



A comparative approach to dogs' &i&t;(Canis familiaris)&t;/i&t; and human infants' comprehension of various forms of pointing gestures

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1 **A comparative approach to dogs' (*Canis familiaris*) and human infants' comprehension**
2 **of various forms of pointing gestures**

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24 **Abstract**

25

26 We investigated whether dogs and 2-, and 3-year-old human infants living, in some
27 respects, in very similar social environments are able to comprehend various forms of the
28 human pointing gesture. In the first study we looked at their ability to comprehend different
29 arm pointing gestures (long cross-pointing, forward cross-pointing and elbow cross-pointing)
30 to locate a hidden object. Three-year-olds successfully used all gestures as directional cues,
31 while younger children and dogs could not understand the elbow cross-pointing. Dogs were
32 also unsuccessful with the forward cross-pointing.

33 In the second study we used unfamiliar pointing gestures i.e. using a leg as indicator
34 (pointing with leg, leg cross-pointing, pointing with knee). All subjects were successful with
35 leg pointing gestures, but only older children were able to comprehend the pointing with knee.

36 We suggest that 3-year-old children are able to rely on the direction of the index finger,
37 and show the strongest ability to generalize to unfamiliar gestures. While some capacity to
38 generalize is also evident in younger children and dogs, especially the latter appear biased in
39 the use of protruding body parts as directional signals.

40 **Keywords:** dogs, children, communication, human gestures, pointing.

41 **Introduction**

42

43 Dogs' comprehension of human gestural communication including pointing, head
44 turning and gazing has received increased interest in recent years (for a review see Miklósi
45 and Soproni, 2006). Most studies focused on the dog's ability to comprehend human pointing
46 gestures because it was assumed that in the course of domestication dogs might have gained
47 some advantage in reading human communicative signals (e.g. Hare et al. 2002). Recent
48 investigations have revealed that dogs are able to find hidden food on the basis of different
49 human gestural cues (Miklósi et al. 1998; Hare and Tomasello, 1999; McKinley and
50 Sambrook, 2000) in the so called two-choice task (see Anderson et al 1995, and Methods). In
51 a series of such experiments Soproni et al. (2002) varied the form of the pointing gesture in
52 order to determine the critical visual features of this signal. The results of this study suggest
53 that dogs are sensitive to the relation between the hand/arm and the torso, that is, they infer
54 the directionality of the gesture by observing the direction in which part of the arm/hand
55 protrudes from the upper body.

56 Interestingly, in contrast to the many investigations of pointing in dogs there are only a
57 few experimental studies on pointing and gazing comprehension in human children. Most of
58 our knowledge is based on longitudinal investigations (Morisette et al. 1995) revealing that
59 human infants are able to look in the general direction indicated by the mothers' gaze at 12
60 months of age, and they are able to look at the indicated target at 15 months of age if the
61 targets are close and at 18 months of age if the targets are distant (see Morisette et al. 1995).
62 But when gazing is accompanied by a pointing gesture children look at the indicated distant
63 target at 15 months of age. According to Butterworth and Grover (1998) the comprehension of
64 manual pointing develops by 12 months of age, and the exhibition of pointing for others is
65 observed in most children at about 14 months of age (Leung and Rheingold, 1981). More

66 recently Behne et al. (2005) found that 14 months old children are able to choose an object in
67 an object-choice task on the basis of two different types of cues when the cues are given in a
68 communicative way but they show very poor performance if the same cues are given in a non-
69 communicative way.

70 The social environment of the human infants is often shared by pet dogs in the family.
71 Although for many researchers this does not come as a surprise, others debate that there is a
72 similarity between the social stimulation received by human infants and pet dogs. In any case
73 recent experimental research has revealed some striking similarities. At the level of
74 behavioural interaction both children and pet dogs develop an attachment relationship toward
75 adult humans (e.g. Topál et al. 1998; Prato-Previde et al. 2006), and there are also functional
76 similarities in their communicative behaviour especially between dogs and pre-verbal infants
77 (Miklósi et al. 2000; 2005). Moreover pet-directed speech shares similarities with ‘motherese’
78 used to talk to infants (‘doggerel’ see Hirsch-Pasek and Treiman, 1981; Mitchell, 2001), and
79 owners have complex beliefs as regards the verbal comprehension of their pets (Pongrácz et
80 al. 2001).

81 Albert and Bulcroft (1987, 1988) found that pets are viewed as important family
82 members by people who live in the city. At the psychological level dogs are often described as
83 family members (e.g. Cain 1985), and humans perceive thinking and feeling processes in dogs
84 to be very similar to that of preschool children where the difference lies not so much in quality
85 but rather in quantity (Rasmussen and Rajecki, 1995). Actually, many studies on the dog-
86 human interactions describe this relationship as an inter-specific parental contact, and there is
87 now both behavioural and psychological evidence that the behaviour of adults toward dogs
88 and infants shares many similarities (Hirsch-Pasek and Treiman, 1981; Mitchell, 2001; Prato-
89 Previde et al., 2006). This gives support for the view that dogs and children have the chance to
90 experience a similar social environment during their early socialisation in human families.

91 Earlier studies have shown that the comprehension of simple pointing gestures emerges
92 already at the age of 2-4 month in dogs (Hare et al. 2002) and shows little variation over the
93 first year of life (Gácsi et al. 2009a). There are no similar longitudinal observations in infants
94 but studies indicate that by their first year children also comprehend pointing gestures in a
95 communicative situations, and after this period they show a rapid development in their
96 comprehension of human communicative gestures, which is probably facilitated by the
97 production of similar pointing gestures in the framework of communicative behaviour
98 including language learning (e.g. Tomasello and Camaioni, 1997). Thus the first goal of the
99 present study was to find a period of human development in which children and dogs display
100 similar levels of performance. Given the stable performance of dogs beyond their first year we
101 compared adult dogs to 2 and 3 years old infants.

102 The second aim of this investigation was to gather comparative evidence on the ability
103 to generalize to unfamiliar gestures in both species. It has been suggested that the use of
104 unfamiliar signals could provide some evidence for referential understanding (Povinelli et al.
105 1997). Therefore we investigated whether dogs and human infants are able to generalize from
106 familiar pointing gestures to unfamiliar ones, and whether they comprehend these unfamiliar
107 gestures as being directional. In this regard two specific questions were investigated. First, we
108 wanted to know whether children and dogs are able to generalize to a topographically similar
109 gesture that is executed with a different body part (pointing with the leg) based on the
110 assumption that subjects have been rarely (if at all) exposed to such body movements in a
111 communicative context. Second, we asked whether dogs and children at a certain age gain the
112 capacity to recognize the significance of the pointing finger in the communicative context.

113

114 **General methods**

115

116 **Subjects**

117

118 As testing place, we chose the most natural environment for each group so as to keep stress
119 levels at a minimum. Therefore in the case of dogs and 2-year-old children we conducted the
120 experiments in the home of the subjects in the presence of the owner/parent. In the case of 3-
121 year-old children we conducted the experiments in two nursery schools in Budapest and in
122 one kindergarten in Budaörs. In all cases we obtained the parents' permission. In addition we
123 carried out a pilot study with five 3-year-old children tested in their homes instead of the
124 nursery to evaluate the potential effects of setting, however no difference emerged between
125 children tested in the two settings.

126 *Dogs* (N=15): All individuals participated in both studies (pointing with arms and
127 pointing with legs). Eleven males, four females; the mean age of the dogs was 4.9 years, SD
128 was 2.4 years and the range was 1 - 12 years. Eight individuals were naive, 7 individuals had
129 participated in other studies recently, in which they had been exposed to some simpler kind of
130 gestures (dynamic-sustained proximal and distal pointing, and momentary proximal and distal
131 pointing gestures; Miklósi et al., 2005). The age of the owners was $24.75 + 5.2$ years (mean +
132 SD); range was 18 – 38; two men and twelve women. Previous study found that the age and
133 other specific experiences (agility training) of the dogs do not have an effect on their ability to
134 utilize the momentary pointing gesture (Gácsi et al. 2009a).

135 *2-year-old children* (N=13): Twelve individuals' behaviour was measured in both
136 studies. Eleven individuals out of the thirteen children participated in both studies and 2
137 individuals participated only in one of the studies. Seven girls and five boys participated in
138 both tests. Ten children were younger than 2-year-old and three children were older than 2-
139 year-old in this group. The mean of the children's age was 21.1 months, SD was 3.7 months
140 and the range was 16.5 - 27.5 months in the case of Study 1. The mean of the children's age

141 was 21.1 months, SD was 3.8 months and the range was 16.5 - 27.5 months in the case of
142 Study 2.

143 *3-year-old children* (N=11): All individuals, eight girls and three boys, participated in
144 both studies. Ten children were older than 3-year-old and one child was younger than 3-year-
145 old in this group. The mean of the children's age was 38.7 months, SD was 2.4 months and
146 the range was 34 - 41 months.

147

148 **Pretraining: Familiarization with the situation**

149

150 In the present studies we used the same method described in earlier studies (e.g. Soproni
151 et al. 2001, 2002; Miklósi et al. 2005). The experimenter placed two bowls (brown plastic
152 flower pots: 13 cm in diameter, 13 cm in height) 1.3 - 1.6 metres apart, in front of her, on the
153 floor in the case of dogs, and on two chairs in the case of children. The experimenter, in the
154 presence of the subject, placed a reward in one of the bowls: food for the dogs and a favourite
155 toy for the children. The subjects could witness this hiding from a distance of 2 - 2.5 m with
156 their owner/parent standing behind them. After having the experimenter put the food/toy into
157 the bowl, the owner/parent allowed the subject to take the reward out from the bowl. One trial
158 lasted 30 seconds, and the procedure was repeated twice for each bowl to ensure that the
159 subject knew that the bowls might contain some reward.

160

161 **Testing**

162 The position of the participants was the same as above, but during the testing the subject
163 was prevented from observing the hiding. The experimenter picked up the bowls, put the
164 reward (a piece of food in the case of dogs and a favourite toy in the case of children) into one
165 of the bowls and after that she placed both bowls back onto the floor/chairs at the same time.

166 During the pointing the experimenter was standing 0.5 m back from the middle line between
167 the two bowls, facing the subject at a distance of 2-2.5 m. The owner/parent was holding back
168 the subject gently until the experimenter gave the cue. The experimenter drew the subject's
169 attention to herself (any sounds, like clapping or/and the subject's name could be used) and
170 presented the visual cue when the subject looked in the direction of her face. During pointing
171 the experimenter was looking at the subject. If the subject did not set out at the first cue, the
172 experimenter repeated the pointing gesture again for a maximum of three times. The subject
173 was allowed to choose only one bowl, if it chose the incorrect one the experimenter picked up
174 the baited bowl from the floor while the subject approached the unbaited one.

175 We used four types of pointing gestures in both tests (Study 1 and 2) ("Probe trial
176 method", in which novel test treatments were presented by embedding them into a background
177 of a very familiar gesture, the distal pointing; see below and see also Povinelli et al. 1999;
178 Soproni et al. 2002; Miklósi et al. 2005). Apart from the pointing gesture with an extended
179 arm and index finger ("control trials": distal pointing), we used three other kinds of pointing
180 gestures (probe trials), which differed from each other in certain important features of the
181 gesture (see below). Each test session consisted of 12 trials in the case of dogs, which
182 contained 4 trials of momentary distal pointing gesture and 8 probe trials, with all three
183 unfamiliar gestures included (3 trials of two types of the probe trials and 2 trials of the third
184 type). Unfamiliar gestures were also displayed in a momentary manner. The presentation of
185 the cues was in a predetermined semi-random order and was balanced for right and left side.
186 Neither the same gesture, nor the same place for the reward was used more than two times in a
187 row. With each dog we staged three test sessions. Overall the dogs received 8 trials for each
188 type of the unfamiliar pointing gestures in both studies. A minimum of one day and a
189 maximum of two weeks passed between the two test sessions in both studies.

190 In the case of children pilot studies have shown that they are not able to concentrate for
191 too many trials and we also needed to take into consideration that at this age their capacities
192 develop rapidly. Thus we decided to have fewer sessions with the children and thereby they
193 received fewer trials overall than dogs. With each child we had one test session consisting of
194 18 trials, which contained 6 trials of pointing gesture and 4-4-4 trials of each probe trial in
195 both studies (See also Table 1).

196 All subjects participated in Study1 for the first time, and after it was completed they
197 participated in Study2. There were a maximum of two weeks between the two studies.

198 All experimental trials were recorded on video. Trials were scored in real time by the
199 experimenter.

200

201 **Study 1: Pointing with arms**

202

203 In this study we wanted to test the effect of a protruding body part and the index finger
204 on the comprehension of the pointing gesture. Therefore we systematically varied the pointing
205 gesture by comparing gestures that either presented a protruding upper arm and elbow (elbow
206 cross pointing), a pointing gesture when no parts of the hand appeared outside the body
207 outline (cross-forward pointing), and a pointing gesture when the hand (including the
208 extended index finger) protruded on one side of the body (long cross-pointing) (see Fig. 1
209 from left to right). If the subjects are interested only in the protruding body part (as was
210 hypothesized earlier see Soproni et al. 2002) then they should choose the "indicated" bowl
211 both in the elbow cross pointing and in the long cross-pointing condition (note that in the case
212 of the former this results in incorrect choice). In parallel subjects should not be able to choose
213 correctly in the cross-forward pointing condition. If however subjects realize the significance

214 of the index finger as an "invariant" feature of the pointing gesture then they should be correct
215 in all conditions.

216 It should be noted that in a former experiment with a smaller sample we found that
217 dogs showed no preference in the elbow cross pointing condition but were able to find the
218 hidden food based on the long cross-pointing gesture (Soproni et al. 2002). In this regard this
219 study is a replication of those observations (including an additional gesture) on a new, larger
220 sample of animals. Povinelli et al. (1997) used the dynamic-sustained version of our
221 momentary elbow cross pointing gesture (for the importance of temporal structure of the
222 gesture see Methods) with chimpanzees and children. They found that in the case of the elbow
223 cross pointing (the only condition comparable to the gestures used in this study) the apes
224 showed a strong preference for the unbaited container "indicated" by the "elbow", whilst
225 children older than 2 years were looking in the bowl indicated by the index finger.

226

227 **Method**

228

229 Types of momentary pointing gestures used (see also Miklósi and Soproni, 2006):

230 1. *Distal pointing*: the experimenter pointed with extended arm and index finger in the
231 direction of the correct location using her closer hand. After signalling (it lasted about 1
232 second), she lowered her arm to the starting position beside her body before the subject was
233 allowed to approach the bowls (Figure 1.a).

234 2. *Elbow cross-pointing*: the experimenter pointed with her contralateral hand, with bent arm,
235 so her elbow stuck out to the side of the empty bowl and her extended index finger did not
236 extend beyond the mid-line of her body. After signalling (1 sec), she lowered her arm to the
237 starting position beside her body before the subject was allowed to approach the bowls (Figure
238 1.b).

239 3. *Forward cross-pointing*: the experimenter stepped back about 0.5 metres from the bowls
240 and she pointed with her contralateral hand, but her extended index finger did not protrude
241 from her silhouette. After signalling (1 sec), she lowered her arm to the starting position
242 beside her body before the subject was allowed to approach the bowls (Figure 1.c).

243 4. *Long cross-pointing*: the experimenter pointed with her contralateral hand, with an
244 extended arm, and her extended index finger protruded from her silhouette to the side of the
245 rewarded bowl. After signalling (1 sec), she lowered her arm to the starting position beside
246 her body before the subject was allowed to approach the bowls (Figure 1.d).

247

248 **Statistical analysis**

249

250 The statistical analysis was based on the number of the correct choices (in percent) and
251 non-parametric procedures (Kruskal-Wallis test, One-sample Wilcoxon signed-rank test) were
252 used.

253

254 **Results and discussion**

255

256 Between-group comparisons: We compared the performance of the three experimental
257 groups by Kruskal-Wallis test (with Dunn's post hoc tests, $p < 0.05$) separately for each
258 gesture (Figure 2, Table 2). In the case of the “Distal pointing” we found that 3-year-old
259 children perform significantly better than dogs. In the case of “Long cross-pointing” and the
260 “Forward cross-pointing” we revealed that the both groups of children performed significantly
261 better than the dogs. In the case of the “Elbow cross-pointing” we found that 3-year-old
262 children displayed significantly better performance in choosing the correct bowl in
263 comparison to the younger children and dogs.

264 We compared the performance (mean percentage) of the experimental groups to the
265 expected chance level using One-sample Wilcoxon signed-rank tests (Table 3). Given the
266 ceiling level of performance for 3-year-old children (which obviously differs significantly
267 from chance level), we compared the performances to the chance level only in those cases
268 when the mean percentages differed significantly from the data for 3-year-old children
269 according to the Kruskal-Wallis test (see above). 2-year-old children's performance differed
270 significantly from the 3-year-old children's performance only in the case of the "Elbow cross-
271 pointing". According to the One-sample Wilcoxon signed-rank test their performance was at
272 chance level in this case. In the dogs' case the Kruskal-Wallis test showed that the 3-year-old
273 children performed better in all types of pointing gesture. If we look at the results of the One-
274 sample Wilcoxon signed-rank tests we find that the dogs' performance is significantly above
275 chance only in the case of the "Distal pointing" and the "Long cross-pointing", their
276 performance does not differ from chance for the "Forward cross-pointing". In the case of the
277 "Elbow cross-pointing" they prefer the side of the elbow (they choose the empty bowl), thus
278 performing significantly below chance level (Figure 3).

279 There was no sign of learning during testing for any of the gestures in any of the
280 experimental groups. The comparison of the performance in the first and the second half of
281 gestures for each type revealed no significant changes (Wilcoxon matched pairs test; 3-year-
282 old children: we could not make the statistical analysis in case of "Distal pointing" and "Long
283 cross-pointing", because there were $SD=0$, and in case of the "Forward cross-pointing",
284 because there was no any difference between the results of the two halves; "Elbow cross-
285 pointing" ($T(+)=3.0$; $p=0.5$). 2-year-old children: "Distal pointing" ($T(+)=4.0$; $p=0.75$);
286 "Elbow cross-pointing" ($T(-)=-12.0$; $p=0.31$); "Forward cross-pointing" ($T(+)=9.0$; $p=0.81$);
287 "Long cross-pointing" ($T(-)=-4.0$; $p=0.75$). Dogs: "Distal pointing" ($T(-)=-53.5$; $p=0.59$);
288 "Elbow cross-pointing" ($T(-)=-43.5$; $p=0.73$); "Forward cross-pointing" ($T(+)=22.5$; $p=0.55$);

289 “Long cross-pointing” ($T(+)=24.0$; $p=0.46$).

290 The varied age of the group of 2-year-old children allowed for a correlative analysis.
291 We found that there was no correlation between age and performance with the “Distal
292 pointing” and the “Forward cross-pointing” (Spearman $\rho = 0.10$, $p = 0.76$ and $\rho = 0.15$, p
293 $= 0.65$) but older children were better in the case of the “Long cross pointing” and the “Elbow
294 cross-pointing” (Spearman $\rho = 0.64$, $p < 0.02$ and $\rho = 0.62$; $p < 0.03$, respectively).

295 Supporting our hypothesis, the present study shows that dogs can choose on the basis
296 of the “Distal pointing” and “Long cross-pointing”. In addition, and contrary to earlier
297 findings (Soproni et al. 2002) dogs also preferred the incorrect container "indicated" by the
298 elbow of the experimenter. Whilst this tendency gives further support to our theory at the
299 moment we have no explanation for this difference. Taken together, these findings suggest
300 that dogs choose on the basis of a body part that protrudes from the signalling person's
301 silhouette, and it seems that the directionality of the index finger plays a small role in
302 influencing the choice.

303 Three-year-old infants' performance was significantly better in the case of the “Elbow
304 cross-pointing” than 2-year-old infants' performance, and this was the only gesture in which
305 younger children did not choose above chance level. The effect of age (and/or experience) was
306 also supported by the correlation analysis. In the group of younger children we saw that they
307 performed at chance level (at the group level), but older children in this group (older than 2
308 years) seemed to take into account the direction of the index finger.

309

310 **Study 2: Pointing with legs**

311

312 In this study we used three different kinds of pointing gestures using the leg as the
313 signalling body part. We relied on the apparent visual similarity of the pointing arm and leg,

314 and wanted to find out whether subjects could generalize from the hand to the leg pointing
315 gestures. We hypothesized that if the subjects use the visual image of a protruding body part
316 as a directional signal then they should be able to perform well in the case of leg pointing.

317

318 **Method**

319

320 The method used was similar to that described above. The following momentary
321 pointing gestures were utilized:

322 1. *Distal pointing*: the experimenter pointed with extended arm and index finger in the
323 direction of the correct location using her closer hand. After signalling (1 sec), she lowered
324 her arm to the starting position before the subject was allowed to approach the bowls (Figure
325 1.a.).

326 2. *Pointing with leg*: the experimenter pointed with an extended leg in the direction of the
327 correct location using her closer leg. After signalling (1 sec), she lowered her leg to the
328 starting position before the subject was allowed to approach the bowls (Figure 4.a.). The
329 distance between the pointing leg and the baited bowl was about 15 centimetres.

330 3. *Cross-pointing with leg*: the experimenter pointed with an extended leg in the direction of
331 the correct location using her contralateral leg. After signalling (1 sec), she lowered her leg to
332 the starting position before the subject was allowed to approach the bowls (Figure 4.b.). The
333 distance between the pointing leg and the baited bowl was about 30 centimetres.

334 4. *Pointing with knee*: the experimenter pointed with a bent leg, so her closer knee was
335 signalling the baited bowl. After signalling (1 sec), she lowered her leg to the starting position
336 before the subject was allowed to approach the bowls (Figure 4.c.). The distance between the
337 experimenter's knee and the baited bowl was about 60 centimetres.

338

339 **Results and discussion**

340

341 Between-group comparisons: We compared the performance of the three experimental
342 groups with Kruskal-Wallis test (with Dunn's post hoc tests, $p < 0.05$) in the case of each
343 gesture separately (Figure 5, Table 2). In the case of the “Distal pointing” 3-year-old
344 children’s performance was better than the other two experimental groups’. In the case of the
345 “Pointing with leg” 3-year-old children performed significantly better than both the 2-year-old
346 children and dogs. And in the case of the “Cross-pointing with leg” and the “Pointing with
347 knee” we also found that 3-year-old children displayed a significantly better performance than
348 the subjects in the two other experimental groups. In contrast to the previous study we found
349 no correlation between age and performance in 2-year-olds.

350 We compared the performance (mean of percentage) of the experimental groups to the
351 chance level by One-sample Wilcoxon signed-rank tests (Table 3). Given the ceiling level of
352 performance for 3-year-old children, we compared the performances to chance level only in
353 those cases when the mean percentages differed significantly from the data for 3-year-old
354 children according to the Kruskal-Wallis test (see above) as we did in the Study 1. According
355 to the Kruskal-Wallis test the 3-year-old children’s performance was better than both the 2-
356 year-old children’s and dogs’ for each kind of pointing gesture. If we look at the results of the
357 One-sample Wilcoxon signed-rank test we find that 2-year-old children perform significantly
358 better, than chance in the case of the “Distal pointing”, “Pointing with leg” and “Cross-
359 pointing with leg”, but their performance is at chance level in the case of the “Pointing with
360 knee”. Dogs’ performance differs significantly from the chance level only in the case of the
361 “Distal pointing”, the “Pointing with leg” and the “Cross-pointing with leg”, their
362 performance does not differ from the chance level in the case of the “Pointing with knee”.

363 There was no sign of learning during testing for any of the gestures in any of the
364 experimental groups. The comparison of performance in the first and the second half of
365 gestures for each type revealed no significant changes (Wilcoxon matched pairs test; 3-year-
366 old children: we could not make the statistical analysis in case of “Distal pointing”, “Pointing
367 with leg”, and in case of “Cross-pointing with leg” because there were $SD=0$; “Pointing with
368 knee” ($T(+)=2$; $p>0.99$). 2-year-old children: “Distal pointing” ($T(-)=-5.0$; $p=0.5$); “Pointing
369 with leg” ($T(+)=7.0$; $p=0.62$); “Cross-pointing with leg” ($T(+)=10.5$; $p>0.99$); “Pointing with
370 knee” ($T(+)=32.5$; $p=0.25$). Dogs: “Distal pointing” ($T(+)=18.0$; $p=0.58$); “Pointing with leg”
371 ($T(+)=43.0$; $p=0.41$); “Cross-pointing with leg” ($T(-)=-28.5$; $p=0.92$); “Pointing with knee”
372 ($T(-)=33.0$; $p>0.99$).

373 In summary the above results show that the 3-year-old infants’ performance was
374 significantly higher in the case of all unfamiliar gestures signaled by the leg (“Pointing with
375 leg”, “Cross-pointing with leg” and “Pointing with knee”) than the 2-year-old infants’
376 performance. Further it seemed that there was little difference in the performance of 2-year-
377 old children and dogs, including the fact that neither group performed above chance level in
378 the “knee-pointing”. This suggests that to some extent subjects were able to generalize from
379 their previous experience to a relatively novel directional gesture, and this generalization was
380 based possibly on the similarity of the visual image, that is, the leg as well the hand provides a
381 contrasting directional signal in which the limb protrudes from the body contour.

382

383 **General discussion**

384

385 We studied the behaviour of adult dogs and children of different ages in an object-
386 choice task, in which we investigated whether they are able to use various gestural signals to
387 locate a hidden object. The first study supported the idea that the basis for the utilization of

388 the more and less familiar gestures was to rely on the protruding arm and/or hand. However,
389 in older children this overall tendency was overridden by the understanding that the key feature
390 of the pointing gesture is not the directionality of the hand or arm *per se* but the direction of
391 the pointing index finger. This ability seems to emerge at around 2 years of age because all
392 children in the 3-year-old group and the oldest ones in the 2-year-old group seemed to base
393 their choice on the direction indicated by the index finger. This was revealed in the case of the
394 "Elbow cross-pointing" condition, in which dogs preferred the (incorrect) bowl, which was
395 located on the side of the protruding elbow, 2 years olds showed no preference whilst older
396 children based their choice on the direction indicated by the pointing finger in front of the
397 chest. Interestingly, in similar conditions chimpanzees also tended to prefer the bowl closer to
398 the elbow in the case of a dynamic pointing gesture (Povinelli et al. 1997) just like dogs,
399 however, note that the same chimpanzees were less successful in many other forms of the
400 pointing gesture compared to dogs (see Miklósi and Soproni, 2006). This suggests that
401 younger children and dogs do not grasp the meaning of the pointing index finger in this
402 situation, instead, they rely on a common simple rule: follow the direction indicated by the
403 protruding body part.

404 Both children and dogs showed some evidence of generalization in the presence of
405 unfamiliar gestures i.e. when the pointing was done with the leg, and it is likely that they
406 relied on the same rule referred to above. Interestingly, neither dogs nor 2-years olds were able
407 to find the object when it was indicated by the "pointing" knee. Although the "pointing" knee
408 gesture also protrudes from the body contour, its visual image is distinctly different from the
409 "stick-like" image of a pointing limb. These results suggest that the ability to generalize is
410 more limited in dogs and 2-year-old children than in 3-year-old children.

411 The results clearly indicate a ceiling effect in the case of 3-years-olds which suggests
412 that by the age of 2-3 years marked changes have taken place in their capacity to utilize visual

413 communicative signals. We think that the synergic effect of at least three processes could lead
414 to this development. First, they seem to grasp the meaning of a directional signal in general
415 terms, that is, any signal (body movement) that is displayed on one side is regarded as an
416 indication to the location of the reward (e.g. the knee of the experimenter). We were led to
417 this conclusion by the result that 3-year-old children's performance was very high in the case
418 of all gestures used and, in contrast to the 2-year-old children, they were able to choose also
419 on the basis of the "pointing with knee" gesture.

420 Second, 3-year-old children's performance in the case of the "Elbow cross-pointing"
421 suggests that they are able to understand the meaning of the index finger and use it as a
422 guiding cue. This capacity could be the result of two different processes. Children acquire the
423 use of this gesture by 14 months of age (Leung and Rheingold, 1981; Butterworth and Grover,
424 1998), and by this time become proficient users of the pointing gesture (e.g. Dobrich and
425 Scarborough, 1984). Thus they are in the position to realize the correspondence between their
426 own pointing action and the pointing action of the experimenter (Butterworth and Grover,
427 1998). In addition they have been exposed to pointing gestures during language learning when
428 the index finger has a specific role (Leavens and Hopkins, 1999), (although we note that the
429 use of the index finger for pointing does not appear to be universal, there are reports about
430 cross-cultural differences in the semiotics of pointing (Wilkins, 2003)). It is likely that
431 interactions during language learning facilitate the understanding in children that the index
432 finger has the important role of indicating objects of interest even over long distances. This
433 suggests a feedback of referential (linguistic) communication on the understanding of pointing
434 with the index finger. Thus children younger than 2 years of age have either too little exposure
435 to pointing gestures or they lack the necessary cognitive structures for being able to extract the
436 significance of the index finger. The lack of linguistic training could also explain why dogs in
437 our study could not overcome this hurdle.

438 Third, the present task has been often interpreted as requiring certain capacities of
439 cooperation. Actually, Hare et al (2000) used this argument to explain the low performance in
440 such object choice tasks in chimpanzees. There is evidence, in children, that the cooperative
441 ability both towards adults and especially toward peers increases markedly between 2 and 3
442 years of age (e.g. Brownell et al. 2006). Thus older children might be more at ease in
443 cooperating with an unfamiliar adult in the present task, and thus are more attentive to minor
444 behavioural signals that indicate intentional action on the part of the other (Tomasello et al.
445 1997). This latter ability could be enhanced by the development of complex representations of
446 shared intention (see also Tomasello et al. 2004). Behne et al. (2005) also argued that children
447 as young as 14 months of age can comprehend also the communicative intentions behind
448 gestures, like gazing or pointing.

449 It is also important to note that although there is a quantitative difference between the
450 performance of the dogs and the 3-years-olds in the comprehension of the pointing gesture, at
451 the functional level dogs' performance is comparable to that of 2-year-old children. Given that
452 dogs are not required to acquire complex linguistic forms of communication, their level of
453 comprehension seems to be proportional to the challenges set by their natural human social
454 environment. It remains to be shown whether, after further training, dogs may learn the
455 significance of the directionality of the index finger including the skill to generalize to novel
456 forms of the index gesture. On the positive side dogs have been able to learn the significance
457 of minute directional eye movements in an object choice task (Miklósi et al. 1998).

458 From a broader, comparative perspective, various studies have pointed out the
459 limitation of apes in comprehending some forms of the pointing gesture and other unfamiliar
460 forms of pointing signals. The majority of apes tested do not perform spontaneously above
461 chance level in object-choice tasks (Povinelli et al. 1997; Tomasello et al. 1997; Call et al.
462 1998; Itakura et al. 1999; Call et al. 2000; Hare et al. 2002; Bräuer et al. 2006). Although,

463 intensive socialisation (enculturation) enhances performance in object-choice tasks when
464 humans provide them with communicative cues such as pointing (Tomasello et al. 1997;
465 Itakura and Tanaka, 1998), even in this case individuals did not seem to comprehend that the
466 experimenter was attempting to communicate with them (Tomasello et al. 1997; Call et al.
467 2000). Results of the present study suggest that dogs are relatively flexible in their
468 comprehension (see also Hare et al. 1999, 2002; Soproni et al. 2002; Miklósi et al. 2005),
469 especially if we take into account that in our studies dogs are exposed to more difficult
470 gestures. Although some studies suggest that the ability to rely on complex human pointing
471 gestures might be present in some other species (seals: Shapiro et al. 2004; Scheumann and
472 Call, 2004; dolphins: Tschudin et al. 2001; Herman et al. 1999), the results do not offer an
473 easy interpretation. However, controlled experiments involving dogs and wolves socialized
474 with humans at the same level clearly pointed at species differences. Two studies have
475 provided evidence that in young dogs show better performance in such object choice tasks
476 (Miklósi et al. 2003, Virányi et al. 2008) in comparison to wolves, however this difference
477 seems to disappear in adults if subjects of the later species are socialized intensively (Gácsi et
478 al 2009b). This suggests that at least within the Canidae domesticated dogs represent a unique
479 species which, through their evolutionary association with humans, gained some advantages
480 in their sensitivity to human communicative signals (Frank et al. 1980; Miklósi et al. 2004).
481 Miklósi et al. (2003) suggested that the difference in performance could be partially explained
482 on the basis of the dogs' preference to gaze at humans in spontaneous situations in contrast to
483 that observed in wolves (Gácsi et al 2005).

484 Many researchers agree that the human pointing gesture has a referential nature
485 (Tomasello and Camaioni, 1997), but they disagree (Povinelli et al. 1997) as to whether
486 animals can also comprehend this aspect of the pointing action. According to Povinelli et al.
487 (1997) and Herman et al. (1999) supporting evidence for such comprehension can be gained

488 by showing that the subject is able to generalize (from familiar gestures to unfamiliar ones and
489 to comprehend the familiar gestures in unfamiliar situations), and to recognize the
490 communicative intention of the signaller. Based on the present studies we can reach some
491 conclusion as regards the dog's generalization ability but it is difficult to determine the level
492 of comprehension in terms of the communicative intentions behind the gestures. Children
493 display a gradually developing capacity to grasp the referential aspect of the gesture (but this
494 situation is made more complex by their own use of this gesturing). In the case of dogs the
495 effect of their own utilisation can be excluded (they do not use limbs for pointing), although
496 some assume that the dog's ability to "body point" (looking with stiff body in the direction of
497 prey) could facilitate the emergence of such a skill. In any case a relatively simple rule leads to
498 a flexible comprehension of the pointing gesture in dogs, which clearly suffices in everyday
499 situations. Thus one might be tempted to refer to "functional referentiality" (Evans, 1997) in
500 the case of dogs but the use of this terminology does not provide a solution to the problem.

501 Many authors draw a parallel between object choice tasks based on social cueing
502 (when the place is signalled by a human) and experimental ("foraging") situations when the
503 correct location of hidden target is indicated by the nearby presence of an object or visual cue
504 ("beacon") (without the involvement of humans). According to this view both the hand/finger
505 and the object/visual cue plays the role of a discriminative stimulus which becomes associated
506 with the location of the hidden reward. However, importantly, there is evidence available that
507 in choice tasks using visual beacons the distance of the signalling object and the location of
508 the reward is critical. Neither apes (Jenkins 1943; Murphy and Miller, 1955) nor dogs
509 (Milgram et al. 1999) are able to rely on beacons that appear further than 10-20 cm from the
510 hidden target. In contrast in the communicative version of this task, when the "beacon" is the
511 pointing hand, at least dogs seem to have no problem even if the distance is much greater and
512 the "beacon" disappears at the time of choice. This difference in performance suggests that the

513 behaviour is under different cognitive control when the search for a target takes place in an
514 asocial or a social situation. Thus on functional grounds it might be useful to differentiate
515 social and asocial foraging tasks. Interestingly this might suggest that human children do not
516 use a simple rule based on discrimination learning because if this were the case even younger
517 children should have been able to rely on all gestures presented (see Povinelli et al. 1997).
518 Although we do not want to exclude the role of discrimination learning it seems that this
519 process works very differently under social and asocial conditions, and on its own does not
520 explain the observed performance. It does not mean that other types of learning cannot play a
521 role, e.g. in the case of the human children we have seen that it takes them about three years to
522 learn how to follow the index finger when it is presented in novel configurations, for which
523 rule-based learning might provide a possible explanation (Allan, 1993).

524 In summary, the subjects' responsiveness to the variations of the pointing gesture
525 suggests that both dogs and children (of both ages) have the ability to use rules to generalize
526 from the pointing gesture to other similar types of gestures. Three-year-olds seem to recognize
527 the index finger as a general directional signal. In younger children protruding body parts
528 provide the main cue for deducing directionality. At least at the functional level dogs show a
529 similar performance as 2 year-olds that can be explained as a joint outcome of their
530 evolutionary history and their socialization in a human environment.

531

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533

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538 The experiments delineated in this manuscript comply with the current Hungarian
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540

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688

689 **Figure legends**

690

691 Figure 1. a. Distal pointing b. Elbow cross-pointing c. Forward cross- pointing, d. Long cross-
692 pointing

693

694 Figure 2. The comparison of the group performance in Experiment 1 (“Pointing with arm”)
695 (Mean + SE). Line represents chance level. Different letters label significant differences by
696 Kruskal-Wallis test among the three experimental groups.

697

698 Figure 3. Dogs’ performance in the Experiment 1 (“Pointing with arm”) (Mean + SE). Dotted
699 line represents chance level. The asterisks over the bars refer to the significant differences
700 (One-sample Wilcoxon signed-rank test) from the chance level (** $p < 0.01$, *** $p < 0.001$).

701

702 Figure 4. a. Pointing with leg b. Cross-pointing with leg c. Pointing with knee

703

704 Figure 5. Comparison of group performance in Experiment 2 (“Pointing with leg”) (Mean +
705 SE). Line represents chance level. Different letters label significant difference by Kruskal-
706 Wallis test between the three experimental groups.

707

708 Table 1. The experimental procedure for the different groups. In the case of dogs each test
709 session consisted of 12 trials, which contained 4 trials of momentary distal pointing gesture

710 (control trials) and 8 probe trials, with all three unfamiliar gestures included (3 trials of two
711 types of the probe trials and 2 trials of the third type of the probe trials in). With each dog we
712 staged three test sessions. At the end the dogs got 8 trials of each type of the unfamiliar
713 pointing gestures in both studies. In the case of children in both age-groups we had one test
714 session consisting of 18 trials with each child, which contained 6 trials of momentary distal
715 pointing gesture (control trials) and 4-4-4 trials of each probe trial in both studies.

716

717 Table 2. Results of the Kruskal-Wallis tests (with Dunn's post hoc tests, $p < 0.05$) separately
718 for each gesture.

719

720 Table 3. Results of the One-sample Wilcoxon signed-rank tests (in those cases when the mean
721 of percentages differed significantly from the 3-year-old children's performance according to
722 the Kruskal-Wallis test).

723 Figure 1.

724



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726 1/a.

1/b.

1/c.

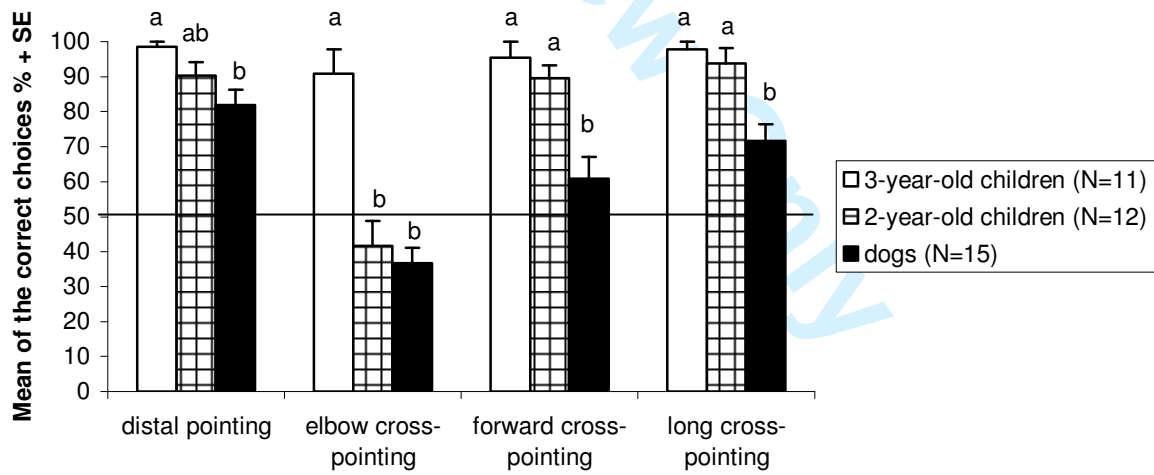


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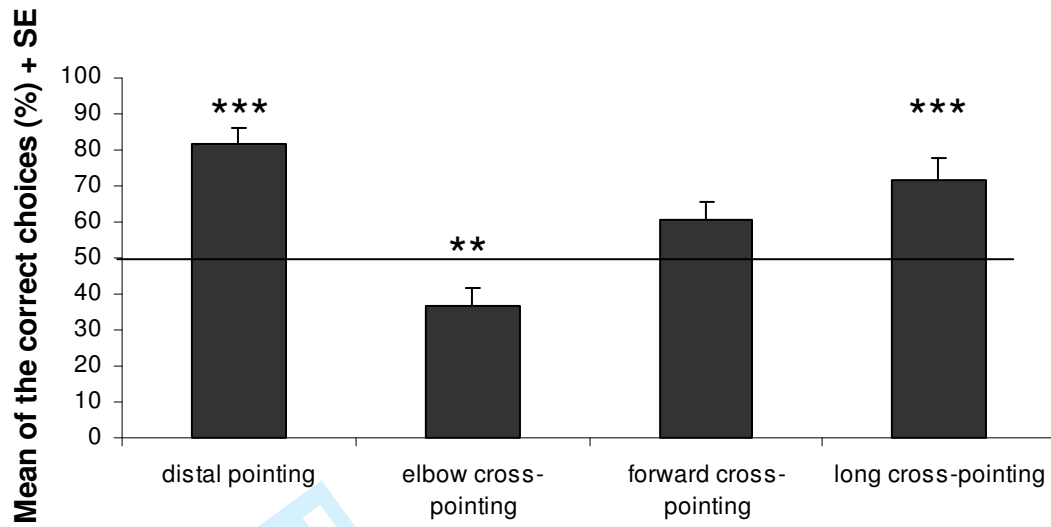
730 Figure 2.



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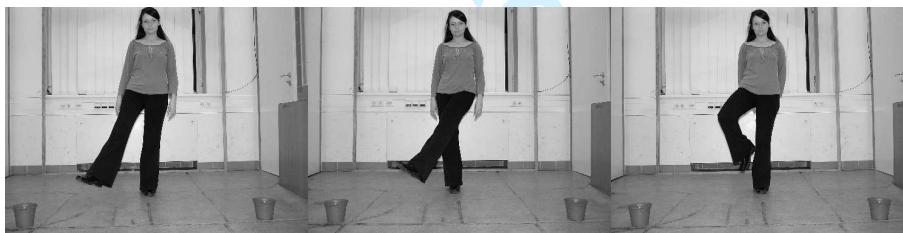
733 Figure 3.



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735 Figure 4.

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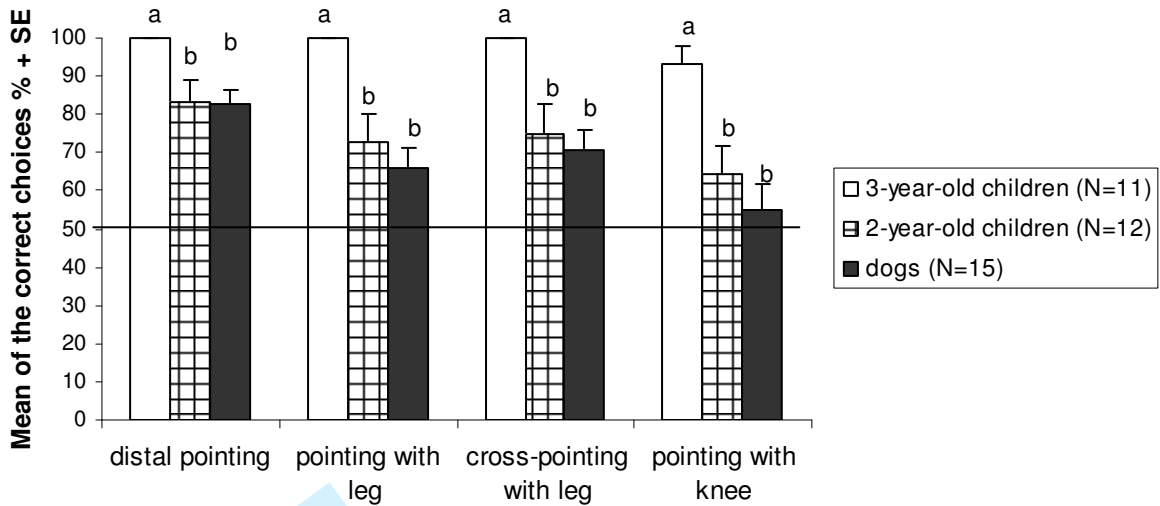
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746 Figure 5.

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For Review Only

753 Table 1. The experimental procedure for the different groups.

	Subjects	
	Dogs	Children (in both age-groups)
1. Pointing with arm test		
1. Session	12 mixed trials: 4 control trials, 3-3-2 probe trials	18 mixed trials: 6 control trials, 4-4-4 probe trials
2. Session	12 mixed trials: 4 control trials, 3-2-3 probe trials	
3. Session	12 mixed trials: 4 control trials, 2-3-3 probe trials	
2. Pointing with leg test		
1. Session	12 mixed trials: 4 control trials, 3-3-2 probe trials	18 mixed trials: 6 control trials, 4-4-4 probe trials
2. Session	12 mixed trials: 4 control trials, 3-2-3 probe trials	
3. Session	12 mixed trials: 4 control trials, 2-3-3 probe trials	

754 Table 2. Results of the Kruskal-Wallis tests (with Dunn's post hoc tests, $p < 0.05$) separately
 755 for each gesture.

756

Type of the pointing gesture	Kruskal-Wallis test		Dunn's posthoc test ($p < .05$)
	χ^2	p	
Distal pointing (Study 1)	13.37	0.01	3 year-old-children > dogs
Elbow cross-pointing	17.87	0.001	3-year-old children > 2-year-old children 3-year-old children > dogs
Forward cross-pointing	18.52	0.001	3 year-old-children > dogs 2-year-old-children > dogs
Long cross-pointing	16.24	0.001	3 year-old-children > dogs 2-year-old-children > dogs
Distal pointing (Study 2)	11.16	0.01	3-year-old children > 2-year-old children 3-year-old children > dogs
Pointing with leg	17.60	0.001	3-year-old children > 2-year-old children 3-year-old children > dogs
Cross-pointing with leg	14.90	0.001	3-year-old children > 2-year-old children 3-year-old children > dogs
Pointing with knee	13.82	0.001	3-year-old children > 2-year-old children 3-year-old children > dogs

757

758 Table 3. Results of the One-sample Wilcoxon signed-rank tests (in those cases when the mean
 759 of percentages differed significantly from the 3-year-old children's performance according to
 760 the Kruskal-Wallis test)

761

Type of the pointing gesture	One-sample Wilcoxon signed-rank test			
	2-year-old children		dogs	
	T	p	T	p
Distal pointing (Study 1)			104.0	0.001
Elbow cross-pointing	-32.0	0.30	-61.0	0.01
Forward cross-pointing			50.0	0.15
Long cross-pointing			88.5	0.001
Distal pointing (Study 2)	66.0	0.001	105.0	0.001
Pointing with leg	21.0	0.05	77.5	0.05
Cross-pointing with leg	42.5	0.05	75.5	0.01
Pointing with knee	37.5	0.09	59.0	0.37

762