

## ORIGINAL ARTICLE

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**Use of human-given cues by domestic dogs (*Canis familiaris*) and horses (*Equus caballus*)**

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**Abstract** Sixteen domestic dogs (*Canis familiaris*) and four horses (*Equus caballus*) were tested for their ability to use human-given manual and facial cues in an object-choice task. Two of the four horses used touch as a cue and one horse successfully used pointing. The performance of the dogs was considerably better, with 12 subjects able to use pointing as a cue, 4 able to use head orientation and 2 able to use eye gaze alone. Group analysis showed that the dogs performed significantly better in all experimental conditions than during control trials. Dogs were able to use pointing cues even when the cuer's body was closer to the incorrect object. Working gundogs with specialised training used pointing more successfully than pet dogs and gundog breeds performed better than non-gundog breeds. The results of this experiment suggest that animals' use of human given communicative signals depends on cognitive ability, the evolutionary consequences of domestication and enculturation by humans within the individual's lifetime.

**Key words** Dog · Horse · Social cues · Human-animal communication

**Introduction**

A number of recent studies have addressed the question of the extent to which a variety of animal species share with humans the ability to attribute attention based on the behaviour of other individuals. Beyond increasing our knowledge of the species under study, this area of research also aims to increase understanding of how these abilities develop both in human children and during human evolution. As communicative signals such as point-

ing, head orientation and eye gaze can be used by humans to indicate the direction of an individual's attention, the ability of animals to use these cues may help answer questions about animals' understanding of the attention of others. Alternatively, animals may be able to use visual cues to direct their behaviour without any attribution of attention or understanding of the communicative nature of such cues.

There is considerable evidence to suggest that some non-human primates do respond to changes in the visual attention of both conspecifics and humans when this is indicated by changes in head and body orientation (Tomasello et al. 1998; Emery et al. 1997; Anderson and Mitchell 1999; Povinelli and Eddy 1996).

In addition to studies of gaze following, another experimental paradigm that has been widely used in this area is the object-choice task. This paradigm, in which the animal must use a variety of cues to find the location of hidden food, has been used to assess the ability of animals to use human-given facial and gestural cues in a problem-solving situation. Previous investigations have found that, given their performance in studies of gaze following, the performance of a number of monkey species on this type of task has been surprisingly poor (Anderson et al. 1995, 1996; Itakura and Anderson 1996).

Studies of great ape species have produced mixed results. (Peignot and Anderson 1999). In a comparative study of chimpanzees (*Pan troglodytes*), orangutans (*Pongo pygmaeus*) and 30- to 36-month-old human children using novel cues such as pointing, placing a wooden block on the correct container or showing a replica of the correct container, Tomasello et al. (1997) found that while the human children performed above chance levels on all three conditions, only ape subjects using cues learned during a previous experiment were successful. It is interesting to note that the one ape subject who was above chance on all three conditions was the language-trained orangutan, Chantek.

One study finding positive results in this task, and suggesting possible differences between monkeys and apes, was an experiment conducted by Itakura and Tanaka

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(1998) who found chimpanzees (*Pan troglodytes*), an orangutan (*Pongo pygmaeus*), and 18-month-old human infants, were all able to use tapping, pointing, gaze (head+eyes) and glance (eyes only) in an object-choice task. The performance by the subjects in this task may have been enhanced by the order in which the cues were presented, starting with the easiest (tapping the correct object) and proceeding sequentially to the hardest (glance). However, although the chimpanzees in this study learned to use all cues quickly, the orangutan and the human infants responded correctly from the first trial. The authors suggested that this may be due to the orangutan having been raised in a more “encultured” environment than the chimpanzees. This, coupled with the success of the language-trained orangutan in the experiment of Tomasello et al. (1997), raises the possibility that success on this type of task depends to some extent on previous experience of human communicative behaviour.

Whether non-human subjects understand the referential nature of cues is debatable. Successful use of cues such as pointing in an object-choice task may rely on the proximity between the experimenter’s hand and the correct object, thus providing a spatial, rather than a referential cue (Anderson et al. 1995; Itakura and Anderson 1996). Alternatively, visual co-orientation could be achieved by mechanisms such as social facilitation, contagion or operant learning (Anderson et al. 1995). Povinelli et al. (1999) have suggested that although chimpanzees are able to “form impressive procedural rules for processing social information”, they do not conceptualize the behaviour of others in terms of internal, unobservable mental states.

## Dogs

Primates have been the focus of the comparative study of cognition, historically because of the assumption of shared competence with humans resulting from recent shared evolutionary descent and more recently because the effects of enculturation are presumed to be most effective in a behaviourally plastic animal such as a great ape. A combination of these two effects could arise in a species whose evolution was characterised by habitual association with, and dependence upon, humans, producing an innate propensity to be encultured. Domestic dogs (*Canis familiaris*), are the prime example.

Domestic dogs competently use a variety of human-given cues during object-choice tasks. Hare et al. (in press), found that the two dogs they tested used pointing alone and combined head orientation and eye gaze to find the location of hidden food. They were unable to use eye direction alone.

A similar experiment by Miklósi et al. (1998) allowed the subjects to learn by showing them the food location following an incorrect response. The authors aimed to determine not only what the dogs could already do, but what they were capable of learning during the course of the experiment. The subjects were immediately able to use the

cues of pointing, nodding and bowing, and learned to use head orientation, glancing and eye direction although no information is given on the trials required.

Hare and Tomasello (1999) also found that dogs were able to use experimenter- as opposed to owner-given cues and, in addition, were also able to use cues given by conspecifics. However, the types of dog used in this experiment did not allow analysis of breed difference, which could begin to examine the possible effects of selective breeding. Of the two subjects in the experiment of Hare et al. (in press), a Labrador retriever, trained to perform a variety of tasks associated with hunting, performed better than the mongrel which was kept purely as a pet.

Domestication of the dog has led to the creation of hundreds of different breeds. Organisations such as the Kennel Club of Great Britain place these breeds into different groups according to the purpose for which they were originally bred. Breeds have different behavioural characteristics, some of which are largely genetically determined (Scott and Fuller 1965). Gundogs have been bred to move in directions indicated by humans and are trained to respond to a variety of hand signals. They are also more easily trained and attentive towards humans than other breeds (Scott and Fuller 1965).

In addition to replicating early tests of dogs’ ability to use human cues, we also wished to investigate the origins of this ability. We studied three kinds of dog: non-gundog pets, untrained gundog breeds kept as pets, and trained gundogs. An evolutionary origin for attentiveness to human cues, and the findings of Scott and Fuller (1965), suggest that gundog breeds kept as pets ought to perform better than non-gundog breeds kept as pets. Alternatively, or perhaps additionally, if dogs generalise from previous experience to the experimental situation, gundogs trained to respond to human-given cues should out-perform those kept as pets with no specialised training. Taken together, these comparisons should shed light on whether canine ability to use various human communicative signals is predominantly innate or learned.

A dog’s relationship with its owner has also been shown to affect its behaviour. Topál et al. (1997) tested dogs in an unfamiliar situation to assess their level of attachment to their owners. The dogs were then given a problem-solving task. The results showed that dogs who were highly attached to their owners performed less well than dogs who were not. In addition, dogs who were highly attached glanced at their owners significantly more often during the problem-solving task. The authors suggest that dependence on their owners had reduced the ability of highly attached dogs to solve problems independently. In this experiment, the owners gave no assistance during the problem-solving task. In an object-choice task, where success depends on using human-given cues, it would seem that a tendency to look to humans for assistance would be of benefit. Behavioural effects of attachment in dogs look remarkably similar to the process that in primates has been described as enculturation.

The first aim of the present study was to replicate the experiment conducted by Hare et al. (in press) using a

greater number of dogs of specific breeds. In addition, Anderson et al. (1995, 1996), have pointed out that successful use of pointing cues may depend on the fact that the experimenter's hand is simply closer to the correct object. The second objective of the present study was to investigate the effects of hand proximity, a confounding factor in previous studies on pointing.

## Horses

The conjecture that domestication explains canine attentiveness to humans can be tested by looking at other domestic animals. Horses (*Equus caballus*), have been domesticated for thousands of years and although the exact date of domestication is unknown, it seems that various cultures domesticated the horse independently (Edwards 1985).

The famous case of the horse "Clever Hans" may suggest that these animals are extremely sensitive to human cueing. This horse appeared able to do simple mathematical sums and could also correctly answer questions by tapping with his foot, having been taught a number to correspond with each letter of the alphabet. Although the abilities of this horse were accepted by many prominent scholars, scientists, psychologists and others at the time, subsequent investigations by Oskar Pfungst revealed that Clever Hans was, in fact, being cued by his audience who would unconsciously tense up as he approached the correct answer (Hediger 1981). However, it is worth noting that this experiment has never been replicated and that Hans received extensive training which may simply have shaped his tendency to respond to increasingly subtle cues.

Horses are highly social grazing ungulates with a flexible, hierarchical social structure. Horses use a variety of facial expressions, the position of the ears, mouth and nose, combined with head movements and body tension to convey a variety of messages from threats to intention to groom (Rees 1993).

Given the perils of comparing a specific cognitive ability across species with quite different perceptual systems (Macphail 1985), some observations of the equine visual system must be made. Unlike primates and canids, equine eyes are laterally placed resulting in relatively limited binocular vision and a blind zone behind the body and a little way in front of the head (Rees 1993). In addition, the density of ganglion cells over most of the horse retina is low which suggests that the acuity of equine vision is poor in comparison to other mammals such as dogs, pigs and primates (Saslow 1999). Research has found that the horse has little ability to focus by changing the shape or position of the lens and limited ability to swivel its eyes in the sockets. To focus and compensate for limited binocular vision, horses thus need to move their heads (Rees 1993). The ratio of rod to cone cells also suggests that colour vision, while present to some extent, may not be crucial in horse visual discrimination and it appears that motion and visual contrast are of primary importance (Waring 1983; Saslow 1999).

Despite their long association with humans, little is known about the cognitive capabilities of horses and even less on horse-human interactions (Crowell-Davis 1992). Some studies suggest inflexibility in horse behaviour. For example, Sappington et al. (1997), found that horses performed poorly on a discrimination-reversal learning task. Subjects who had learned that either a black or a white bucket contained food and were then faced with reversal of the rule performed badly.

While horses provide a second species for investigating the effects of domestication on cognition they also pose other interesting questions for comparative psychology. Theories of visual attention have focused on species with forward-looking, binocular vision designed to look at one thing at a time. It is possible that horses, with nearly 360° vision, do not show the focal attention of animals with binocular vision (Lea and Kiley-Worthington 1996), and it may be that the large visual field characteristic of many prey species is associated with non-selectivity of attention. For ungulates, it may be adaptive to respond rapidly to events in a wide visual field (e.g. the approach of a predator) rather than attend in advance to a smaller area. "Attention" as a cognitive feature, should not then be regarded as somehow indicative of increased intelligence, but as a specific design feature of a cognitive system, adaptive in some niches and not in others.

Horses and dogs differ in other ways. Domestic dogs are more heavily encultured in that they usually live as part of human families, and they have been selectively bred for their ability to relate socially to humans (Hare et al., in press) while horses remain in the company of conspecifics, often showing signs of behavioural distress if kept in isolation (Kiley-Worthington 1997).

By subjecting both dogs and horses to the same experimental procedure we here attempt to use their differences to shed light on the origins of animals' abilities to use human-given cues. However, as there have been no previous studies using equine subjects on this type of task, the main objective of the horse section of this experiment was to investigate the suitability of the object-choice task as a tool for investigating the use of referential cues by these animals.

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## Materials and methods

### Subjects

#### Dogs

Sixteen domestic dogs (*Canis familiaris*), served as subjects and are detailed in Table 1. These were divided into three groups. "Gundog pets" were breeds recognised by the Kennel Club of Great Britain and listed in the gundog group (Glover 1982), living with a human family as a pet with no specialised training. "Non-gundog pets" were also dogs kept only as pets but not breeds belonging to the gundog group. "Working gundogs" were gundog breeds kept as working dogs that had been trained for various tasks such as retrieving objects from locations indicated by the direction in which a human was pointing. Each dog was accustomed to being fed once per day and although different owners fed their dogs

**Table 1** Breed, sex and age of all dog subjects

Name	Breed	Sex	Age (years)
Non-gundog pets			
Lucy	Terrier cross	Female	3
Star	German shepherd	Female	2
Kizzy	German shepherd	Female	5
Sumo	German shepherd	Female	2
Ruby	German shepherd	Female	8
Coco	Standard poodle	Male	9
Gundog pets			
Robbie	Labrador retriever	Male	6
Dover	Golden retriever	Female	7
Chancer	Labrador retriever	Male	10
Sheba	Cocker spaniel	Female	7
Sam 1	Labrador retriever	Male	13
Trained gundogs			
Amy	Labrador retriever	Female	5
Jack	Labrador retriever	Male	2
Cass	Labrador retriever	Female	2
Sam 2	Springer spaniel	Male	3
Sally	Springer spaniel	Female	8

at different times, all subjects had received their feed prior to testing.

### Horses

Although four thoughtbred and three Anglo-Arab horses and three Welsh ponies (*Equus caballus*), originally served as subjects, by the end of the training phase, only three male thoroughbred horses and one male pony would perform the task reliably enough to participate in the testing phase. Subjects lived in private yards with other equine companions, indoor stabling and access to outdoor grazing. The three horses were trained to saddle and ridden regularly by their owners. The pony was too young to be ridden but was well handled by humans, walked out regularly in hand and trained in a variety of procedures such as walking into horseboxes for transportation.

The pony (Jasper) and one of the horses (Indiana) differed from the other two horses in their rearing history. Indiana and Jasper had both been trained using the relatively new method of co-operative training which is characterised by attempts to understand the natural behavioural characteristics of horses and elicit co-operation by mimicking equine communicative signals (Bayley and Maxwell 1996). Preliminary scientific assessment suggests that horses trained in this way voluntarily associate with, and are more attentive to humans than horses trained using more traditional methods (Kiley-Worthington 1997). However, as pointing is not a natural equine communicative signal, there is no reason to suspect that these animals had more experience of this cue than the other two subjects.

All horse subjects received two feeds of grain or alfalfa per day, once at 7.30 a.m. and again at 6p.m. In addition, all horses had hay or grass available ad libitum. Testing was conducted several hours prior to the evening feed.

### Apparatus and procedure

#### Dogs

Food (dry commercial treats) was hidden under one of two opaque plastic cups placed behind screens measuring 38 cm wide and 25

cm in height. Screens were placed approximately 70 cm apart and were used to ensure that the subject could not see where food was placed when the cup was lifted during the baiting procedure. The cups subtended an angle of approximately 75° at the cuer. Subjects were tested at their owners' homes, with subjects tested indoors if sufficient space was available. To control for odour cues, a handful of the food treats was rubbed over the carpeted area around the screens before testing commenced. When insufficient space was available indoors, dogs were tested in their owners' gardens with the cups and screens placed on pieces of carpet previously rubbed with the food treats.

#### Horses

Food treats (sliced apples, carrots and commercial horse treats) were hidden under one of two black plastic buckets placed in the centre of two 61 cm × 61 cm fibreboard boards positioned 60 cm apart, making the buckets themselves approximately 95 cm apart. The buckets subtended an angle of approximately 84° at the experimenter. The use of the boards enabled the food to be placed on a uniform surface for subjects tested in different home yards. The placement of the black buckets on the light coloured boards also helped provide contrast which is an important element in visual perception by horses (Saslow 1999). A semi-circular hole, approximately 20 cm in diameter, was cut from the rim of each bucket, on the side facing away from the subject. This allowed the experimenter to place food under the inverted bucket without lifting it, preventing subjects seeing food placement, obviating the need for screens.

#### All subjects

Both dog and horse subjects were easily able to knock over the buckets or cups to search underneath them. A random selection of sessions were videotaped to allow blind scoring by another observer.

#### Dogs: training phase

To avoid conditioning the animals to a specific location, training was carried out in a different location from the actual experiment. Training was accomplished using one cup, the experimenter kneeling directly behind it. Subjects were shown food being placed under the cup and allowed to retrieve it; they readily searched for the food but if they failed to locate it, the experimenter lifted the cup using both hands to reveal its location. Once the subjects reliably looked under the cups, the procedure was repeated with the cup placed behind a screen so that the subject could not see the food being hidden. All subjects learned to move the cup and retrieve the food quickly, typically after five or six demonstrations.

When two possible locations were introduced in the experimental phase, the dogs chose between locations without further training.

#### Horses: training phase

Prior to training, the buckets and boards were left in the home yards to allow habituation. Even though the horses were accustomed to being fed from similar buckets, and they searched the buckets when they were placed in an upright position, none of the subjects would spontaneously search for food under an inverted bucket even when shown it being placed there. Consequently, subjects were thus first trained to associate tapping on the bucket with food being placed under it. Shaping through positive reinforcement was then used to teach the horses to respond to the command "get it" by moving the buckets with their noses to find the food reward.

The function of the training phase was to alert subjects to the fact that food could be found under one of the buckets, using cues

other than those used in the experimental phase. As with the dogs, initial training was conducted in a different location from the experiment and only one bucket was used. As previous research with horses suggests that long sessions lead to inefficient learning (McCall 1990), each training session lasted no longer than 10 min.

The first attempt to conduct the experiment failed as the subjects were inflexible in their choice of bucket. Each subject continued to choose whichever location it visited on the first trial on all subsequent trials, whether it found a food reward or not. Additional training, in which the subject was shown the food alternating randomly between locations, was necessary in order to teach the horses to choose between the two buckets. The four subjects who reliably performed the task subsequently participated in the experimental phase.

#### *Dogs: experimental phase*

As the performance of dogs on problem-solving tasks has been shown to be influenced by their relationships with humans (Topál et al. 1997), all cues were given by their owners as it seemed that they would be the person the dog would most readily attend to. All owners were female and were well practised before the experiment.

Subjects who would reliably “sit” and “stay” began approximately 1.5 m in front of the screens and were verbally released to find the food. Subjects who would not “stay” were held gently by the experimenter. Each subject received 20 experimental trials in three conditions (pointing, head orientation and gaze), and 20 control trials, giving 80 trials in total, spread over four sessions. Testing was conducted at the owner’s convenience so there was no regular interval between sessions, although all subjects completed testing within a 1-month period.

Each session began with five warm-up trials using the cue for that session, followed by the experimental trials. Food placement for each condition was semi-randomised with each location baited an equal number of times and the same location never baited more than three times in a row. All subjects received experimental blocks in the same order: pointing, head orientation, eye gaze. Half the subjects received control trials first and half were given control trials last.

In all trials, baiting was accomplished by the owner passing a closed fist behind each screen in a order fixed across all trials, baiting one location and sham baiting the other while the subject watched. A choice was recorded when the subject touched a cup either with the face or front foot. A number of randomly chosen trials were scored blind by a second observer using the videotapes, and inter-observer reliability was 100%. Correct responses earned the food treat and a wrong response did not, and the subject was not allowed to visit the other location and was not shown where the food was actually hidden. To encourage responding, subjects were praised irrespective of choice. If no response was made after 1 min the subject was given a 10-min break before testing resumed.

Cues were given as follows:

1. *Point*: having baited, the owner stood at a position equidistant from and approximately 0.75 m back from the two cups. She then called the subject’s name and pointed towards the correct location twice, keeping her head oriented forward and holding the second point, giving whatever command the dog normally associated with looking for an object after 5 s, at which point the dog was released. To investigate the effects of proximity as a cue (as noted in the Introduction), on odd-numbered trials (reduced distance), the owner stepped directly (i.e. diagonally) towards the correct location, while on even-numbered trials (increased distance), she stepped diagonally away from the correct location.

2. *Head*: in both the head orientation and gaze trials the owners knelt on the ground to make these subtle cues more salient. The owner knelt in a position equidistant from and approximately 65 cm behind the two screens. She then called the subject’s name to get their attention. Once the subject was looking at its owner, she

turned her head towards the correct location, back towards the dog, then back to the correct location and held it there, keeping her eyes looking directly ahead throughout. After 5 s the owner told the dog to find the food and the subject was released.

3. *Gaze*: in a similar position and sequence, the owner kept her head pointed straight ahead and moved her eyes to gaze at the correct location.

4. *Control*: ten of the control trials were conducted with the owner standing in the same position as for the pointing trials and ten with the owner kneeling in the position used for the head orientation and gaze trials. Whilst the dogs searched for food, the owner kept her hands by her side, her head bowed and eyes closed, having called the dog’s name immediately after assuming this position and given the command to find the food 5 s later.

#### *Horses: experimental phase*

All cues in the horse trials were given by the experimenter, as she was familiar to all subjects. Procedure resembled that used for the dogs with the start position approximately 3 m in front of the two buckets. The baiting procedure was identical to that used for the dogs except that following baiting, the experimenter tapped both buckets simultaneously to indicate that food had been placed.

To see if horses could benefit from being given the more explicit cues first, two randomly chosen subjects received the touch condition followed by the pointing condition with the reverse order given to the remaining two subjects. All subjects received control trials last for fear that they might revert to inflexibly choosing the same location on all trials in the absence of cues.

Cues were given as follows:

1. *Touch*: the experimenter squatted behind the two buckets then touched the correct location. As movement is important to the equine visual system (Saslow 1999), the experimenter moved her hand up and down; however, unlike the tapping used to indicated food placement, touches were gentle with one hand and made no noise. The experimenter continued to give the cue until the subject chose a bucket.

2. *Point*: this resembled the dogs’ cue except that again the experimenter moved her hand up and down until the subject chose one of the buckets.

3. *Control*: as for dogs.

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## Results

### Dogs

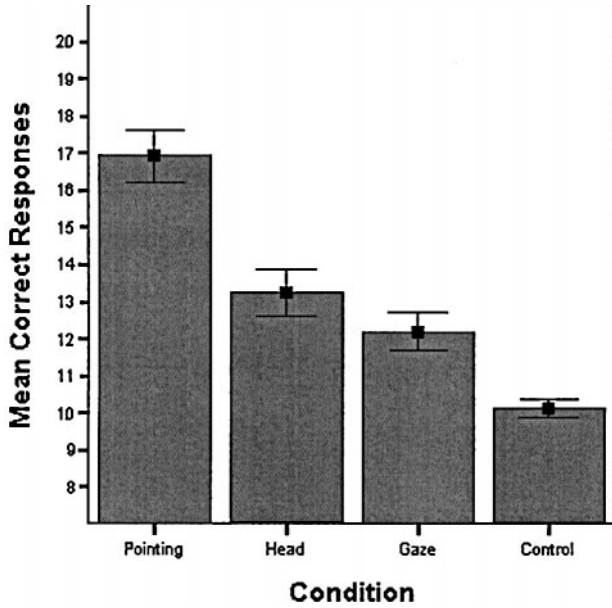
#### *Number of correct responses*

The number of correct responses by each subject in each condition is presented in Table 2. We compared the number of correct responses against chance for each subject for each of the conditions separately, using the chi-square goodness-of-fit test: 15/20 correct is statistically significant, ( $\chi^2 = 3.84$ ,  $df = 1$ ,  $P < 0.05$ ). Results is showed that: for pointing, 12 of the 16 subjects chose the correct location more often than would be expected by chance; for head orientation 4 subjects performed above chance; and for the gaze condition 2 subjects performed above chance. No subjects performed above chance in the control condition.

**Table 2** Performance of each dog subject in experimental and control conditions (*non-GD* non-gundog pets, *GD* gundog pets, *GD(W)* working gundogs)

Name	Group	Control	Point	Head	Gaze
Lucy	Non-GD	9	15*	12	13
Star	Non-GD	9	17**	11	12
Kizzy	Non-GD	11	19**	12	9
Sumo	Non-GD	11	14	10	14
Ruby	Non-GD	9	11	11	10
Coco	Non-GD	10	18**	11	11
Robbie	GD	8	13	13	9
Dover	GD	11	16**	12	11
Chancer	GD	11	18**	18**	15*
Sheba	GD	10	14	17**	16**
Sam 1	GD	10	18**	13	12
Amy	GD(W)	9	18**	11	11
Jack	GD(W)	9	20**	14	14
Cass	GD(W)	11	20**	16**	11
Sam 2	GD(W)	10	20**	14	13
Sally	GD(W)	11	20**	17**	14

\* $P < 0.05$ , \*\* $P < 0.01$

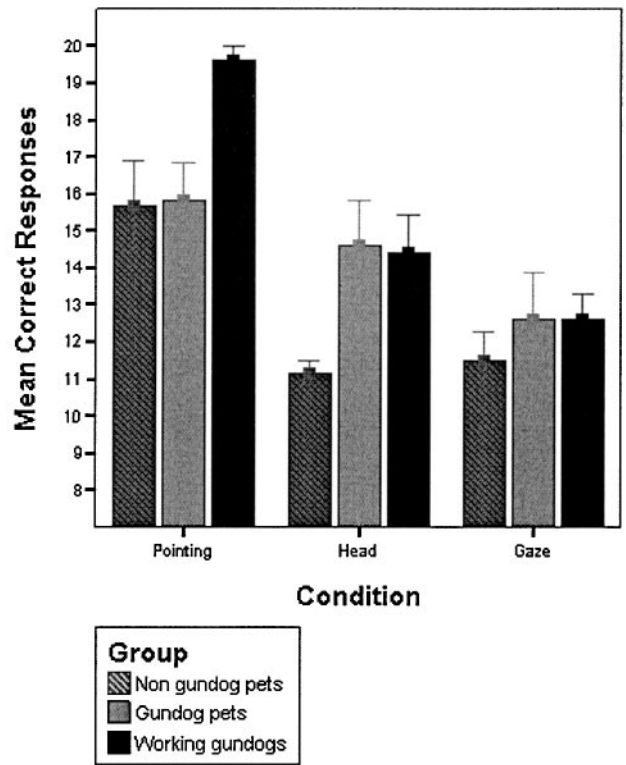


**Fig.1** Bar chart showing mean correct responses by all dogs in each condition

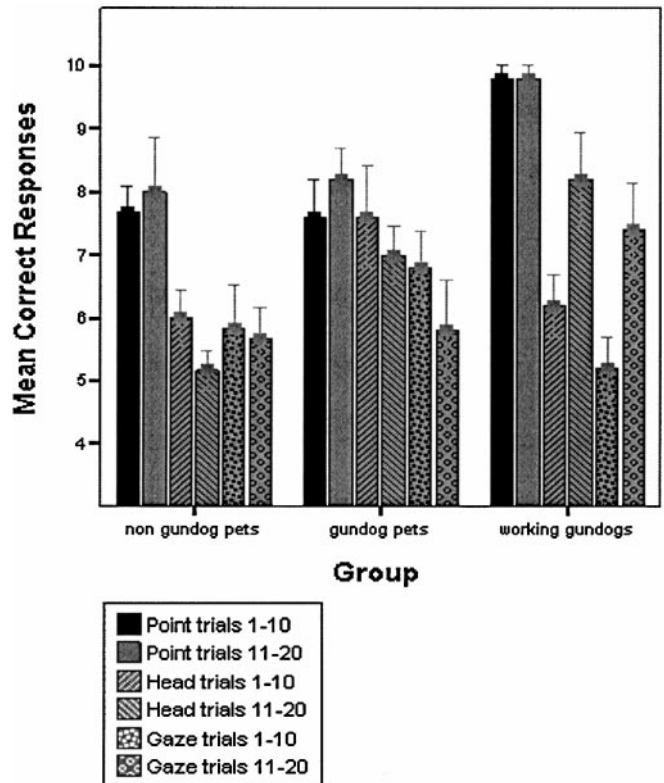
*Group analysis*

Since only six errors would preclude a significant performance by subjects, dogs partially using the experimental cues but mistakenly using other cues or momentarily distracted might be prejudiced. A group-level analysis is sensitive to this possibility.

Figure 1 shows the mean correct responses shown by all dogs in the three experimental conditions and control trials. Subjects' performance in all four conditions was compared using a repeated-measures ANOVA. The result of this test was significant ( $F(3,45) = 37.4, P < 0.001$ ).



**Fig.2** Bar chart showing mean correct responses by the dog groups in the three experimental conditions



**Fig.3** Bar chart showing the mean correct responses by the dog groups on the first and last ten trials of the three experimental conditions

Paired sample *t*-tests showed that performance in all three experimental conditions was significantly better than in the control condition (pointing;  $t(15) = 10.43$ ,  $P < 0.001$ , 2-tailed; head orientation,  $t(15) = 5.00$ ,  $P < 0.001$ , 2-tailed; gaze,  $t(15) = 4.09$ ,  $P = 0.001$ , 2-tailed).

To assess the effect of proximity in the pointing trials, a paired sample *t*-test was performed comparing the number of correct responses on the odd numbered trials (reduced distance), with the number of correct responses on the even numbered trials (increased distance). The results showed that the pet dogs performed significantly better on the odd numbered trials when the distance between the owner's hand and the correct location was reduced ( $t(15) = 2.30$ ,  $P = 0.036$ , 2-tailed). As they had been specifically trained to follow manual cues, the performance of the working Gundogs was examined separately. This group showed a ceiling effect with only one subject ever choosing the unbaited cup, once on each type of trial.

In order to investigate the possibility that the dogs performed significantly better than chance on the pointing trials solely as a consequence of the proximity of the owner's hand, a paired sample *t*-test was performed comparing the scores solely from the even-numbered trials (increased distance) with the results from the corresponding control trials. The results showed that dogs still performed significantly better on the pointing trials than the control trials ( $t(15) = 3.26$ ,  $P = 0.005$ , 2-tailed).

To test for the effect of rearing history on each cue, a mixed ANOVA (within-factor cue, between-factor working/pet) was performed comparing working Gundogs and Gundog pets on the three experimental conditions. The results showed a significant main effect for cue ( $F(2,16) = 25.47$ ,  $P < 0.001$ ), not rearing effect ( $F(1,8) = 1.151$ ,  $P = 0.315$ ), and a significant cue  $\times$  group interaction, ( $F(2,16) = 4.87$ ,  $P = 0.02$ ). Post-hoc *t*-tests found that this was due to the working Gundogs performing significantly better than the pets on the pointing trials ( $t(8) = 3.47$ ,  $P = 0.008$ ).

To assess the effects of breed group, a similar mixed ANOVA was performed, instead using the between-factor comparison of pet Gundogs versus pet non-Gundogs. These again showed a significant main effect of cue ( $F(2,18) = 9.586$ ,  $P < 0.001$ ), but no effect of group ( $F(1,9) = 2.529$ ,  $P = 0.146$ ), and no significant cue  $\times$  group interaction ( $F(2,18) = 1.849$ ,  $P = 0.186$ ).

To assess the possibility that the dogs were learning during the experiment, a three-way mixed ANOVA was run using the number of correct responses shown in the first and last ten trials for the three dog groups and the three experimental conditions [within-factors cue and order (first ten versus last ten trials), between-factor group].

The results showed no significant effect of order ( $F(1,26) = 2.82$ ,  $P = 0.117$ ) but a significant interaction of order and group ( $F(2,26) = 10.83$ ,  $P = 0.02$ ). Post hoc related-sample *t*-tests showed that the only significant effect of order occurred with the working Gundogs on head trials ( $t(4) = 2.83$ ,  $P = 0.047$ , 2-tailed). However, there was a marginally non-significant effect for this group on gaze trials ( $t(4) = 2.06$ ,  $P = 0.108$ ), and no effect in the point trials since this group performed without error across all

**Table 3** Performance of each horse subject in experimental and control conditions

Name	Control	Touch	Point
William <sup>a</sup>	10	11	11
Henry <sup>b</sup>	9	14	12
Indiana <sup>a</sup>	9	17**	9
Jasper <sup>b</sup>	10	17**	16*

\* $\chi^2 = 7.2$ ,  $P < 0.01$ , \*\* $\chi^2 = 9.8$ ,  $P < 0.05$

<sup>a</sup>Pointing trials first

<sup>b</sup>Touch trials first

20 trials. This differentiated order effect depending on cue underlies the non-significant three-way interaction of order  $\times$  group  $\times$  cue ( $F(4,26) = 1.99$ ,  $P = 0.124$ ).

## Horses

Performance for each subject in each condition is presented in Table 3. For individual performance, chi-square tests were performed in the same way as for the dogs. Results showed that for the touch condition, two subjects chose the correct location significantly more often than would be expected by chance and in the point condition, one subject. There was no effect of proximity as subjects made no fewer errors on the odd than even numbered trials.

An independent sample *t*-test on the results of the pointing trials found no significant difference between the subjects who received the touch trials first and those who received the pointing trials first, ( $t(2) = 1.79$ ,  $P = 0.216$ , 2-tailed), though the small sample size is clearly a factor here.

Due to the small number of subjects, no further analysis was performed on the horse data.

## Discussion

### Dogs

As has been shown in previous studies, the dogs were very skilful in using pointing as a cue to find the hidden food. Although the importance of proximity to this ability was not investigated during previous experiments, this study found that dogs were able to use the pointing cue even when the distance between the owner's hand and the correct cup was increased, although the performance of the pet dogs was impaired to some extent. These results suggest that the dogs understood that it was the direction of owner's hand which provided the cue, as during reduced proximity trials the owner's body was closer to the incorrect location. The results from the pointing trials also indicate the effects of prior learning, as the working Gundogs, who had been trained to follow manual cues, performed significantly better than either pet group. Although proximity might generally be expected to be a more salient cue than pointing this was not so for the

trained gundogs, since only one of the dogs made any mistakes, once in an increased and once in a decreased distance trial. It seems that when a pointing cue is available, proximity is disregarded by these animals. In contrast, untrained gundogs showed poorer performance when body distance and pointing were in conflict although the high rate of success in these cases still indicates that for these animals pointing has primacy as a cue.

Previous research into dogs' ability to use combined eye and head orientation has produced mixed results. Miklósi et al. (1998) found that although their subjects were initially unable to use this cue, they learned to do so during the experiment. Hare et al. (in press) found that their dogs were able to use this cue. This may be due to the fact that the cue was available for a longer time during Hare et al.'s experiment. If the success of the subjects of Hare et al. (in press) as opposed to those of Miklósi et al. (1998) was due to the longer presentation of the cue, the performance of individual dogs in the present study was surprisingly poor. Only four subjects performed above chance, even though the owners kept their heads oriented towards the correct cup until the dog had responded. A possible explanation for this is that, unlike previous studies, in this experiment head orientation was not co-directed with eye gaze. While this allowed us to separate out the contribution of these elements of the signal, from the point of view of the dog, this may have produced an ambiguous or peculiar cue. It is also unlikely that the dogs would have encountered this cue prior to the experiment since humans do not normally turn their heads in one direction while keeping their eyes fixed directly ahead.

A new finding of this experiment is that some dogs appear respond to eye gaze alone as a cue. Two dogs were significantly more likely to choose the object the experimenter was looking at and whilst other dogs fell below the threshold of significance their generally increased choice of the correct cup resulted in significance at the group level, suggesting that the subjects overall were at least partly attending to this cue. Hare et al. (in press) found that neither of their two subjects were able to do this and the subjects of Miklósi et al. (1998) had no initial tendency to do this. While it is likely that our subjects benefited from receiving the easier cues first, another possible explanation for the poorer performance of these authors' subjects is the way in which the gaze cues were presented. In the experiment of Hare et al. (in press), the gaze cue was delivered from a standing position while in this experiment the owners sat on the ground, nearer the dog's height. It is possible that this simply made the cue more salient. It is also possible that sitting down modified the cue and made it less likely to be interpreted as threatening, just as the direct stare used as a threat by dogs is modified by lowered body posture into an invitation to play (Bradshaw and Nott 1995). Miklósi et al. (1998) also gave gaze cues from a sitting position but these cues consisted of a brief glance lasting about 1–2 s whereas in this study the owner continued to gaze at the correct cup until the dog made a response.

The behaviour of the dogs during the gaze trials was also interesting. During control trials the dogs continued to respond willingly for all 20 trials although most of them quickly developed a preference for one location. During gaze trials many of the dogs showed signs of frustration, whining or barking at their owners. It is possible that the dogs had come to expect a cue when the owner called their name but were unable to detect one. Alternatively, it is also possible that some of the dogs were detecting the cue but found their owner's attempts to establish eye contact threatening. Several of the dogs responded on some of the gaze trials by moving directly to their owners and rolling onto their backs, which in dogs is a sign of submission. While we can only speculate as to the cause of this behaviour, it is interesting to note that Peignot and Anderson (1999) report similar difficulties during gaze trials with gorilla subjects.

The results of the dogs as a group suggest that eye gaze as a cue was having some effect, yet only two dogs chose the correct cup more often than would be expected by chance. Since eye gaze is a subtle cue it may be easier to miss or perhaps more easily masked on trials where subjects were distracted in some way. Examination of the raw data showed that mistakes were more common on some trials than on others. One particular problem was that finding food in a particular location effectively reinforced that response, especially if a subject happened to find food in the same location twice in a row. If a subject found food in the same location three times in a row it almost inevitably chose that location on the next trial and some dogs would continue to choose that location for the remainder of the session. This effect was particularly noticeable during control trials but it was also apparent during gaze trials. The baiting rule was that no location would be baited more than three times in a row. With hindsight, twice in a row might have been better. We can conclude that whilst gaze is a cue that dogs can use, it does not have the immediacy of pointing.

Although comparison between gundog and non-gundog pet groups showed no significant difference, all of the individual dogs who were able to use head orientation and eye gaze as a cue were gundog breeds. This may have been because gundogs have been selectively bred to perform tasks which involve moving in a direction and retrieving objects from a location indicated by humans. A comparison of individual rearing history also revealed differences: trained gundogs considerably outperformed untrained gundogs on the pointing trails, the trained dogs having been taught to follow manual cues prior to the experiment.

The comparison in performance between the first and the last ten trials showed that the trained gundogs improved in their use of the head orientation cue during the course of the experiment while the pet dogs did not. In addition, improvement in the gaze trials was only marginally non-significant. One possible explanation is that unlike the pet dogs, all of the working dogs participate in regular training sessions. It has been shown that animals who receive a great deal of training begin to learn new tasks



faster than animals who do not (McCall 1990). It could be that the working dogs had “learned to learn”.

## Horses

The results of the horses trials were mixed, with two of the four subjects able to find the hidden food when the experimenter touched the correct bucket, but only one subject (Jasper), able to use pointing as a cue. Individual differences are a common feature of all object-choice task experiments, and are interesting, as comparison between successful and unsuccessful subjects may provide some clues as to the ontogeny of this ability.

Primate subjects have been found to benefit from being given the easiest cue in an experiment first, before progressing to the hardest (Itakura and Tanaka 1998). As Jasper received the touch condition first this might have helped him learn the pointing cue although this was not the case with the other subject who received the touch condition first yet failed to use any cue.

One possible source of variation between the two subjects who showed some ability to use human-given cues and the two who did not was that the successful subjects were those trained using the relatively new method of cooperative training. This would support the belief that horses trained in this way are more attentive to humans than horses trained using more traditional methods (Kiley-Worthington 1997). However, another difference between the subjects was age since the two successful subjects were both young and horses are known to learn from humans less easily as they age (McCall 1990).

Overall, the horses certainly performed much more poorly than the dogs. One possible explanation for this is that while searching for discrete pieces of food is a natural behaviour for dogs and primates, it is not a natural behaviour for grazing ungulates such as horses. When shown food being hidden during training, the dogs readily looked under the cup whereas the horses required a considerable amount of shaping before they would do this. Piaget-type studies of domestic dogs suggest that they display stage 6 object permanence, as demonstrated by their willingness to search for invisibly displaced objects (Gagnon and Doré 1992). Studies of object permanence in horses do not appear to have been conducted.

If domestication over many thousands of years, combined with extensive experience of human communicative behaviour does lead to an increased ability to respond to human-given cues (Hare et al., in press), then the performance of the horses in this experiment was surprisingly poor. Although dogs and horses are both domesticated animals, they typically experience different forms of animal-human interactions. As already stated, horses do not usually live as part of human families. It could be argued that an analogy between the environments of these two domesticated species and primates is that pet dogs are in many ways similar to encultured, language-trained apes while horses have more in common with captive-born, laboratory housed primates.

Despite the finding that one horse subject did use pointing as a cue within 20 trials, there is no evidence to suggest that Jasper understood anything of the referential nature of pointing and his behaviour on the pointing trials suggests that he did not. Povinelli et al. (1999) suggested that chimpanzees could use gaze as a cue simply by orienting themselves to the experimenter’s face then choosing the correct cup as it is then the closest. In the light of this it is worth making some qualitative observations on the horses’ behaviour during the trials since it differed strikingly from the dogs’. The dogs moved directly to their chosen location but the horses typically moved towards the experimenter and then “at the last minute” made their choice. During training the horses had been taught to move towards the experimenter and then randomly choose a bucket. The fact that obsolete elements of the training regime were preserved therefore suggests that the horse subjects’ success was achieved by chaining of additional rules to their prior experience rather than an understanding of the significance of the cue as such.

This is the most parsimonious interpretation of the horses’ success on the touch trials. However, given that the horses’ training strongly resembled the experimental situation, and given the evidence of horse inflexibility cited earlier, it could be that elements of stereotypy in the horses’ behaviour persisted, belying a deeper cognitive understanding of the task. The horses did not, after all, waste much extra time in their idiosyncratic manner of response. We only leave this open as a possibility, aware of the frailty of accounts of cognition contraindicated by behaviour.

Jasper’s (successful) responses to the pointing trials were similar, and in addition he tended to move his nose down the length of the experimenter’s arm, past her hand and then onto the correct bucket. Once again, although this is not how humans would solve the task and we would probably perform the action of running our *gaze* along the experimenter’s arm. Given the horses’ poor ability to focus, Jasper’s manner of response may simply have reflected his perceptual constraints. A cognitive middle ground between this and purely behavioural chaining might be that horses are poorer than dogs, primates or humans at computing “lines of sight” (in this case a “line of arm”) that originate from somewhere other than themselves. If this was the case then the solution would be to reduce disparity between the two lines of sight, as was done by the subject.

These alternatives can only be resolved by modifying the object-choice methodology. At present however, we can suggest that at least some horses are capable of using pointing to locate food without specific training in the use of this cue.

What might the comparison between dogs and horses tell us about the effect of domestication on cognition? Although it is only possible to draw tentative conclusions from the results of this experiment, they do suggest greater performance on the part of dogs. Dogs showed greater ability, flexibility and motivation. A number of contributory factors are possible. One is a fundamental difference in canid and equine intelligence (for want of a

better word), at least in a problem-solving context. Alternatively, it might be more the form of equine and canid intelligence that differs, as a consequence of these animals' respective grazing and predatory niches. Wolves, the ancestors of dogs, can be eclectic feeders and can more effectively exploit their environment by taking interest in objects, a propensity perhaps inherited by the domestic dog. The visual system of horses seems ill-suited for attention to objects, again suggesting these have not been an important element in equine evolution.

Alternatively, dog-horse differences may originate from the selective pressures imposed by humans in recent history. Whilst both species are domesticated, this process began much earlier with dogs and their dual role as workers and companions with humans may have imposed a greater tendency to be receptive to human cues. An evolved and dependent relationship with humans may certainly underlie their vastly greater motivation on the task although this cannot entirely explain their superiority over the horses.

A third source of explanation is the enculturation process that dogs undergo in their own lifetimes which typically involves a greater intimacy with humans than that experienced by horses. It is difficult to say whether this is a more powerful influence than innate ability. At the best of times it is difficult to distinguish between evolved and acquired abilities without large scale longitudinal studies and this is especially so in the present case where a possible middle ground, an evolved susceptibility to enculturation, could be a plausible and potent mechanism in domesticated animals. Nevertheless, our subjects showed considerable variation, and in both species there was evidence to suggest that this was due to the manner in which the subjects had previously interacted with humans. Given that attentiveness to human cues, more than any other cognitive ability, is likely to depend on a reinforcement history supplied by a human rearing environment, it is to date inappropriate to refer to a species' innate ability at this capacity.

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