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The use of human-given cues by domestic horses, *Equus caballus*, during an object choice task

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Selection pressures during domestication are thought to lead to an enhanced ability to use human-given cues. Horses fulfil a wide variety of roles for humans and have been domesticated for at least 5000 years but their ability to read human cues has not been widely studied. We tested the ability of 28 horses to attend to human-given cues in an object choice task. We included five different cues: distal sustained pointing, momentary tapping, marker placement, body orientation and gaze (head) alternation. Horses were able to use the pointing and marker placement cues spontaneously but not the tapping, body orientation and gaze alternation cues. The overall pattern of responding suggests that horses may use cues that provide stimulus enhancement at the time of choice and do not have an understanding of the communicative nature of the cues given. As such, their proficiency at this task appears to be inferior to that of domestic dogs, *Canis lupus familiaris*, but similar to that of domestic goats, *Caprus hircus*.

The ability to acquire information about the external world from the communicative gestures of social partners has obvious adaptive advantages and raises intriguing questions about the sensitivity of receivers to the underlying mental states of signallers. The extent to which animals use human cues to locate hidden food has been effectively studied using the object choice task. In this paradigm subjects are presented with two or three opaque containers and human experimenters provide gestural cues as to the location of hidden food. A wide variety of species have been studied using this protocol, primarily domestic dogs, *Canis lupus familiaris* (e.g. Miklósi et al. 1998) and nonhuman primates (e.g. Povinelli et al. 1997; Byrnit 2009) but also other species including wolves, *Canis lupus* (e.g. Hare et al. 2002), cats, *Felis catus* (Miklósi et al. 2005), goats, *Capra hircus* (e.g. Kaminski et al. 2005), South African fur seals, *Arctocephalus pusillus* (e.g. Scheumann & Call 2004), bottlenosed dolphins, *Tursiops truncatus* (e.g. Pack & Herman 2004), jackdaws, *Corvus monedula* (e.g. von Bayern & Emery 2009), ravens, *Corvus corax* (e.g. Schloegl et al. 2008) and horses (Maros et al. 2008).

It has been suggested that domestication has led to an enhanced ability to read human cues and domestic dogs show a flexibility and ability to generalize in the object choice task that has not been seen in other species (Miklósi et al. 1998; Hare et al. 2002, 2005). Their ability to use a wide variety of cues from the first trial (Miklósi et al. 1998; Agnetta et al. 2000; Miklósi & Soproni 2006) and the fact that they distinguish between situations in which a person is looking at a target object and ones in which they are looking above the target object suggest that they may have some appreciation of the referential nature of these cues (Soproni et al. 2001). Cats have also been found to use a variety of pointing cues including momentary distal pointing (Miklósi et al. 2005). However, other domestic animals have not performed as well. Goats spontaneously use pointing and tapping cues but not head and gaze orientation alone, indicating that they may be using the more basic mechanism of stimulus enhancement rather than comprehending the communicative nature of the cues provided (Kaminski et al. 2005).

The results from primate studies have been much more mixed and are difficult to interpret. Many primates perform poorly in object choice tasks and appear to have to learn the cues as discriminative stimuli through the testing process (Povinelli et al. 1997, 1999; Tomasello et al. 1997; Hare & Tomasello 2005; Byrnit 2009). However, other studies using highly enculturated subjects, or slightly different methodologies including competitive rather than cooperative paradigms, have shown that some primate subjects are able to use pointing and more subtle human cues such as gaze (Itakura et al. 1999; Hare & Tomasello 2004; Barth et al.

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2005; Mulcahy & Call 2009). This suggests the poor performance of some primate subjects may be caused by motivational rather than cognitive factors. Indeed, in one object choice study, apes that were trained to use a marker placed by an experimenter used this cue only if it appeared the experimenter placed the marker intentionally rather than by accident (Call & Tomasello 1998). This result suggests that some primates are sensitive to the intent underlying human action.

To understand the proximate and ultimate factors that produce an ability to use human-given cues, it is important to test a wide variety of domestic and wild species. Horses have been domesticated for at least 5000 years (Clutton-Brock 1999; Outram et al. 2009) and to date two studies have conducted object choice tests with domestic horses. However, limited sample sizes and types of cue tested do not allow any firm conclusions to be drawn about the processes underlying the behaviours observed. The first study required the operant conditioning of horses to retrieve food from an upturned bucket, making the task much harder than simply approaching a particular container (McKinley & Sambrook 2000). Here only four of the 11 subjects that were recruited completed the training phase and, of those, one subject could use a dynamic pointing cue and two could use a dynamic-sustained touching cue. In the second, more extensive study, horses were simply required to approach one of two buckets to look for food. In this study 20 of 27 horses completed the training phase and results indicated that subjects could use pointing cues when the finger was close to the target and distal pointing if it was sustained but not when the hand was removed before the choice was made (Maros et al. 2008). Thus the horses appeared to perform much better in the second study, possibly because the more complicated methodology in the other study hindered the performance of subjects. Further work is therefore required to determine why these differences are observed and to test horses with new types of cue.

Our new experimental paradigm tested existing object choice skills by using a simple method of requiring subjects to approach one of two buckets rather than training subjects to overturn buckets themselves to find food. Moreover, we tested for abilities to use a more extensive range of cues to throw light on the proximate mechanisms used in this task and to allow for greater comparison of cue use between species. Previous observations of horses performing the object choice task reveal that, when using the pointing cue, subjects tend to approach the experimenter's hand before choosing the nearby bucket (McKinley & Sambrook 2000; Maros et al. 2008). This suggests that horses, like goats, may be using stimulus enhancement to choose the correct container. To determine whether this is the process used, we included cues that did not involve stimulus enhancement: body orientation and gaze alternation and also a momentary tapping cue that only provided stimulus enhancement temporarily, prior to the time when the choice was actually made. We also assessed the ability of horses to use a totally novel cue, the placement of a marker in front of the correct bucket, and included a distal sustained pointing cue to help interpretation of previous studies.

METHODS

Subjects

A total of 34 domestic horses from four locations participated in this study. Of these subjects, 28 (11 females and 17 gelded males) completed the initial warm-up phase and took part in the test trials. Ages ranged from 3.5–38 years ($\bar{X} + SE = 13.16 + 1.54$). Subjects were privately owned, riding school horses or were rescue animals kept at a horse sanctuary. Horses kept at private yards or the riding school had daily interaction with humans; the horses at the sanctuary were checked once a day but remained with the herd most of the time. Subjects were not food deprived prior to the study. The study was approved by the University of Sussex Ethics board.

Procedure

Trials were conducted January–March 2009 in a paddock or school depending on the location of the subjects. The set-up procedure can be seen in Fig. 1. The experimenter providing the cues was a female unknown to the subjects and the handler was a female experimenter that the subjects had not or only rarely encountered before. Subjects were led from the left side at all times. An initial reinforcement phase was given to each subject to create an association between the experimenter, buckets and a food reward. The experimenter stood at centre point E with two black buckets (40 cm diameter, 19 cm height) stacked together in front of her. As the subject was led along the centre line towards point E, the experimenter dropped a piece of carrot into the bucket for the subject to collect. The horse was then led in a semicircle to the left or the right, returned to the centre line and the reinforcement trial repeated. Over a maximum of 10 trials the behaviour of the horse was gradually shaped so that it could be released at a point on the centre line 4 m from the experimenter and would walk forwards to take the carrot from the bucket.

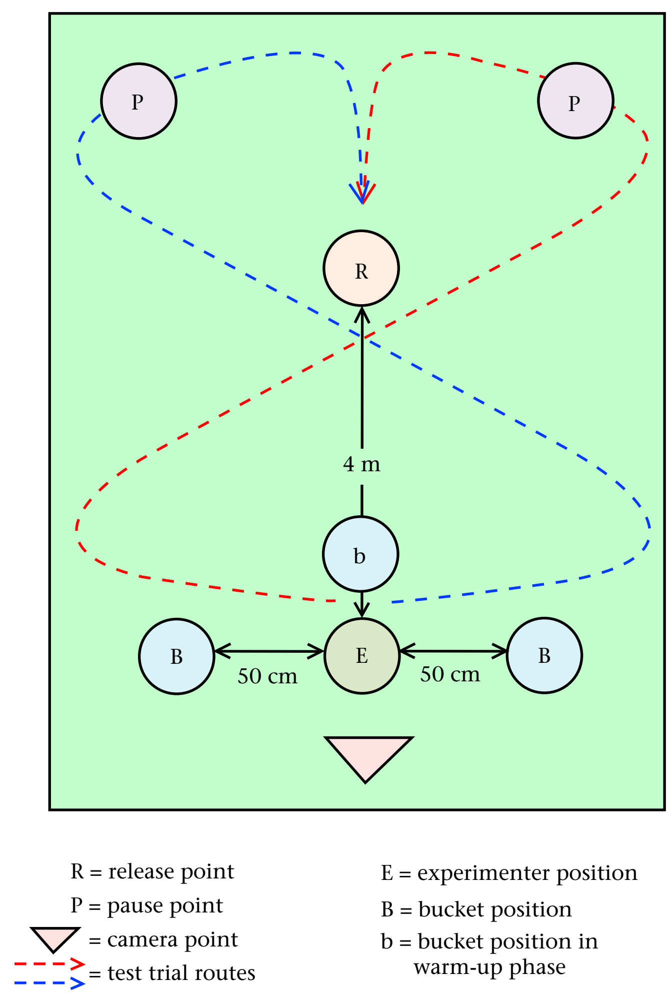

Figure 1. Diagram of the experimental set-up.

Test trials were conducted immediately after the reinforcement phase. In these trials, two buckets were placed 50 cm to the left and right of the experimenter. As the horse approached the release point, the experimenter gave one of five cues towards one of the buckets. The horse was then released to move forwards towards the buckets while the handler remained at the release point until the trial was completed. If the horse chose the bucket that was cued, a reward was placed in the bucket by the experimenter as soon as the decision had been made. The carrot was not placed in the bucket before the choice was made to prevent any odour cues and to ensure that the horses could not see the carrot in the bucket as they approached the containers. The side of the cue was counterbalanced across subjects with half receiving three cues to the left and half receiving three to the right. The order was pseudorandomized with the constraint that trials in which a response was given could not cue the same side more than twice in a row. The order of cue presentation was counterbalanced across trials with each cue being presented first, second, third, fourth and fifth an equal number of times. After each test trial there was an additional reinforcement trial to maintain the motivation of the subjects. In these trials the buckets were again placed in front of the experimenter and a piece of carrot placed in the bucket as the horse approached. Subjects were then led in a figure of eight around the test area, either to the left or the right and held, facing away from the centre at point P for 30 s before beginning the next trial (see Fig. 1). Pilot trials showed that pausing between test trials, leading horses in a figure of eight so they travelled across both the left and right side of the test area before each trial and introducing a reinforcement trial between each test trial considerably reduced perseveration rates and improved response rates. If horses failed to respond to a cue, another reinforcement trial was given and the test trial then repeated. Test trials were repeated a maximum of three times before moving on to the next cue and recording a ‘no response’ score for that cue type. One horse failed to respond to the body cue. We tested the following five cues.

(1) Marker placement cue: a blue and yellow striped wooden block (18.5 × 7 × 3.5 cm) was used as the marker. As the horse approached the release point the experimenter placed this on the ground in front of, and touching, the correct bucket. She then returned to a standing posture, body oriented forwards, looking directly ahead.

(2) Distal sustained pointing cue: as the horse approached the release point the experimenter brought her ipsilateral arm out from the side of her body to point towards one of the buckets. This position was held with the body oriented forwards, looking directly ahead until a choice was made. The index finger was approximately 65 cm from the top of the bucket.

(3) Momentary tapping cue: as the horse approached the release point the experimenter reached towards the correct bucket and tapped the side of the bucket slowly three times with large movements of the arm producing an audible sound each time. She then returned to a standing posture, body oriented forwards, looking directly ahead.

(4) Body orientation cue: as the horse approached the release point the experimenter turned her whole body towards the correct bucket and stood looking down at the bucket until a choice was made.

(5) Gaze alternation cue: keeping her body oriented forwards, the experimenter alternated the direction of her head and gaze between the horse and the correct bucket until a choice was made.

Behavioural and Statistical Analysis

Trials were recorded using a Sony digital handycam TRV 19E video recorder and converted to .mov files for behavioural analysis. A choice was recorded as correct if the subject's head approached within 20 cm of a bucket within 60 s of being released. In most trials subjects touched the chosen bucket but in some cases subjects looked into the bucket without touching it. Responses were coded live and verified by two independent experimenters using the video footage. Interobserver reliability was 0.96 ($P < 0.0001$) measured by Spearman ρ correlation. To test for a difference in the number of correct and incorrect responses given to the five different cue types, a Pearson chi-square test was used. Additional post hoc contrasts were performed on 2 × 2 tables. Where expected values were greater than 5, the chi-square values are reported and in the one case where expected values were less than 5, the Fisher's exact test (FET) is reported. The Bonferroni correction was not used with this small sample because of the high likelihood of Type II errors; instead we report effect sizes in the form of Cramer's V, as suggested by Nakagawa (2004). Effect sizes reflecting the strength of the relationship between variables, such as Cramer's V, are considered small, medium and large at values 0.1, 0.3 and 0.5, respectively (Nakagawa 2004). The number of subjects correctly choosing the cued bucket for each cue type was analysed using two-tailed binomial tests. The total number of correct scores was calculated for each subject and the effects of age and location were analysed using a Spearman ρ correlation and a Kruskal–Wallis one-way analysis of variance test. Overall side biases were assessed using a Wilcoxon signed-rank test. All statistical analyses were performed using SPSS version 16.0.1 software for Mac (SPSS Inc., Chicago, IL, U.S.A.).

RESULTS

There were significant differences in the horses' ability to use the five cues ($\chi^2_4 = 13.887$, $P = 0.008$, $V = 0.316$). Horses used the marker placement ($K = 26$, $N = 28$, $P < 0.0001$) and pointing cues ($K = 23$, $N = 28$, $P = 0.001$) to choose the correct bucket but not the tapping ($K = 16$, $N = 28$, $P = 0.572$), body orientation ($K = 16$, $N = 27$, $P = 0.442$) or gaze alternation cues ($K = 17$, $N = 28$, $P = 0.345$; Fig. 2). Post hoc analyses revealed that there were significant differences between the ability of subjects to use the marker cue compared to the tapping ($\chi^2_1 = 9.524$, $P = 0.002$,

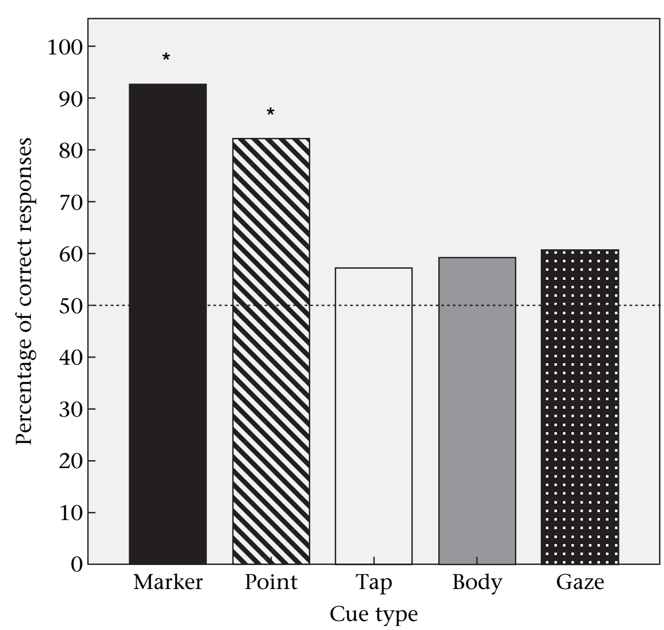

Figure 2. Percentage of correct responses for each cue type. *$P < 0.05$ (binomial probabilities, two-tailed predictions).

$V = 0.412$), gazing ($\chi^2_1 = 8.114$, $P = 0.004$, $V = 0.381$) and body orientation cue ($\chi^2_1 = 8.586$, $P = 0.003$, $V = 0.395$). In these comparisons the effects of the different cues were medium/large. There was no significant difference between the use of the marker and pointing cues (FET: $N = 56$, $P = 0.422$, $V = 0.162$). The difference between the ability of horses to use the pointing cue compared to the tapping was also significant ($\chi^2_1 = 4.139$, $P = 0.042$, $V = 0.272$), while the comparison between performance of subjects given the pointing cue compared to the body orientation ($\chi^2_1 = 3.489$, $P = 0.062$, $V = 0.252$) and gaze cues approached significance ($\chi^2_1 = 3.150$, $P = 0.076$, $V = 0.237$). Here the effect sizes were medium/small. There were no differences in the ability of horses to use the tapping cue compared to the body orientation cue ($\chi^2_1 = 0.25$, $P = 0.874$, $V = 0.021$) or the gaze cue ($\chi^2_1 = 0.074$, $P = 0.786$, $V = 0.036$) or in their ability to use the body cue compared to the gaze cue ($\chi^2_1 = 0.012$, $P = 0.912$, $V = 0.015$).

Of the 23 subjects that correctly used the pointing cue, 14 investigated the outstretched arm before moving to the bucket. All of the subjects that correctly chose the bucket given the marker placement cue investigated the marker before investigating the bucket.

Total scores across all cue types were not correlated with age ($r_S = -0.325$, $N = 28$, $P = 0.091$). There was no difference in the total scores of the subjects caused by location ($H_3 = 2.255$, $P = 0.521$). There were no overall side biases ($Z = 0.478$, $N = 28$, $P = 0.632$). At an individual level, one horse consistently chose the left-hand bucket and all other subjects chose each side at least once across the five test trials. Only three of the 28 horses failed to respond to a test trial, with a total of 10 'no responses' recorded within these subjects. One subject failed to respond to the tapping cue twice, another subject failed to respond to the tapping cue once, the gaze cue once, the point cue twice and the body cue three times, and a third subject failed to respond to the pointing cue once.

DISCUSSION

Horses were able to use the pointing and object placement cues spontaneously to choose between objects but did not use the tapping, body orientation or gaze alternation cues. As such the ability of horses in this respect appears inferior to that of domestic dogs (Miklósi & Soproni 2006). Horses have previously been shown to use subtle cues such as gaze and body orientation when determining the focus of human attention (Proops & McComb 2010); however, they were unable to use these cues in the object choice task presented here. As such their performance could be seen as comparable to that of domestic goats, although goats were able to use a continuous dynamic touch cue whereas horses could not use a momentary tapping cue (Kaminski et al. 2005). The ability of horses to use the pointing cue confirms the findings of Maros et al. (2008) that horses are able to use a distal sustained point as a cue to locate food and suggests that the poor performance of horses in the McKinley & Sambrook (2000) study may be because of the more complex methodology used. This conclusion is further confirmed by the high 'drop out' rate in the McKinley & Sambrook (2000) study (64%) compared to that found in our study (18%) and Maros et al.'s (2008) study (26%).

The fact that horses were able to use the pointing and marker placement cues but not the gaze alternation and body orientation cues suggests that horses use stimulus enhancement to choose the correct container, a more basic cognitive mechanism than that used by domestic dogs. This is further confirmed by our observations (and those of previous studies) that when using the pointing cue many horses initially approached the outstretched hand and only subsequently went to the correct bucket. Similarly, all of the subjects that chose the correct bucket using the marker cue investigated the marker before the bucket, strongly suggesting that it was the marker itself that provided stimulus enhancement and indirectly attracted the horses to the correct bucket. Dogs are able to use markers as cues even when they are removed before a choice is made, but they do not readily use markers if they do not see a human place the marker; thus for dogs, the human element of marker placement appears to be an important factor (Riedel et al. 2006; Udell et al. 2008a). In our study the human element was also involved and so further research with horses incorporating different test permutations would help to clarify the mechanisms involved. If stimulus enhancement alone rather than the human action associated with marker placement was key to the horses' response, then they would be less likely to use the cue if it was removed prior to making the choice (but unlike dogs would still use the cue even if the placement of the marker by the experimenter had not been observed).

Perhaps surprisingly, horses did not appear to use the tapping cue despite this ability being shown in goats and horses previously (McKinley & Sambrook 2000; Kaminski et al. 2005). One difference between our study and previous studies was that in our study the cue was removed before the choice was made, so that at the actual time of choice there was no stimulus enhancement. However, one may have expected that such a salient cue, given only a few seconds before the choice was made, would have been a reliable indicator of the correct bucket. Indeed, Maros et al. (2008) found that horses could use a pointing cue that was removed seconds before the choice was made, providing the cue was given close to the bucket. Another difference between those studies and ours is that in our study an audible sound was made when touching the bucket. Although previous studies have found that the performance of subjects improved when cues were accompanied by audible sounds (Itakura et al. 1999) it is possible that in this case the sound led some subjects to avoid the cued bucket deliberately. Communicative signals can be given in both cooperative and competitive situations and some subjects may have interpreted the audible tapping on the bucket combined with direct gaze of the experimenter towards the horse as a demonstration of possession of that particular bucket. Primate subjects that did not use a pointing cue to choose a container in a cooperative context used a pointing gesture combined with a firm vocal command ('don't take this one') to avoid a container in a prohibitive context (Hermann & Tomasello 2006). Alternatively, since the food was not placed in the bucket prior to the cue being given, the noise may have signalled to the horses that the bucket was empty. Indeed apes are able to infer the location of hidden food in an object choice task if they hear either the empty or baited container being rattled (Call 2004). To determine why horses did not use this cue, further research could usefully investigate the efficacy of different modes of tapping in cueing object choice, with and without direct eye contact and with and without the bait being placed in the container when the tapping cue is given.

In tests of object choice, the target container is often baited before the subject makes its choice, whereas in our study the reward was placed in the bucket after the choice was made. This design was chosen specifically to avoid the possibility that the horses could choose on the basis of cues emanating from the food itself (colour, odour, etc.) rather than on the basis of the communicative gesture itself (see also Udell et al. 2008b who used a similar method). Rather than signalling the location of hidden food that the experimenter revealed if the correct container was chosen, in our experiment, the experimenter presented the gesture in isolation to investigate whether it was spontaneously attended to. Although we believe this is unlikely to change the behaviour of the subjects significantly, the variation in methodology means that we must be cautious in comparing our results to those of other studies. Further research directly comparing the performance of horses given these different procedures would allow for greater comparison between our findings and those of other studies. As has been noted with these tests of social cognition, relatively small changes in method may lead to significant differences in performance (Barth et al. 2005; Udell et al. 2008b; Mulcahy & Call 2009).

In conclusion, in our study horses demonstrated an ability to use human-given cues in an object choice task that appeared inferior to that seen in dogs but similar to the ability of domestic goats. Their pattern of responding suggests that, although horses are able to use some cues spontaneously, this may be achieved through a basic cognitive mechanism rather than through understanding the communicative nature of the cues provided. Given that horses have proved inferior to dogs in their ability to read human cues in object choice tasks, it seems unlikely that domestication in general gives rise to highly evolved skills in reading human-given cues; instead it seems more likely that a variety of genetic, ontogenic and environmental factors contribute to this ability.

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