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Referential communication in the domestic horse (*Equus caballus*): first exploration in an ungulate species

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An important question in the study of animal communication is whether non-human animals are able to produce communicative gestures, i.e. nonvocal bodily actions directed to a recipient, physically ineffective but with a meaning shared in the social group [1]. Passive gestures are instrumental, tuned to the mere presence/absence of others, whereas active informers recognize receivers as communicative agents and activate shared-attention mechanisms for identifying their attentional state (SAM [2]; e.g. Schwab and Huber [3]). Six operational criteria must be evaluated to classify a signal as referential and intentional [4]: (1) alternative gazes between the partner and the target; (2) apparent attention-getting behaviours are deployed; (3) an audience is required to exhibit the behaviour; (4) the attentional status of an observer influences the propensity to exhibit behaviours; (5) communication is persistent and (6) there is elaboration of communicative behaviour when apparent attempts to manipulate the partner fail. Dogs [5] and non-human primates (reviewed in Liebal and Call [6]) can tune a human receiver's attention to the object of interest by combining directional and attention-getting signals, such as turning the head or body, gazing to the receiver, and/or establishing eye contact. Research on other species is scarce.

Horses rely on humans to survive in domestic settings and may have evolved skills for communicating flexibly with them [7]. Horses understand human attentional cues (such as body and head orientation, eyes opened/closed) [8], permanent pointing [9] and, to some extent, gazing [10]. Here we tested the ability of 14 outdoor, herd-living domestic horses to communicate referentially with a human partner about the location of a desired target, a bucket of food out of reach. After the baiting of two buckets placed in opposite, unreachable locations were shown by the experimenter, the subject would walk to one of the two buckets. Because approaching a bucket would reveal that the food is out of reach, we expected the horse to look back to the experimenter, then to the bucket, and alternate this gazing several times to indicate its intention. To test whether our prediction is correct and alternate gazing is indeed the result of the horse's referential communication, we video-recorded the behaviour of the subjects in the test (FORWARD) and three control conditions: (1) FORWARD: experimenter oriented to the center of the arena, (2) BACK: experimenter backward oriented in respect to the arena, (3) ALONE: experimenter absent, (4) MANY: as FORWARD plus a familiar human oriented to the subject behind the bucket (Figure 1).

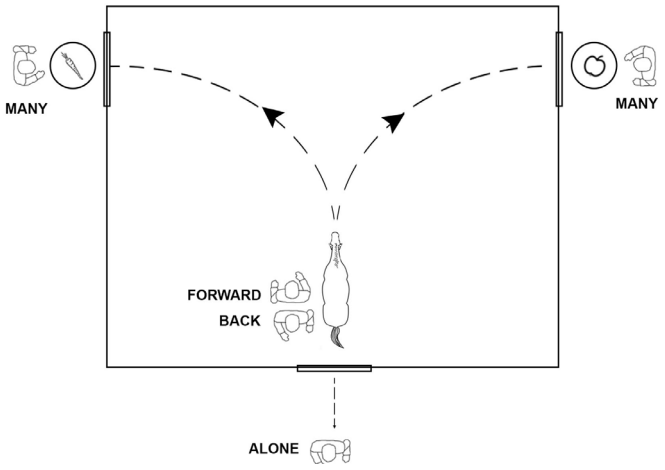

Figure 1: Sketch of the experimental set-up from above. MANY, BACK, FORWARD, ALONE: position of the experimenter and/or the familiar humans during test FORWARD and its three controls. The dotted line represents the direction headed by the experimenter while distancing from the test arena.

We used a conservative criterion of back gazing by considering only turning the head back more than 90 degrees. The results confirmed our prediction. The horses alternated gazes between the partner and the buck significantly more often in the FORWARD than in all the other

FREQUENCIES	FWD vs ALONE	FWD vs MANY	FWD vs BACK
Gazes to Partner			
N positive differences	3	1	2
N negative differences	8	13	10
Smaller total of ranks	20	5.5	7.5
Two-tailed probability	P = 0.278	**P = 0.001*** **	**P = 0.009** **
Head Nods			
N positive differences	14	3	2
N negative differences	0	9	12
Smaller total of ranks	0	18	9
Two-tailed probability	**P = 0.001*** **	P = 0.110	**P = 0.004** **
Head pointed to buck			
N positive differences	3	8	2
N negative differences	10	5	9
Smaller total of ranks	13.5	37	8
Two-tailed probability	**P = 0.021***	P = 0.588	**P = 0.000*** **
ALTERNATIONS			
Gazes to partner / buck			
N positive differences	3	3	1
N negative differences	11	11	12
Smaller total of ranks	21	10	8.5
Two-tailed probability	**P = 0.049***	**P = 0.005** **	**P = 0.006** **
Gazes to partner / head nods			
N positive differences	3	2	3
N negative differences	10	10	10
Smaller total of ranks	14	5	9
Two-tailed probability	**P = 0.026***	**P = 0.005** **	**P = 0.008** **

Table 1:
Comparisons of Frequencies and Alternations Between the Test Forward and All Other Conditions. Head Nods: extension of muzzle left/right or up/down; Head pointed to buck: neck stretched towards the buck. All given results are from Wilcoxon's tests and are two-tailed. Mean and standard deviation are indicated for each condition.

conditions (Table 1), thus satisfying operational criteria #1, #3 and #4. They also alternated head nods with gazes to the partner significantly more often during the FORWARD condition. We thus considered head nods not an instrumental signal of arousal, but an attention-getting behaviour with communicative function. Subjects used both head nods and neck stretched toward the buck more often in the FORWARD than in the BACK and the ALONE conditions, thus satisfying criteria #2, #3 and #4. In condition MANY, the frequency of head nods did not differ from condition FORWARD, probably because nods were directed to the additional partner behind the buck. This also satisfies criteria #4. The horses gazed to the partner most often in the FORWARD than in the BACK and the MANY conditions, but not in the ALONE. In this condition, subjects could observe the partner walking further from the test arena. To test for the different functions of gazes in presence and in absence of the partner, we compared their average duration between the two conditions: the significantly longer duration of gazes when the subject was alone suggests the instrumental monitoring function of gazes in this experimental condition.

Altogether, the findings suggest that domestic horses possess the ability to use referential communication in an interspecific context, but additional analyses are needed to test for operational criteria #5 and #6. Flexible and voluntary use of communicative signals reveal sophisticated cognitive processes involved in the strategic emission of these signals, and the finding of referential communication skills in an ungulate species forces us to reconsider the evolutionary path of intelligence. Furthermore, ungulates are used intensively by humans (transportation, meat, agriculture, leisure activities), and their welfare is often compromised. Determining whether ungulates can communicate their needs and preferences is paramount to a proper ethical management.

Key words: domestic horse, referential communication, human-horse communication, intentionality

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