards the feed buckets and the person after being released, we continued with the test phase. During the test phase the test person approached the horse, showed it some feed, walked towards one of the three buckets in a semi-random but predetermined order (making sure not to approach the same bucket more than twice in a row), and squatted down to place the feed in the bucket. The test person stayed in contact with the horse throughout the whole process by calling its name to keep its attention. The person then positioned him/herself behind that bucket. The test person could then:

1) a) remain squatting behind the filled bucket and look back and forth between the bucket and the horse, (squatting/alternating gaze, Fig. 1a) or b) squat, but hold visual contact to the horse without looking into the bucket (squatting/permanent gaze),

2) a) stand and look back and forth between the bucket and the horse (standing/alternating gaze) or b) stand behind the filled bucket and hold visual contact to the horse, without looking into the bucket (standing/permanent gaze, Fig. 1b),

3) stand in a turned position directly behind the bucket (turned/proximal).

4) Finally, the person could turn her back to the bucket and look horizontally away from the horse, then walk 3 meters towards the centre of the three buckets and remain in a standing, turned position (turned/distant, Fig.1c). This was to examine the horse's response to the focus of human attention without strong local enhancement effects for particular feed buckets.

The assistant released the horse, as in the habituation phase. The horse was then allowed to move freely in the test area and make its choice between the three buckets. It was allowed to eat the feed when it correctly approached the bucket in which the test person had previously placed the feed, but when it approached the wrong bucket it did not receive any feed and was calmly led back to the starting position. A third person outside the test area documented the horse's behaviour on paper and continuously on video.

We conducted two experiments, experiment 1 (table 1) with the test situations (1a), (2b) and (4), and experiment 2 (table 2) with the test situations (1b), (2a) and (3). Experiment 2 was conducted to control for gaze and for local enhancement effects from persons close to the bucket for 6 horses (experiment 2.1.) and additionally for order effects for another 6 horses (experiment 2.2.). To control for order effects in experiment 2.2., we reversed the trial order such that the turned/proximal person situation (3) was first, then the squatting/permanent gaze (1b), and finally, the standing/alternating gaze (2a) situation.

The same horses participated in all three test situations of one experiment and were given 6 consecutive choices in each test situation. All habituation and test trials were conducted in a single session, which did not last longer than 20 minutes for any horse. One horse from the second experiment had to be removed because of its strong side bias.

Test persons

Two persons participated in each test and each test was recorded on video. An independent third person later wrote down the horses' choices and approaches to persons. Four different test persons participated in the unfamiliar person situation of experiment 1 and another four in experiment 2. They tested the horses in random order. In the familiar person situation, the test person was the horse's owner or caretaker. The assistant handling the horses was the same, unfamiliar, person for all horses in experiment 1 and 2. Test persons wore the same clothes throughout all the trials.

Data collection

We recorded each horse's choices of feed bucket, distinguishing between correct, incorrect and no choice, and calculated the percentages of correct choices (Fig. 2). Additionally, we counted the cases in which the horses approached the test person without first feeding from the buckets. Instances where horses moved into the direction of the test person and then either stood motionless and faced the person, or passed the buckets and approached the person in the squatting or standing person situations were counted as approaches. Some of the horses fed from the bucket after approaching the person standing at

Table1: Individual counts of correct choices, experiment 1													
		squatting / alternating gaze				standing / permanent gaze				turned / distant			
	horse name	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦
unfamiliar test person	Diva	1	6 **	0	0	1	4	0	0	1	5 *	1	0
	Hamra	0	4	0	0	1	6 **	0	0	0	2	2	2
	Malawit	1	6 **	0	0	1	4	0	0	1	2	0	0
	Bibilotta	1	5 *	0	0	0	5 *	1	1	1	5 *	0	0
	Angie	1	6 **	0	1	1	6 **	0	0	0	6 **	0	0
	Leika	1	6 **	0	0	0	4	0	0	1	3	0	0
	Fritzl	1	6 **	0	0	1	6 **	0	0	1	6 **	0	0
	Luna	1	6 **	0	0	1	6 **	0	0	1	4	0	0
	Merlin	1	6 **	0	0	1	5 *	0	0	1	4	0	0
	Camillo	1	6 **	0	0	1	6 **	0	0	1	4	0	0
	Sissi	1	6 **	0	0	1	6 **	0	0	1	4	0	0
	Anja	0	2	0	1	1	5 *	0	0	0	0	2	0
	Peppy	1	6 **	0	0	1	6 **	0	0	1	5 *	0	0
	Billy	1	5 *	0	NA	1	4	0	NA	0	4	0	NA
	Alexia	1	5 *	0	NA	1	3	0	NA	0	3	0	NA
	Sara	0	4	0	NA	0	5 *	0	NA	0	0	0	NA
	Farina	1	6 **	0	NA	1	5 *	0	NA	0	3	0	NA
	Pepper	1	5 *	0	NA	1	6 **	0	NA	0	3	0	NA
	Anou	0	4	0	NA	0	6 **	0	NA	0	3	0	NA
mean total performance		79%	88%	0%	2.5%	79%	86%	1%	1%	53%	58%	4%	2.5%
Familiar test person	Joschi	1	6 **	0	0	1	6 **	0	2	0	3	2	2
	Sunny	1	6 **	0	3	0	3	0	1	0	4	0	0
	Bingo	1	6 **	0	1	1	6 **	0	0	0	1	3	2
	Pretty	1	6 **	0	0	1	5 *	0	1	0	3	0	0
	Sammy	1	6 **	0	4	1	6 **	0	1	1	4	1	1
	Bonita	1	6 **	0	4	1	6 **	0	2	0	0	2	2
	BillTeiser	1	6 **	0	1	1	5 *	0	1	0	3	2	2
	Sheraz	1	6 **	0	3	0	2	3	3	0	0	6	4
	Sambor	1	6 **	0	2	1	5 *	0	1	1	4	0	0
	Hjötra	1	6 **	0	0	1	6 **	0	0	0	4	1	1
	Mahranya	1	5 *	0	0	1	6 **	0	2	1	4	0	0
	Manon	1	5 *	0	0	1	4	0	1	1	2	2	2
	Monty	1	6 **	0	4	1	5 *	0	1	1	3	1	1
	Romeo	0	4	1	3	1	4	2	3	0	0	4	3
	GrafAstor	1	6 **	0	2	1	5 *	0	2	0	2	2	2
	Hexi[1]	1	3	NA	0	NA	NA	NA	NA	NA	NA	NA	NA
mean total performance		94%	93%	1%	28%	87%	82%	5.5%	23%	33%	41%	29%	24%

. p = 0.001, . p < 0.05, Binomial test (hypothesised probability of success at 33%).
♦: 1 = correct 0 = wrong. ♦♦: from 6 choices. ♦♦♦: within 6 trials.
[1]: horse has been deleted from the data as it refused to participate in the test after 3 trials.

the correct bucket. In the turned person situation, approaches were counted as in the squatting and standing person situation and, in addition, we recorded instances of horses passing the person and walking in the direction of the person's gaze (Fig.3).

Data processing

Horses were used only for either an unfamiliar or familiar person test, as habituation effects would have confounded the results if they had been tested in both situations. One horse from the familiar person group had to be deleted from the data as it refused to participate after 3 trials in the standing person situation, another horse in experiment 2 had to be replaced as it showed a strong bias for the left side. For each trial we recorded the choice bucket (Fig. 2), and whether the horse approached the person before feeding from the bucket (Fig. 3). Even though we

Table 2: Individual counts of correct choices, experiment 2													
		squatting / permanent gaze				standing / alternating gaze				turned / proximal			
	horse name	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦	first choice ♦	total success ♦♦	nr. no choice ♦♦	approach to pers. ♦♦♦
	Vittoria	1	5 *	0	0	1	5 *	0	0	0	1	0	0
unfamiliar test person	Savannah	1	4	0	0	1	2	0	0	1	1	0	1
	Fiona	1	4	0	0	1	4	0	0	1	2	1	1
	Gyula	1	6 **	0	0	1	3	0	0	1	2	1	0
	Sarastro	1	4	0	0	1	4	0	0	1	5 *	0	0
	Jeamy	1	6 **	0	0	0	1	4	2	0	0	5	2
	Czaba	1	4	0	0	1	3	0	0	1	4	0	0
	Toffee	1	4	0	0	0	4	0	0	1	4	0	0
	Plainsman	1	6	0	0	1	5	0	0	0	2	0	1
	Nicolas	1	5	0	0	1	3	0	0	1	2	0	0
	Eccos	1	4	0	0	1	4	0	0	1	4	0	0
	Giardino	1	6	0	0	1	5	0	1	1	2	0	0
mean total performance		100%	80%	0%	0%	83%	60%	5.5%	4%	75%	40%	9%	7%
familiar test person	Lagsi	1	6 **	0	1	1	5 *	0	0	1	4	0	0
	Ronny	1	6 **	0	0	0	4	0	1	1	4	2	3
	Naedingur	1	6 **	0	0	1	5 *	0	0	1	6 **	0	0
	Lilly 1	0	3	0	0	0	4	1	3	0	2	2	2
	Wacker	1	6 **	0	0	1	5 *	0	2	1	4	0	1
	Prince	1	4	2	3	1	6 **	0	5	1	5 *	1	5
	Lilly 2	1	5*	0	0	1	6 **	0	2	1	6**	0	1
	Rambo	1	6 **	0	0	0	4	2	0	1	4	1	2
	Gustav	1	6 **	0	1	1	6 **	0	1	1	6**	0	3
	Zirkonia	1	6 **	0	0	1	6 **	0	0	1	6**	0	0
	Nevada	1	6 **	0	0	1	6 **	0	1	0	5 *	0	1
	Lugana	1	6 **	0	3	1	3	1	0	0	3	0	2
mean total performance		92%	92%	3%	11%	75%	83%	5.5%	21%	75%	76%	8%	27%

. p = 0.001,. p < 0.05, Binomial test (hypothesised probability of success at 33%).
♦: 1 = correct 0 = wrong. ♦♦: from 6 choices. ♦♦♦: within 6 trials.

conducted six repetitions for each horse in each test situation we attached great importance to the analysis of the first trial, as here the horse's behaviour is least distorted by learning and habituation effects (Mal et al. 1993). This procedure is justified by the results of many other studies which show an animal's success to be consistent over only a few repetitions (e.g. goats: Kaminski et al. 2005; dogs and cats: Miklósi et al. 2005; horses: Maros et al. 2008). However, as wolves improved their success rate with extensive training (Virányi et al. 2008) we will give the results for the total data as well.

For the analysis of the horses' total performance in each particular test situation their success rate was adjusted according to their participation in the particular test situations (e.g.: if the horse made no choice in 2 of the 6 trials, made 3 correct choices and 1 incorrect choice, the 2 no choice trials were discounted, and the individual performance was then calculated from the percentage of correct choices out of total choices, i.e. 3 out of 4, or 75%).

Statistics

We applied the statistical software SPSS 15 and the R-project statistical environment (2009) to the data analysis. The goodness of fit to an expected participation of above 50%, i.e. of making a choice in more than 50% of the trials, was tested with Chi square tests. Then, the complete binomial data for the first choices in experiment 1, as well as for whether horses approached the persons, were tested for effects of sex and breed, as were the data from experiment 2, which were additionally tested for order effects, with Generalized Estimating Equations (GEE). As not all variables were normally distributed (tested with a Kolmogorov-Smirnov-Test), we continued with applying non parametric tests. Additionally, because data sample sizes were low and standard deviations relatively high, we followed the generally accepted procedure to enhance the robustness of the non parametric test by applying exact procedures.

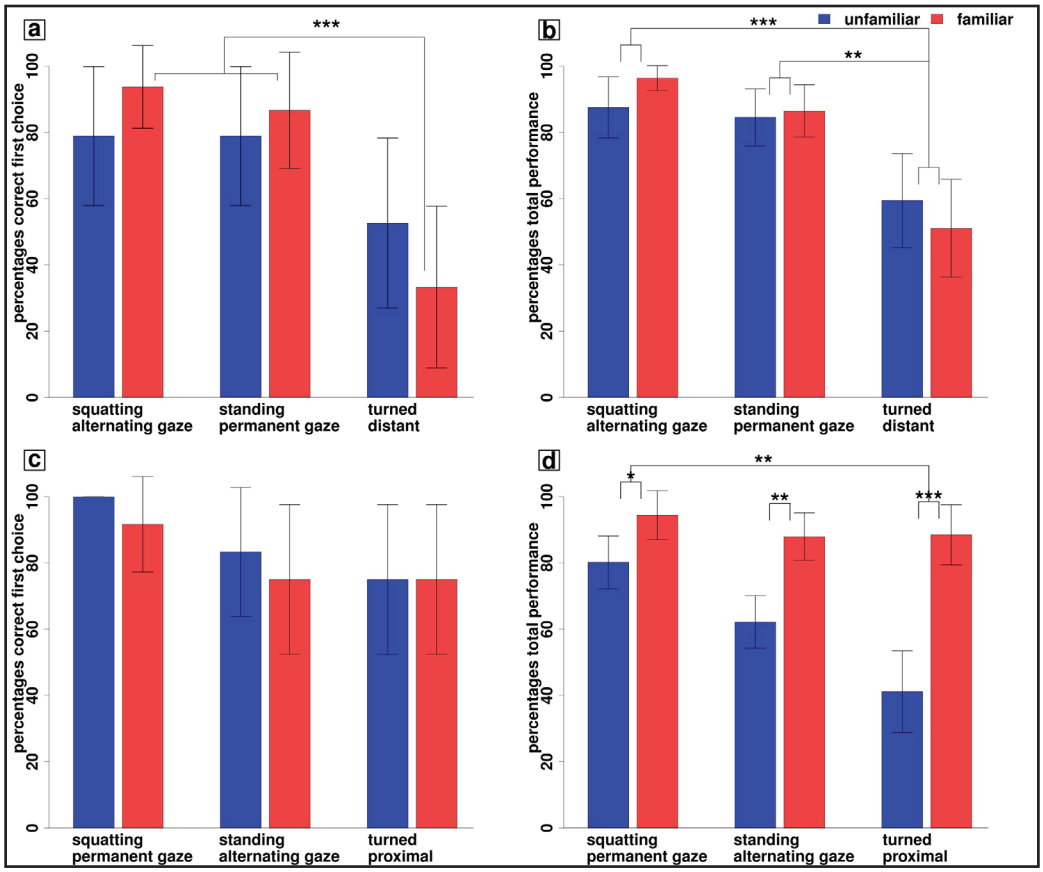
To clarify the complex results section, the main conclusions of each sub-point were first analysed for the

Fig. 2:
The horse's choice for the feed bucket

a) depicts the horses' correct choices in the first trial of experiment 1,
b) the correct total performance in experiment 1,
c) the correct first choices in the experiment 2 and
d) the correct total performance in experiment 2.

First choices and total choices are given in percent. The percentages of total success have been calculated from the number of trials horses actually participated in (i.e. after subtracting "no choice" trials).

Significant deviations between datasets are given with
*** for $p < 0.001$,
** for $p \leq 0.01$ and
* for $p \leq 0.05$.



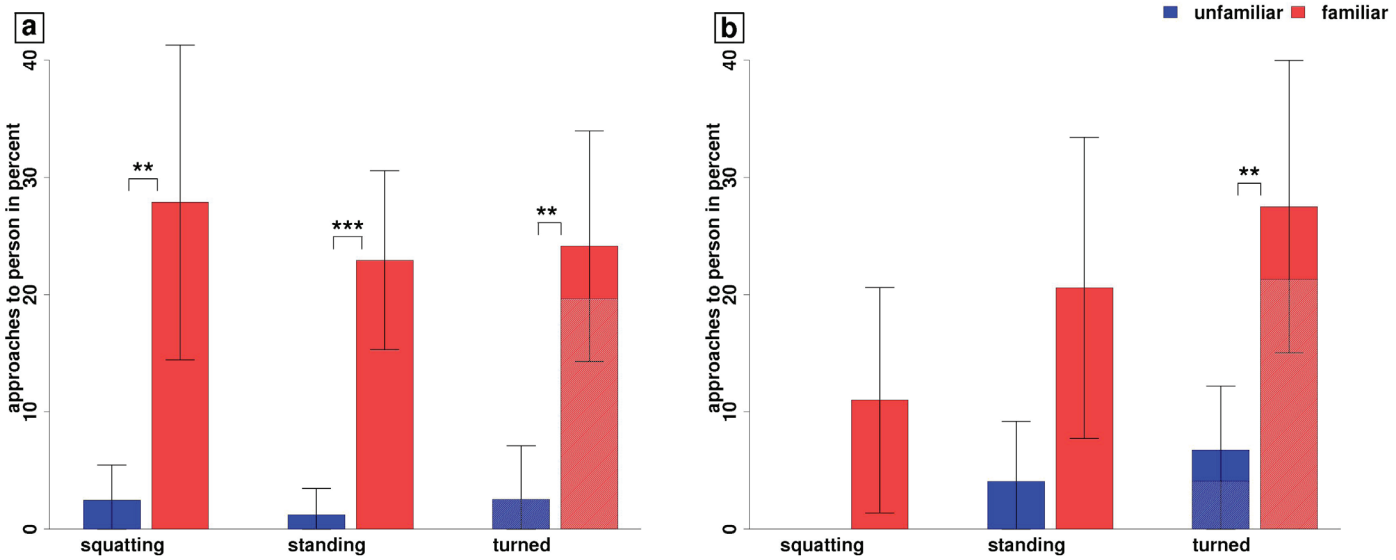


Fig. 3: Approaches to test persons
The two graphs show the percentages of approaches to the test person without prior feeding from the buckets, a) for experiment 1 and b) for experiment 2.
The shaded parts of the two columns from the turned person situation stand for incidences in which the horses walked into the direction of the person's gaze after approaching him/her in this situation.
Significant differences are given with *** for $p < 0.001$, ** for $p \leq 0.01$ and * for $p \leq 0.05$.

complete dataset. We analysed possible influences of the persons' familiarity, consistency and gaze alternation on the binomial dataset of the horses' first choices with multivariate test (Generalized Estimating Equation, GEE).The horse's total performance was analysed with Wilcoxon Exact Tests, as independent and dependent data had to be mixed for giving overviews on effects of the persons' familiarity, gaze consistency and body position.
A detailed analysis with conventional statistical tests will be provided, when the analysis of the two experiments or separate analysis of sub-point with the respective factors (e.g. squatting with permanent and alternating gaze and standing with permanent and alternating gaze) reveals differing results. Friedman Exact tests were used for comparisons of the data from all the test situations within the unfamiliar and familiar person situations. Wilcoxon Exact Tests were applied to compare data from the different test situations within both the unfamiliar and familiar person situations. The comparison between data of independent test situations and between unfamiliar and fami-

liar person situations was done with Mann-Whitney U Exact Tests. Probabilities of choosing the middle bucket in the turned person situation were calculated with Chi square tests. All tests were two-tailed and the significance level was set at 0.05, which was corrected by a Sequential Bonferroni Procedure (Holm 1979) after multiple testing.

Results

General effects on bucket choices and approaches to persons

The horses' participation

Before we analysed our test hypotheses we studied some variables that might have affected the horse's general performance. First was the horses' motivation to participate in the tests. Horses were very motivated to participate, which derives from their highly significant level of bucket choosing, no matter whether tested with unfamiliar (N = 92, df = 4, p <0.001) or familiar persons (N = 80, df = 6, p < 0.001). Only in few trials did horses make no choice of a feed bucket (tables 1 and 2), which was most apparent for the familiar person situation when he/she turned away and remained distant from the buckets. These "no choice" trials are generally in line with instances of approaching the test person and may simply be explained by the fact that horses stayed with the person or walked in the direction of his/her gaze.

Sex and breed

We then analysed the total data sets for possible effects of the horses' sex and breed on the first bucket-choices and on whether they approached the test persons. For the squatting, standing, turned, unfamiliar and familiar person situations in experiment 1 and 2 we found neither of these were significant (first bucket choice: N = 180, sex: robust Z = 2.408, p = 0.92, breed: robust Z = 3.01, p = 0.99; approach to person: N = 157, sex: robust Z = 1.26, p = 0.9; breed: robust Z = -0.89, p = 0.81). Therefore the sex and breed of the horses are not taken into account for further analysis.

Order effects

Furthermore, the order did not influence either the outcome of the experiment 2 (first choice: N = 72, robust Z = -0.03, p = 0.51; total choice: N = 72, robust Z = -0.86, p = 0.8), or the likelihood of the horses approaching the persons (N = 72, Z = -0.55, p = 0.62), or walking in the direction of the person's gaze (N = 72, Z = -0.74, p = 0.5; Fig. 3). Therefore data for experiments 2, part 1 and 2, were analysed and presented in total for each test situation.

The horses' performance

Performance with unfamiliar versus familiar persons

In general, horses did not perform differently when tested with unfamiliar or familiar persons, either in their first choice (N = 174, robust Z = -0.09, p = 0.54; Fig. 2) or their total performance (N = 81, Z = -0.42, p = 0.68; Fig. 2).

However, when the total performance is calculated separately for the situations in the two experiments there was no difference between performance with the unfamiliar and familiar persons in experiment 1 (N = 35, squatting: Z = -1.49, p = 0.23, standing: Z = -0.28, p = 0.81, turned: Z = -0.51, p = 0.63; Fig. 2b), but they performed significantly better with familiar rather than unfamiliar persons in experiment 2 (N = 24, squatting: Z = -2.28, p = 0.04, standing: Z = -3.1, p = 0.001, turned: Z = -3.67, p < 0.001; Fig. 2d). We will therefore proceed with providing data separately for unfamiliar and familiar test person situations when they explain differences in the effect of other factors.

Performance when tested with permanent versus alternating gaze

There was generally no difference in performance between the permanent and alternating gaze situations, either for the first choice (N = 174, robust Z = 4.48, p = 0.99; Fig. 2), or for the total performance (N = 58, Z = -1.28, p = 0.21; Fig. 2).

Also separate analysis for the effect of the gaze persistency on the first choice and total performance in the squatting and standing situations revealed no significant difference after Sequential Bonferroni Correction (Fig. 2).

Performance when tested with persons in different body postures (i.e. squatting, standing)

The test person's posture (squatting or standing) did not have any significant effect on the horses' first choice performance (Fig. 2; tables 1 and 2) (N = 174, robust Z = -0.28, p = 0.61), but significantly affected their total performance (N = 58, Z = -2.66, p = 0.007; Fig. 2).

When separating the permanent and alternating gaze situations for the postures, the horses' total performance was better when tested with a squatting rather than a standing person only in the situation where persons gave alternating gaze cues (N = 58, Z = - 3.44, p < 0.001). Furthermore, for the unfamiliar and familiar person situations, performance was better in the squatting rather than the standing position (N = 31, Z = - 3.43, p < 0.001) only for the total performance of horses that were tested with unfamiliar, persons offering alternating gaze..

Please insert Fig 2 about here

Performance with a turned proximal person

The performance of horses that adjust to the person's focus of attention is expected to decline when the person turns away from the buckets (Fig. 2; table 2), as they choose the focus of attention over the feed. In general we found no effect of the turned proximal person for the first choice (N = 24, χ^2 = 5.25, p = 0.13), but for the total performance of the horses (N = 24, χ^2 = 10.1, p = 0.005; Fig. 2d).

But when comparing the turned proximal situation to the squatting and standing situations of experiment 2 separately, we found a significant difference between the squatting and the turned proximal person ($N = 24$, $Z = -2.97$, $p = 0.001$; Fig. 2d), but not between the standing and the turned proximal person situations ($N = 24$, $Z = -1.76$, $p = 0.08$). First bucket choices were also lower in the turned/proximal person situation than in the squatting and standing person situations. However differences were not significant ($N = 24$, $\chi^2 = 5.29$, $p = 0.13$; table 2; Fig. 2c). As there were no effects of the person's familiarity in this experiment we refrained from testing the data for unfamiliar and familiar test person situations separately.

Performance with a turned distant person

We expected an additional decline in the horse's performance when the person turned and moved away from the feed buckets. This expectation was generally supported by the data both for the first choice ($N = 34$, $\chi^2 = 19.6$, $p < 0.001$) and the total performance ($N = 34$, $\chi^2 = 40.54$, $p < 0.001$, Fig. 2a).

The first choice performance differed significantly between test situations. The successes in first choice trials decreased from the squatting to the turned/distant ($N = 34$, $Z = -4.79$, $p < 0.001$) and from the standing to the turned/distant situation ($N = 34$, $Z = -4.09$, $p < 0.001$). The same was true for the total performance. Here again, the number of correct choices for the total performance decreased from the squatting to the turned/distant ($N = 34$, $Z = -3.74$, $p < 0.001$) and from the standing to the turned/distant situation ($N = 34$, $Z = -3.3$, $p = 0.001$).

Approaches to test persons

Horses sometimes approached the person, possibly seeking their attention. In both experiments (exp. 1 and exp. 2) some horses approached the test person before feeding from the buckets (i.e. when the person stood close to the bucket), with no significant variation between test situations ($N = 28$, $\chi^2 = 0.47$, $p = 0.8$; Fig. 3). However, in experiment 2, horses approached the turned proximal person most frequently, less frequently the standing, and least the squatting person. Details for the approaches of individual horses are given in the tables 1 and 2. However, the differences between the test situations were not significant ($N = 12$, $\chi^2 = 5.28$, $p = 0.07$).

Please insert Fig 3 about here

Walking into the turned person's gaze direction

If horses orientate on the person's focus of attention they might be expected to walk into the direction of a turned person's gaze. The behaviour of the horses in this study met this expectation in the turned proximal and the turned distant person situations (Fig. 3). Large differences in this behaviour occurred when horses were tested either with familiar and unfamiliar test persons (see below).

Two horses that were tested with familiar persons even moved around the test persons in the squatting and standing situation and approached the feed buckets in direction of the person's gaze.

Attending to unfamiliar versus familiar persons' focus of attention

In contrast to the horses' performance in finding the correct buckets, we found a significant difference in their approaches to unfamiliar and familiar test persons. In both experiments (1 and 2), familiar persons were approached significantly more often than unfamiliar persons in the squatting ($Z = -2.81$, $p = 0.004$), the standing ($Z = -3.99$, $p \leq 0.001$), and the turned, distant person situation ($Z = -3.28$, $p = 0.003$; Fig. 3a). Additionally, in the turned distant person situation, horses walked significantly more often in the direction of a familiar person's gaze than an unfamiliar person's gaze ($Z = -2.94$, $p = 0.004$; Fig.3a). The results were confirmed in experiment 2, only here the differences were not significant for the squatting ($Z = -2.14$, $p = 0.09$) and standing person ($Z = -2.1$, $p = 0.05$, not significant after Bonferroni Correction), but were significant for the turned, proximal person situation ($Z = -3.22$, $p = 0.001$), and when horses walked into the direction of the turned person's gaze ($Z = -3.58$, $p = 0.001$; Fig. 3b).

It is also interesting to note that 26 of the 28 horses tested with a familiar person (93%), approached the person at least once during all the trials, while only 11 of the 31 horses (35%) tested with unfamiliar people approached them ($N = 59$, $Z = -4.51$, $p < 0.001$). In the distant turned away person situation, 11 of the 15 horses approached the familiar person at least once (73%), significantly more than the 1 out of 13 horses tested that approached an unfamiliar person (8%) ($N = 28$, $Z = -3.44$, $p = 0.002$). There were no instances of a horse only approaching the person under any of the conditions, there was always a mixture of choosing the person and choosing a bucket.

Central bucket preferences in the turned, distant person situation?

For the turned/distant person situation in experiment 1 an additional control for a possible central bucket preference is needed, as only in this situation did the test person move to and remain in a fixed central posture. However, horses showed no preference for the middle bucket. As their first choice, horses chose the middle bucket at chance in the unfamiliar person situation (31%; $N = 13$, $\chi^2 = 1.08$, $p = 0.69$), and in the familiar person situation (33%; $N = 15$, $\chi^2 = 0.00$, $p = 1$). For the total choices in this situation the horses' performances were similar to the first choices, both with the unfamiliar person (39%, SD: 14.6%) and the familiar person (43.67%, SD: 27.1%) (unfamiliar: $N = 13$, $\chi^2 = 3.92$, $p = 0.32$; familiar: $N = 15$, $\chi^2 = 3$, $p = 0.75$). In comparison, the total choices for the middle bucket in the turned/distant person situation did not differ significantly between the unfamiliar and the familiar person group ($Z = -0.66$, $p = 0.75$).

Discussion

In this study, horses consistently used human local enhancement cues for finding food when persons remained at the location of the feed, i.e. behind the filled bucket. In general, the person's body position (i.e. squatting or standing), and whether the person used a permanent or alternating gaze, did not have an effect on the horse's performance, which corresponds to recent findings (Proops et al. 2010).

In horses, there is no scientific evidence that there is any difference between a human's standing or squatting position in terms of influencing the horse's reactions and, according to our and previous results (Maros et al. 2008; Proops and McComb 2010; Proops et al. 2010), this is not a very important factor in an object choice task. However some horses preferentially approached the persons in a squatting position, which may indicate that horses find this posture more attractive.

When the persons turned around and faced away, the decline in the horses' performance was only partially significant, but it declined significantly when the turned person moved to a distant position after depositing the feed. Proops et al. (2010) found no effect of proximate body orientation cues on the horse's performance in an object choice task, but their body orientation cues differed from those given in the this study. The experimenters from this study turned their back on the horse and faced horizontally away, while experimenters in the Proops et al. (2010) study turned only through 90° and faced a baited bucket. With the turned distant person situation our primary intention was not to investigate the horse's ability to memorize the placement of food, but rather whether the horses motivation to approach the food would be affected by the person's changed body orientation and changed focus of attention, as reported for dogs (Gácsi et al. 2004; Virányi et al. 2004), and/or by the person's familiarity. The turned distant person removed the local enhancement cues provided by persons that face the horses and/or stay at the bucket, and gave the horse a simple choice of either approaching the food or approaching the person.

The familiarity of the person generally did not affect the horses` performance in choosing the correct bucket. However in experiment 2, the horses tended to perform better when tested by a familiar person. This partial result is supported by the fact that familiar persons. were approached significantly more often than unfamiliar persons when horses approached the squatting, standing and turned persons before feeding. Additionally, when the person turned and faced away from the feed buckets, horses walked into the direction of a familiar person's gaze significantly more often than with an unfamiliar person. This is in line with prior observations from social situations, where horses paid more attention to the behaviour of known than unknown conspecifics (Krueger and Heinze 2008). Moreover, the animals' performance improved when tested with familiar conspecifics when they focused on a specific task (e.g. feeding) rather than dividing their attention across several tasks (e.g. aggression and feeding) (Griffiths et al. 2004).

When the horses were tested with familiar persons the difference between the horses' performance in the squatting and standing situations compared to the turned distant person situation can be explained by analysing the approaches horses showed towards the test persons without prior feeding from the buckets. Approaching the test person did not affect their performance in finding the food in the squatting or the standing person situations, nor in the turned proximal person situation when the person stayed behind the bucket, as horses could then still feed from the buckets. However in the turned distant person situation when the person was a couple meters away from the bucket, the horses which approached the person did not return to the buckets afterwards, i.e. they did not make choices of feed buckets in these trials. An additional decline in the horse's performance in both turned person situations was caused by incidences in which horses walked into the direction of the person's gaze.

The approach to persons may indicate that some horses simply expected, or have learned, that food can be obtained from familiar persons. As the horse's long term memory has recently been shown to be excellent (Hanggi and Ingersoll 2009) and a multitude of prior experiences with well known humans would affect the horse's behaviour towards specific persons (Hausberger et al. 2008), the horse's expectation of receiving food from familiar persons is not very surprising. However only one horse nudged at the person after the approach, which may be considered attention demanding behaviour (Proops and McComb 2010), so it is possible that the horses may rather have adjusted to the person's focus of attention. In this regard it may also be interesting that two horses even walked around familiar squatting and standing persons and approached the buckets from behind the person in direction of the person's gaze. These findings are in line with prior studies on horses (Proops and McComb 2010) and dogs (Gàcsi et al. 2004), where some individuals placed themselves in line with the focus of a turned person's attention.

For some horses the need to adjust to another individual's focus of attention may even override their desire for food. Responding to the alertness, or simply changes in the attention, of other individuals of the same or other species may have survival benefits for a prey animal. Very simply put: when it comes to the necessity to flee from a predator, those that recognize a danger faster by adjusting to their own species or other species predator alarm behaviour, will have a survival benefit (Goodwin 2002).

Both explanations confirm that at least some horses

respond to the direction of human attention. Generally, our results indicate that the horse's willingness to orientate on a person's attention increases with the closeness of the relationship with that particular human, as horses showed orientation behaviour more often when the person was familiar to the horse.

As in other studies, we found large individual differences in approaching the test person, which could reflect the horses' different temperaments (Lansade et al. 2005; Lansade and Bouissou 2008; Visser et al. 2001, 2002, 2003). However, we refrained from testing the horses with other persons as a control, as the results would have been influenced by habituation effects (Mal et al. 1993). Differences in response to the test person could also have been caused by kin or by breed specific temperament (Hausberger and Muller 2002; Hayes 1998; Houpt and Kusunose 2000). Even though the horse's breed did not significantly affect our results, the sample size of this study does not allow for clear conclusions concerning kin and breed specific temperament effects. We can, however, support the evidence from other studies that gender is not decisive in the horse's behaviour towards humans (Hausberger et al. 2004; Henry et al. 2005; Visser et al. 2001, 2002, 2003).

We would like to conclude, that horses generally use humans as local enhancement cues when searching for food, and the horse's propensity to adjust to the person's focus of attention is affected by the human's familiarity, and body orientation. We confirm prior findings of horses being able to read gesticular cues (Maros et al. 2008; McKinley and Sambrook 2000) and react to the human's focus of attention (Proops and McComb 2010) analogous to other species (Hare et al. 2002). Furthermore, as horses respond to attention cues from familiar more strongly than from unfamiliar persons, and for horses tested with unfamiliar humans the food is of greater importance than the person's attention, we suggest that domestication is only partially responsible for the animal's choice to adjust to the human focus of attention. This is supported by the inconsistencies in human cue reading in other species (Gácsi et al. 2005; Hostetter et al. 2001;Theall and Povinelli 1999; Virányi et al. 2004). On top of domestication, socialisation and training enhance the horse's ability to read human cues as in other species such as apes (Itakura et al. 2001; Povinelli and Eddy 1996), dolphins (Pack and Herman 2004; Tschudin 2001), seals (Scheumann and Call 2004; Shapiro et al. 2003), ravens (Schloegl et al. 2008), parrots (Giret et al. 2009), and wolves (Gácsi et al. 2009b). Further studies on wild equids are urgently needed to clarify whether domestication set the stage for these abilities.

Behavioural explanations (Povinelli and Vonk 2003), in terms of animals learning attention cues, and cognitive explanations (Tomasello et al. 2003) which emphasise the understanding of the signaller's intentions, are both valid for this study. However, we may point out that the cognitive ability to read the focus of attention generally has to be present in order to learn how to apply it and use it as a cue. Additionally, the horse's propensity to orientate on human attention differs when tested with unfamiliar and familiar persons, and that some horses adjust themselves to the focus of human attention, points to cognitive processes. This is further supported by the fact that no horse consistently orientated on the attention, as one might expect if this was a behavioural response connected with previous experience of receiving food from the person. Furthermore, in the distant, turned person situation, where the horse had to make a clear choice between the person and the buckets, a significantly higher percentage of horses approached the familiar person than the unfamiliar person in the same position, but this decision was nevertheless taken on a trial by trial basis neither the bucket nor the human was consistently preferred by any horse. The horse's choice is obviously connected to its relationship with the person and the representation of the person's focus of attention. Further research is needed to establish which factors may influence the horse's decision to approach the familiar human or the bucket in each instance. Horses may readily apply their cognitive abilities for generalizing and categorizing learning tasks (Hanggi 1999) in social settings.

In closing, a word should be said about the possible distracting effect of the assistant on the test horse's performance. Even though we were careful that the assistants controlled their behaviour and posture, we can not totally exclude the possibility that they may have influenced the horses' behaviour subconsciously as they had seen the placement of the feed (Pfungst 1907). We could have excluded this possibility by using a station and release system from which horses are released automatically with no further person needed. In several mammal species station and release systems are used on a regular basis, and were applied to equine studies in recent decades (e.g. Christensen et al. 2005; Hanggi 1999). However, this was not practical for this field study. We chose to conduct our tests in a well habituated surrounding to avoid separation and novelty anxiety in our test horses. For most horses the test area was a part of their enclosure (all horses were kept in social housing systems with attached enclosures) or the riding arena. Solid wood fencing for a station and release system, with a pole at the entrance that could be removed by a hidden person outside, would not have been tolerated by the stable or horse owners in these premises. Additionally, changes in the well known areas would call for habituating the horses to the novelty. This can be very time consuming for some horses and the horse owners would not have been willing to invest so much of their time. For the test persons it is nearly impossible to habituate 60

horses in 14 different locations within a reasonable time frame. Finally, we could have used portable electric fencing. We actually tried to apply such systems prior to the tests. However some horses were frightened of electric fencing right from the beginning and would not remain calm and motivated for the test in an electrically fenced area. Other horses had prior experiences of going through electric fences that were not on charge. Applying electric station and release system without extensive training prior to the tests could have caused severe welfare problems for these horses.

Finally, we propose that when choosing test persons for future studies, a familiar person that faces the horse in a squatting or standing body posture, should be used when a strong interaction with the horse is needed, e.g. when responses to human cueing are studied. Unfamiliar persons and station and release systems should be used to achieve least affected test results.

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