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The Role of Past Interactions in Great Apes' Communication About Absent Entities

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## PAST INTERACTIONS IN APE COMMUNICATION

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35

36 **Abstract**

37 Recent evidence suggests that great apes can use the former location of an entity to  
38 communicate about it. In this study we built on these findings to investigate the social  
39 cognitive foundations of great apes' communicative abilities. We tested whether great  
40 apes (n = 35) would adjust their requests for absent entities to previous interactions  
41 they had with their interlocutor. We manipulated the apes' experience with respect to  
42 the interlocutor's knowledge about the previous content of the now empty location, as  
43 well as their experience with the interlocutor's competence to provide additional food  
44 items. We found that apes adjusted their requests to both of these aspects but failed to  
45 integrate them with one another. These results demonstrate a surprising amount of  
46 flexibility in great apes' communicative abilities while at the same time suggesting  
47 some important limitations in their social communicative skills.

48 **Keywords:** communication; common ground; displacement; social cognition; great  
49 apes

50

### Introduction

51           Communication is a social endeavour. Human communication is a social-  
52 *cognitive* endeavour in that humans interpret and produce signals in the light of the  
53 common ground they share with their interlocutor (Clark, 1996; Sperber & Wilson,  
54 2001; Tomasello, 2008). This way of communicating enables a great deal of  
55 flexibility but it entails a considerable degree of cognitive complexity. For example,  
56 by pointing to an empty red chair one could communicate such diverse things as  
57 “This is the colour I want for my kitchen table” or “Where did Petra go?”. In order to  
58 ask about the whereabouts of Petra the pointer has to consider whether the receiver  
59 knows that somebody was sitting on the chair a minute ago as well as whether she  
60 knows that the pointer is looking for someone. This information has to be part of the  
61 common ground between the interlocutors to make the pointing gesture meaningful.  
62 To form common ground, interlocutors have to interact with one another. On the basis  
63 of these interactions humans attribute psychological states such as knowledge, beliefs  
64 or competencies to one another and subsequently consider them in communicative  
65 interactions.

66           Human infants engage in communicative interactions that suggest sensitivity  
67 to common ground from their first birthday onwards. They interpret ambiguous verbal  
68 utterances or pointing gestures depending on how they interacted with the speaker  
69 before (Liebal, Behne, Carpenter, & Tomasello, 2009; Moll & Tomasello, 2007;  
70 Saylor & Ganea, 2007; Tomasello & Haberl, 2003). Slightly older children also adjust  
71 their own communicative acts to the prior interactions with their interlocutor (Liebal,  
72 Carpenter, & Tomasello, 2010). The extent to which non-human animals also rely on  
73 common ground for communication is often debated (Leavens et al., 2015; Moore,  
74 2013; Scott-Phillips, 2015b; Tomasello, 2008) but rarely addressed empirically.

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75 Common ground is one source that specifies the intended referent of an utterance and  
76 it is therefore important in the discussion whether animal signals have (non-natural)  
77 meaning in the same way as human signals do (Grice, 1957; Hobaiter & Byrne, 2014;  
78 Moore, 2015; Scott-Phillips, 2015a).

79         Great apes display some abilities that are important prerequisites to use  
80 common ground in communication. They are known to be flexible and intentional  
81 communicators who adapt their communication to the present social context (Call &  
82 Tomasello, 2007; Hobaiter & Byrne, 2011; Leavens, Russell, & Hopkins, 2005).  
83 During communicative interactions with conspecifics, chimpanzees adjust their  
84 gestures to the attentional state of their recipient by actively moving into the line of  
85 sight of the recipient or resorting to tactile gestures (Call & Tomasello, 2007; Liebal,  
86 Call, & Tomasello, 2004; Liebal, Call, Tomasello, & Pika, 2004). In a similar way, all  
87 great ape species prefer to beg food from a human who is attending to them  
88 (Kaminski, Call, & Tomasello, 2004; Tempelmann, Kaminski, & Liebal, 2011).  
89 Outside the realm of communication there is evidence showing that chimpanzees  
90 prefer to approach food items that a competitor cannot see or has not seen (Hare, Call,  
91 Agnetta, & Tomasello, 2000; Hare, Call, & Tomasello, 2001; Karg, Schmelz, Call, &  
92 Tomasello, 2015) suggesting that they expect their competitor to act based on what  
93 she sees or has seen in the immediate past. However, the question is whether great  
94 apes adjust their own communication depending on what the partner has seen in the  
95 immediate past. Recent evidence suggests that this indeed the case. Crockford and  
96 colleagues (2012) found that wild chimpanzees emitted alarm calls depending on  
97 whether or not they witnessed group members receiving information about the  
98 presence of a predator.

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99 All the studies reported above are concerned with tracking interactions that  
100 happened in the immediate past. What about information about others derived from  
101 long term interactions? Woodruff and Premack (1979) confronted chimpanzees with  
102 two humans who would, when informed about hidden food, either hand it over to the  
103 subject (cooperative) or take it away (competitive). The competitive human wore a  
104 distinct outfit and behaved in a hostile way toward the chimpanzees outside the  
105 experiment. Subjects initially failed to withhold information from the competitive  
106 human but eventually learned to do so after a substantial amount of training.  
107 However, the long training period suggests that, instead of ascribing enduring  
108 characteristics to a person, subjects learned to inhibit communication in the presence  
109 of a human wearing the competitive outfit.

110 To sum up, there is ample evidence that great apes adjust their behavior to  
111 their partner's psychological states (e.g. seeing or knowing). Furthermore, there is at  
112 least some evidence apes adjust their own communication to these psychological  
113 states if they are the consequence of a relatively recent interaction. However, it is not  
114 clear if they are able to take into account characteristics of others deduced from more  
115 distant interactions with them. Furthermore, to our knowledge, there is no study that  
116 has systematically investigated if great apes are able to integrate two different  
117 psychological states of another individual in a communicative interaction.

118 A powerful way to investigate the role of common ground in non-linguistic  
119 communication is by studying pointing to absent entities. Language-trained apes have  
120 been reported to use tokens, lexigrams or gestures to refer to absent referents (e.g.  
121 Gardner, Gardner, & Van Cantfort, 1989; Premack & Premack, 1983; Savage-  
122 Rumbaugh, McDonald, Sevcik, Hopkins, & Rubert, 1986) and to point to occluded  
123 objects (Menzel, 1999; Roberts, Vick, Roberts, & Menzel, 2014). However, in the

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124 case of pointing to absent entities, the referent is not present, neither visible nor  
125 occluded, in the moment it is communicated about (see also Lyn et al., 2014 for this  
126 distinction). The interlocutors have to rely on past interactions in which both of them  
127 jointly witnessed the presence of the referent. Recently, Liszkowski, Schäfer,  
128 Carpenter, and Tomasello (2009) tested whether 12-month old human infants and  
129 chimpanzees use pointing to communicate about absent entities. In this study, the  
130 non-verbal subjects had the opportunity to point to the previous location of a now  
131 absent object to request more of it. The underlying assumption was that doing so  
132 requires the subject to keep track of the relevant common ground, in this case the  
133 former content of the location, they share with the individual they request from.  
134 Whereas this study found that only human infants communicate about absent entities,  
135 two subsequent studies found that apes do so as well (Bohn, Call, & Tomasello, 2015;  
136 Lyn et al., 2014). However, even though these studies rely on it for the explanation of  
137 their results, none of them investigated common ground or its prerequisites directly. It  
138 is unclear whether apes base their communicative acts on the psychological states  
139 they attribute to others as a consequence of interacting with them. For example, in a  
140 situation as described above, apes should refrain from pointing to the empty location  
141 in a situation in which their interlocutor doesn't know about the former content of the  
142 location. Or they should not point in a situation in which the interlocutor lacks the  
143 competence to provide additional objects.

144 To address these issues, we modified the methodology established by Bohn et  
145 al. (2015). They presented subjects with two plates from which apes could request  
146 food items by pointing. The type of food presented in both plates was either of the  
147 same quality (both high quality: HQ or both low quality: LQ) or of different quality  
148 (one HQ and one LQ). During test trials, one plate still contained food while all items

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149 from the other plate had already been requested. In general, subjects preferred to point  
150 to the remaining visible food items instead of the empty plate. More importantly  
151 however, whenever subjects pointed to the empty plate they did so in a highly  
152 systematic way. Apes ignored the otherwise desirable visible food item and pointed to  
153 the empty plate only when the visible food item was of lower quality compared to the  
154 absent items. This result showed that apes requested *specific* absent entities. We  
155 adjusted this procedure to test whether apes would further adjust their communication  
156 about absent entities to the knowledge and competence of their interlocutor. Even  
157 though this setup does not allow us to investigate full-blown common ground (i.e. the  
158 sharedness of the psychological states in question)—it tests whether apes consider the  
159 necessary prerequisites to form common ground and thereby allows us to determine  
160 the evolutionary origins of the ability in question.

161         We presented apes with two plates containing food items of different quality.  
162 As soon as all items from one plate were requested, the experimenter left the room  
163 and, after a short delay, the same or a different experimenter returned. To investigate  
164 the role of the experimenter’s knowledge we tested whether apes would point to the  
165 empty plate differently depending on whether or not the returning experimenter had  
166 seen what was on the plate previously (predictor: *see*). To investigate the role of the  
167 experimenter’s competence, we tested whether apes would point to the empty plate  
168 differently depending on whether the experimenter did or did not bring additional  
169 food items in an earlier interaction (predictor: *bring*). If apes would consider both of  
170 these predictors, this would be good evidence that they evaluate the prior interactions  
171 with the experimenter for their relevance in the on-going communicative interaction.  
172 This in turn would suggest that some important prerequisites to form common ground  
173 are evolutionary ancient. Furthermore, by varying the experimenter’s knowledge and

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174 competence at the same time, we were able to investigate whether apes are able to  
175 integrate different aspects of previous interactions.

### 176 **Method**

#### 177 *Subjects*

178 We tested 35 non-human great apes (*Gorilla gorilla*, *Pan troglodytes*, *Pongo*  
179 *abellii*, *Pan paniscus*) housed at the Wolfgang Köhler Primate Research Center at Zoo  
180 Leipzig, Germany. All apes participated in an earlier study using the same setup  
181 (Bohn et al., 2015). Four apes completed only parts of the experiment (see Table S1  
182 in the supplemental material). Participation was voluntary, apes were never food  
183 deprived and water was available ad libitum throughout the experiment. Research was  
184 non-invasive and strictly adhered to the legal requirements of Germany. Animal  
185 husbandry and research complied with the EAZA Minimum Standards for the  
186 Accommodation and Care of Animals in Zoos and Aquaria and the WAZA Ethical  
187 Guidelines for the Conduct of Research on Animals by Zoos and Aquarium.

#### 188 *Setup*

189 Apes were presented with two identical plates on a table in front of a Plexiglas  
190 window (see Figure 1). They could request food items placed on these plates one by  
191 one from an experimenter seated on the other side of the table by pointing with their  
192 finger through a hole in front of the respective plate. The experimenter handed the  
193 items over through a third hole in the middle of the panel.

194

195 --- *Insert Figure 1* ---

196

#### 197 *Procedure*

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198           Each session comprised two phases, the warm-up phase and the test phase (see  
199 Figure 1). During the warm-up phase both plates were baited with three food items on  
200 each plate. As soon as the subject requested all food items from one plate, the  
201 experimenter left the room. After a ten second delay the test phase began with the  
202 return of an experimenter. During the test phase, one plate contained food items  
203 whereas the other was empty. Subjects were allowed to request further items by either  
204 pointing to the plate containing food or the empty plate. The session ended if the  
205 subject a) pointed to the empty plate, b) requested all remaining visible food items or  
206 c) did not point for 90s. If the subject pointed to the empty plate, the experimenter left  
207 the room and retrieved one more item of the kind that was previously on that plate.  
208 The maximum number of points per session was one for the empty plate and three for  
209 the visible alternative.

210           Following Bohn et al. (2015) there were two different conditions with respect  
211 to the baiting of the plates. In the *same* condition, both plates contained the same food  
212 type (HQ = grapes or LQ= pieces of apple or carrot) and in the *different* condition the  
213 plates contained different food types (one HQ and the other LQ) resulting in 4  
214 different constellations (Table S2 in supplemental material shows the different baiting  
215 constellations). We made sure that the LQ food was desirable for the apes when  
216 presented on its own. If apes were specific in their requests for absent entities, they  
217 should point to the empty plate more often in the *different* condition (Bohn et al.,  
218 2015).

219           All apes participated in another study comprising the same setup and the same  
220 E1 immediately prior to the current experiment (Bohn et al., 2015). In this study E1  
221 repeatedly re-baited the plates with food and thereby demonstrated that he was able to  
222 bring new food items. However, apes were never trained to point to empty plates

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223 during this study. We introduced a novel E2 with whom apes never interacted in a  
224 similar way before (see supplemental material for details). If the same experimenter  
225 returned in the test phase as was present in the warm-up phase she had seen the food  
226 on the now empty plate: *see(+)*, if a different experimenter returned she had not:  
227 *see(-)*. If the returning experimenter was E1, he had demonstrated his ability to bring  
228 more food before: *bring(+)*, if it was E2, she had not: *bring(-)*. This resulted in four  
229 different configurations (see Figure 1). For each of these configurations, each subject  
230 received one session in the *same* condition and one session in the *different* condition,  
231 resulting in eight test sessions per individual. For each unique combination of  
232 condition and configuration, subjects received only a single test session.

233         The order of sessions was counterbalanced across subjects. Due to a two-  
234 month hiatus half way through the study apes received additional training sessions  
235 before the second half of the experiment. In these training sessions apes requested  
236 food items presented on a single plate from E1 who re-baited the plate multiple times  
237 with the same kind of food. Importantly, subjects were never rewarded for pointing to  
238 an empty plate during training sessions (see supplemental material for details on  
239 counterbalancing and the training procedure).

240         In order to point to the empty plate apes had to disregard an otherwise  
241 desirable food item. We therefore expected a rather low rate of pointing to empty  
242 plates. However, this alternative option is crucial to draw conclusions about the  
243 psychological processes underlying subjects' behaviour. In the absence of an  
244 alternative, apes might consider the relevant aspects of prior interactions with the  
245 experimenter but point to the empty plate nevertheless, simply because they have  
246 nothing else to do (see Bohn et al., 2015 for theoretical and empirical support for the  
247 necessity of an alternative option).

248 *Coding and analysis*

249           For each trial in the test-phase we coded whether subjects pointed or not,  
250 through which hole the subject pointed and whether the subject requested absent food  
251 items or not. We defined pointing in the following way: the subject inserted one or  
252 more fingers into *one* of the holes in the Plexiglas panel so that they protruded on the  
253 other side. We did not code as pointing if the subject simultaneously inserted fingers  
254 into more than one hole at the same time or if subjects inserted a finger while E was  
255 not present. A second coder, blind to the purpose of the study, coded a random  
256 selection of 25% of test-trials. There was a very high agreement of 98.81% between  
257 the two coders ( $\kappa = .98$ ).

258           We used generalized linear mixed models (GLMM) with a binomial error  
259 structure to analyse if the binary response (point to absent or not) was influenced by  
260 condition and the different configurations. All models were fitted in R (R Core Team,  
261 2012) using the function *glmer* of the R-package *lme4* (Bates, Maechler, & Bolker,  
262 2012). We used likelihood ratio tests (LRT) to assess whether the inclusion of  
263 predictors and their interactions improved the general fit of a model to the data by  
264 comparing models with and without the respective effects (Dobson & Barnett, 2008).  
265 All models comprised subject ID as a random effect to account for repeated testing of  
266 the same individuals.

267 **Results**

268           We observed a total number of 665 points during test sessions. 639 points  
269 were directed at visible food items and 26 points were directed at the empty plates. As  
270 expected, the rate of pointing to empty plates was low because apes chose the visible  
271 alternative instead (see Bohn et al., 2015 for similar results and supplemental material  
272 for details). Nevertheless, we observed a sufficient number of points to empty plates

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273 to investigate whether they were influenced by the experimental manipulations. Points  
274 to the empty plate were distributed in the following way: 18 points occurred in the  
275 *different* condition, 16 of which were directed at the plate that previously contained  
276 HQ food items. Eight occurred in the *same* condition, five of which in sessions with  
277 LQ food on both sides. The number of points to empty plates did not increase across  
278 test sessions. On the contrary, it decreased across test sessions (see supplemental  
279 material for details). Figure 2 shows how these points were distributed across the  
280 different configurations. In trials in which apes did not point to the empty plate they  
281 pointed to the visible alternative in 99% of trials when E1 had returned and in 97% of  
282 trials when E2 had returned. There was no significant difference in the rate of  
283 pointing in general between E1 and E2 (Wilcoxon signed ranks test,  $T^+ = 253.5$ ,  $p =$   
284  $.12$ ).

285

286 --- Insert Figure 2 ---

287

288 A model comprising condition as a fixed within subject effect fitted the data  
289 significantly better compared to a null model lacking it (LRT:  $\chi^2(1) = 4.54$ ,  $p = .033$ ;  
290 GLMM estimate:  $\beta = 0.99$ , 95% CI = [0.08: 2.00]). Apes pointed to the empty plate  
291 more often in the *different* than in the *same* condition. This finding replicates the  
292 result of Bohn et al. (2015) and adds to evidence that apes' points to empty plates  
293 follow a systematic pattern. The inclusion of sex, species and session as fixed effects  
294 did not improve the model fit significantly and these predictors were therefore  
295 dropped for the subsequent analysis (LRT:  $\chi^2(5) = 5.28$ ,  $p > .250$ ). To determine  
296 whether the previous interactions with the experimenter further influenced apes'  
297 pointing to empty plates we added *see*, *bring* and the interactions with condition up to

298 the third order as fixed within subject effects. Inclusion of these predictors  
299 significantly improved the model fit compared to the model only comprising  
300 condition (LRT:  $\chi^2(6) = 22.14, p = .001$ ). This result shows that apes' requests for  
301 absent entities were influenced by the previous interactions with the experimenter.

302 Subsequently, we investigated the contribution of *see* and *bring* to this result  
303 in more detail by looking at the three-way interaction between condition, *see* and  
304 *bring*. This interaction was not significant (LRT:  $\chi^2(1) = 0.37, p > .250$ ). We therefore  
305 removed the three-way interaction and looked at the two-way interactions among  
306 condition, *see* and *bring*. We found a significant interaction between condition and  
307 *bring* (LRT:  $\chi^2(1) = 5.49, p = .019$ ; GLMM estimate:  $\beta = 2.62, 95\% \text{ CI} = [0.44:$   
308  $5.08]$ ). Apes pointed more often to an empty plate in the *different* condition if the  
309 returning experimenter provided additional food items in previous interactions. In  
310 contrast, we found no effect of the interactions between condition and *see* (LRT:  $\chi^2(1)$   
311  $= 0.05, p > .250$ ) or *see* and *bring* (LRT:  $\chi^2(1) = 0.02, p > .250$ ). After excluding the  
312 non-significant two-way interactions we found a main effect of *see* (LRT:  $\chi^2(1) =$   
313  $4.97, p = .026$ ; GLMM estimate:  $\beta = 1.12, 95\% \text{ CI} = [0.13: 2.24]$ ). Apes pointed more  
314 often to an empty plate if the experimenter had previously seen the content of the  
315 plate.

### 316 Discussion

317 Great apes flexibly adjusted their requests for absent entities depending on  
318 three factors: the previous content of a now empty plate (condition), whether the  
319 experimenter had seen the content of the now empty plate (*see*) and whether the  
320 experimenter provided additional food items in a previous interaction (*bring*). This is  
321 evidence that apes tracked the relevant aspects of previous interactions with their

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322 interlocutor and considered them when engaging in subsequent communicative  
323 interactions with him or her.

324         These results cannot be explained by task specific associative learning or  
325 simple heuristics. First, apes only received one test session for each combination of  
326 condition and configuration so that each subject could only contribute one point to  
327 empty plates for each of these combinations. Any association formed as a  
328 consequence of being rewarded for pointing to the empty plate could therefore not  
329 influence the result of that specific combination any further. If being rewarded for  
330 pointing to the empty plate had any effect at all, it should have increased the number  
331 of points to empty plates in subsequent test sessions regardless of combination.  
332 However, this was not the case since the number of points to empty plates decreased  
333 rather than increased in later sessions (see supplemental material for details). Second,  
334 apes did not simply associate E1 with more food as they only pointed more often for  
335 him in the *different* condition. Finally, our results cannot be explained by a general  
336 unwillingness to point for E2, since the rate of pointing in general did not differ  
337 between the E1 and E2. Taken together this suggests that apes' requests were not  
338 directly influenced by the amount and kind of food they got from each experimenter  
339 but rather by *how* they interacted with him/her previously. Next we discuss in more  
340 detail the factors that affected subjects' choices and their interpretation.

341         Overall, apes were specific in their requests as they requested more absent  
342 entities in the *different* condition, i.e. when the previous content of the now empty  
343 plate was of higher quality than the visible content of the other plate. This finding  
344 replicates the earlier study by Bohn et al. (2015). More importantly, we found that the  
345 type of interaction they had with the experimenter previously further modulated these  
346 specific requests. Apes requested specific absent entities more often from an

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347 experimenter (E1) who previously demonstrated his competence to provide additional  
348 food than from a novel experimenter (E2). Even if E2 had just given them HQ items  
349 in the *different* condition, they did not request additional items from her. These results  
350 show that apes communicated with a *specific* individual about *specific* absent entities.  
351 This kind of spontaneous and flexible adjustment of communicative acts to past social  
352 interactions goes beyond what has been shown in earlier studies in which  
353 chimpanzees were directly trained to inhibit and redirect communicative acts in the  
354 presence of specific individuals (Woodruff & Premack, 1979). Moreover, the  
355 differential pattern of responses suggests that apes may have ascribed a general  
356 competence to E1 (“able to bring more of what was previously on that plate”) instead  
357 of an object specific one (“able to bring grapes”). In the latter case they should not  
358 have adjusted their requests to the previous content of the plate as well and should  
359 have made more requests in the *same* condition with LQ items on both plates.

360         However, since we did not counterbalance the identity of E1, we cannot rule  
361 out that apes’ evaluation of E1’s ability to provide additional food items was solely  
362 based on our experimental manipulations. It is conceivable that other factors such as  
363 E1’s gender or general appearance, rather than the specific past interactions with E1,  
364 might have been responsible for the effect of *bring*. While such an alternative  
365 explanation is certainly possible, we think that it is highly unlikely that apes’ prior  
366 experiences outside the studies considered here led them to learn that only E1 (or  
367 other humans who resembled E1) would provide additional food items after pointing  
368 to their previous location. We think that it is more likely that the specific experiences  
369 with E1 during training trials and the study by Bohn et al. (2015), which involved the  
370 same setup and food items, influenced how apes communicated with E1 in the current  
371 study.

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372 We also found that apes were more likely to point to the empty plate if the  
373 returning experimenter had seen the content of the now empty plate, regardless of his  
374 competence and condition. This result is in line with previous research showing that  
375 apes adjust their behaviour depending on whether another individual has experienced  
376 something or not (Crockford et al., 2012; Hare et al., 2001). The presence of a main  
377 effect of *see* rather than an interaction between *see* and condition reveals how subjects  
378 judged the importance of the two factors relative to one another. The general rate of  
379 pointing for absent entities for E2 – *bring(-)* – was too low to differ between the two  
380 conditions or the two levels of *see* (see Figure 2). This means that the experimenter's  
381 competence was a necessary requirement for *see* or condition to have an effect at all.  
382 This is reminiscent of apes preferentially begging from a human whose face was  
383 oriented towards them but only when that human was in a position in which she was  
384 capable of handing over food (body oriented towards the ape) (Kaminski et al., 2004).  
385 When her body was oriented away from the ape, they generally begged less from her  
386 and did not care about her face orientation anymore.

387 Even though we observed most points to empty plates in the *different*  
388 condition for an experimenter who was knowledgeable as well as competent, apes  
389 also requested specific absent entities from E1 when E1 had not seen the absent food  
390 before (see Figure 2). This suggests that apes did not take into account the  
391 interdependent nature of knowledge and competence. In order to use a location to  
392 request more of its previous content, it is not sufficient to know that the other person  
393 is willing and able to provide more food, *at the same time* it is necessary to know  
394 whether she knows what the location contained previously. If we are willing to see the  
395 adjustment for knowledge and competence in this study as cases of attribution of  
396 psychological states, we might conclude that apes are limited in their ability to

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397 integrate different psychological states of the same individual. This might help to  
398 explain why great ape communication among conspecifics is usually based on  
399 naturally meaningful embodied behaviours instead of more ambiguous signals that  
400 require a detailed tracking of common ground (Moore, 2013; Tomasello, 2008).  
401 However, future research should investigate if these results are specific to  
402 communicative interactions about absent entities or constitute a general limitation of  
403 great apes' social-cognitive abilities. As we highlighted in the introduction, this study  
404 did not address full-blown common ground but only its necessary prerequisites.  
405 Following studies with children (Moll, Carpenter, & Tomasello, 2007) it would be  
406 necessary to vary how apes learn about the experimenter's psychological states (in  
407 joint engagement or while eavesdropping) to determine whether they consider how  
408 psychological states come to be shared between individuals.

409         In sum, these results show that great apes consider relevant aspects of previous  
410 interactions with other individuals that are necessary prerequisites to form common  
411 ground with them. However, our results also suggest that apes might be limited in  
412 their ability to integrate different psychological states of an individual simultaneously.  
413 Overall, our study sheds light on the social embedding of great apes' communicative  
414 abilities and thereby helps to identify the evolutionary foundations on which human  
415 communication rests.

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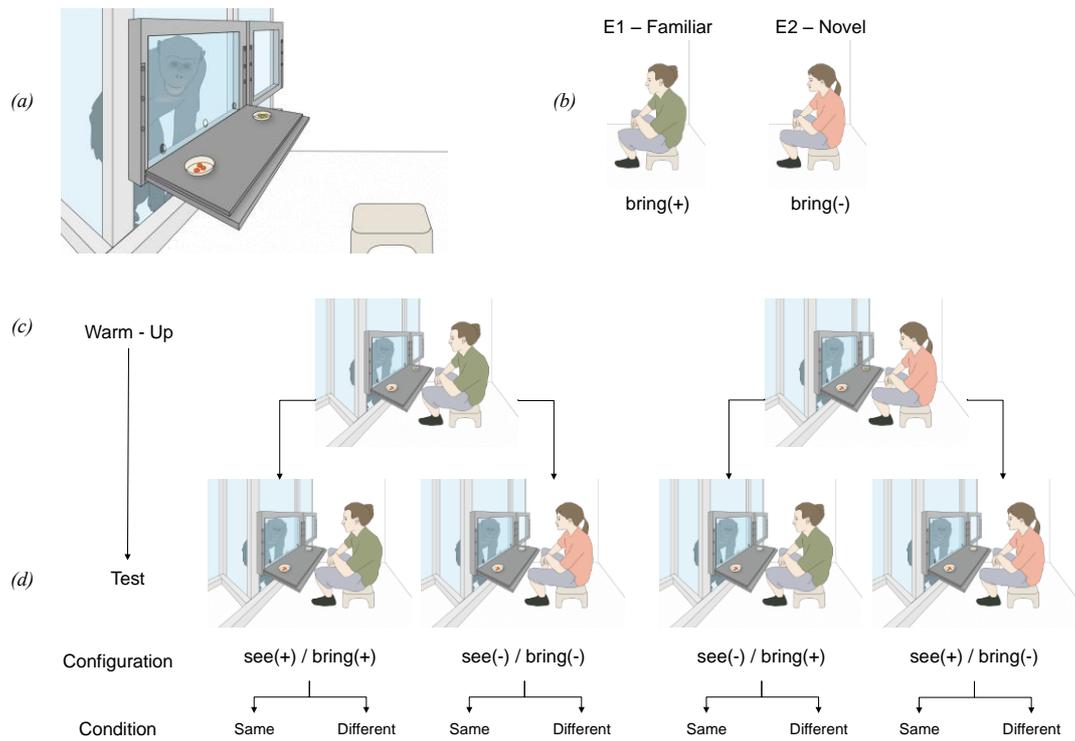
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522 **Figures and Captions**



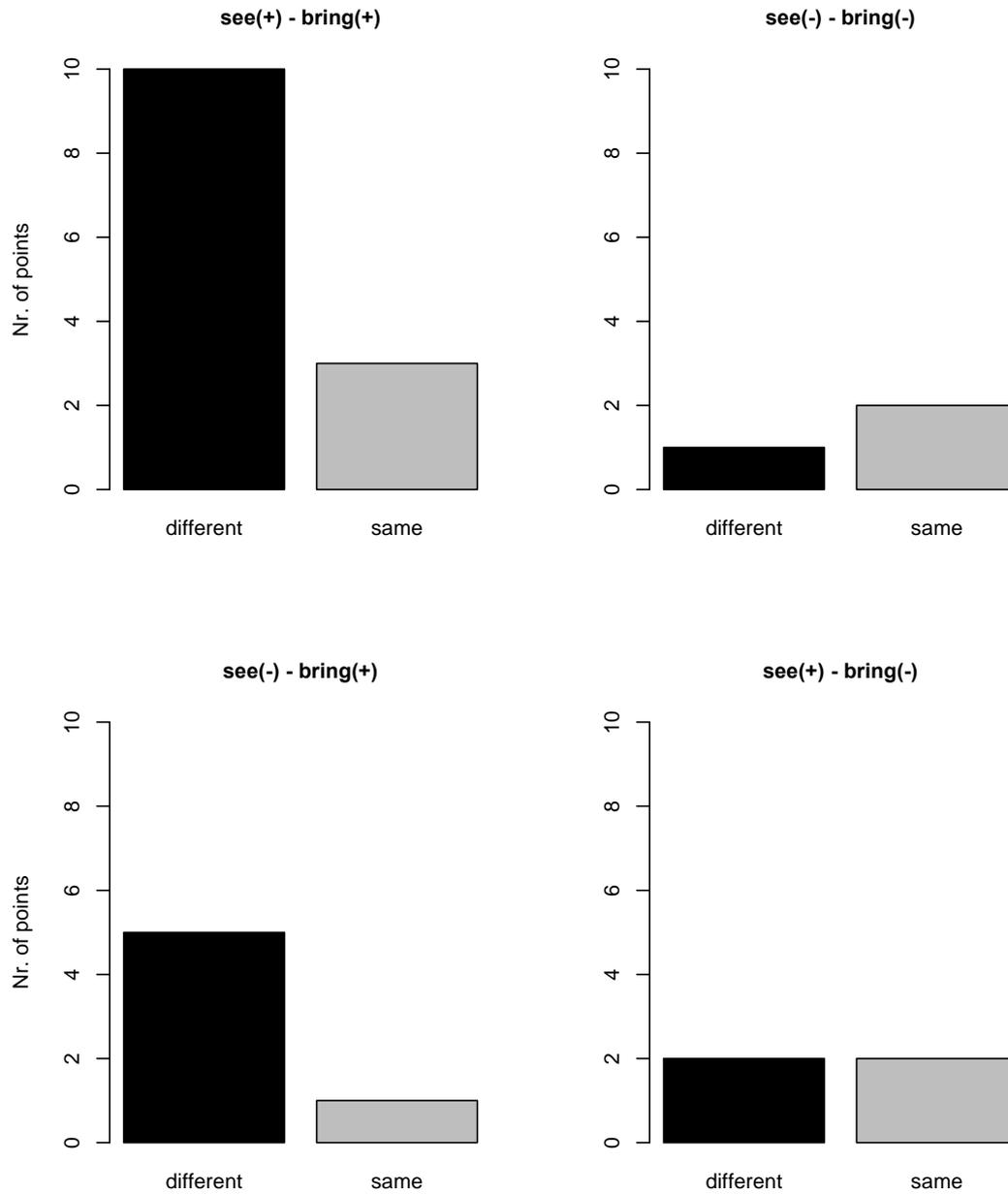
523

524 *Figure 1.* Schematic overview for (a) the basic setup with two baited plates, (b) the  
 525 experimenters involved in the study, (c) the two different variants of the warm-up  
 526 phase and (d) the resulting four different configurations in the test phase (with two  
 527 different conditions per configuration). Subjects received a single test session per  
 528 condition for each configuration. Subjects could request food items by pointing  
 529 through the hole in front of the two plates.

530

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## PAST INTERACTIONS IN APE COMMUNICATION



532

533 *Figure 2.* Number of points to empty plates per configuration and condition. Each

534 subject received one test session per condition in each configuration.

535