Human head orientation and eye visibility as indicators of attention for goats (*Capra hircus*)

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Animals domesticated for working closely with humans (e.g. dogs) have been shown to be remarkable in adjusting their behaviour to human attentional stance. However, there is little evidence for this form of information perception in species domesticated for production rather than companionship. We tested domestic ungulates (goats) for their ability to differentiate attentional states of humans. In the first experiment, we investigated the effect of body and head orientation of one human experimenter on approach behaviour by goats. Test subjects (N = 24) significantly changed their behaviour when the experimenter turned its back to the subjects, but did not take into account head orientation alone. In the second experiment, goats (N = 24) could choose to approach one of two experimenters, while only one was paying attention to them. Goats preferred to approach humans that oriented their body and head towards the subject, whereas head orientation alone had no effect on choice behavior. In the third experiment, goats (N = 32) were transferred to a separate test arena and were rewarded for approaching two experimenters providing a food reward during training trials. In subsequent probe test trials, goats had to choose between the two experimenters differing in their attentional states. Like Experiment 1 and 2, goats did not show a preference for the attentive person when the inattentive person turned her head away from the subject. In this last experiment, goats preferred to approach the attentive person compared to a person who closed their eyes or covered the whole face with a blind. However, goats showed no preference when one person covered only the eyes. Our results show that animals bred for production rather than companionship show differences in their approach and choice behaviour depending on human attentive state. However, our results contrast with previous findings regarding the use of the head orientation to attribute attention and show the importance of cross-validating results.

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18 **Abstract**

19 Animals domesticated for working closely with humans (e.g. dogs) have been shown to be

20 remarkable in adjusting their behaviour to human attentional stance. However, there is little

21 evidence for this form of information perception in species domesticated for production rather than

22 companionship. We tested domestic ungulates (goats) for their ability to differentiate attentional

23 states of humans. In the first experiment, we investigated the effect of body and head orientation

24 of one human experimenter on approach behaviour by goats. Test subjects (N = 24) significantly

25 changed their behaviour when the experimenter turned its back to the subjects, but did not take

26 into account head orientation alone. In the second experiment, goats (N = 24) could choose to

27 approach one of two experimenters, while only one was paying attention to them. Goats preferred

28 to approach humans that oriented their body and head towards the subject, whereas head

29 orientation alone had no effect on choice behavior. In the third experiment, goats (N = 32) were

30 transferred to a separate test arena and were rewarded for approaching two experimenters

31 providing a food reward during training trials. In subsequent probe test trials, goats had to choose

32 between the two experimenters differing in their attentional states. Like Experiment 1 and 2, goats

33 did not show a preference for the attentive person when the inattentive person turned her head

34 away from the subject. In this last experiment, goats preferred to approach the attentive person

35 compared to a person who closed their eyes or covered the whole face with a blind. However,

36 goats showed no preference when one person covered only the eyes. Our results show that

37 animals bred for production rather than companionship show differences in their approach and

38 choice behaviour depending on human attentive state. However, our results contrast with

39 previous findings regarding the use of the head orientation to attribute attention and show the

40 importance of cross-validating results.

41

42

43 **Introduction**

44

45 Body and head orientation are an important component of social interaction and the ability to

46 recognise different attentive states of conspecific or heterospecifics yields adaptive advantages

47 in the contexts of predation, deception or cooperation (Emery, 2000). For example, gaze directed

48 towards an individual might be considered as threat and elicit anti-predator response (Kummer,

49 1967). American crows (*Corvus brachyrhynchos)* have been shown to adjust their behaviour

50 based on human gaze (Clucas et al., 2013). When an experimenter approached the subjects,

51 crows fled sooner when the person was directly gazing at them compared to when gaze was

52 averted. Jackdaws (*C. monedula)* showed similar avoidance behavior during an approach task.

53 When an unfamiliar human paid attention to them, their time to approach a reward was higher

54 compared to when the unfamiliar human looked away or had its eyes closed (von Bayern &

55 Emery, 2009). Beausoleil et al. (2006) investigated whether human staring altered the behaviour

56 of domestic sheep (*Ovis aries*) compared with no human eye contact. They found that sheep

57 glanced at the staring human's face more often and showed higher levels of locomotor activity.

58 However, researchers did not find differences in fear-related behaviours. Research on wild and

59 captive primates have shown that when they have the opportunity to steal from one of two

60 experimenters, Rhesus monkeys (*Macaca mulatta*) and several species of lemurs choose to take

61 food from an experimenter who was not looking at the reward (Flombaum & Santos, 2005; Sandel,

62 MacLean & Hare, 2011). Being habituated to humans and knowing that people regularly deliver

63 food, individuals might opt to position themselves to be seen by humans or to choose a person

64 that pays attention towards them, expecting to receive a food reward or one with less delay. When

65 they have to make a choice, captive chimpanzees (*Pan troglodytes*) have been found to prefer to

66 beg from an attentive rather than an inattentive person (Bulloch, Boysen & Furlong, 2008).

67

Dogs (*Canis familiaris*) are assumed to be specifically attuned to human cues due to their domestication history as companion animals (Hare et al., 2002). For example, they show great sensitivity to human communicative cues, such as human pointing and gazes, to find a reward in an object choice task (Agnetta, Hare & Tomasello, 2000; Riedel et al., 2008). In these tasks, subjects have to choose between two or more containers while only one is containing food (Miklósi & Soproni, 2006). However, domestic goats have also been shown to use a basic human pointing gesture, but nor head direction or gazes, to find a reward in this task (Kaminski et al., 2005; Nawroth, von Borell & Langbein, 2015). Similar findings have been obtained for other domestic species, such as cats, *Felis catus*, (Miklósi et al., 2005), horses, *Equus caballus*, (Proops, Walton & McComb, 2010; Proops et al., 2013). Dogs are also able to comprehend more complex gestures and can distinguish whether information is intended for them (Kaminski, Schulz & Tomasello, 2012; Lakatos et al., 2012). They are also sensitive to the attentional stance of humans. When not allowed to obtain a reward in front of them, they disobeyed faster when the human was distracted or not looking at the dog (Call et al., 2003). When dogs had to choose between either a person that was looking at them versus a person that had turned their back to them, dogs approached the attentive experimenter (Udell, Dorey & Wynne, 2011). But here again, horses (Proops & McComb, 2010) and pigs, *Sus scrofa*, (Nawroth, Ebersbach & von Borell, 2013) have been shown to express similar preferences.

We investigated the ability of goats to perceive information from human attentional states. Using a food-anticipating paradigm, Nawroth et al. (2015, 2016) found that goats adapted their anticipation behaviour depending on the presence or absence of an experimenter in general and his/her head and body orientation in particular. In these experiments, an experimenter remained for 30 seconds in an assigned posture before delivering a reward to the tested subject, and the goats' active anticipation and standing alert behaviour were analysed. The level of subjects' active anticipatory behaviour was highest when the experimenter looked in the direction of the test

94   subject, and decreased with a decreasing level of attention paid to the subject by the

95   experimenter. Additionally, goats 'stared' (i.e., stood alert) at the experimental setup for

96   significantly more time when the experimenter was present but had his head and/or body directed

97   away from the subject. However, due to previous training, it was not clear if simple conditioned

98   responses were responsible for the goats' change in behaviour (Proops & McComb, 2010).

99   Subjects may have learned that a certain posture of the experimenter (head and body oriented

100   towards subject) would yield a reward.

101

102   To cross-validate and extend these previous findings on goats' ability to differentiate between

103   human attentive states, we examined the approach and choice behaviour of goats towards

104   humans who were paying different degrees of attention to them. In an important contrast to

105   previous research on goats, these approach and choice tasks involved little or no task-related

106   learning prior to the actual test. In Experiment 1, goats had the opportunity to approach either an

107   attentive or inattentive person and their approach behavior (i.e. if they preferred to move into the

108   'attention window' of the human) was examined. We expected goats to move around the

109   experimenter when the person was not paying attention towards them. Being aware that both

110   behavioural outcomes (moving around the human or not) require different amounts of energetic

111   costs, we subjected goats to additional choice experiments. In Experiment 2 and 3, goats had to

112   choose between an attentive versus an inattentive person. While Experiment 2 involved no

113   training and spontaneous choice behavior in the field, Experiment 3 was conducted in a separate

114   test arena to control in more detail for environmental factors. Being familiar with human presence,

115   we expected subjects to choose in a cooperative manner (i.e. choose the human that was paying

116   attention to them) because this would decrease a delay in potential reward delivery or grooming

117   events.

118 **Animals, materials & methods**

119

120 **Ethical Note**

121

122 Animal care and all experimental procedures were in accordance with the ASAB/ABS Guidelines

123 for the Use of Animals in Research (Association for the Study of Animal Behaviour, 2016). The

124 study was approved by the Animal Welfare and Ethical Review Board committee of Queen Mary

125 University of London (Ref. QMULAWERB032015). All measurements were non-invasive, and the

126 experiment lasted no more than 10 min for each individual goat. If the goats had become

127 distressed, the test would have been stopped.

128

129 **Subjects, housing and general procedure**

130

131 The experiments were carried out at Buttercups Sanctuary for Goats, UK

132 (http://www.buttercups.org.uk). Goats were fully habituated to human presence because of

133 previous research (e.g. Baciadonna et al., 2016; Nawroth, Brett & McElligott, 2016). They were

134 aged 2-14 years and of various breeds. Routine care of the animals was provided by sanctuary

135 employees and volunteers. The goats had ad libitum access to hay and were not food restricted

136 before testing. Subjects were tested from 12:00-16:00 in June - August 2015.

137

138 **Experiment 1: Approach behaviour in the field**

139

140 Experiment 1.1: Body orientation

141

142 *Procedure*

143   The experimenter approached a focal subject that was separated from other groups by about 5-

144   10 m. He then proceeded to get its attention by calling 'Come here'. As soon as the goat

145   approached, a trial started. When the goat approached to about 2 m from the experimenter, the

146   person either stayed with his front and head oriented towards the subject ('front') or turned 180

147   degrees ('back'). During both conditions, the hands of the experimenter were oriented away from

148   the subject (behind the experimenter's back in the 'front' condition; in front of experimenter in the

149   'back' condition). A total of 29 trials were conducted. Five goats had to be excluded because they

150   stopped approaching the experimenter, leaving 24 successful approach trials. Twelve subjects

151   received the 'front' condition and the other 12 subjects received the 'back' condition. Goats were

152   never rewarded during trials.

153

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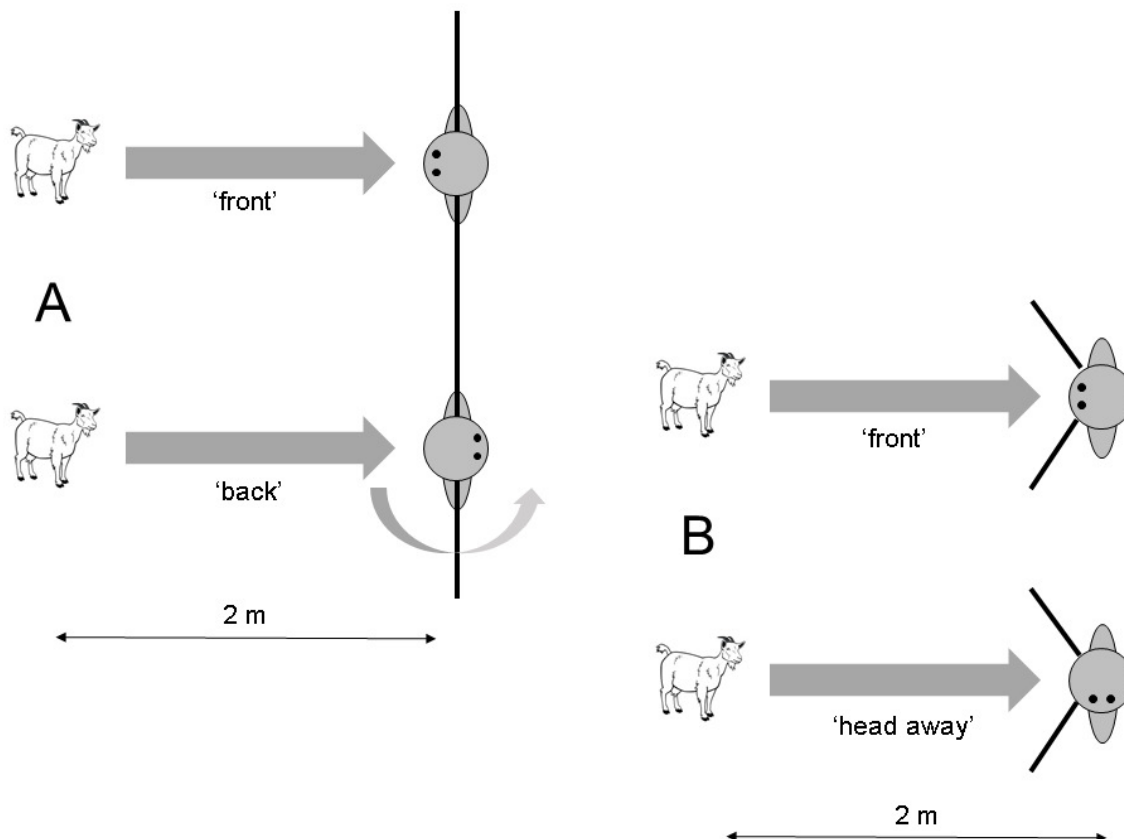
155   **Figure 1**. Setup of the approach task in a) Experiment 1.1 and b) Experiment 1.2. The black lines

156   close to the experimenter indicate threshold lines that were used to define a specific approach

157   behaviour. If a subject did not cross the line (and thus remained in front of it), it was scored as

158   'front approach'. If it crossed the line, it was scored as 'behind approach' (Experiment 1.1) or 'side

159   approach' (Experiment 1.2).

160

161   *Data scoring and analysis*

162   Approach behaviour of the goats was scored live. After a goat approached the experimenter to

163   approximately 1 m, the experimenter scored the behaviour of the goats during the following 5

164   seconds. If a goat crossed the midline of the experimenter during these 5 seconds with its head

165   (threshold line; Figure 1a), this was scored as a 'behind approach'. If the goat remained in front

166   of the threshold line during these five seconds, this was scored as 'front approach'. Fisher's exact

167   test was used to compare the amount of both approach behaviours in the two different conditions.

168

169   *Results*

170   A strong difference in the approach behaviour between the two conditions was found for the 'front

171   approach'. Whereas all 12 subjects in the 'front' condition stayed in front of the threshold line for

172   5 s, only two out of 12 subjects did so in the 'back' condition (Fisher's exact test: N = 24; *P* <

173   .0001). Whereas none of the subjects in the 'front' condition crossed the threshold line (Figure

174   1a), all 10 subjects in the 'back' condition that did not stay in front of the midline moved around

175   the human by crossing the threshold line during the duration of 5 s ('back approach').

176

177   Experiment 1.2: Head orientation

178

179 Experiment 1.1 showed that goats alter their approach behaviour depending on whether a human

180 is orienting his front or back towards the subjects. Using a similar setup, we here investigated

181 whether goats also alter their behaviour depending only on the head orientation of a human.

182

183 *Procedure*

184 The experimenter approached a focal subject that was separated from other groups by about 5-

185 10 m. He then proceeded to get its attention by calling 'Come here'. As soon as the goat

186 approached, a trial started. When the goat approached as close as 2 m towards the experimenter,

187 he either kept his front and head oriented towards the subject ('front') or turned his head 90

188 degrees to the left or right ('head away'), respectively (Figure 1b). During both conditions, the

189 hands of the experimenter were behind his back to avoid inadvertently cueing the tested subject.

190 A total of 27 trials were conducted. Three goats had to be excluded because they stopped

191 approaching the experimenter, leaving 24 successful approach trials. Twelve subjects received

192 the 'front' condition and the other 12 subjects received the 'head away' condition. Head orientation

193 in the 'head side' condition was counterbalanced for the left and right side. Goats were never

194 rewarded during trials.

195

196 *Data scoring and analysis*

197 Approach behaviour of the goats was scored live. Because goats often moved in front of the

198 human when not rewarded instantly, we used a slightly different criterion compared to Experiment

199 1a. In this experiment, the experimenter scored the behaviour of the goats in their initial approach

200 orientation. If the goats approached the experimenter in the middle, this was scored as 'front

201 approach'. If the goats approached the experimenter from the left or the right side by crossing a

202 threshold line with an angle of about 90 degrees on each side of the experimenter, this was scored

203 as 'side approach' (Figure 1b). Fisher's exact test was used to compare the amount of both

204 approach behaviours in the two different conditions.

205

206   *Results*

207   There was no difference in approach behaviour between the two conditions. Eleven of 12 subjects

208   in the 'front', and 8 out of 12 in the 'head away' condition approached the experimenter from the

209   front and not the side (Fisher's exact test: N = 24; P = .32). From the four subjects that approached

210   the side of the experimenter in the 'head away' condition, only two did so for the same side the

211   experimenter was facing. Notably, none of the goats instantly moved behind the experimenter to

212   approach his hands in order to receive food.

213 **Experiment 2: Choice behaviour in the field**

214

215 In Experiment 1.2, goats did not differ in their approach behaviour when a human experimenter

216 was looking at them compared to when he was looking to the side. However, goats may have just

217 avoided additional movement or preferred to remain in front of the experimenter because they

218 previously experienced humans moving their head frequently while living at the study site.

219 Therefore, we conducted a second experiment, in which the energetic effort for indicating a

220 preference for either an attentive or a non-attentive person was equal. In Experiment 2, we used

221 a modified test paradigm to cross-validate the findings from Experiment 1. In this experiment, we

222 used two experimenters, one paying attention to the subject while another one remained

223 inattentive. Goats were free to approach either of the experimenters.

224

225 Experiment 2.1: Body orientation

226

227 *Procedure*

228 Two experimenters approached a focal subject that was separated from other groups by about 5

229 – 10 m and took position (see Figure 2a). They then proceeded to get its attention by calling

230 'Come here'. As soon as the goat approached, a trial started. When the goat approached as close

231 as 4 m to the experimenters, one experimenter turned his/her back towards the subject whereas

232 the other experimenter remained with his/her body and head oriented to the subject. Side and

233 identity of the attentive person was assigned in a pseudo-randomised manner. A total of 29 trials

234 were conducted. Five goats had to be excluded because they stopped approaching the

235 experimenter or their choice was ambiguous, e.g. standing in the middle of both experimenters,

236 leaving 24 successful approach trials. Goats were never rewarded during trials.

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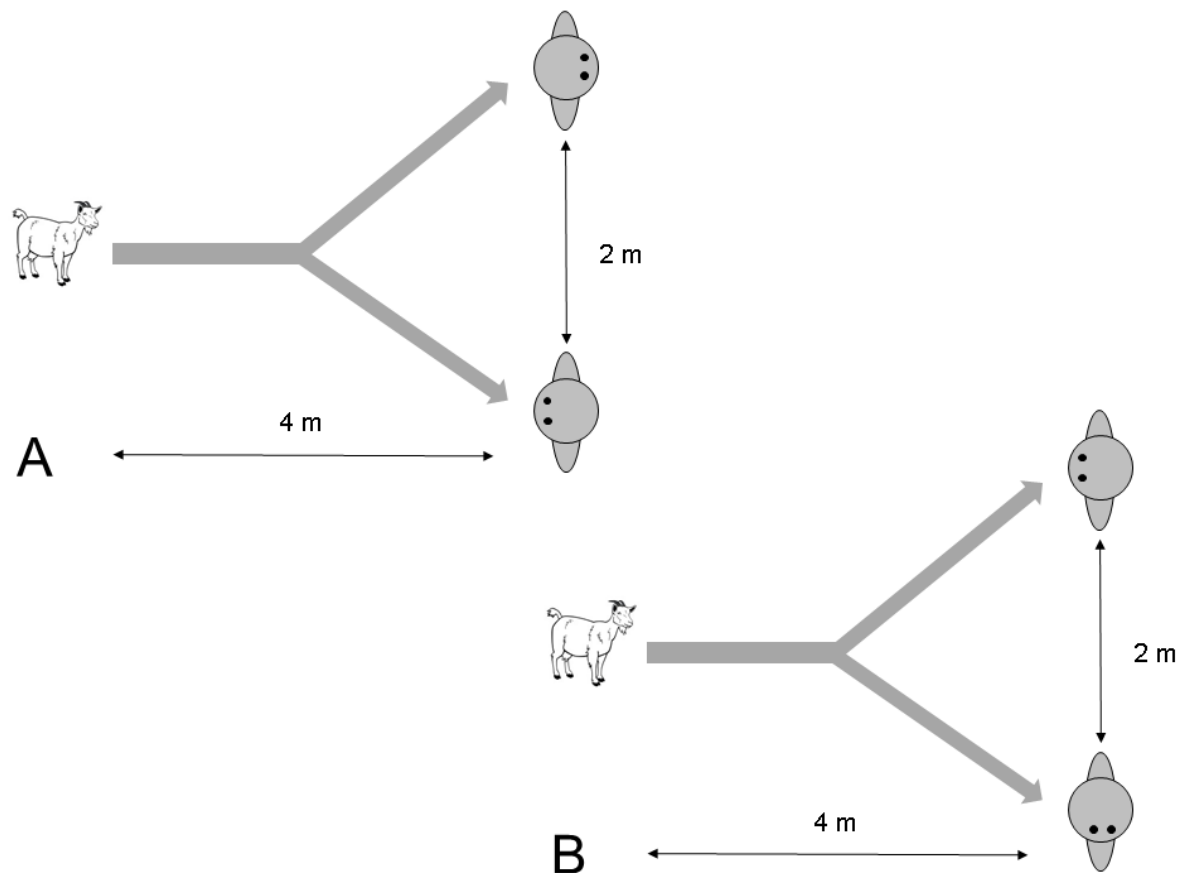
239 **Figure 2**. Setup of the choice task in a) Experiment 2.1 and b) Experiment 2.2. After a test subject

240 started to approach the experimenters from a distance of about 4m, one of them either turned

241 his/her body (Experiment 2.1) or head (Experiment 2.2) away from the subject.

242

243 *Data scoring and analysis*

244 Behaviour of the goats was recorded live. If a goat approached the attentive person, this choice

245 was scored as 'correct'. Both experimenters had to agree that the focal subject approached one

246 of them. Approach behaviour was unambiguous in all trials. To analyze preferences in the choice

247 behaviour of goats, a binomial test was conducted in which the number of approaches to the

248 attentive person was compared to chance level (50%).

249

250 *Results*

251   Goats showed a preference for the attentive experimenter (n = 24; K = 22; P < 0.001, two-tailed).

252   There was no side preference (n = 24; K = 14; P > 0.5, two-tailed) and no preference for one of

253   the experimenters (n = 24; K = 14; P > 0.5, two-tailed).

254

255   Experiment 2.2: Head orientation

256

257   *Procedure*

258   Two experimenters approached a focal subject that was separated from other groups by about 5

259   – 10 m and took position (see Figure 2b). They then proceeded to get its attention by calling

260   'Come here'. As soon as the goat approached, a trial started. When the goat approached as close

261   as 4 m to the experimenters, one experimenter turned his/her head away from the subject

262   whereas the other experimenter remained with his/her head oriented to the subject. All other

263   conditions were the same as in Experiment 2.1. A total of 30 trials were conducted. Six goats had

264   to be excluded because they stopped approaching the experimenter or their choice was

265   ambiguous, e.g. standing in the middle of both experimenters, leaving 24 successful approach

266   trials. Goats were never rewarded during trials.

267

268   *Data scoring and analysis*

269   Same as in Experiment 2.1.

270

271   *Results*

272   Goats showed no preference for either the attentive or the non-attentive experimenter (n = 24; K

273   = 13; P = 0.83, two-tailed). There was no side preference (n = 24; K = 15; P > 0.3, two-tailed) and

274   no preference for one of the experimenters (n = 24; K = 13; P > 0.5, two-tailed).

275

276   Experiment 2.3: Hand orientation

277

278   In Experiment 2.1., we could not rule out hand orientation as a confounding factor and thus

279   conducted a control experiment to investigate if the position of the hands (front or back) influenced

280   the choice behaviour of the goats.

281

282   *Procedure*

283   Two experimenters approached a focal subject that was separated from other groups by about 5

284   - 10 m and took position. They then proceeded to get its attention by calling 'Come here'. As soon

285   as the goat approached, a trial started. When the goat approached as close as 4 m to the

286   experimenters, both remained with their body and head oriented forward, while one experimenter

287   placed his/her hands towards his/her back, whereas the hands of the other experimenter

288   remained in front. All other conditions were the same as in Experiment 2.1. A total of 17 trials

289   were conducted. Five goats had to be excluded because they stopped approaching the

290   experimenter or their choice was ambiguous, e.g. standing in the middle of both experimenters,

291   leaving 12 successful approach trials. Goats were never rewarded during trials.

292

293   *Data scoring and analysis*

294   Same as in Experiment 2.1.

295

296   *Results*

297   Goats showed no preference for either experimenter presenting the hands or the experimenter

298   covering the hands (n = 12; K = 7; P = 0.77, two-tailed). There was no side preference (n = 12; K

299   = 9; P > 0.1, two-tailed) and no preference for one of the experimenters (n = 12; K = 7; P > 0.5,

300   two-tailed).

Experiment 3: Choice behaviour in a controlled setting

In Experiment 1 and 2, goats showed a preference for humans that oriented their body and head, but not head only, towards them. The negative results for differentiating the head orientation may be a product of confounding factors that may have influenced decision making of the goats in the previous experiments, e.g. distracting factors like environmental noise and nearby conspecifics, or their specific motivation to approach the human. Because subjects could move freely, we were not able to control for environmental disturbances and the position of conspecifics, which may have biased their decision making. In terms of their motivation, we could not exclude whether goats approached humans for other reasons than to receive a reward. For example, goats sometimes rubbed themselves against the experimenter's clothing (pers. obs.), which would only require the presence but not the attention of the human. To account for this, we conducted a third and last experiment in a controlled setting. Prior to testing, subjects received food rewards while they were trained to approach two human experimenters. During test trials, subjects had the opportunity to approach one of two experimenters; one paid attention while the other was either orienting her head away from the subject or closed her eyes (Proops & McComb, 2010; Nawroth, Ebersbach & von Borell, 2013). In addition, we investigated whether goats understand the role of occlusion, by either holding a big blind in front of the face or a small blind in front of the eyes of one of the two experimenters (Flombaum & Santos, 2005).

Procedure

The experiment was carried out in a temporary test arena, which we set up within the normal daytime range of the goats. Goats were individually transferred to a test arena. During training trials, the subject was brought to the start position at the entrance of the arena, held on a leash. Two experimenters were positioned 4 m away from the starting point, kneeling, at the other side of the arena. When both experimenters took position, the goat was released from the leash and

327   was free to approach the experimenters and to receive the reward that they offer. To prevent the

328   goats developing a preference for one of the experimenters, the reward was administered jointly

329   by crossing over their arms and holding out their hands together with a piece of food (pasta) in

330   the middle of both of their hands. The experimenters also swapped sides between each trial.

331   Eighteen subjects were given an introductory training phase in which experimenters faced

332   forwards when giving a reward ('attentive training', Figure 3a). Another 18 goats received a

333   different training phase in which the experimenters were not attentive to the subjects and adopted

334   body postures that were not repeated in the test trials ('non-attentive training', Figure 3b). In this

335   phase, the experimenters kneeled at 90 degrees from the subject facing each other with their

336   hands outstretched together and a reward held in their hands. If necessary, goats were brought

337   on a leash to the experimenters in the first training trial. If subjects did not approach the

338   experimenter after 1 min, a training trial was aborted. After a maximum of five training trials, all

339   but four goats instantly and reliably approached the experimenters and thus proceeded to the test

340   trials.

341

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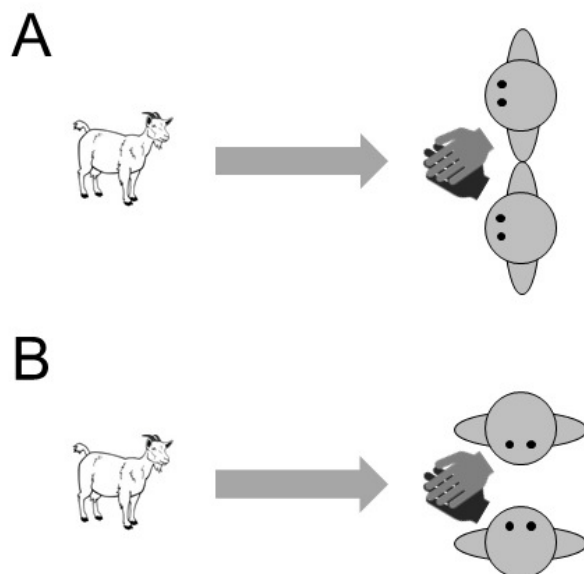
343   **Figure 3.** Images of the two training conditions in Experiment 3 a) attentive training b) non-

344   attentive training. A reward was administered jointly by both experimenters by crossing over their

345   arms and holding out their hands together with a piece of food (pasta) in the middle of both of

346   their hands

347

348   The procedure was the same as in the training trials, except that each experimenter took place in

349   a separate corner of the arena at 5 m from the starting point and 2.5 m away from each other.

350   Both experimenters differed in their degree of attention towards the subject. While one

351   experimenter paid attention to the goat, the other one had her attention oriented away from the

352   subject or her visual access was occluded. Four different test conditions were administered

353   (Figure 4):

354

355   A) Head away – both experimenters oriented their bodies to the front while one looked to the front,

356   whereas the other one turned her head away

357   B) Eyes closed – both experimenters oriented their bodies and heads to the front, while one closed

358   her eyes and the other remained with eyes open

359   C) Covered head – both experimenters oriented their bodies and heads to the front, while one

360   covered the whole face and the other covered the chest with a blind (28 cm x 24 cm)

361   D) Covered eyes – both experimenters oriented their bodies and heads to the front, while one

362   covered the eyes and the other covered the mouth with a blind (28 cm x 11 cm)

363

364   Each subject received one session of testing included four test trials, one for each condition.

365   Conditions were counterbalanced for side (left/right) and experimenter (E1/E2). Goats were never

366   rewarded during test trials. To ensure motivation, goats received a rewarded training trial after

367   each test trial (delivered by the same experimenters as the initial training trials).

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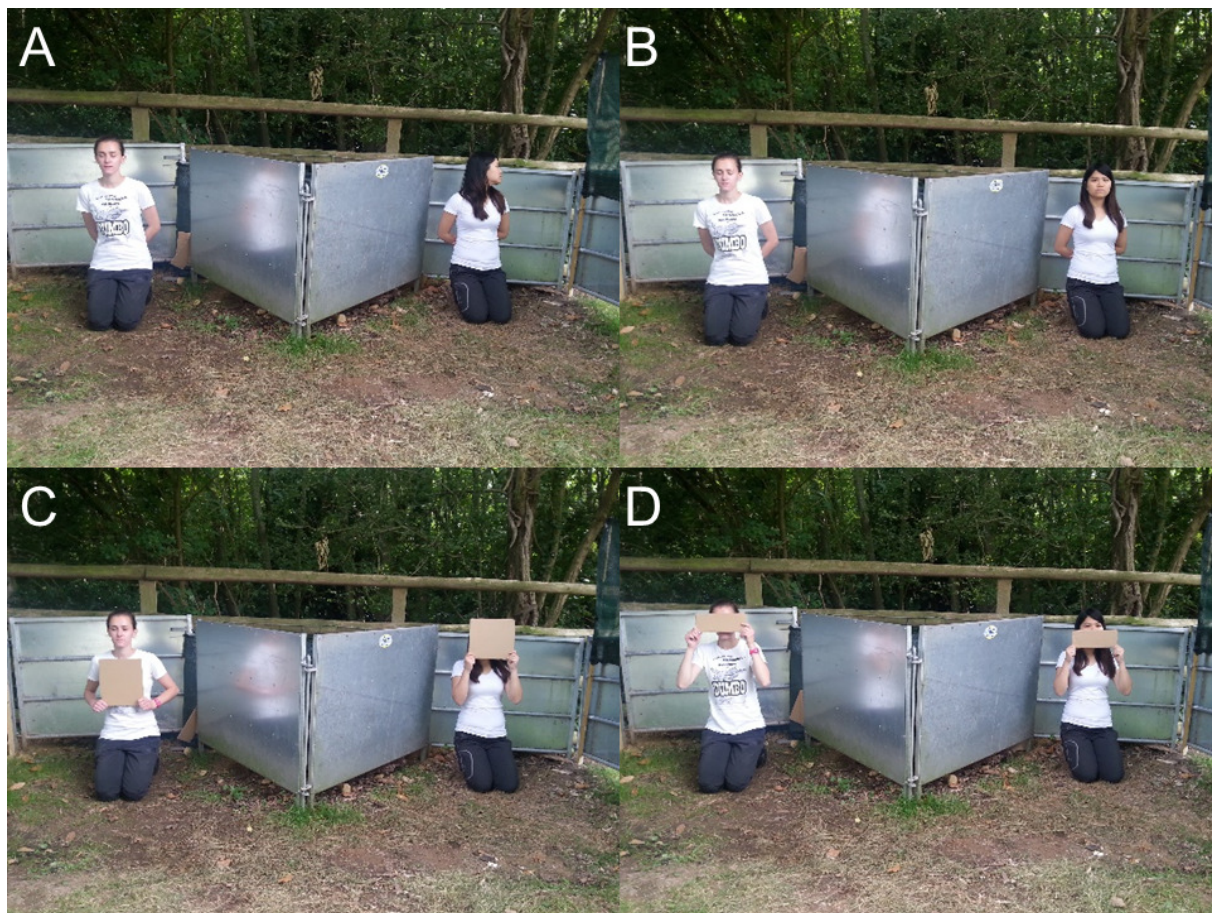

370   **Figure 4.** Images of the different test conditions in Experiment 3 a) Head away b) Eyes closed c)

371   Covered head d) Covered eyes.

372

373   *Data scoring and analysis*

374   Trials were scored live and were video recorded (Sony DCR-SX33E camcorder). We analysed

375   goat choice and latency to approach. Latency times were defined as the time between a subject's

376   first step from the starting position and the time it approached one of the two experimenters. An

377   approach was defined as the goat getting as close as 15 cm to one of the experimenters with the

378   head raised towards them. A second observer coded 25% of the test trials. Inter-observer

379   reliability for choice (Cohen´s k = 1.00) and latency to approach (Spearman rank correlation; r_s =

380   0.948; P < 0.001) was excellent. Preference for the attentive or the non-attentive person, effect

381   of experimenter identity and side preferences were calculated using the binomial test for choice

382   behaviour of goats. Effects of goat sex and of the different warm-up types on choice behaviour

383   were analysed using Fishers Exact Test. Data for latency times were positively skewed and so

384   were log$_{10}$ transformed. The potential effects of condition and response accuracy

385   (correct/incorrect) on the latency to approach an experimenter were analysed as fixed factors in

386   a Linear Mixed Model. Alpha level was set at 0.05 in all comparisons.

387

388   *Results*

389   Four subjects had to be excluded because they did not reliably approach the experimenters after

390   5 training trials. This left 16 subjects with the attentive and 16 subjects with the inattentive training.

391   One of the subject showed a strong side bias in all trials and was therefore excluded from further

392   analysis. One subject did not make any choice after 1 min in the 'Head away' and 'Eyes closed'

393   condition, another subject did not respond in time in the 'Covered head' condition. The training

394   procedure, with either attentive or non-attentive experimenters, had no significant effect in any of

395   the test conditions (Table 1). In test trials, goats did not show a preference for the attentive person

396   when the other person looked away from the subject ('Head away'; n = 30; K = 16; P = 0.856,

397   Figure 5). There was a significant preference for the attentive person compared to the one that

398   closed their eyes ('Eyes closed'; n = 30; K = 21; P = 0.043, Figure 5). In addition, goats preferred

399   to approach the attentive person compared to a person that covered the face with a blind

400   ('Covered head'; n = 30; K = 23; P = 0.005, Figure 5), but not when the other person was covering

401   the eyes ('Covered eyes'; n = 31; K = 18; P = 0.473, Figure 5). We found no effect of sex (Fisher's

402   Exact Test; P = 0.83), experimenter identity (n = 121; K = 68; P = 0.2) or side (n = 121; K = 63; P

403   = 0.72) on choice behaviour of goats. Latency times to approach an experimenter did not vary as

404   a function of performance ($F_{1,110}$ = 1.173; P = 0.281) or condition ($F_{3,106}$ = 0.610; P = 0.610). No

405   interaction effect was found ($F_{3,106}$ = 1.987; P = 0.120).

406

407

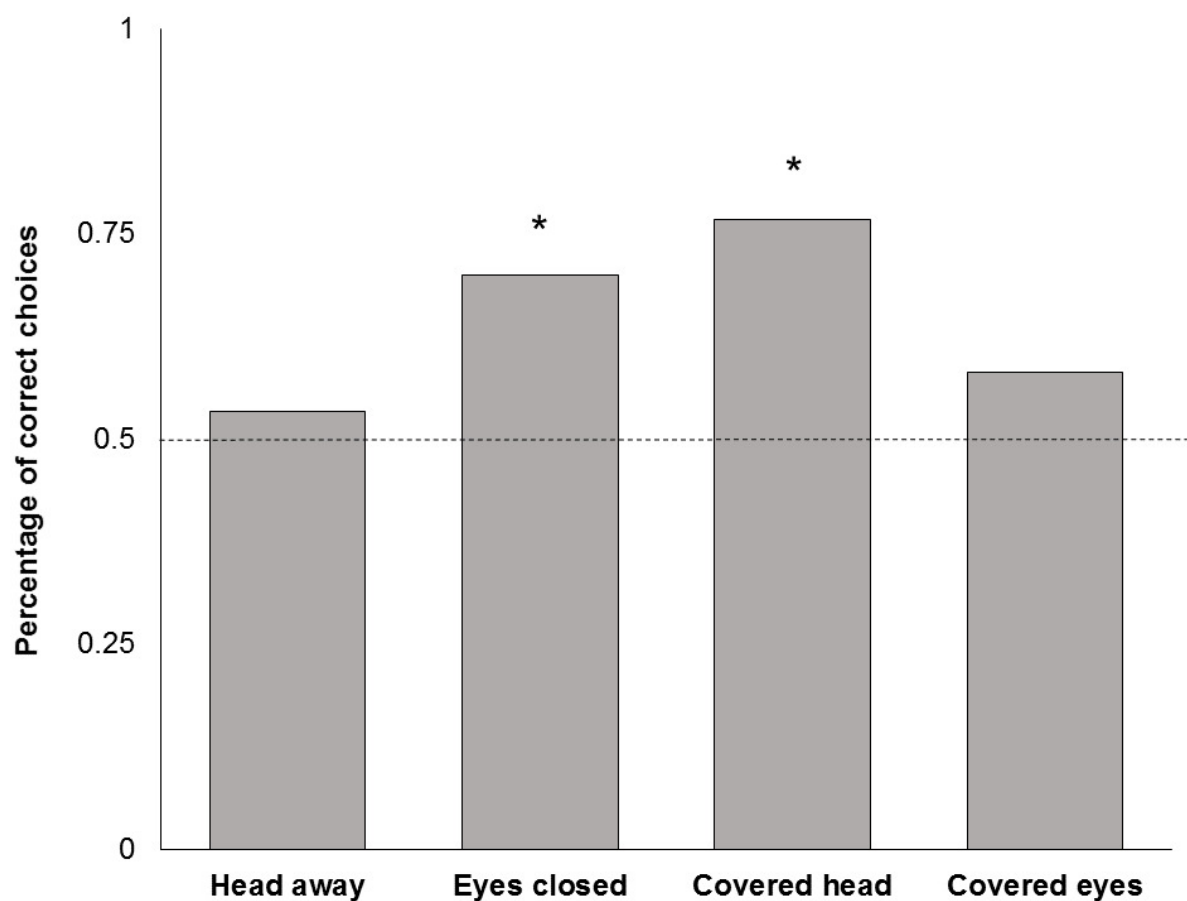
408

409 **Table 1**. Comparison of absolute and relative choices of goats for attentive humans given the

410 different training trials with either attentive or non-attentive experimenters

Condition	Attentive training		Non-attentive training		FET (*P*)
Head away	6/14	43%	10/16	63%	0.46
Eyes closed	11/14	79%	10/16	63%	0.44
Covered head	11/15	73%	12/15	80%	1.00
Covered eyes	8/15	53%	10/16	63%	0.72
Total	36/58	62%	42/63	67%	0.70

411

412

413 **Figure 5.** Relative number of choices for the attentive person by goats in the four test conditions.

414 * P < 0.05 (binomial test, two-tailed)

415

416 **Discussion**

417

418 In a series of three experiments, we investigated whether domestic goats that are habituated to

419 human presence show a preference to approach an attentive compared to a non-attentive person.

420 Experiment 1 and 2 took advantage of the general approach behaviour of goats towards humans

421 at the study site. The results of these experiments show that goats actively try to position

422 themselves where a human is likely to notice them, and prefer to approach an experimenter who

423 orients his/her body towards them. However, they showed no preference in their approach and

424 choice behaviour when only the head orientation was given as a cue for the attentional stance.

425 Experiment 3 was conducted in a more controlled setting and confirmed the lack of preference

426 when only the head orientation of a human was altered. In addition, goats in this last experiment

427 preferred to approach a person whose face was not occluded and whose eyes were not closed,

428 indicating that they rely on cues other than head orientation when attributing attention. Contrary

429 to previous studies in horses and pigs that reported an effect of test condition and/or performance

430 on approach latencies (Proops & McComb, 2010; Nawroth, Ebersbach & von Borell, 2013), we

431 did not find a difference in the approach times of goats in our experiment. Our results show that

432 animals domesticated for production rather than companionship show differences in their

433 approach and choice behaviour depending on human attentive states (Hare et al., 2002; Nawroth,

434 Brett & McElligott, 2016).

435

436 Contrary to previous research, all three experiments indicate that goats do not pay attention to

437 the head direction of a human experimenter. While it has been shown that goats decrease their

438 anticipatory behaviour in a food-anticipation paradigm when a person is directing their head away

439 from them (Nawroth, von Borell & Langbein, 2015, 2016), we could not find behavioural

440 differences in our subjects. It is possible that this non-preference might be due to their specific

441 experience with humans. Goats at our study site interact with humans on a daily basis and are

442   used to receiving food directly, although the human head is not necessarily in the direction of the

443   goat at that time. This might have altered their general anticipation of receiving food when

444   approaching humans that differ in their attentional stance. Alternatively, goats may not have

445   interpreted the human with its head turned away as an 'inattentive' subject. Goats, as animals

446   with laterally positioned eyes, might still be able to pay attention to events and subjects even

447   though their head is averted from those. Thus, head orientation might not be a reliable cue of

448   attention for goats and other ungulates. This explanation is partially in line with the finding that

449   goats can use human pointing gestures, but not human head orientation, to find a hidden food

450   reward (Kaminski et al., 2005; Nawroth, von Borell & Langbein, 2015).

451

452   The first two experiments showed that goats evaluate the body orientation of the experimenter

453   when approaching a human or choosing between two experimenters. A control test showed that

454   goats do not simply prefer to approach the experimenter whose hands were visible. Our results

455   validate previous findings in similar experiments on goats (Nawroth, von Borell & Langbein, 2015;

456   Nawroth, Brett & McElligott, 2016), which show that goats alter their behaviour depending on

457   human body orientation. Body orientation is a more salient cue than head orientation alone

458   (Emery, 2000). Similar results have been obtained for dogs (Call et al., 2003) and primates

459   (Flombaum & Santos, 2005; Bourjade et al., 2014).

460

461   Although goats did not alter their behaviour depending on head orientation, they preferred to

462   approach a human that was not covering her face behind a blind. This indicates that, although

463   the head direction might not be taken into account when making a choice, the human head itself

464   conveys crucial information for goats (Tate et al., 2006). However, goats did not prefer to

465   approach the person that was not covering her eyes with small blinds. It is possible that this lack

466   of preference might be because both experimenters partially covered their faces with the small

467   blinds (eyes vs mouth), and thus leading to an indifferent choice in our test subjects.

468

469 Goats preferred to approach humans that had their eyes open vs closed, while the visibility vs-

470 non-visibility of the area of the eyes did not alter their behaviour. This is a rather unexpected

471 result, given their insensitivity to the head orientation in the same experiment. Several primate

472 species (Flombaum & Santos, 2005; Bourjade et al., 2014), but also dogs (Udell, Dorey & Wynne,

473 2011) and horses (Proops & McComb, 2010), have been found to be sensitive to open vs closed

474 eyes of human. However, all these studies showed also that subjects considered the human head

475 orientation as crucial when attributing attention. It is possible that our subjects were distracted by

476 the small blinds, paying more attention to the blind rather than to the eye visibility. Goats might

477 also have been sensitive to the eyes closed, but not to the eyes covered, because the previous

478 reflects a more naturalistic setting. Future studies need to further examine when and how evaluate

479 eye visibility.

480

481 In conclusion, our results provide evidence that species domesticated for production are sensitive

482 to subtle human cues, such as whether eyes are open or closed. Our lack of evidence for goats'

483 interpretation of human head orientation as a cue to their attentional stance demands further

484 evaluation. We propose that ontogenetic factors such as previous experience with humans might

485 play a crucial role in the development of human-directed behaviour.

486

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