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**Title:** Horses prefer to solicit a person who previously observed a food-hiding process to access this food: a possible indication of attentional state attribution

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## Abstract

Inferring what others witnessed provides important benefits in social contexts, but evidence remains scarce in nonhuman animals. We investigated this ability in domestic horses by testing whether they could discriminate between two experimenters who differed in what they previously witnessed and decide whom to solicit when confronted with an unreachable food source based on that information. First, horses saw food being hidden in a closed bucket (impossible for them to open) in the presence of two experimenters who behaved identically but differed in their attention to the baiting process (the “witness” experimenter faced the bucket, the “non-witness” faced away). Horses were then let free with both experimenters, and their interest towards each (gaze and touch) was measured. They gazed at and touched the witness significantly more than the non-witness ( $n = 15$ , gaze:  $p = 0.004$ ; touch:  $p = 0.003$ ). These results might suggest that horses inferred the attentional state of the experimenters during the baiting process and used this information to adapt their later behavior. Although further study would be necessary to conclude, our study provides new insight into attentional state attribution in horses and might hint to the existence of precursors of a Theory of Mind in horses.

**Keywords:** Horse, *Equus caballus*, Social cognition, Attentional state, Theory of Mind, Horse-human relationship

## Disclosure of potential conflicts of interest

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17 further study would be necessary to conclude, our study provides new insight into attentional  
18 state attribution in horses and might hint to the existence of precursors of a Theory of Mind in  
19 horses.

20

21 **1. Introduction**

22

23 Several nonhuman species exhibit outstanding sensitivity to the behavior of others  
24 (conspecifics or not; e.g., Call and Tomasello 2008; Drayton and Santos 2016; Meunier 2017;  
25 Keefner 2016; Kaminski et al. 2009; Maginnity and Grace 2014; Malavasi and Huber 2016).  
26 This sensitivity can provide important benefits: for instance, by inferring what others have  
27 witnessed an individual can maximize its access to food resources (e.g., by following a  
28 knowledgeable conspecific: Hirata and Matsuzawa 2001; by avoiding competition: Hare et al.  
29 2001; Marticorena et al. 2011; or by preventing pilfering: Bugnyar and Heinrich 2005).  
30 It is particularly interesting to study this sensitivity to the behavior of others in domestic  
31 animals because through the domestication process and their daily interactions, this behavior  
32 might also extend interspecifically to humans. For instance, horses (domesticated 6000 years  
33 ago; Levine 2005) have been shown to respond to human attention towards them (their

34 “attentional state”) to choose from whom to beg for food or by accordingly adapting their  
35 communication behavior (Krueger et al. 2011; Malavasi and Huber 2016; Maros et al. 2008;  
36 Proops and McComb 2010). In another study, a bucket, unreachable by horses, was filled with  
37 food either in the presence (witness condition) or absence (non-witness condition) of the  
38 animal’s caretaker (Ringhofer and Yamamoto 2016). When confronted with the caretaker in a  
39 second phase, the horses solicited the caretaker more in the non-witness condition. This  
40 difference in behavior in the two conditions might suggest that horses have adapted their  
41 behavior to what humans have previously witnessed. However, that might also be explained by  
42 the fact that, in the witness condition, horses had already solicited the caretaker (without  
43 success) during the first phase, which might have led to a reduced interest in the second phase.  
44 The question of whether horses can infer whether humans have or have not witnessed a scene  
45 thus remains unanswered. In our study, we addressed this question by investigating whether  
46 horses can use information about the attentional state of two experimenters (a witness and a  
47 non-witness) during an initial baiting process to adapt their subsequent begging behavior. We  
48 solved the potential confounding issue in the previous study by Ringhofer and Yamamoto  
49 (2016): in the present study, both experimenters were simultaneously present during the baiting  
50 process and acted identically. They differed only in their visual access to the baiting process  
51 during the first phase as the witness faced the bucket while the non-witness faced away.  
52 Moreover, we used a new set of individuals and doubled the sample size. Our hypothesis was  
53 that if horses were able to adapt their behavior to what the experimenters observed, they would  
54 show more interest (by increased gaze and touches) towards the witness than the non-witness in  
55 the second phase.

## 56 **2. Methods**

57

### 58 **2.1. Animals and apparatus**

59

60 We tested 19 adult saddle horses (age: mean  $\pm$  SE = 10  $\pm$  4 years old; 7 geldings, 11 mares and  
61 1 stallion) in a private stable in France. These were privately owned horses with various  
62 lifestyles, ridden several times a week. They were housed in individual stalls and fed three  
63 times a day with concentrates and hay. They were not food restricted for the experiment.

64 The horses were individually tested in a familiar indoor paddock covered with sand (Fig. 1).

65 All experiments involved the same two female experimenters (a witness and a non-witness)  
66 who were unfamiliar to the horses at the beginning of the experiment and were placed at two

67 predetermined points on each side of a fixed bucket (1 m away). Two assistants also  
68 participated in the experiment to handle the horse and place the food inside the bucket.

69

## 70 2.2. Procedure

71

72 Experiments were performed once (one control and one test trial per horse) and consisted of the  
73 following three consecutive steps.

74 1. Familiarization with the apparatus: The horse had a free habituation period of five minutes in  
75 the paddock containing an open, empty bucket.

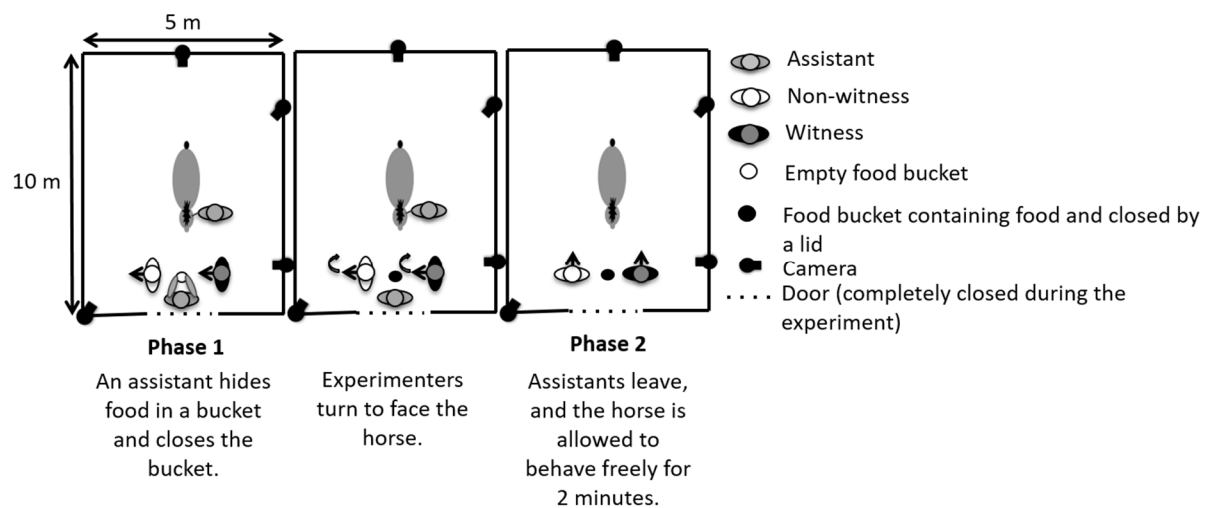
76 2. Control trial: Experiments always began with the control trial to check for the absence of a  
77 pre-existing arbitrary preference for a side of the bucket or an experimenter. The control trial  
78 consisted of two phases.

79 *Phase 1:* An assistant entered and held the horse at the center of the paddock, facing towards  
80 the empty bucket. The two experimenters then placed themselves on each side of the bucket  
81 with the witness facing the bucket and the non-witness facing away (Fig. 1). A second assistant  
82 entered the paddock, approached the horse with her hands behind her back and then stood  
83 behind the bucket until the end of phase 1. The witness and the non-witness displayed exactly  
84 the same gestures, looking straight ahead and slightly bowing so that the witness could pretend  
85 to pay attention to the actions of the second assistant. Which experimenter acted as witness and  
86 whether she was standing to the left or to the right of the bucket was counterbalanced among  
87 the horses.

88 *Phase 2:* The two experimenters turned to face the horse, and both stood still, looking at the  
89 ground and displaying a neutral posture and facial expression. The first assistant released the  
90 horse, and both assistants exited the paddock and stayed out of sight of the horse. The horse's  
91 behavior was then filmed for 120 s.

92 3. Test trial: The test trial was identical to the control trial except that, in phase 1, the second  
93 assistant approached the horse to show the food rewards and then put the food inside the bucket  
94 before closing the lid.

95



96  
 97 **Figure 1. Schematic representation of a trial.** During phase 1, an assistant was standing to the left of the horse, facing the bucket  
 98 but with his eyes on the ground so that he didn't know who/where the witness was.  
 99

100 2.3. Coding and statistical analyses

101  
 102 Video recordings were analyzed using BORIS software (v. 6.0.6; Friard and Gamba 2016).  
 103 We analyzed gaze duration (as defined in Ringhofer and Yamamoto 2016) during phase 2 for  
 104 both the control and test trials. This target behavior has been widely used in horses in person-  
 105 discrimination tasks (e.g., Lampe and Andre 2012; Malavasi and Huber 2016; Ringhofer and  
 106 Yamamoto 2016; Proops and McComb 2012) and was the most sensible among the different  
 107 variables used in the previous study (Ringhofer and Yamamoto 2016). All of the videos were  
 108 analyzed by two coders who were blind to the role of the experimenters (interobserver  
 109 reliability: ICC = 0.79; lower bound = 0.69, which is considered a good reliability: Koo and Li  
 110 2016). We used the arithmetic means of the gaze durations coded by the two coders for the  
 111 analyses. Additionally, the number of touches (physical contacts between the horse muzzle and  
 112 an experimenter) was recorded because this tactile signal has been proposed to be an attention-  
 113 seeking behavior in horses (Malavasi and Huber 2016; Ringhofer and Yamamoto 2016).  
 114 Touches were usually a brief pushing of the experimenter to attract attention; however, when  
 115 those were longer, we took this into account by counting a new occurrence every three seconds  
 116 if a horse continuously touched an experimenter for more than three seconds (the same  
 117 procedure was used, for instance, in Lansade et al., 2018).

118  
 119 Statistical analyses were performed with R 3.0.2 (R Core Team, 2013) with a significance  
 120 threshold of 0.05. To check for the absence of a pre-existing preference for a side or an

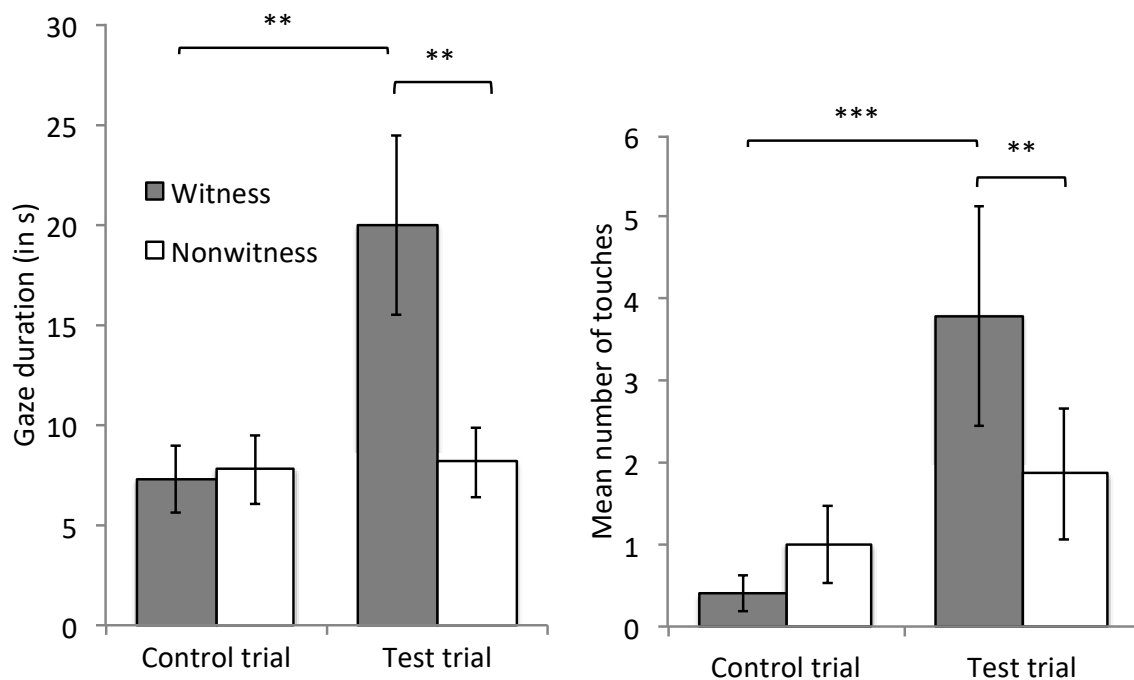
121 experimenter, a two-tailed binomial test was run that compared the gaze duration towards the  
122 witness during phase 2 of the control trial to that expected by chance (defined as:  
123  $\frac{\text{proportion of time spent looking at witness} + \text{proportion of time spent looking at non-witness}}{2}$ ). Four of  
124 our 19 horses showed a significant bias and were excluded from the experiment.  
125 The gaze duration was analyzed with a mixed linear model using the ‘lmer’ function in the  
126 lmerTest package (Kuznetsova et al., 2015). The mean number of touches was analyzed with a  
127 generalized linear mixed model with a Poisson distribution (as it was count data) using the  
128 same function. In both models, type of trial (test or control), role of the experimenter the horse  
129 was looking at (witness or non-witness), and their interaction effect were included as fixed  
130 effects. Trial number nested in the identity of the horse was added as a random effect. As the  
131 interaction between the trial and role was significant for both models, post hoc interaction  
132 analyses with a Bonferroni adjustment for the P-values were performed using the “test  
133 Interaction” function of the Phia package (De Rosario-Martinez et al., 2015). We checked the  
134 residuals graphically for normal distribution and homoscedasticity.

### 135 **3. Results**

136  
137 There was a significant interaction effect of trial by role ( $X^2 = 5.34$ ,  $p = 0.021$ ). The horses  
138 looked significantly longer at the witness than at the non-witness during the test trial (witness:  
139  $19.94 \pm 4.51$  s (mean  $\pm$  s.e.m), non-witness:  $8.12 \pm 1.78$  s;  $X^2 = 9.57$ ,  $p = 0.004$ ), but not during  
140 the control trial (witness:  $7.25 \pm 1.65$  s, non-witness:  $7.77 \pm 1.71$  s;  $X^2 = 0.02$ ,  $p = 1.000$ ).  
141 Similarly, horses looked significantly longer at the witness in the test compared to the control  
142 trial ( $X^2 = 11.03$ ,  $p = 0.002$ ) but there was no difference with the non-witness ( $X^2 < 0.01$ ,  $p =$   
143  $1.000$ ; Fig. 2).

144 There was a significant interaction effect of trial by role on the mean number of touches ( $X^2 =$   
145  $10.28$ ,  $p = 0.001$ ). The horses touched the witness significantly more times than the non-witness  
146 during the test trial (witness:  $4.00 \pm 1.43$ , non-witness:  $1.93 \pm 0.87$ ,  $X^2 = 9.90$ ,  $p = 0.003$ ) but  
147 not during the control trial (witness:  $0.36 \pm 0.22$ , non-witness:  $1.00 \pm 0.50$ ,  $X^2 = 3.75$ ,  $p =$   
148  $0.105$ ). They touched the witness significantly more during the test trial than during the control  
149 trial ( $X^2 = 28.70$ ,  $p < 0.001$ ), while this difference was not present with the non-witness ( $X^2 =$   
150  $3.97$ ,  $p = 0.093$ ; Fig. 2).





151

152 **Figure 2. Gaze duration and absolute number of touches (mean  $\pm$  s.e.m.) towards the witness and the non-witness.**  
 153 Significance was tested by a linear mixed model followed by post hoc interaction analysis with a Bonferroni adjustment: \*  $p <$   
 154 0.05, \*\*  $p <$  0.01, \*\*\*  $p <$  0.001.  $n = 14$  individuals.

155

#### 156 4. Discussion

157 Our results showed that horses can discriminate between an experimenter who faced a food-  
 158 hiding process and an experimenter who did not. Consistent with our hypothesis, the horses  
 159 looked at and touched the witness significantly more than the non-witness. Moreover, horses  
 160 interacted more with the witness when food was hidden in the bucket (in the test trials  
 161 compared to the control trials), suggesting that horses understood the food was unreachable and  
 162 solicited assistance.  
 163

164 The preference for the witness is unlikely to be explained by the behavior of the experimenters  
 165 since they both behaved identically. The use of learned associative rules specific to testing  
 166 design (such as the use of the eyes-to-object line proposed by Heyes 1994) can also be ruled  
 167 out as these horses had not been previously confronted with a similar test situation and the  
 168 experiment consisted of only one test trial. However, we cannot completely exclude that horses  
 169 used the target-directed behavior that the witness showed towards the bucket as a cue instead of  
 170 inferring the witness' attention towards the baiting (i.e., the witness slightly bowed towards the

171 bucket while the non-witness bowed facing away), although the horses did not show this bias in  
172 the control trials.

173 Previous studies (Proops and McComb 2010; Proops et al. 2013) had suggested that horses  
174 were able to infer the human attentional state, and this might have been the case in our study as  
175 well: horses might have inferred the attentional state of the experimenters towards the baiting  
176 process (and not only towards themselves, as it was the case in these other studies) and hence  
177 show more interest towards the witness later on. That horses might adapt their behavior to what  
178 a human had witnessed was already suggested by the results from Ringhofer and Yamamoto  
179 (2016). However, their results were counterintuitive as the horses actually solicited the non-  
180 witness more than the witness. In their experiment, the horses' caretaker was present during the  
181 baiting process in the witness (but not in the non-witness) condition. Thus, the horses might  
182 have begged the caretaker for the food with no success during baiting and could have  
183 interpreted that the caretaker had no intention to help them get the food, which might explain  
184 their results. Here, the two experimenters were present during the entire trial and behaved  
185 similarly, and the horses reacted as predicted, showing more interest in the witness who was  
186 more likely to help them access the food.

187 That the horses would have inferred what the experimenters witnessed in our experiment seems  
188 plausible considering the long evolutionary history horses share with humans and that many  
189 horses (including our test subjects) interact daily with them. In that sense, a high sensitivity to  
190 human behavior—either by innate or by acquired mechanisms—is likely to be a crucial issue  
191 for domestic horses and was, for instance, observed in the case of Clever Hans (Pfungst and  
192 Rahn 1911). It would be interesting in future studies to investigate the effect of the relationship  
193 between the horses and humans (e.g., the level of training of the horse) and of their age on their  
194 sensitivity to human behavior.

195 In conclusion, and consistent with our hypothesis, we found that horses preferred an  
196 experimenter who witnessed a food-hiding process over a non-witness when they needed  
197 assistance accessing a food source. Hence, although further study would be necessary to draw  
198 this conclusion, horses might have inferred the attentional state of human experimenters  
199 towards a baiting event and used this information to accordingly act at a later time. These  
200 results might hint at the existence of precursors of a Theory of Mind (i.e., mental state  
201 attribution, Call and Tomasello 2008) in horses and call for further study with horses in this  
202 research area.

203

204 **Compliance with ethical standards**

205  
206 All applicable international, national, and/or institutional guidelines for the care and use of  
207 animals were followed. All procedures performed in studies involving animals were in  
208 accordance with the ethical standards of the institution or practice at which the studies were  
209 conducted.

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219 **References**

220

221 Bugnyar, T., Heinrich, B., 2005. Ravens, *Corvus corax*, differentiate between knowledgeable  
222 and ignorant competitors. *Proc. R. Soc. B Biol. Sci.* 272, 1641–1646.

223 <https://doi.org/10.1098/rspb.2005.3144>

224 Call, J., Tomasello, M., 2008. Does the chimpanzee have a theory of mind? 30 years later.

225 *Trends Cogn. Sci.* 12, 187–192. <https://doi.org/10.1016/j.tics.2008.02.010>

226 De Rosario-Martinez, H., Fox, J., R Core Team, 2015. Post-Hoc Interaction Analysis.

227 Drayton, L.A., Santos, L.R., 2016. A decade of theory of mind research on cayo santiago:

228 Insights into rhesus macaque social cognition. *Am. J. Primatol.* 78, 106–116.

229 <https://doi.org/10.1002/ajp.22362>

230 Friard, O., Gamba, M., 2016. BORIS: a free, versatile open-source event-logging software for

231 video/audio coding and live observations. *Methods Ecol. Evol.* 7, 1325–1330.

232 <https://doi.org/10.1111/2041-210X.12584>

233 Hare, B., Call, J., Tomasello, M., 2001. Do chimpanzees know what conspecifics know? *Anim.*

234 *Behav.* 61, 139–151. <https://doi.org/10.1006/anbe.2000.1518>

235 Heyes, C.M., 1994. Cues, convergence and a curmudgeon: A reply to Povinelli. *Anim. Behav.*

236 <https://doi.org/10.1006/anbe.1994.1234>

237 Hirata, S., Matsuzawa, T., 2001. Tactics to obtain a hidden food item in chimpanzee pairs (*Pan*

238 *troglodytes*). *Anim. Cogn.* 4, 285–295. <https://doi.org/10.1007/s100710100096>

239 Kaminski, J., Bräuer, J., Call, J., Tomasello, M., 2009. Domestic dogs are sensitive to a

240 human's perspective. *Behaviour* 146, 979–998.

241 <https://doi.org/10.1163/156853908X395530>

242 Keefner, A., 2016. Corvids infer the mental states of conspecifics. *Biol. Philos.* 31, 267–281.

243 <https://doi.org/10.1007/s10539-015-9509-8>

244 Koo, T.K., Li, M.Y., 2016. A Guideline of Selecting and Reporting Intraclass Correlation

245 Coefficients for Reliability Research. *J. Chiropr. Med.* 15, 155–63.

246 <https://doi.org/10.1016/j.jcm.2016.02.012>

247 Krueger, K., Flauger, B., Farmer, K., Maros, K., 2011. Horses (*Equus caballus*) use human

248 local enhancement cues and adjust to human attention. *Anim. Cogn.* 14, 187–201.

249 <https://doi.org/10.1007/s10071-010-0352-7>

250 Kuznetsova, A., Brockhoff, P.B., Christensen, R.H.B., 2015. lmerTest: Tests for random and

251 fixed effects for linear mixed effect models.

252 Lampe, J.F., Andre, J., 2012. Cross-modal recognition of human individuals in domestic horses

253 (*Equus caballus*). *Anim. Cogn.* 15, 623–630. <https://doi.org/10.1007/s10071-012-0490-1>

254 Lansade, L., Nowak, R., Lainé, A.L., Leterrier, C., Bonneau, C., Parias, C., Bertin, A., 2018.

255 Facial expression and oxytocin as possible markers of positive emotions in horses. *Sci.*

256 *Rep.* 8, 1–11. <https://doi.org/10.1038/s41598-018-32993-z>

257 Levine, M.A., 2005. Domestication and early history of the horse, in: Mills, D., McDonnell, S.

258 (Eds.), *The domestic horse: the evolution, development and management of its behaviour.*

259 Cambridge University Press, Cambridge, pp. 5–22

260 Maginnity, M.E., Grace, R.C., 2014. Visual perspective taking by dogs (*Canis familiaris*) in a

261 Guesser–Knower task: evidence for a canine theory of mind? *Anim. Cogn.* 17, 1375–

262 1392. <https://doi.org/10.1007/s10071-014-0773-9>

263 Malavasi, R., Huber, L., 2016. Evidence of heterospecific referential communication from

264 domestic horses (*Equus caballus*) to humans. *Anim. Cogn.* 19, 899–909.

265 <https://doi.org/10.1007/s10071-016-0987-0>

266 Maros, K., Gácsi, M., Miklósi, Á., 2008. Comprehension of human pointing gestures in horses

267 (*Equus caballus*). *Anim. Cogn.* 11, 457–466. <https://doi.org/10.1007/s10071-008-0136-5>

268 Martcorena, D.C.W., Ruiz, A.M., Mukerji, C., Goddu, A., Santos, L.R., 2011. Monkeys

269 represent others' knowledge but not their beliefs. *Dev. Sci.* 14, 1406–1416.  
270 <https://doi.org/10.1111/j.1467-7687.2011.01085.x>  
271 Meunier, H., 2017. Do monkeys have a theory of mind? How to answer the question? *Neurosci.*  
272 *Biobehav. Rev.* 82, 110–123. <https://doi.org/10.1016/j.neubiorev.2016.11.007>  
273 Pfungst, O., Rahn, C.L., 1911. *Clever Hans (the horse of Mr. von Osten) a contribution to*  
274 *experimental animal and human psychology.* New York.  
275 Proops, L., McComb, K., 2012. Cross-modal individual recognition in domestic horses (*Equus*  
276 *caballus*) extends to familiar humans. *Proc. R. Soc. B Biol. Sci.* 279, 3131–3138.  
277 Proops, L., McComb, K., 2010. Attributing attention: the use of human-given cues by domestic  
278 horses (*Equus caballus*). *Anim. Cogn.* 13, 197–205.  
279 Proops, L., Rayner, J., Taylor, A.M., McComb, K., 2013. The Responses of Young Domestic  
280 Horses to Human-Given Cues. *PLoS One* 8, 26–28.  
281 <https://doi.org/10.1371/journal.pone.0067000>  
282 Ringhofer, M., Yamamoto, S., 2016. Domestic horses send signals to humans when they face  
283 with an unsolvable task. *Anim. Cogn.* 20, 397–405. [https://doi.org/10.1007/s10071-017-](https://doi.org/10.1007/s10071-017-1074-x)  
284 [1074-x](https://doi.org/10.1007/s10071-017-1074-x)  
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